SOUTHEASTERN VEGETABLE EXTENSION WORKERS

SOUTHEASTERN U.S.

2018

VEGETABLE CROP HANDBOOK

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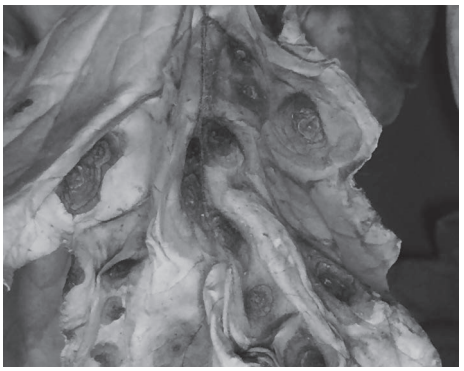
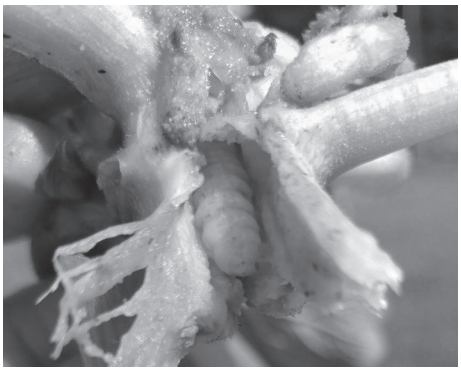

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2018

VEGETABLE CROP HANDBOOK

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Top Left: 'Rainbow' Swiss chard on polyethylene plastic
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Top Center: Early blight lesions on a tomato leaflet
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Top Right: Squash Vine borer
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Center Large: Signs of southern blight on a tomato stem
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Bottom Left: Greenhouse cherry tomato
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SOUTHEASTERN VEGETABLE EXTENSION WORKERS
VEGETABLE CROP HANDBOOK 2018

Dear Reader,

The Southeastern Vegetable Extension Workers Group is proud to offer you the 19th edition of the Vegetable Crop Handbook for the Southeastern United States. For this edition, we have partnered with Meister Media Worldwide, Willoughby, Ohio. We are excited about this new partnership and look forward to working with Meister Media Worldwide as we provide growers, crop advisers, county educators, Extension agents, and specialists throughout the southeastern United States with this handbook.

This handbook represents a joint effort among Extension Specialists and Researchers from 12 land-grant universities in the US who work in the area of vegetable production. These specialists and researchers represent a wide array of disciplines - agricultural engineering, entomology, olericulture (vegetable production), plant pathology, postharvest physiology, soil science, and weed science.

This handbook comprises up-to-the-minute information developed from research and Extension projects conducted throughout the southeastern United States. The key idea behind this handbook is to provide you with a practical resource that conveniently fits on your dashboard. It contains the information that you need to manage your vegetable crops, including which varieties to plant, planting dates, fertilizer recommendations, cover crop selection and conservation tillage options, pesticide selection, grafting, fertigation, plasticulture, postharvest handling, alternative pest management tools and suggestions, as well as many other topics.

An electronic version is available at:
www.GrowingProduce.com/SoutheasternVegetableCropHandbook

In addition to developing this handbook, the SEVEW Group focuses on strengthening and supporting vegetable production programs around the region, identifying emerging issues facing this region, and providing a forum for multistate programming that will benefit growers in the southeastern United States.

Vegetable production in this region faces many challenges. Members of the SEVEW Group have combined their knowledge and experiences to develop approaches and answers that will enable growers in the southeast to optimize their production practices and to increase the sustainability of their operations.

We hope you enjoy this handbook!

Sincerely,
SEVEW Group

The 2017 handbook was prepared and reviewed by the following authors at their respective institutions.
We also wish to thank all of the past authors and participants that have helped to refine and continually improve this handbook.

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The purpose of this book is to provide the best and most up-to-date information available for commercial vegetable growers in the southeastern US: Alabama, Arkansas, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, Texas, Tennessee, South Carolina and Virginia. These recommendations are suggested guidelines for production in the above states. Factors such as markets, weather, and location may warrant modifications and/or different practices or planting dates not specifically mentioned in this book.

UPCOMING EVENTS FOR 2018

DATE/TIME	LOCATION	CONTACT/INFO
REGIONAL MEETINGS		
Southern SAWG Conference – Practical Tools & Solutions for Sustaining Faming Families		
25 to 28 Jan.	Lexington, KY	info@ssawg.org or 404-797-0496 http://www.ssawg.org/january-2017-conference/
ALABAMA		
Farm, Food and Wildlife Expo		
Annually in Aug	Chilton Research and Extension Center, Clanton, AL	James Pitts at 334-850-5805 http://www.aces.edu
Alabama Sustainable Agriculture Network Regional Food and Farm Forums		
Annually from Sept. to Dec. (dates subject to change)	Various locations around Alabama	Alice Evans at 256-682-5742 http://www.asanonline.org
Alabama Fruit & Vegetable Growers Association Annual Conference and Trade Show		
Annually in Nov.	Clanton Performing Arts Center, Clanton, AL	Mac Higginbotham at mhigginbotham@alfafarmers.org http://www.afvga.org
Commercial Horticulture Webinar Series		
Last Monday each month		Online schedule at: http://www.aces.edu/anr/beginningfarms/webinars.php
ARKANSAS		
37th Annual Oklahoma & Arkansas Horticulture Industries Show		
TBA	Tulsa, OK	Donna Dollins at Donna.Dollins@okstate.edu or 405-744-5414
Pecan School		
TBA	Conway, AR	Jackie Lee at jlee@uaex.edu
GEORGIA		
Southeast Regional Fruit & Vegetable Conference		
5 to 8 Jan	Savannah, GA	Tim Coolong at tcoolong@uga.edu Georgia Fruit and Vegetable Growers Association, 877-994-3842 http://www.gfvga.org
Georgia Watermelon Associate Conference		
27 to 29 Jan	St Simons Island, GA	Tim Coolong at tcoolong@uga.edu http://www.georgiawatermelonassociation.org
Georgia Organics Conference & Expo		
17 to 19 Feb	Atlanta, GA	George Boyhan at gboyhan@uga.edu http://georgiaorganics.org
Sunbelt Ag. Expo		
17 to 19 Oct	Moultrie, GA	George Boyhan at gboyhan@uga.edu http://www.sunbeltexpo.com
KENTUCKY		
Kentucky Fruit & Vegetable Conference and Trade Show		
9 to 10 Jan from 8AM to 5PM	Embassy Suites Hotel, 1801 Newton Pike Lexington, KY 40511	John Strang at jstrang@uky.edu or 856-257-5685 Shubin Saha at shubin.saha@uky.edu or 859-257-3374 http://www.kyvga.org
LOUISIANA		
LSU AgCenter/LFVGA Fall Field Day		
TBA	Baton Rouge, LA	Kiki Fontenot at kkfontenot@agcenter.lsu.edu http://www.lsu.edu/LFVGA
GardenFest		
TBA (mid-June)	Baton Rouge, LA	Kiki Fontenot at kkfontenot@agcenter.lsu.edu http://www.lsu.edu/LFVGA
MISSISSIPPI		
North Mississippi Fruit and Vegetable Growers Conference		
9 to 10 Feb Thurs 8AM to 5PM; Fri 8AM to Noon	North Mississippi Research and Extension Center, Verona, MS	Dr. Jeff Wilson, jeff.wilson@msstate.edu
Greenhouse Tomato Short Course		
7 to 8 Mar	Eagle Ridge Conference Center, Raymond, MS	Rick Snyder at Rick.Snyder@msstate.edu; http://greenhousetomatosc.com
Fall Flower & Garden Fest		
Mid-Oct (Friday and Saturday) 9AM to 2PM (both days)	Truck Crops Experiment Station, 2024 Experiment Station Road, Crystal Springs, MS	Rick Snyder at Rick.Snyder@msstate.edu http://extension.msstate.edu/fallfest
NORTH CAROLINA		
Organic Growers School		
9 and 11 Mar	Univ. of North Carolina, Asheville	Rod Bowling rod@organicgrowersschool.com http://organicgrowersschool.org
Tomato Field Day		
TBA (Aug)	Mountain Horticultural Crops Research & Ext. Center, Mills River, NC	Jeff Chandler at 828-684-3562 http://www.cals.ncsu.edu/agcomm/writing/Field_Days

UPCOMING EVENTS FOR 2018 (cont'd)

DATE/TIME	LOCATION	CONTACT/INFO
NORTH CAROLINA (cont'd)		
NC Greenhouse Vegetable Growers Annual Meeting		
TBA (late Oct/early Nov)	Raleigh, NC	http://www.ncagr.gov/markets/assoc/ghvga
Alternative Crops and Organics Field Day		
TBA (Aug)	Mountain Research Station, Test Farm Road, Waynesville, NC	Jeanine Davis at Jeanine_davis@ncsu.edu; http://ncherb.org
SE Vegetable and Fruit Expo		
28 to 29 Nov (jointly held by Clemson and NCSU)	Myrtle Beach, SC	Bonnie Hollowman at 919-334-0099; http://www.ncvga.com; J. Powell Smith at jpsmith@clemson.edu; Chris Gunter at cgunter@ncsu.edu
OKLAHOMA		
37th Annual Oklahoma & Arkansas Horticulture Industries Show		
TBA	Tulsa, OK	**Becky Sellers, Phone (405) 696-3079**
Oklahoma Organic 2018		
October TBA	Oklahoma State University, Oklahoma City Campus Student Center, 900 North Portland, Oklahoma City, OK	Oklahoma State University, Janelle Malone (405) 744-3669
SOUTH CAROLINA		
Preplant Growers Meeting		
31 Jan	USDA Vegetable Lab/Clemson Coastal Research and Education Center (CREC), Charleston, SC	
Watermelon Field Day		
12 July (Registration 8AM; Program 8:30AM to 1:00PM)	Edisto Research and Education Center (EREC), 64 Research Road, Blackville, SC 29817	Gilbert Miller at 803-284-3343 or gmllr@clemson.edu http://www.clemson.edu/public/rec/edisto *Pesticide License and CCA Credits available*
CREC Vegetable Field Day		
6 June	Clemson University Coastal Research & Extension Center, Charleston, SC	Richard Hassell at 843-402-5399 or rhassell@clemson.edu http://www.clemson.edu/public/rec/coastal
SE Vegetable and Fruit Expo		
28 to 29 Nov (jointly held by Clemson and NCSU)	Myrtle Beach, SC	Bonnie Hollowman at 919-334-0099; http://www.ncvga.com; Brian Ward at bw@clemson.edu; Chris Gunter at cgunter@ncsu.edu
TENNESSEE		
Pick TN Conference		
16 to 18 Feb	Cool Springs Marriott Franklin, TN	info@picktnconference.com http://www.PickTNConference.com
UT Steak and Potatoes Field Day		
1 Aug	Plateau Research and Education Center, Crossville, TN	http://plateau.tennessee.edu
UT Organic Crops Field Tour		
TBA (Oct)	East Tennessee Research and Education Center – Organic Crops Unit, Knoxville, TN	http://east.tennessee.edu
VIRGINIA		
Virginia Biological Farming Conference		
23 to 24 Jan	The Homestead Resort; Hot Spring, VA	http://vabf.org/conference
Eastern Shore Ag Conference and Trade Show		
24 to 25 Jan	Eastern Shore Community College, Melfa, VA	Theresa Pittman at 757-787-1361 ext. 14 or tmjlong@vt.edu
Winter Vegetable School		
TBA (Feb)	Warrenton, VA	Kenner Love at 540-675-3619 or klove@vt.edu
Hampton Roads Fruit & Vegetable Meeting		
TBA (Feb)	Chesapeake, VA	Watson Lawrence at 757-382-6348 or watsonL@vt.edu
Virginia Beach Strawberry Field Walk and School		
TBA (Feb/Mar)	Virginia Tech Eastern Shore Agricultural, Research & Extension Center, Painter, VA	Roy Flanagan, III at 757-385-4769 or royf@vt.edu
Richmond Area Vegetable Meeting		
TBA (March)	Dorey Park, Henrico, VA	Laura Maxey at 804-752-7310 or luaram@vt.edu
Virginia Tech Eastern Shore AREC Research Field Day		
TBA (late July/August)	Virginia Tech Eastern Shore Agricultural, Research & Extension Center, Painter, VA	Mark Reiter at 757-414-0724 ext. 16 or mreiter@vt.edu
Northern Neck Vegetable Growers Conference		
TBA (Dec)	Warsaw, VA	Stephanie Romelczyk at 804-493-8924 or sromelcz@vt.edu

Vegetable Production Information Web Sites

ALABAMA

Alabama SARE Program
http://www.southernsare.org/SARE-in-Your-State/Alabama

Alabama Cooperative Extension System
http://www.aces.edu

Commercial Vegetable Information
http://www.aces.edu/dept/com_veg

AU Plant Diagnostic Lab
http://www.aces.edu/dept/plantdiagnosticlab

AL IPM Newsletter
http://www.aces.edu/ipmcommunicator

Vegetable IPM Info
http://www.aces.edu/vegetableipm

Alabama Beginning Farms Program
http://www.aces.edu/beginningfarms

ARKANSAS

Arkansas Cooperative Extension Service
http://www.uaex.edu

Arkansas Fruit, Vegetable, and Nut Update, UK Cooperative Extension Specialist' Blog
http://www.uaex.edu/hortblog

UK CES Commercial Vegetable Production
https://www.uaex.edu/farm-ranch/crops-commercial-horticulture/horticulture/vegetables.aspx

FLORIDA

University of Florida Cooperative Extension Service
http://edis.ifas.ufl.edu

GEORGIA

University of Georgia Cooperative Extension Service
http://extension.uga.edu

UG Fruits & Vegetable Info
http://extension.uga.edu/agriculture/ag-fruits-vegetables

University of Georgia College of Agriculture and Environmental Sciences Publications
http://www.caes.uga.edu/publications

KENTUCKY

University of Kentucky Cooperative Extension Service
http://ces.ca.uky.edu/ces

UK Ag Center for Crop Diversification
http://www.uky.edu/Ag/CCD

Kentucky Vegetable Integrated Pest Management Program
http://www.uky.edu/Ag/IPM/ipmveg/

LOUISIANA

Louisiana SARE Program
http://www.southernsare.org/SARE-in-Your-State/Louisiana

LSU AgCenter
http://www.lsuagcenter.com

LSU Horticulture Pathology
http://www.lsuagcenter.com/hortpathology

Louisiana Fruit & Vegetable Growers Association
http://www.facebook.com/LAFVGA and http://www.lsu.edu/LFVGA

MISSISSIPPI

Mississippi State University Extension Service
http://extension.msstate.edu

MS Greenhouse Tomato Production FAQ
http://extension.msstate.edu/crops/commercial-horticulture/greenhouse-tomatoes

MS Greenhouse Tomato Short Course
http://greenhousetomatosc.com

Mississippi Commercial Horticulture Information
http://extension.msstate.edu/agriculture/crops/commercial-horticulture

MISSISSIPPI (CONT'D)

Farmers' Markets
http://extension.msstate.edu/crops/commercial-horticulture/farmers-markets

NORTH CAROLINA

North Carolina Cooperative Extension Service
http://www.ces.ncsu.edu

Information on Herbs, Organics, & Specialty Crops
http://ncherb.org

NCSU Vegetable Pathology
http://go.ncsu.edu/veggiepathology

NCSU Extension Plant Pathology Portal
http://plantpathology.ces.ncsu.edu/

NCSU Plant Disease and Insect Clinic
http://www.cals.ncsu.edu/plantpath/extension/clinic/

NCSU Entomology Portal
http://entomology.ces.ncsu.edu/

NCSU IPM Portal
http://ipm.ces.ncsu.edu/

North Carolina Pest News
http://ipm.ncsu.edu/current_ipm/pest_news.html

Horticulture Information Leaflets
http://www.ces.ncsu.edu/depts/hort/hil

NC Organic Agriculture Internet Resource
http://ncorganic.org

Wolfpack Weeds
http://wolfpackweeds.com/

Fresh Produce Safety
http://ncfreshproducesafety.ces.ncsu.edu/

OKLAHOMA

Oklahoma Cooperative Extension Service
http://www.oces.okstate.edu

OK Dept. of Horticulture Vegetable Fact Sheets
http://www.hortla.okstate.edu/research-and-outreach/research/

OK Dept. of Horticulture Vegetable Variety Trial Info
http://www.hortla.okstate.edu/research-and-outreach/research/vegetable-trial-reports

SOUTH CAROLINA

Clemson University Cooperative Extension Service
http://www.clemson.edu/extension

Clemson Coastal Research & Education Center
http://www.clemson.edu/public/rec/costal/

Clemson Edisto Research and Extension Center
http://www.clemson.edu/public/edisto

TENNESSEE

University of Tennessee Extension
https://extension.tennessee.edu

UT Vegetable Production
http://vegetables.tennessee.edu

UT Organic & Sustainable Crop Production
http://organics.tennessee.edu

TEXAS

Texas Agricultural Extension Service
http://agrilifeextension.tamu.edu

VIRGINIA

Virginia Cooperative Extension
http://www.ext.vt.edu

Virginia Tech Vegetable Entomology Facebook
http://www.facebook.com/VirginiaTechVIPRlab

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General Production Recommendations

VARIETIES

New vegetable varieties are constantly being developed throughout the world. Since it is impossible to list and describe all of them, only some of the better performing commercial types are listed in the specific crop section, either alphabetically or in order of relative maturity from early to late. These varieties are believed to be suitable for commercial production under most conditions in the southeastern US.

The ultimate value of a variety for a particular purpose is determined by the grower, the variety's performance under his or her management, and environmental conditions. Several years of trial plantings are suggested for any variety not previously grown. For a true comparison, always include a standard in the same field.

Disease Resistance or Tolerance. Natural variation within a crop species particularly from wild types can be a source of disease resistance. Plant scientists have taken advantage of this natural variation to develop varieties that are resistant or tolerant. Superscripts appearing after the variety names refer to the disease resistance or tolerance these are are spelled out in the footnotes.

Specialty Vegetables. Many producers are considering growing specialty or "gourmet" vegetables.

A limited number of pesticides are registered for many specialty vegetables and herbs. Successful pest control in these crops is dependent on sanitation, seed treatment, crop rotation, planting site, mechanical cultivation, and the use of resistant varieties when available.

Promising specialty vegetable crops crops include asparagus, Belgian endive, dandelion (blanched), kale, Swiss chard, tyfon (Holland greens), herbs, ethnic vegetables, red leaf lettuce, romaine lettuce, scallions, snap peas, and snow peas.

Other promising types include bok choy, Chinese cabbage, endive and escarole (blanched), garlic (pink skin), Japanese melons, leeks, pak choi, pepper, potato (red, blue, yellow, and golden), red radicchio, rhubarb, sweet onions, and sweetpotatoes (moist and dry types with unusual colors).

Miniature or baby vegetables are vegetables that are harvested at an immature stage to insure tenderness and often sweetness. These include beets, carrots (finger and round types), cucumbers, eggplant (little finger types), Jersey Golden acorn squash (immature with blossom attached), baby lettuce, pickling corn, snap beans (small sieve types), summer squash (immature with blossom attached), and winter squash (Oriental and Little Dumpling).

Before planting a specialty crop; however, **growers must determine that specific retail, wholesale, restaurant, or processing markets exist.**

CROP ROTATION

Crop rotation is an effective and widely used cultural practice to prevent or reduce the buildup of soil-borne plant pathogens. An effective rotation sequence includes crops from different families that are poor or non hosts of these pathogen(s). In general, the longer the rotation, the better the results; a 3- to 5-year rotation is generally recommended. However, from a practical standpoint this will depend upon the availability of land, the markets, the selection of alternate crops suited to grow in the area, the pathogen(s), and the purpose of the rotation (prevention versus reduction). When used to reduce pathogen populations, rotations of longer than 5 years may be required (see Table 1A).

SOILS AND SOIL FERTILITY

The best soils for growing vegetables are well-drained, deep soils that are high in organic matter. These soils should have good structure and have been adequately limed and fertilized. Loamy sand and sandy loam soils are generally better suited for growing early market crops because they drain quickly and warm early in spring. Deep, well-drained organic soils are ideal for leafy vegetables, bulb and root crops that offer a high return per acre.

Soils that are not ideal for vegetable production may be made suitable for production by addressing the underlying problem(s). For example, poorly drained soils may require the use of cover crops and/or tiling to improve drainage.

TABLE 1A. VEGETABLE FAMILIES

Grass Family	**Pea Family**
Sweet corn	Garden/English Pea
Popcorn	Bean (lima, snap)
Ornamental Corn	Cowpea or Southernpea
Allium Family	Soybean
Onion	**Parsley Family**
Leek	Carrot
Garlic	Parsley
Shallot	Celery
Chive	Cilantro
Goosefoot Family	**Solanaceae Family**
Beet	Potato
Chard	Eggplant
Spinach	Tomato
Mustard Family	Pepper
Kale	**Gourd Family**
Collard	Pumpkin
Brussels Sprout	Squash
Cabbage	Watermelon
Cauliflower	Cucumber
Broccoli	Muskmelon
Kohlrabi	Cantaloupe
Rutabaga	**Composite Family**
Turnip	Chicory
Mustard	Endive & Escarole
Upland cress	Dandelion
Radish	Lettuce
Mallow Family	Artichoke
Okra	Jerusalem artichoke
Bindweed Family	
Sweetpotato	

A large percentage of the vegetables grown in mineral soils of the Coastal Plain are grown in soils with essentially no structure. These sandy soils also have little intrinsic fertility; however, they can be productive if managed properly. Adequate fertilization, adjusting pH as needed, and use of irrigation water are required.

Soil Management. In a good soil management program, proper liming and fertilization, good tillage practices, crop rotation, annual additions of organic matter with cover crops, and adequate irrigation are all necessary to maintain high levels of production. Winter cover crops and periodically resting the land with summer cover crops between vegetable plantings are essential in preventing deterioration of the soil structure. In soil management, this is vital for maintaining highly productive soils.

Nutrient Management and the Environment. The sandy soils preferred for vegetable production in the southeastern US result in an aerated root zone and enable timely tillage, planting, and harvesting. The same drainage allows water and dissolved nutrients to move through the soil profile. Even with loams or clays, nutrients retained in surface soil may be carried with sediment or as dissolved run-off to surface water. Nitrates and phosphorus remain the two agricultural nutrients of greatest environmental concern. Even agronomically small losses of N & P can impact water quality, especially in eco-sensitive regions. Other issues of potential concern include K fertilizer losses and accumulation of heavy metals such as copper, zinc, etc. supplied with organic amendments.

Ongoing research has documented increased costs and reduced profits, as well as natural resource degradation and human health risks, due to over-fertilization. It is therefore critical that both nutrients and irrigation are managed to optimize vegetable production while minimizing impact on the environment. Careful nutrient management includes at least the following four issues: rate, timing, placement, and source. Land-grant university recommendations are based on calibrated crop response studies that can differ substantially across the region. Producers should consult guidelines prepared specifically for their state for the most appropriate nutrient management recommendations. A well-balanced nutrient management plan represents good stewardship and should satisfy any applicable environmental regulations.

Soil Acidity and Liming. Many soils in the southeast are naturally acidic, or become acidic with cropping, and need liming to attain optimum production levels. Soil acidity is the term used to express the quantity of hydrogen (H^+) and aluminum (Al^{3+}) cations (positively charged ions) in soils. Soil pH is determined by using a 1:1 soil-to-water solution. The pH of the solution is measured by a pH meter (potentiometer). Soil pH is an indicator of "soil acidity". Combined, the use of the soil pH and soil textural class determines the lime requirement. A pH of 7.0 is defined as neutral, with values below 7.0 being acidic and above 7.0 being basic or alkaline. Root growth and plant development may be severely restricted if acidic cations, especially aluminum, occupy a large percentage of the negatively charged soil cation exchange capacity (CEC). This negative charge is due to the chemical makeup of the soil clay and organic matter, and means that they can attract positively charged ions. Soils become acidic due to the leaching of calcium (Ca^{2+}) and magnesium (Mg^{2+}), especially in sandy coastal plain soils. Acidification also occurs when H^+ is added to soils by decomposition of plant residues and organic matter, and during the nitrification of ammonium when added to soils as fertilizer (UAN solutions, urea, ammonium nitrate, ammonium sulfate, anhydrous ammonia), manures, or plant residues. Declines of one pH unit can occur even in properly fertilized beds. The H^+ added to soils reacts with the clay minerals (aluminum silicates) and releases Al^{3+}, the most deleterious component of soil acidity. Lime is applied to neutralize soil acidity by releasing a base (HCO_3^-, OH^-) into the soil solution, which reacts with acid-forming ions (H^+). Increasing soil pH reduces the concentration of dissolved aluminum, as well as influencing the concentrations of other ions.

Lime recommendations must take into account differences in acidity among soils as well as differences among various crops' tolerance to acidity. Both the soil pH and some measure of residual or exchangeable acidity are needed to calculate lime recommendations. Although portable soil test kits determine pH rapidly, it is not possible to make an accurate lime recommendation based solely on a pH measurement. Another issue to consider is that different soil laboratories may use different testing methods developed for their particular soil conditions. Due to these differences, producers should consult with their local Extension office about laboratory methods and target pH assumptions used in determining lime recommendations. Consult your state guidelines for a description of the current soil test method and interpretation guidelines.

If soil pH is too high for the desired crop, elemental sulfur (S) is the most effective material to reduce soil pH.. The amount of acidity generated by 640 pounds of elemental S is the same as that neutralized by 1 ton of lime. Soil pH can be lowered by applying aluminum sulfate or iron sulfate. Whether trying to increase or decrease the pH of your soil, always follow the manufacturer's instructions for appropriate rates. A slight pH reduction can be produced by using ammonium sulfate, ammonium nitrate, or urea as a fertilizer source of nitrogen.

Liming materials containing only calcium carbonate ($CaCO_3$), calcium hydroxide [$Ca(OH)_2$], or calcium oxide (CaO) are called calcitic limes. Pure calcium carbonate is used as the standard for liming materials and is assigned a rating of 100 percent. This rating is also known as the "calcium carbonate equivalent, and is referred to as the CCE. All other liming materials are rated in relationship to pure calcium carbonate. Liming materials with significant amounts of magnesium carbonate ($MgCO_3$) are called dolomitic limes. Dolomitic limes should be used on soils low in magnesium, as indicated by the soil test report. It is possible to use a magnesium fertilizer instead of dolomitic lime, but the costs of this source of magnesium are almost always considerably higher. Because lime dissolves very slowly, it must be finely ground to effectively neutralize soil acidity. Lime laws in most states describe standards for composition and particles sizes.

The most commonly used liming materials are finely ground dolomitic or calcitic rock. Most agricultural lime is sold in bulk by the ton. Additional liming materials include burnt lime or hydrated lime, pelleted lime, liquid lime, wood ash, ground seashells, and industrial slags. Lime pellets and lime suspensions (liquid lime) can be convenient and fast-acting, but are usually considerably more expensive than ground limestones. Industrial by-product liming materials can be useful soil amendments capable of reducing soil acidity and supply a variety of nutrients including calcium,

magnesium, potassium, phosphorus, and micronutrients. Each lot of such materials should be analyzed as considerable variation in CCE, fineness, and nutrient composition may occur.

Within a one to three year time-period, lime moves little in the soil and neutralizes acidity only in the zone where it is applied. To be most effective, lime must be uniformly spread and thoroughly incorporated. In practice, rates are adjusted after checking the spreader pattern and making appropriate corrections. If the application is not correct, strips of under-limed soil could result, possibly reducing crop yields. The most commonly used lime incorporation tool is the disk. It will not incorporate lime as well as offset disks that throw the soil more vigorously. The best incorporation implement is a heavy-duty rotary tiller that mixes the soil throughout the root zone.

Lime and Fertilizer. Lime and fertilizer work together synergistically to produce high yields and better crops. Lime is not a substitute for fertilizer, and fertilizer is not a substitute for lime.

How to Use Plant Nutrient Recommendation Table #1 and #2. Use Table 1 to determine the relative levels of phosphorus and potassium in the soil based on the soil test report from the laboratory. Use Table 2 as a guide in conjunction with specific soil test results. Plant nutrient recommendations listed in Table 2 are expressed in terms of nitrogen (N), phosphate (P_2O_5), and potash (K_2O), rather than in specific grades and amounts of fertilizer. When soil test results are not available, use recommended amounts of P_2O_5 and K_2O listed under medium phosphorus and medium potassium soil test levels for the crop to be grown. When soil test results are available, the phosphate (P_2O_5) and potash (K_2O) needs for each cropping situation can be determined by selecting the appropriate values under the relative soil test levels for phosphorus and potassium: very low, low, medium, high, or very high.

The cropping and manuring history of the field must be known before a fertilization program can be planned (see Table 3). This history is very important in planning a nitrogen fertilization program, because a reliable soil test for nitrogen is not available.

Plant nutrient recommendations listed in Table 2 were developed for fields where no manure was applied and where no legume crop is being turned under prior to the planting of a new crop. If manure and/or legume crops are used, the plant nutrient recommendations listed in Table 2 should be reduced by the amounts of nitrogen (N), phosphate (P_2O_5), and potash (K_2O) being contributed from these sources. See Tables 3 and 3A for nutrient values of various products.

Once the final fertilizer-plant nutrient needs are known, determine the grade and rate of fertilizer needed to fulfill these requirements. For example, if the final plant nutrient requirements that need to be added as a commercial fertilizer are 50 pounds of nitrogen (N), 100 pounds of phosphate (P_2O_5), and 150 pounds of potash (K_2O), a fertilizer with a 1-2-3 ratio, such as 5-10-15, 6-12-18, 7-14-21, is needed. Once the grade of fertilizer is selected, the quantity needed to fulfill the plant nutrient requirements can be determined by dividing the percentage of N, P_2O_5, or K_2O contained in the fertilizer into the quantity of the respective plant nutrient needed per acre and multiplying the answer by 100.

For example, if a 5-10-15 fertilizer grade is chosen to supply the 50 pounds of N, 100 pounds of P_2O_5, and 150 pounds of K_2O needed, calculate the amount of 5-10-15 fertilizer needed as follows: Divide the amount of nitrogen (N) needed per acre (50 pounds) by the percentage of N in the 5-10-15 fertilizer (5 percent), and multiply the answer (10) by 100, which equals 1,000 pounds. This same system can be used for converting any plant nutrient recommendations into grades and amounts.

NUTRIENT MANAGEMENT AND MAXIMIZING PRODUCTION

Plants remove substances from the soil and air to enable them to grow and reproduce. The specific substances they remove are termed nutrients. Certain of these are generally required in larger quantities, and termed macronutrients. Those needed in smaller quantities, micronutrients, are as important as macronutrients for achieving required metabolic processes in the plant. Most commercial fertilizers include macronutrients nitrogen (N), phosphorus (P), and/or potassium (K), expressed as a weighted percentage (N-P_2O_5-K_2O). Micronutrients may be supplied along with macronutrients.

Nitrogen Management. Nitrogen is one of the most difficult nutrients to manage in vegetable production systems. Nitrogen is readily leached in sandy textured soils that dominate vegetable production regions of the southeastern US. Nitrogen can be immobilized by soil microbes, volatilized if not quickly incorporated, or lost via denitrification under water-saturated soil conditions. Nitrogen recommendations are based on years of fertilizer trials and yield potential. Nitrogen application timings, application methods, and sources are also commonly tested in state university fertilizer trials and have resulted in recommendations for splitting nitrogen fertilizer application for increased fertilizer use efficiency.

Heavy rainfall, higher than normal yields, and production following non-legume cover crops are a few examples where nitrogen fertilizer may be immobilized or lost from the production system. When these nitrogen reduction scenarios arise, an addi-

TABLE 1. SOIL TEST INTERPRETATIONS AND RECOMMENDATIONS BASED ON SOIL TEST RESULTS

Soil Test Rating	Relative Yield without Nutrient (%)	Recommendations
Low	50–75	Annual application to produce maximum response and increase soil fertility.
Medium	75–100	Normal annual application to produce maximum yields.
High*	100	Small applications to maintain soil level. Amount suggested may be doubled and applied in alternate years.
Very high*	100	None until level drops back into high range. This rating permits growers, without risk of loss in yields, to benefit economically from high levels added in previous years. Where no P or K is applied, soils should be resampled in 2 years. When phosphorus is extremely high, further additions may limit the availability of Fe and/or Zn.

* Some states recommend that no fertilizer P or K be added when the soil test rating is either “High” or “Very High”, in order to minimize runoff in nutrient-sensitive watersheds

tional application of nitrogen is warranted. Leaf tissue testing is the best option when deciding if and how much more nitrogen is needed to meet expected yields and is described below. Leaf tissue testing can help identify any "*hidden hunger*" that might exist in the crop. A "*hidden hunger*" develops when a crop needs more of a given nutrient but has shown no deficiency symptoms. With most nutrients on most crops, responses can be obtained even though no recognizable symptoms have appeared.

Evaluating the Effectiveness of Your Fertility Program—Using Plant Analysis/Leaf Tissue Testing. Plant analysis is the chemical evaluation of essential element concentrations in plant tissue. Essential elements include those that are required to complete the life cycle of a plant. The elements carbon (C), oxygen (O), and hydrogen (H) are supplied by the atmosphere and water and generally are not considered limiting. Scientists place most emphases on essential elements supplied by soil or feeding solutions. Macronutrients — nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) — are required in greatest quantities. Micronutrients — iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), and chlorine (Cl) — are required in very small quantities. Toxicities of micronutrients are equally important and yield limiting as deficiencies. Plant analysis is also effective in diagnosing toxicities of micronutrients. The interpretation of plant analysis results is based on the scientific principle that healthy plants contain predictable concentrations of essential elements.

State and private soil testing laboratories can provide nitrogen concentrations as well as those of the other essential macro- and micronutrients to aid in mid-season fertilizer application decisions. A program of periodic leaf tissue sampling and analysis will help you optimize your fertility program and often can allow you to correct deficiencies before symptoms become apparent. The best indicator samples have been identified for most economically important vegetable crops. In turn this has provided the basis for developing data for which we can compare values from our analysis to those of established, recognized values. These are called *Sufficiency Ranges* or *Critical Values*. For those crops such as tomatoes which receive the greatest research support, indicator samples have been identified by stage of growth. In tomato we have sufficiency ranges established for plant tissue samples taken at mid-bloom of the first, second, third, fourth, fifth, and sixth flower clusters.

Critical values have been defined as the concentration at which there is a 5–10% yield reduction. The use of critical values for practical interpretation has limited value. It is best suited to diagnose severe deficiencies and has little application in identifying hidden hunger. Symptoms are generally visibly evident when nutrient concentrations decrease below the critical value. Critical values play an important role in establishing lower limits of sufficiency ranges.

Sufficiency range interpretation offers significant advantages over the use of critical values. First, hidden hunger in plants can be identified since the beginning of the sufficiency range is clearly above the critical value. Sufficiency ranges also have upper limits, which provide some indication of the concentration at which the element may be in excess.

Method for Collecting Leaf Tissue Samples for Analysis

- Each vegetable crop has a specific corresponding plant part that is collected and used to determine foliar nutrient levels. Often this corresponds to sampling the most recently matured or fully expanded leaves. Careful sampling ensures the effectiveness of plant analysis as a diagnostic tool. For major crops, best indicator samples have been identified by stage of growth. For young seedlings, the entire plant is sampled 2.5 cm above the soil level. For larger plants, the most recent fully expanded or mature leaf is the best indicator of nutritional status. As some crops, including corn, approach flowering and fruiting, the best indicator of nutritional status is the leaf adjacent to the uppermost fruit (ear leaf). When unfamiliar with sampling protocol for a specific crop, it is generally acceptable to select the most recent mature leaf as the best indicator of nutritional status. Detailed information for sampling most vegetable crops can be found at http://www.ncagr.gov/agronomi/saaesd/scsb394.pdf.
- Sample from 20 to 30 plants.
- Sample across the field, from different rows, and avoid problem areas (low spots, ridges, washed out areas, etc.) unless you are trying to diagnose a problem in one of these areas.
- Sample when the plants are actively growing (typically between 9 a.m. and 4 p.m.).
- Do not collect samples from water stressed plants.
- Send samples to a laboratory in a paper bag. DO NOT SEND SAMPLES IN A PLASTIC BAG. Plastic bags will cause your samples to spoil and will impact results. Contact your local Extension office for information on how to submit leaf tissue samples to your state diagnostic labs.

Phosphorus Management. Crops are very likely to respond to P fertilization when the soil test indicates that P is *deficient—very low* or *low*. A soil testing *deficient—medium* will sometimes respond to P fertilization and will sometimes not. Soils testing *optimum* or *exceeds crops needs* are unlikely to respond to P fertilizer, but P may be applied to maintain the fertility level in the *optimum* range. Crops are more likely to respond to P fertilizer when growing conditions are favorable for high yields.

It is often recommended that a band of P fertilizer be placed near the seed as a starter fertilizer regardless of the P fertility level. High phosphorus fertilizers are often referred to as 'pop-up' fertilizers because of their positive effect during early growth when soil temperatures in early spring can be very low. Banded P is especially helpful at low soil test levels. Even at P soil test levels that exceed crop needs, a small amount of banded P may benefit crop establishment. When the soil test level is *deficient*, P should generally be applied as a combination of broadcast and banded methods. When the level exceeds crop needs, only a small amount of P should be applied as a band. Many soils exceed crop needs category for P due to previous fertilizer and manure applications. When applied in excess of crop removal, P accumulates in the soil. Phosphorus is strongly adsorbed to soil particles and very little is subject to loss via leaching. When the soil test level exceeds crop needs, growers can benefit economically by withholding P fertilizers.

Potassium Management. Crops are very likely to respond to K fertilizer when the soil test indicates that K is *deficient—very low* or *low*. A soil testing *deficient—medium* in K may or may not respond to K fertilizer. Crops are more responsive to K when growing under drought stress than when growing under favorable conditions. Soils testing *optimum* or *exceeds crop needs* are unlikely to respond to K fertilizer, but K may be applied to maintain the soil fertility level in the *optimum* range.

In general, most of the K fertilizer should be broadcast. When the fertility level is *deficient*, it may be advantageous to apply a portion of the total K application as a band. There is generally no benefit to applying banded K when soil fertility levels are *optimum* or *exceeds crop needs*. Crops remove larger amounts of K than P from the soil during a growing season. In addition, sandy soils have low reserves of K, and K is susceptible to leaching. Therefore, frequent applications of K are needed to maintain K at an optimum fertility level.

Secondary Nutrients. Calcium (Ca), magnesium (Mg), and sulfur (S) are included in the secondary element group. Calcium may be deficient in some soils that have not been properly limed, where excessive potash fertilizer has been used, and/or where crops are subjected to drought stress. Magnesium is the most likely of these elements to be deficient in vegetable soils. Dolomitic or high-magnesium limestones should be used when liming soils that are low in magnesium. Magnesium should be applied as a fertilizer source on low-magnesium soils where lime is not needed (Table 4). Magnesium may be applied as a foliar spray to supply magnesium to the crop in emergency situations (2 TBSP of Epsom salts per gallon of water).

Sulfur is known to be deficient in vegetable crop soils in coastal plain soils. Sulfur deficiency is often mistaken for lack of nitrogen because the symptoms are similar. Onions are one crop that will need additional sulfur over what vegetables normally require, particularly on coastal plain soils.

Micronutrients. Boron is the most widely deficient micronutrient in vegetable crop soils. Deficiencies of this element are most likely to occur in the following crops: asparagus, most bulb and root crops, cole crops, and tomatoes. Excessive amounts of boron can be toxic to plant growth. This problem can occur when snap beans (a sensitive crop) follow sweetpotatoes (a crop where boron is applied late in the season). Do NOT exceed recommendations listed in Table 2.

Manganese deficiency often occurs in plants growing on soils that have been overlimed. In this case, broadcast 20 to 30 pounds or band 4 to 8 pounds of manganese sulfate to correct this. Do not apply lime or poultry manure to such soils until the pH has dropped below 6.5, and be careful not to overlime again.

Molybdenum deficiency of cauliflower (which causes whiptail) may develop when this crop is grown on soils more acid than pH 5.5. An application of 0.5 to 1 pound of sodium or ammonium molybdate per acre will usually correct this. Liming acid soils to a pH of 6.0 to 6.5 will usually prevent the development of molybdenum deficiencies in vegetable crops.

Deficiencies of other micronutrients in vegetable crops in the Southeast are rare; and when present, are usually caused by overliming or other poor soil management practices. Contact Extension if a deficiency of zinc, iron, copper, or chlorine is suspected. Sources of fertilizers for the essential plant nutrients are found in in Tables 3A and 4.

Municipal Biosoilds. *Biosolids Should Not Be Applied to Land on Which Crops Will Be Grown That Will Be Entering the Human Food Chain.* Municipal biosolids are the solid material removed from sewage in treatment processes. Biosolids treated by one of the digestive or similar processes to reduce pathogens is a low-analysis fertilizer suitable for application to nonfood crops under specific soil conditions. It should not be applied to sloping land, to highly leachable soils, to poorly drained soils, to soils with high water tables or near surface water, or to soils having a pH less than 6.2. Check with your local or state department of environmental management for latest regulations. The time required to wait prior to planting a food crop varies from state to state.

Foliar Fertilization. Foliar feeding of vegetables is usually not needed. Plants usually obtain their nutrients from the soil through their roots. It is known that plants can also absorb a limited amount of some nutrients through aerial organs such as leaves. Properly managed soils will supply the essential mineral nutrients the crop will need during its development. If, for some reason, one or more soil-supplied nutrients becomes limiting or unavailable during the development of the crop, foliar nutrient applications may then be advantageous but likely only with the micronutrients.

TABLE 2. GENERAL FERTILIZER SUGGESTIONS FOR VEGETABLE CROPS*

CROP	Desirable pH	Nitrogen (N) lb/acre	Recommended Nutrients Based on Soil Tests								Nutrient Timing and Method
			Soil Phosphorus Level				Soil Potassium Level				
			Low	Med	High	Very High	Low	Med	High	Very High	
			P_2O_5 lb/acre				K_2O lb/acre				
ASPARAGUS											
	6.5 to 7.0	100	250	150	100	0	250	225	150	0	Total recommended.
		50	250	150	100	0	150	100	75	0	Broadcast before cutting season.
		50	0	0	0	0	100	125	75	0	Sidedress after cutting.
		Apply 2 lb boron (B) per acre every 3 years on most soils.									
BEAN, Lima											
...Single crop	6 to 6.5	70 to 110	120	80	40	20	160	120	80	20	Total recommended.
		25 to 50	80	40	20	0	120	80	60	0	Broadcast and disk-in.
		20	40	40	20	20	40	40	20	20	Band-place with planter.
		25 to 40	0	0	0	0	0	0	0	0	Sidedress 3 to 5 weeks after emergence.
BEAN, Snap											
	6 to 6.5	40 to 80	80	60	40	20	80	60	40	20	Total recommended.
		20 to 40	40	40	0	0	40	40	0	0	Broadcast and disk-in.
		20 to 40	40	20	40	20	40	20	40	20	Band-place with planter.
BEET											
	6 to 6.5	75 to 100	150	100	50	0	150	100	50	0	Total recommended.
		50	150	100	50	0	150	100	50	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress 4 to 6 weeks after planting.
		Apply 2 to 3 lb boron (B) per acre with broadcast fertilizer.									
BROCCOLI											
	6 to 6.5	125 to 175	200	100	50	0	200	100	50	0	Total recommended.
		50 to 100	150	100	50	0	150	100	50	0	Broadcast and disk-in.
		50	50	0	0	0	50	0	0	0	Sidedress 2 to 3 weeks after planting.
		25	0	0	0	0	0	0	0	0	Sidedress every 2 to 3 weeks after initial sidedressing.
		Apply 2 to 3 lb boron (B) per acre with broadcast fertilizer.									
BRUSSEL SPROUTS, CABBAGE, and CAULIFLOWER											
	6 to 6.5	100 to 175	200	100	50	0	200	100	50	0	Total recommended.
		50 to 75	200	100	50	0	200	100	50	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress 2 to 3 weeks after planting.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress if needed, according to weather.
		Apply 2 to 3 lb boron (B) per acre and molybdenum per acre as 0.5 lb sodium molybdate per acre with broadcast fertilizer.									
CANTALOUPES and MELONS											
...Bareground	6 to 6.5	75 to 115	150	100	50	25	200	150	100	25	Total recommended.
		25 to 50	125	75	25	0	175	125	75	0	Broadcast and disk-in.
		25	25	25	25	25	25	25	25	25	Band-place with planter.
		25 to 40	0	0	0	0	0	0	0	0	Sidedress when vines start to run.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									
...Plasticulture		100 to 150	125	75	25	25	200	150	100	25	Total recommended.
		25	125	75	25	25	100	75	50	25	Broadcast and disk-in.
		75 to 125	0	0	0	0	100	75	50	0	Fertigate.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer. Drip fertilization: See “cantaloupe” in specific commodity recommendations later in this handbook.									
CARROT											
	6 to 6.5	90 to 120	150	100	50	0	150	100	50	0	Total recommended.
		50	150	100	50	0	150	100	50	0	Broadcast and disk-in.
		40 to 70	0	0	0	0	0	0	0	0	Sidedress if needed.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilzer.									
CUCUMBER											
...Bareground	6 to 6.5	80 to160	150	100	50	25	200	150	100	25	Total recommended.
		40 to 100	125	75	25	0	175	125	75	0	Broadcast and disk-in.
		20 to 30	25	25	25	25	25	25	25	25	Band-place with planter 7 to 14 days after planting.
		20 to 30	0	0	0	0	0	0	0	0	Sidedress when vines begin to run, or apply in irrigation water.
...Plasticulture		120 to 150	150	100	50	25	150	100	50	25	Total recommended.
		25	125	75	25	0	150	100	50	0	Broadcast and disk-in.
		95 to 125	25	25	25	25	0	0	0	25	Fertigate.
		Drip fertilization: See “cucumber” in specific recommendations later in this handbook.									

* Nitrogen rates should be based on your local fertilizer recommendations.

TABLE 2. GENERAL FERTILIZER SUGGESTIONS FOR VEGETABLE CROPS* (cont'd)

CROP	Desirable pH	Nitrogen (N) lb/acre	Recommended Nutrients Based on Soil Tests								Nutrient Timing and Method
			Soil Phosphorus Level				Soil Potassium Level				
			Low	Med	High	Very High	Low	Med	High	Very High	
			P_2O_5 lb/acre				K_2O lb/acre				
EGGPLANT											
...Bareground	6 to 6.5	100 to 200	250	150	100	0	250	150	100	0	Total recommended.
		50 to 100	250	150	100	0	250	150	100	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress 3 to 4 weeks after planting.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress 6 to 8 weeks after planting.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									
...Plasticulture		145	250	150	100	0	240	170	100	0	Total recommended.
		50	250	150	100	0	100	100	100	0	Broadcast and disk-in.
		95	0	0	0	0	140	70	0	0	Fertigate.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer. Drip fertilization: See "eggplant" in specific recommendations later in this handbook.									
ENDIVE, ESCAROLE, LEAF and ROMAINE LETTUCE											
	6 to 6.5	75 to 150	200	150	100	0	200	150	100	0	Total recommended.
		50 to 100	200	150	100	0	200	150	100	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress 3 to 5 weeks after planting.
HOPS											
	6.0	100 to 150	80 to 120	30 to 80	0 to 30	0	100 to 140	50 to 100	0 to 50	0	Total recommended.
		50 to 75	80 to 120	30 to 80	0 to 30	0	100 to 140	50 to 100	0 to 50	0	Broadcast
		50 to 75	0	0	0	0	0	0	0	0	Sidedress 4 weeks after bines emerge
		Apply 1 lb of boron (B) per acre with broadcast fertilizer. NOTE: First year planting N rate should be reduced to 75 lbs/acre. Nitrogen should not be applied after flowering.									
HERBS (BASIL, PARLESY, CLIANTRO)											
	6 to 6.5	100 to 175	200	150	100	0	200	150	100	0	Total recommended.
		50 to 75	200	150	100	0	200	150	100	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress after first cutting.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress after each additional cutting.
LEAFY GREENS, COLLARD, KALE, and MUSTARD											
	6 to 6.5	75 to 80	150	100	50	0	150	100	50	0	Total recommended.
		50	150	100	50	0	150	100	50	0	Broadcast and disk-in.
		25 to 30	0	0	0	0	0	0	0	0	Sidedress, if needed.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									
LEEK											
	6 to 6.5	75 to 125	200	150	100	0	200	150	100	0	Total recommended.
		50 to 75	200	150	100	0	200	150	100	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress 3 to 4 weeks after planting, if needed.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									
OKRA											
	6 to 6.5	100 to 200	250	150	100	0	250	150	100	0	Total recommended.
		50 to 100	250	150	100	0	250	150	100	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress 3 to 4 weeks after planting.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress 6 to 8 weeks after planting.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									
		NOTE: Where plastic mulches are being used, broadcast 50 to 100 lb nitrogen (N) per acre with recommended P_2O_5 and K_2O and disk incorporate prior to laying mulch. Drip fertilization: See "okra" in specific commodity recommendations later in this handbook.									
ONION											
...Bulb	6 to 6.5	125 to 150	200	100	50	0	200	100	50	0	Total recommended.
		50 to 75	200	100	50	0	200	100	50	0	Broadcast and disk-in.
		75 to 100	0	0	0	0	0	0	0	0	Sidedress twice 4 to 5 weeks apart.
		Apply 1 to 2 lb boron (B) and 20 lb sulfur (S) per acre with broadcast fertilizer.									
...Green		150 to 175	200	100	50	0	200	100	50	0	Total recommended.
		50 to 75	200	100	50	0	200	100	50	0	Broadcast and disk-in.
		50	0	0	0	0	0	0	0	0	Sidedress 4 to 5 weeks after planting.
		50	0	0	0	0	0	0	0	0	Sidedress 3 to 4 weeks before harvest.

* Nitrogen rates should be based on your local fertilizer recommendations.

TABLE 2. GENERAL FERTILIZER SUGGESTIONS FOR VEGETABLE CROPS* (cont'd)

CROP	Desirable pH	Nitrogen (N) lb/acre	Recommended Nutrients Based on Soil Tests								Nutrient Timing and Method
			Soil Phosphorus Level				Soil Potassium Level				
			Low	Med	High	Very High	Low	Med	High	Very High	
			P_2O_5 lb/acre				K_2O lb/acre				
		Apply 1 to 2 lb boron (B) and 20 lb sulfur (S) per acre with broadcast fertilizer.									
PARSNIP											
	6 to 6.5	50 to 100	150	100	50	0	150	100	50	0	Total recommended.
		25 to 50	150	100	50	0	150	100	50	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress 4 to 5 weeks after planting.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									
PEA, Garden/English											
	5.8 to 6.5	40 to 60	120	80	40	0	120	80	40	0	Total recommended. Broadcast and disk-in before seeding.
PEPPER											
...Bareground	6 to 6.5	100 to 130	200	150	100	0	200	150	100	0	Total recommended.
		50	200	150	100	0	200	150	100	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress after first fruit set.
		25 to 30	0	0	0	0	0	0	0	0	Sidedress later in season, if needed.
...Plasticulture		100 to 185	320	250	100	0	350	250	100	40	Total recommended.
		50	200	150	100	0	200	150	100	40	Broadcast and disk-in.
		50 to 135	120	100	0	0	150	100	0	0	Fertigate.
		Drip fertilization: See "pepper" in specific commodity recommendations later in this handbook.									
POTATO											
...Loams and silt loams	5.8 to 6.2	100 to 150	110	90	70	50	200	150	50	50	Total recommended.
		85 to 135	60	40	20	0	200	150	50	50	Broadcast and disk-in.
		15	50	50	50	50	0	0	0	0	Band-place with planter at planting.
...Sandy loams and loamy sands		150	200	150	100	50	300	200	100	50	Total recommended.
		50	200	150	100	50	300	200	100	50	Broadcast and disk-in.
		100	0	0	0	0	0	0	0	0	Sidedress 4 to 5 weeks after planting.
PUMPKIN and WINTER SQUASH											
...Bareground	6 to 6.5	80 to 90	150	100	50	0	200	150	100	0	Total recommended.
		40 to 50	150	100	50	0	200	150	100	0	Broadcast and disk-in.
		40 to 50	0	0	0	0	0	0	0	0	Sidedress when vines begin to run.
...Plasticulture		80 to 150	150	100	50	0	200	150	100	0	Total recommended.
		25 to 50	150	100	50	0	100	75	50	0	Disk in row.
		55 to 100	0	0	0	0	100	75	50	0	Fertigate.
RADISH											
	6 to 6.5	50	150	100	50	0	150	100	50	0	Total recommended. Broadcast and disk-in.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									
RUTABAGA and TURNIP											
	6 to 6.5	50 to 75	150	100	50	0	150	100	50	0	Total recommended.
		25 to 50	150	100	50	0	150	100	50	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress when plants are 4 to 6 in. tall.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									
SOUTHERNPEA											
	5.8 to 6.5	16	96	48	0	0	96	48	0	0	Total recommended. Broadcast and disk-in.
SPINACH											
...Fall	6 to 6.5	75 to 125	200	150	100	0	200	150	100	0	Total recommended.
		50 to 75	200	150	100	0	200	150	100	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Sidedress or topdress.
...Overwinter		80 to 120	0	0	0	0	0	0	0	0	Total recommended for spring application to an overwintered crop.
		50 to 80	0	0	0	0	0	0	0	0	Apply in late February.
		30 to 40	0	0	0	0	0	0	0	0	Apply in late March.
SQUASH, Summer											
	6 to 6.5	100 to 130	150	100	50	0	150	100	50	0	Total recommended.
		25 to 50	150	100	50	0	150	100	50	0	Broadcast and disk-in.
		50	0	0	0	0	0	0	0	0	Sidedress when vines start to run.
		25 to 30	0	0	0	0	0	0	0	0	Apply through irrigation system.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									

* Nitrogen rates should be based on your local fertilizer recommendations.

TABLE 2. GENERAL FERTILIZER SUGGESTIONS FOR VEGETABLE CROPS* (cont'd)

CROP	Desirable pH	Nitrogen (N) lb/acre	Recommended Nutrients Based on Soil Tests: Soil Phosphorus Level Low (P_2O_5 lb/acre)	Soil Phosphorus Level Med (P_2O_5 lb/acre)	Soil Phosphorus Level High (P_2O_5 lb/acre)	Soil Phosphorus Level Very High (P_2O_5 lb/acre)	Soil Potassium Level Low (K_2O lb/acre)	Soil Potassium Level Med (K_2O lb/acre)	Soil Potassium Level High (K_2O lb/acre)	Soil Potassium Level Very High (K_2O lb/acre)	Nutrient Timing and Method
		Drip fertilization: See "summer squash" in specific commodity recommendations later in this handbook.									
SWEET CORN											
	6 to 6.5	110 to 155	160	120	80	20	160	120	80	20	Total recommended.
		40 to 60	120	100	60	0	120	100	60	0	Broadcast before planting.
		20	40	20	20	20	40	20	20	20	Band-place with planter.
		50 to 75	0	0	0	0	0	0	0	0	Sidedress when corn is 12 to 18 in. tall.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer. NOTE: On very light sandy soils, sidedress 40 lb N per acre when corn is 6 in. tall and another 40 lb N per acre when corn is 12 to 18 in. tall.									
SWEETPOTATO											
	5.8 to 6.2	50 to 80	200	100	50	0	300	200	150	120	Total recommended.
		0	150	60	30	0	150	50	30	0	Broadcast and disk-in.
		50 to 80	50	40	20	0	150	150	120	120	Sidedress 21 to 28 days after planting.
		Add 0.5 lb of actual boron (B) per acre 40 to 80 days after transplant.									
TOMATO											
...Bareground for Sandy loams and loamy sands	6 to 6.5	80 to 90	200	150	100	0	300	200	100	0	Total recommended.
		40 to 45	200	150	100	0	300	200	100	0	Broadcast and disk-in.
		40 to 45	0	0	0	0	0	0	0	0	Sidedress when first fruits are set as needed.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									
... Bareground for Loam and clay		75 to 80	200	150	100	0	250	150	100	0	Total recommended.
		50	200	150	100	0	250	150	100	0	Broadcast and disk-in.
		25 to 30	0	0	0	0	0	0	0	0	Sidedress when first fruits are set as needed.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer.									
...Plasticulture	6 to 6.5	130 to 210	200	150	100	0	420	345	275	0	Total recommended.
		50	200	150	100	0	125	125	125	0	Broadcast and disk-in.
		80 to 160	0	0	0	0	295	220	150	0	Fertigate.
		Apply 1 to 2 lb boron (B) per acre with broadcast fertilizer. Drip fertilization: See "tomato" in specific commodity recommendations later in this handbook.									
WATERMELON											
...Nonirrigated	6 to 6.5	75 to 90	150	100	50	0	200	150	100	0	Total recommended.
		50	150	100	50	0	200	150	100	0	Broadcast and disk-in.
		25 to 40	0	0	0	0	0	0	0	0	Topdress when vines start to run.
...Irrigated		100 to 150	150	100	50	0	200	150	100	0	Total recommended.
		50	150	100	50	0	200	150	100	0	Broadcast and disk-in.
		25 to 50	0	0	0	0	0	0	0	0	Topdress when vines start to run.
		25 to 50	0	0	0	0	0	0	0	0	Topdress at first fruit set.
...Plasticulture		125 to 150	150	100	50	0	200	150	100	0	Total recommended.
		25 to 50	150	100	50	0	100	75	50	0	Disk in row.
		100	0	0	0	0	100	75	50	0	Fertigate.
		NOTE: Excessive rates of N may increase the incidence of hollow heart in seedless watermelon. Drip fertilization: See "watermelon" in specific commodity recommendations later in this handbook.									

* Nitrogen rates should be based on your local fertilizer recommendations.

TABLE 3. NUTRIENT VALUES FOR MANURE APPLICATIONS AND CROP RESIDUES

	N	P_2O_5	K_2O
	Pounds per Ton		
Cattle manure	5-10[1]	3	3
Poultry manure	25-50[1]	20	10
Pig manure	5-10[1]	2	2
Horse manure	6-12[1]	3	6
Liquid poultry manure (5 - 15% solids)	7-15[1]	5-10	5-10
Alfalfa sod	50-100[2]	0	0
Hairy vetch	50-100	0	0

	N	P_2O_5	K_2O
	Pounds per Ton		
Ladino clover sod	60	0	0
Crimson clover sod	50	0	0
Red clover sod	40	0	0
Birdsfoot trefoil	40	0	0
Lespedeza	20	0	0
Soybeans			
Tops and roots	40	0	0
Grain harvest residue	15	0	0

[1] Lower values for fall - and winter - applied manure and higher values for spring - applied manure. Use these figures only if manure being used has not been analyzed.

[2] 75% stand = 100 - 0 - 0, 50% stand = 75 - 0 - 0, and 25% stand = 50 - 0 - 0.

Table 3A. NUTRIENT VALUES FOR VARIOUS PLANT, ANIMAL, AND NATURAL PRODUCTS

	Typical NPK Analysis			
Plant By-Products	**N**	**P_2O_5**	**K_20**	**Release Time**
Alfalfa Meal or Pellets	2.0	1.0	2.0	1 to 4 months
Corn Gluten Meal	9.0	0.0	0.0	1 to 4 months
Cottonseed Meal	6.0	0.4 to 3.0	1.5	1 to 4 months
Soybean Meal	7.0	1.2 to 2.0	1.5 to 7.0	1 to 4 months
Kelp Powder	1.0	0.0	4.0	Immediate to 1 month
Animal By-Products				
Bat Guano (high N)	10.0	3.0	1.0	4 plus months
Bat Guano (high P)	3.0	10.0	1.0	4 plus months
Blood Meal	12.0 to 14.0	2.0	1.0	1 to 4 months
Bone Meal (raw)	3.0	22.0	0.0	1 to 4 months
Bone Meal (steamed)	1.0 to 2.0	11.0 to 15.0	0.0	1 to 4 months
Feather Meal	7.0 to 12.0	0.0	0.0	4 plus months
Fish Emulsion	5.0	2.0	2.0	1 to 4 months
Fish Powder	12.0	0.3	1.0	Immediate to 1 month
Enzymatically Digested Hydrolyzed Liquid Fish	4.0	2.0	2.0	1 to 4 months
Fish Meal	10.0	6.0	2.0	1 to 4 months
Worm Castings	2.0	1.5	1.5	1 to 4 months
Natural Minerals				
“Soft” Rock Phosphate	0.0	14 to 16	0.0	Very slow (years)
Greensand	0.0	0.0	3.0	Very slow

TABLE 4. PERCENTAGE EQUIVALENTS AND CONVERSION FACTORS FOR MAJOR, SECONDARY, AND MICRONUTRIENT FERTILIZER SOURCES

Fertilizer Source Material	Plant Food Contents,%	Lb of Material Required to Supply 1 Lb of the Initially Listed Plant Nutrient
Nitrogen Materials		
Monoammonium phosphate*	11 (N) and 48 (P_2O_5)	9.1
Nitrate of potash*	13 (N) and 44 (K_2O)	7.7
Nitrate of soda-potash*	15 (N) and 14 (K_2O)	6.7
Calcium nitrate*	15 (N) and 19 (Ca)	6.7
Nitrate of soda	16 (N)	6.3
Diammonium phosphate*	18 (N) and 46 (P_2O_5)	5.6
Nitrogen solution	20 (N)	5.0
Ammonium sulfate*	20.5 (N) and 23 (S)	4.9
Nitrogen solution	30 (N)	3.3
Nitrogen solution	32 (N)	3.1
Ammonium nitrate	33.5 to 34.0 (N)	3.0
Nitrogen solution	40 (N)	2.5
Urea	45 to 46 (N)	2.2
Anhydrous ammonia	82 (N)	1.2
Phosphorus Materials		
Normal superphosphate*	20 (P_2O_5) and 11 (S)	5.0
Triple superphosphate*	44 to 46 (P_2O_5)	2.2
Monoammmonium phosphate*	48 (P_2O_5) and 11 (N)	2.1
Diammonium phosphate*	46 (P_2O_5) and 18 (N)	2.2
Potassium Materials		
Nitrate of soda-potash*	14 (K_2O) and 13 (N)	7.1
Sulfate of potash-magnesia*	21.8 (K_2O) and 11.1 (Mg)	4.6
Nitrate of potash*	44 (K_2O) and 13 (N)	2.3
Sulfate of potash*	50 (K_2O) and 17 (S)	2.0
Muriate of potash*	60 (K_2O)	1.7

Fertilizer Source Material	Plant Food Contents,%	Lb of Material Required to Supply 1 Lb of the Initially Listed Plant Nutrient
Magnesium Materials		
Epsom salts*	10 (Mg) and 13 (S)	9.6
Sulfate of potash-magnesia*	11.1 (Mg) and 21.8 (K_2O)	9.0
Kieserite*	18.1 (Mg)	5.5
Brucite	39 (Mg)	2.6
Sulphur Materials		
Granulated sulfur	90 to 92 (S)	1.1
Ammonium sulfate*	23 (S) and 20.5 (N)	4.3
Gypsum*	15-18 (S) and 19 to 23 (Ca)	6.1
Epsom salts*	13 (S) and 10 (Mg)	7.7
Boron Materials		
Fertilizer Borate Granular*	14.30 (B)	7.0
Fertilizer Borate-48	14.91 (B)	6.7
Solubor	20.50 (B)	4.9
Fertilizer Borate-68	21.13 (B)	4.7
Manganese Materials		
Manganese sulfate*	24.0 (Mn)	4.2
Manganese sulfate*	25.5 (Mn)	3.9
Manganese sulfate*	29.1 (Mn)	3.4
Manganese oxide	48.0 (Mn)	2.1
Manganese oxide	55.0 (Mn)	1.8
Zinc Materials		
Zinc sulfate*	36 (Zn)	2.8
Zinc oxide	73 (Zn)	1.4
Molybdenum Materials		
Sodium molybdate	39.5 (Mo)	2.5
Sodium molybdate	46.6 (Mo)	2.1
Ammonium molybdate*	56.5 (Mo)	1.8

* Supplies more than one essential nutrient.

MINIMUM TILLAGE FOR VEGETABLE PRODUCTION

The development of various types of tillage practices was an integral part of the evolution of modern farming practices. Tillage is helpful in crop production systems for purposes of weed management, incorporation of amendments such as lime and fertilizer, burial of crop residues to facilitate other field operations, disease management and the preparation of a seedbed that is conducive to crop establishment. While the use of tillage practices provides a number of benefits to crop producers, agronomists have also learned that the soil disturbance associated with tillage has some drawbacks. In a nutshell, tillage over time results in the degradation of several soil properties that are important to crop productivity.

One of these properties is organic matter content. Organic matter is important because it contributes appreciably to the water and nutrient holding capacity of soil and to the maintenance of a desirable soil structure. These soil properties, in turn, allow soil to better support the weight of equipment and workers. In warm southern climates the loss of organic matter due to tillage is even more pronounced than in cooler climates. Tilled soil is also less hospitable to a variety of soil organisms including microbes, insects and other small animals. When present in adequate numbers these are beneficial for various reasons. When minimum tillage is used, soil structure is improved by the release of exudates of various organisms that glue soil particles together into larger, more desirable aggregates, plant roots benefit from the increased presence of pore spaces in the soil such as earthworm channels, and plant diseases may also be reduced by the increased diversity of soil microorganisms.

Adoption of minimum tillage in vegetable production is possible but requires careful planning and preparation. Making a transition to minimum tillage will affect a number of vegetable production field operations. For example, one common objective of minimum tillage is to retain crop residues on the soil surface. These residues are beneficial for reducing soil erosion but also may interfere with the seeding of crops, particularly small-seeded vegetable crops. Similarly, cultivation, often an important measure for controlling weeds in vegetables, may require different equipment than what the farmer is able to use in conventionally tilled fields. In general, it may be best to start with those vegetables that are grown similarly to agronomic row crops or to use crops that can be established by transplanting through crop residues. Row crop examples include sweet corn and cowpeas. Examples of vegetables that are easily transplanted include tomato, pepper, squash and watermelon.

Growers interested in adopting minimum tillage practices should begin by learning about the practices currently employed by agronomic crop producers and others who grow vegetables using reduced tillage. One such practice is to limit tillage and seedbed preparation to a narrow strip where the crop will be planted. This may be done in combination with the use of cover crops that are killed by rolling and crimping prior to tilling the strip. This method has been used successfully for vegetables such as tomatoes and cucurbits.

Additional Resources

Reduced Tillage Fact Sheet #1: Zone Tillage. (2007) By J. Idowu, A. Rangarajan, H. van Es and B. Schindelbeck. http://www.vegetables.cornell.edu/reducedtillage/ZTFactSheet_1.pdf

Minimum Tillage Vegetable Production in California. (2004) By J. Mitchell, L. Jackson and G. Miyao. http://anrcatalog.ucanr.edu/Details.aspx?itemNo=8132

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COVER CROPS

Many soils that are not productive due to poor physical properties can be restored and made more productive through the continued use of cover crops. Many cover crops can reduce or limit the build-up of some soilborne disease and insect pests that damage vegetable crops.

Prevalent disease and insect pressure should be considered when selecting a cover crop as some covers crops could increase the severity of these pests. In some cases, specific cultivars of cover crops can differ in their reaction to various nematodes. For example, 'Cahaba White' common vetch is suppressive to southern root-knot nematodes while 'Vantage' common vetch is susceptible to southern root-knot nematode. For further reading on nematode suppressive crops and cover crops, go to http://www.aces.edu/pubs/docs/A/ANR-0856/ANR-0856.pdf and http://www.sare.org/Learning-Center/Fact-Sheets/Cultural-Practices-for-Root-Knot-and-Root-Lesion-Nematode-Suppression-in-Vegetable-Crop-Rotations/Text-Version/Cover-Crops-and-Nematode-Management

With intensive cropping, working the soil when it is too wet and excessive traffic from using heavy-tillage equipment all will contribute to severely damaging soils. These practices cause soils to become hard and compact, resulting in poor seed germination, loss of transplants, and shallow root formation of surviving plants. Such soils can easily form crusts becoming compact, making them difficult to irrigate properly. Combined, all of these practices will yield negative consequences for your soil; poor plant stands, poor crop growth, low yields, and loss of income. In some cases, subsoiling in the row might help improve aeration and drainage but its effect is limited and short term. Continued and dedicated use of cover crops will aid in preventing these conditions.

Cover crops can also be planted in strips for wind protection during the early part of the next growing season. Annual rye seeded before November can be a good choice for use in wind protection. Cover crops reduce nutrient loss during the winter and early spring. When using a cover crop, covers crops should be disked or plowed before they seriously deplete soil moisture.

Seeding dates suggested in the following section are for the central part of the Southeastern United States and will vary with elevation and northern or southern locations. For state specific recommendations for planting dates for cover crops, consult your local Extension office.

Summer Cover Crops

Summer cover crops can be useful in controlling weeds, soil borne diseases, and nematodes. They also provide organic matter and can improve soil tilth while reducing soil erosion. There are many potential summer cover crops available but you will need to find one that will work well in your area and into your overall production scheme. Sudex (sorghum-sudan grass cross) (do not allow to exceed 3 ft. before mowing), southernpeas (cowpeas), millet, and Lab Lab are summer cover crops that provide organic matter, control erosion and will enhance the natural biota of your soil.

Summer cover crops, such as sudangrass or sudex, seeded at 20 to 40 pounds per acre are good green manure crops. Sunhemp and pearl millet also provide a good green manure; can be planted as early as field corn is planted requiring eight to 12 weeks of frost-free growth conditions. These crops should be clipped, mowed, or disked to prevent seed development that could lead to weed problems. Summer cover crops can be disked and planted to wheat or rye in September or allowed to winter-kill and tilled-in the following spring.

Soil test to determine lime and fertilizer needs. For state specific recommendations for planting dates, seeding dates and management for cover crops, consult your local Extension office.

Types of Summer Cover Crops: Small Grains

SEEDING RATES AND DEPTHS

SORGHUM-SUDANGRASS: broadcast 50 to 60 lbs/A;
drill 45 to 50 lbs/A (seeding depth: ½ - 1½ in.)

SUDANGRASS: broadcast 40 to 50 lbs/A;
drill 35 to 40 lbs/A (seeding depth: ½ - 1 in.)

JAPANESE MILLET: broadcast 25 to 35 lbs/A;
drill 20 to 25 lbs/A (seeding depth: ½ - 1 in.)

GERMAN FOXTAIL MILLET: broadcast 30 to 40 lbs/A;
drill 25 to 30 lbs/A (seeding depth: ½-1 in.)

PEARL MILLET: broadcast 10-25 lbs/acre;
drill 5 to 15 lbs/A (seeding depth: ½ - 1 in.)

BUCKWHEAT: broadcast 50 to 100 lbs/A;
drill 30 to 90 lbs/A (seeding depth: ½ in.)

Types of Summer Cover Crops: Legumes

SEEDING RATES AND DEPTHS

COWPEAS: broadcast 70 to 120 lbs/A;
drill 40 to 50 lbs/A (seeding depth: 1- 1½ in.)

SESBANIA: broadcast 25 to 40 lbs/A;
drill 20 to 25 lbs/A (seeding depth: ½ - 1 in.)

SOYBEAN: broadcast 80 to 100 lbs/A;
drill 60 to 80 lbs/A (seeding depth: 1- 1½ in.)

SUNNHEMP: broadcast 30 to 40 lbs/A;
drill 25 to 35 lbs/A (seeding depth: ½ - 1 in.)

VELVETBEAN: broadcast 30 to 40 lbs/A;
drill 25 to 35 lbs/A (seeding depth: ½ - 1½ in.)

LAB LAB: broadcast 50 to 60 lbs/A;
drill 40 to 45 lbs/A (seeding depth: ½ - 1½ in.)

For further information on summer cove crops, refer to "Summer Cover Crops" at
http://www.ces.ncsu.edu/depts/hort/hil/hil-37.html

Winter Cover Crops

Choosing a grass cover crop is a little easier than choosing a legume. Rye, triticale, barley, wheat, oats, and ryegrass can be planted in the fall; expect to harvest or plow under anywhere from 1/2 ton to 4 tons of dry matter per acre. Soil test to determine lime and fertilizer needs.

Types Of Winter Cover Crops: Small Grains

RYE: Rye is probably used more as a winter cover than any other grain. Rye can be sown from late September through mid-November. Most ryes will grow well in the fall (even late fall) and in late winter/early spring. This makes rye a top choice for farmers who have late-season vegetable crops with little time left before winter to sow a cover. Spring growth provides excellent biomass to turn under for use in early potatoes, cole crops, etc. Rye also provides a forage source for grazing animals and a straw source if harvested before mature seeds are formed or after rye seed harvest (typical seeding rate: 60-120 lbs/A).

BARLEY: Barley provides an excellent source of biomass in the spring. It grows shorter than rye, will tiller, and potentially produces as much straw/forage/plow-down as rye. Barley takes longer to catch up with equivalent rye biomass in the spring, and the possibility of winter kill will be greater with barley. Late fall planting of barley will often result in winter kill. Plant in September or early October for greatest survival (typical seeding rate: 80-120 lbs/A broadcast; 60-110 lbs/A drilled).

WHEAT: Using wheat as a cover crop works well and provides the additional option of a grain harvest. Wheat can be seeded late September through mid-November. Wheat produces biomass similar to barley but will be a week or two later. It can be grazed before turning under or harvested for grain and the straw removed. Problems may occur if the Hessian fly is abundant, so choose another small grain in areas where Hessian fly is present. (typical seeding rate: 60-120 lbs/A)

OATS: Oats can be managed to provide many options for the cover crop and good late spring biomass. Seeding spring oats during September or October provides a good cover crop that will winter-kill in the colder areas but may overwinter in warmer areas. It can be grazed, made into excellent hay, or the grain harvested and oat straw produced. Planting spring oats in the early fall can provide good winter-killed mulch that could benefit perennial vegetables or small fruits. Spring oats survive through some milder winters; thus, herbicides may be necessary to kill spring oats in perennial plantings (typical seeding rate: 80-120 lbs/A).

RYEGRASS: This grass has great potential use as a green manure and as a forage/hay material, but ryegrass can potentially become a difficult pest in some farm operations. In the mountain region, ryegrass grows rather slowly in the fall and provides only moderate winter erosion protection, but in late spring it produces an abundant supply of biomass.

Grazing and spring hay from ryegrass can be excellent, and a fine, extensive root system makes it a great source for plow-down. (typical seeding rate: 5-10 lbs/A drilled; 15-30 lbs/A broadcast)

TRITICALE: Triticale is a small grain resulting from a cross between wheat and rye. Triticale has similar characteristics to wheat, while the plant has the overall vigor and winter-hardiness of rye.

Fall planting of triticale should follow similar recommendations as wheat, sowing 60 to 120 lbs/acre. Triticale biomass can exceed wheat, thus plowing under or killing for no-till culture should occur at an earlier time in the spring.

NOTES on SMALL GRAINS: Determine small grain fertilizer and lime needs based on soil test results. Successful stand establishment generally can be obtained with planting dates later than those of legumes, even as late as early December in coastal plain regions. This permits establishment of the cover crop after late-fall-harvested crops such as sweetpotatoes. Remember, that some soil erosion protection may be sacrificed with late seeding dates. For sandier coastal plain soils, rye is the preferred small grain cover crop. As previously discussed, seeding depth varies from ½ to 1½ inches, depending on soil texture. Planting methods are the same as described for legumes.

Types Of Winter Cover Crops: Legumes

A wide range in planting dates exists for most legumes, though best results are obtained with early plantings. Early seeding dates are easy to meet with legume cover crops following spring vegetables. Because Cahaba White Vetch possesses little winter hardiness, it is not adapted to western NC and the northern regions of other southeastern states. Freeze damage has also occurred with Austrian Winter Pea in higher elevations (above 2,500 feet). Avoid planting late otherwise you increase the risk of winter kill. For state specific recommendations for planting dates, seeding dates and management for legume cover crops, consult your local Extension office.

SEEDING RATES AND DEPTHS

CRIMSON CLOVER: broadcast 20 to 25 lbs/A;
drill 15 to 20 lbs/A (seeding depth: ¼ - ½ in.)

HAIRY VETCH: broadcast 20 to 30 lbs/A;
drill 15 to 20 lbs/A (seeding depth: ½ - 1½ in.)

CAHABA WHITE VETCH: broadcast 20 to 30 lbs/A;
drill 15 to 20 lbs/A (seeding depth: ½ - 1½ in.)

AUSTRIAN WINTER PEA: broadcast 25 to 35 lbs/A;
drill 20 to 25 lbs/A (seeding depth: ¾ - 1½ in.)

When seeding, use shallow planting depths for finer-textured, clayey soils and deeper depths for coarse-textured, sandy soils. Drilling into a conventional seedbed is the most reliable way to obtain a uniform stand. A no-till grain drill can be used successfully, provided residue from the previous crop is not excessive and soil moisture is sufficient to allow the drill to penetrate to the desired planting depth. Seeds can be broadcast if the soil has been disked and partially smoothed. Cultipacking after broadcasting will encourage good soil/seed contact. Crimson clover, in particular, responds favorably to cultipacking.

MIXING GRASS AND LEGUMES: Planting a single grass or legume may be necessary, but combining a grass and legume together may prove better than either one alone. Grasses provide soil protection during the winter and also produce great forage or plow-down organic matter. Legumes do not grow well during the winter, but late spring growth is abundant and produces high protein forage and nitrogen for the following crop. Crimson clover is a legume to grow in combination with a grass. Crimson clover's height matches well with barley, wheat, and oats, but may be shaded and outcompeted by rye. Hairy vetch has been sown with grass cover crops for many years, using the grass/vetch combination as a hay or plowdown.

BIOFUMIGATION AND COVER CROPS: Biofumigation is the horticultural practice of using naturally produced volatile chemicals or allelochemicals to suppress soil-borne pathogens, pests, and weeds. These allelochemicals (specifically isothiocyanates produced when glucosinolates break down) are produced when crops in the Brassica family decompose in the soil.

Brassica crops have been used extensively as winter cover crops and as "break crops" where the residues are tilled into the soil for their biofumigation effect. They have also been used in rotations, where the Brassica crop is harvested for sale and then the remaining residue is tilled-in for the biofumigation effect. There are several commercially available cover crops that have been used for biofumigation. "Caliente 119" (a mixture of oilseed radish and mustard), oilseed radish, "Florida Broadleaf Mustard", garden cress, penny cress, "Dwarf Essex" rape, and several canola varieties have been reported to have biofumigation potential.

In much of the southeast region of the U.S., these crops can be seeded in fall and over-wintered, or direct seeded in early spring. In either case, the crop should be chopped and tilled-in when it is in the early flowering stage in order to achieve the maximum biofumigation potential. The early flowering stage is the point at which the allelochemical concentrations are their highest. Seeding rates range from 4 to 20 lbs/A and will vary with location and seed size (generally, the smaller the seed size, the lower the rate).

These crops respond and produce more biomass and more biofumigation potential when provided with 30 to 90 lbs/A N fertilizer at planting. These crops grow rapidly and can normally be plowed down in 6 to 10 weeks. In areas where the average last spring frost is 1 May or later, only spring planting is recommended. Optimal results occur when the Brassica cover crop is chopped, and tilled completely into the top 6 to 8 inches of soil and then watered in thoroughly. Watering in will help trap the volatile compounds into the soil. Brassica seed meals (specifically mustard seed meal) may also be utilized for biofumigation. Mustard seed meal is highly concentrated in volatiles and also provides a partial source of organic fertilizer for the following crop. Mustard seed meal can be used as a biofumigant by spreading it like a fertilizer, tilling into the soil, and then watering in to trap the volatiles.

PLOWDOWN: Plowing early defeats the purpose of growing cover crops as little biomass will have been produced by the cover crop. In the case of legume cover crops, they require sufficient time to develop biomass which an early plowdown would prevent. If you need to plow early, use a grass cover crop (rye) that produces good fall growth and will provide maximum biomass for incorporation. Allow 3-6 weeks between plowdown and planting.

TRANSPLANT PRODUCTION

These recommendations apply to plants grown under controlled conditions IN GREENHOUSES OR HOTBEDS. (Field-grown plants are covered under the specific crop.) A transplant is affected by factors such as temperature, fertilization, water, and spacing. A good transplant is one that has been grown under the best possible conditions.

Table 5 presents optimum and minimum temperatures for seed germination and plant growth, time and spacing (area) requirements, and number of plants per square foot for a number of economically important vegetable crops in the southeastern US.

Commercial Plant-growing Mixes. A number of commercial media formulations are available for growing transplants. Most of these mixes will produce high-quality transplants when used with good management practices. However, these mixes can vary greatly in composition, particle size, pH, aeration, nutrient content, and water-holding capacity. Avoid formulations having fine particles, as these may hold excessive water and have poor aeration. Have mix formulations tested by your state's soil test laboratory to determine the pH and the level of nutrients the mix contains.

Treatment of Flats. Flats used in the production of transplants should be new or as clean as new to avoid damping-off and other disease problems. If flats are to be reused, they should be thoroughly cleaned after use and completely submerged in a household bleach solution for at least 5 minutes. Use 5 gallons of 5.25% sodium hypochlorite (such as Clorox) for each 100 gallons of solution required. Permit flats to dry completely prior to use. Never treat flats with creosote or pentachlorophenol.

Plant Containers: There are a wide variety of containers available for starting seeds for transplants. Most growers start seeds either in flats or in cell packs.

The main advantage of using flats is that more plants can fit into the same space compared to cell packs. However, if you start seeds in flats, you will need to transplant to larger cell packs or to individual pots as the seedlings get bigger.

Seeding directly into cell packs saves time, because transplanting into a larger container later is not necessary. Cell packs come in many different cell sizes; the overall tray size is standardized. For tomatoes and peppers, 72-cell packs work well. For larger-seeded vegetables; such as cucumbers, squash, and watermelons, 48-cell packs work better.

TABLE 5. OPTIMUM AND MINIMUM TEMPERATURES FOR TRANSPLANT PRODUCTION

	°F Opt. Day	°F Min. Night	Weeks to Grow
Broccoli	65-70	60	5-7
Cabbage	65	60	5-7
Cantaloupe[1]	70-75	65	3-5
Cauliflower	65-70	60	5-8
Cucumber	70-75	65	2-3
Eggplants	70-85	65	5-8
Endive & Escarole	70-75	70	5-7
Lettuce	60-65	40	5-6
Onions	65-70	60	8-12
Peppers	70-75	60	5-8
Summer squash	70-75	65	2-3
Sweetpotato	75-85	ambient	4-5
Tomatoes	65-75	60	5-6
Watermelon, seeded	85-90	80	3-5
Watermelon, seedless	85-90	85	3-6

[1] Cantaloupe and other melons

Each vegetable crop has specific cell sizes for containerized transplant production and requires a certain number of weeks before they are ready for transplanting (Table 5). For example: broccoli, Brussels sprouts, cabbage, cauliflower, and collards require a 0.8 to 1.0 inch cell and 5 to 7 weeks to reach an adequate size for transplanting; cantaloupe and watermelons require a 1.0 inch cell and 3 to 4 weeks; eggplant and tomato require a 1.0 inch cell and 5 to 7 weeks; and pepper requires a 0.5 to 0.8 inch cell and 5 to 7 weeks. Other options are available depending on the crop and your situation.

Seed Germination. Seed that is sown in flats to be "pricked out" at a later date should be germinated in vermiculite (horticultural grade, coarse sand size) or a plug growing mix. However, it is recommended that no fertilizer be included in the mix or the vermiculite and avoid fertilizing the seedlings until the seed leaves (cotyledons) are fully expanded and the true leaves are beginning to unfold. Fertilization should be in the liquid form and at one-half the rate for any of the ratios listed in the following section on "Liquid Feeding." Seedlings can be held for a limited time if fertilization is withheld until 3 to 4 days before "pricking out." Seed that is sown in pots or other containers and that will not be "pricked out" later can be germinated in a mix that contains fertilizer.

To get earlier, more uniform emergence, germinate and grow seedlings on benches or in a floor-heated greenhouse. Germination can be aided by using germination mats which provide heat directly to the trays. With supplemental heating such as this, seedling emergence and uniformity can be enhanced decreasing the amount of time required to produce a transplant. If floor heating or benches is not available, seed the trays, water, and stack them off the floor during germination. Be sure to unstack trays before seedlings emerge.

Heating and Venting. Exhaust from heaters must be vented to the outside. It is also recommended to have an outside fresh air intake for the heaters. Be sure vents and fans are properly designed and positioned to avoid drawing exhaust gases into the greenhouse. Exhaust gases from oil and improperly adjusted gas heating systems can cause yellowing, stunting, and death of seedlings. Do not grow or hold seedlings in an area where pesticides are stored.

Liquid Feeding. The following materials dissolved in 5 gallons of water and used over an area of 20 square feet are recommended for use on the transplants if needed:

20-20-20 1.2-1.6 oz/5 gal water
15-15-15 2 oz/5 gal water
15-30-15 2 oz/5 gal water

Rinse leaves after liquid feeding. Fertilizers used for liquid feeding must be 100% water soluble.

When transplanting to the field, use a "starter fertilizer" being sure to follow the manufacture's recommendations.

Watering. Keep these mixes moist but not continually wet. Water less in cloudy weather. Watering in the morning allows plant surfaces to dry before night and reduces the possibility of disease development.

Hardening and Transplant Height Control. Proper hardening of transplants, stiffens stems, and hardens the transplants increasing their survival.

There are several methods – chemical and cultural – used to harden transplants and the choice of which to use is often crop-dependent. At this time there is one chemical plant growth regulator available for use in producing vegetable transplants but its use is limited to several solanaceous crops.

Transplant Height Control. The goal of a transplant producer should be to produce a strong transplant with sturdy growth that can withstand transplanting into the field. Tall, spindly, or overgrown transplants can be difficult to remove from the transplant tray and might become entangled in the transplanting equipment. There are a few methods available that can aid the producer to control the top growth of developing transplants. One method is to use cold water for irrigation, 33-34°F, which has been shown in some species to control top growth.

Brushing the plants, or setting up fans so that the plants are moved (brushed by air) is another method. This results in a mechanical stress of the plant stem and can result in shorter plants overall. The intensity and frequency of brushing will have to be adjusted to avoid damage to developing foliage while still achieving height control.

Chemical Hardening. Recently, a label for Sumagic™ (uniconazole) has been released allowing foliar sprays on the following vegetable transplants: tomato, pepper, ornamental pepper, eggplant, tomatillo, ground cherry, and pepino. But the new label is rather restrictive; the maximum total allowed application is 10 ppm at 2 quarts per 1,000 square feet. This means only one 10-ppm spray, two 5-ppm, or four 2.5-ppm sprays are allowed, and so on. The final spray must be made no later than two weeks after the two- to four-leaf stage, about four to six weeks after sowing.

For production of retail tomato transplants in six-packs to 4-inch pots, we recommend an initial uniconazole spray at 1 to 2.5 ppm two weeks after sowing. If additional height control is needed, up to three additional applications of 1 to 2.5 ppm can be made at seven-day intervals. Until we know more about the post-harvest effects and the range of sensitivity each cultivar demonstrates, we recommend growers avoid the use of higher rates in excess of 5 ppm. Uniconazole is a highly active PGR (plant growth regulator), it is critical to emphasize that caution is paramount while implementing uniconazole for vegetable transplant height control.

Cultural Methods for Hardening. Cultural methods used to harden transplants employ reducing water and altering the ambient temperatures. Combinations of these two methods are often used. By reducing the amount of water used and lowering ambient temperatures, one can cause a "check" in plant growth (a "slow down") to prepare plants for field setting. Never reduce or limit fertilizer as a means to harden transplants because it will often delay maturity. If ambient temperatures are too low, chilling injury can result causing plant damage and delayed re-growth after transplanting. Caution: Lowering air temperature on some crops, such as cool season crops, might induce bolting.

DIF. Plant height can be held in check and hardening can be improved by using a process that reduces or increases ambient temperatures in the early morning over the course of several days. Plants elongate most at daybreak. Raising the temperature before daybreak (2 hours before) or lowering the temperature just after daybreak (2 hours after) by 10°F will cause plants to be shorter and more hardened. This process is called DIF, because you are employing a difference in temperature. DIF can be positive or negative, but positive DIF is more commonly used for hardening transplants. Negative DIF can cause crop injury on cold sensitive crops or bolting on cool season crops.

GRAFTING IN VEGETABLE CROPS

The phase-out of methyl bromide fumigation is driving the search for alternative methods to manage soilborne pathogens in vegetable crops. Although alternative pesticides and other physical treatments are being tested and developed, grafting with resistant rootstocks offers one of the best methods to avoid soilborne disease. Grafting involves combining a desirable scion which is the fruit bearing portion of a grafted plant with a rootstock which provides resistance to various soilborne pathogens. The scion is generally from a plant that produces highly desirable fruit. As well as managing soilborne diseases, grafting can influence vegetative growth and flowering; affect fruit ripening and fruit quality; enhance abiotic stress resistance; and enhance yield especially under low-temperature conditions.

At present, most research is being conducted on grafting tomato and watermelon. The primary motive for grafting tomato and watermelon (and other cucurbits) is to manage soilborne pests and pathogens when genetic or chemical approaches for management of these diseases are not available. Grafting a susceptible scion onto a resistant rootstock can provide a resistant cultivar without the need to breed a resistant cultivar. Furthermore, grafting allows a rapid response to new races of pathogens, and, in the short-term, provides a less expensive and more flexible solution for controlling soilborne diseases than by breeding new, resistant cultivars.

Grafted transplants are more expensive than non-grafted transplants due to labor, material costs (grafting supplies, seed costs of rootstock and scion), and specialized facilities required to produce grafted plants. These specialized facilities include healing chambers and trained personnel both to produce the grafted transplants and to care for them. Potential changes in fruit quality, which occur with some rootstocks, must also be considered. Some commercial transplant producers offer grafting services and with improved grafting techniques and mechanization, costs will being to decrease.

Due to the status of current research, new developments in grafting can be found at http://www.graftingvegetables.org. This site consists of the latest findings on grafting Solanaecous (tomatoes, peppers, eggplants, etc.) and cucurbit (watermelons, melons, etc.) crops. You will find detailed tables listing researched root stocks and their specific attributes.

Cucurbit Grafting. Beginning in the 1920's, cucurbits grafting has become the predominately practiced growing method in Asia. Currently 95% of watermelons and Oriental melons are grafted in Japan, Korea and Taiwan. Grafting has only recently been consid-

ered as a practice for cucurbits in the United States due to transplant costs. Currently those costs are as much as $1.30 per transplant. This is nearly five times the cost of a standard transplant. Grafting presents an option, however, for soilborne pathogen management for diseases such as Fusarium wilt, Monosporascus Vine Decline, Phytophthora blight, and other soilborne diseases.

Additionally, grafting can enhance tolerance to abiotic stress; increase water and nutrient use efficiency; extend harvest periods; and improve fruit yield and quality in certain cucurbits. There is a wide array of potential rootstocks: Lagenaria spp. (Bottled Gourd), interspecific squash hybrids, wild watermelon or melon. These rootstocks can produce vigorous plants with resistance to many soilborne diseases. Each rootstock type provides advantages under certain environmental conditions.

Grafting Methods for Cucurbits. There are four commonly used methods in production to date: Tongue Approach Graft, Hole Insertion Graft, One Cotyledon Graft, and Side Graft. Each of these methods are described in detail in the following publication: R. Hassell, F. Memmott, and D Liere (2008) *Grafting methods for watermelon production in HortScience 43(6):1677-1679*.

Only one of these methods is automated (one cotyledon graft method). The other three methods are labor intensive. Remember that grafting is an art that requires attention to detail. The major concern with cucurbit grafting is the constant threat of regrowth of the rootstock which needs to be removed by hand. Current research by Hassell and Daley at Clemson University has eliminated any chance of regrowth by destroying the growing point of the rootstock. You can read about this method by acquiring the following publications:

1. Daley, S.L., J. Adelberg, and R. L. Hassell. 2014. Improvement of grafted watermelon transplant survival as a result of size and starch increased over time caused by rootstock fatty alcohol treatment: part 1. HortTechnology 24(3):343-349.
2. Daley, S.L., W. P. Wechter, and R. L. Hassell. 2014. Improvement of grafted transplant survival as a result of size and starch increase over time caused by rootstock fatty alcohol treatment: part ll. HortTechnology 24(3): 350-354.
3. Daley, S.L. and R. L. Hassell. 2014. Fatty alcohol application to control meristematic regrowth in bottle gourd and interspecific hybrid squash rootstocks used for grafting watermelon. HortScience 49(3):206-264.

Additional information can be found at http://www.graftingvegetables.org

Grafting Methods for Tomatoes. There are three primary techniques used for grafting tomatoes, Tongue Approach Grafting, Cleft Grafting, and Tube (or Clip) Grafting. Cleft grafting and tube grafting are similar in that the shoot of the fruit producing scion is completely cut off from its own roots and attached to the severed stem of the rootstock. The name 'Tube Grafting' originated because when the technique was first developed; a tube was used to attach the shot to the root. Clips are now used to make this graft. Tube grafting is quicker and less complicated to do than cleft grafting because it only requires a single, straight cut on both the rootstock and the scion. Also, because fewer intricate cuts are involved, this technique can be used on very small seedlings. Grafting can be performed at various stages of seedling growth. Grafting at the 2-3 true leaf stage is common. With both cleft and tube grafting, the newly grafted plants must be protected from drying out until the graft union is healed. This usually involves covering the plants with a plastic cover or protecting them in some type of healing chamber where temperature and humidity can be regulated. Some method should be employed to reduce light intensity to the grafted plants for several days after the procedure. It is critical to increase the humidity in the chamber to near 100% for the first two days. Humidity must then be reduced incrementally over the next five days to prohibit the formation of adventitious roots from the scion and to properly heal the graft. Tomato grafts heal quickly and the seedlings can be to be acclimated back into the greenhouse after 4-5 days.

With both cleft and tube grafting, it is important that the diameter of the cut ends (of the scion and the rootstock) match up perfectly. If the diameter does not match, the graft may not heal properly, if at all. Rootstock cultivars tend to have different growth habits than scion cultivars so it is important to grow a small amount of rootstock and scion seed at first to determine their growth rate relative to each other. Rootstock cultivars tend to be more vigorous than scion cultivars. Another critical factor is to cut rootstock seedlings below the cotyledons. If the cotyledons are left they will generate suckers that will compete with the scion requiring pruning. For step by step instructions, go to http://graftvegetables.org/.

DISEASE CONTROL IN PLANT BEDS

For the best control of all soil-borne diseases, use a good commercial plant-growing mix. If this is not possible, use one of the following procedures:

Preplant. The only practice that ensures complete sterilization of soil is the use of steam. When steam is used, a temperature of 180°F must be maintained throughout the entire mass of soil for 30 minutes.

A list of recommended procedures to sanitize a greenhouse or soil is listed in Table 3-46. Further information on sanitizing equipment, storage houses, produce and water can be found in Tables 3-52 and 3-53.

Seed Treatment. Seed treatment is important to control seed-borne diseases. Use of untreated seed could lead to diseases in the plant bed which could reduce plant stands or result in diseased transplants and potential crop failure. See sections on SEED TREATMENTS in Tables 3-49, 3-50, and 3-51 for detailed information on how to properly treat seeds and for materials labeled for use as seed treatments.

Postplant. Damping-off and foliar diseases can be a problem in plant beds. To prevent these diseases, it may be necessary to apply fungicide sprays especially as plants become crowded in plant beds. Refer to label clearance before use. The use of sphagnum moss as a top dressing will reduce damping-off because it keeps the surface dry. See the section on GREENHOUSE VEGETABLE CROP DISEASE CONTROL SCHEDULE in Tables 3-46, 3-47, and 3-48.

TABLE 6. VEGETABLE SEED SIZES

Crop	Seeds/Unit Weight
Asparagus	13,000-20,000/lb
Beans:	
small seeded lima	1,150-1,450/lb
large seeded lima	440-550/lb
snap	1,600-2,200/lb
Beets	24,000-26,000/lb
Broccoli	8,500-9,000/oz
Brussels sprouts	8,500-9,000/oz
Cabbage	8,500-9,000/oz
Cantaloupes	16,000-19,000/lb
Carrots	300,000-400,000/lb
Cauliflower	8,900-10,000/oz
Collards	7,500-8,500/oz
Cucumbers	15,000-16,000/lb
Eggplants	6,000-6,500/oz
Endive, Escarole	22,000-26,000/oz
Kale	7,500-8,900/oz
Kohlrabi	9,000/oz
Leeks	170,000-180,000/lb
Lettuce:	
head	20,000-25,000/oz
leaf	25,000-31,000/oz
Mustard	15,000-17,000/oz
Okra	8,000/lb
Onions:	
bulb	105,000-144,000/lb
bunching	180,000-200,000/lb
Parsnips	192,000/oz
Parsley	240,000-288,000/lb
Peas	1,440-2,580/lb
Peppers	4,000-4,700/oz
Pumpkins	1,900-3,200/lb
Radishes	40,000-50,000/lb
Rutabaga	150,000-192,000/lb
Spinach	40,000-50,000/lb
Squash:	
summer	3,500-4,800/lb
winter	1,600-4,000/lb
Sweet corn:	
normal and sugary enhanced	1,800-2,500/lb
supersweet (sh2)	3,000-5,000/lb
Tomatoes:	
fresh	10,000-11,400/oz
processing	160,000-190,000/lb
Turnip	150,000-200,000/lb
Watermelons:	
small seed	8,000-10,400/lb
large seed	3,200-4,800/lb

TABLE 7. POPULATION OF PLANTS PER ACRE AT SEVERAL BETWEEN-ROW AND IN-ROW SPACINGS

Between-row spacing (in.)	In-row spacing (in.)												
	2	4	6	8	10	12	14	16	18	24	30	36	48
7	448,046	224,023	149,349	112,011	89,609	74,674	64,006						
12	261,360	130,680	87,120	65,340	52,272	43,560	37,337	32,670	29,040	21,780	17,424	14,520	10,890
18	174,240	87,120	58,080	43,560	34,848	29,040	24,891	21,780	19,360	14,520	11,616	9,680	7,260
21	149,349	74,674	49,783	37,337	29,870	24,891	21,336	18,669	16,594	12,446	9,957	8,297	6,223
24	130,680	65,340	43,560	32,670	26,136	21,780	18,669	16,335	14,520	10,890	8,712	7,260	5,445
30	104,544	52,272	34,848	26,136	20,909	17,424	14,935	13,068	11,616	8,712	6,970	5,808	4,356
36 (3 ft)	87,120	43,560	29,040	21,780	17,424	14,520	12,446	10,890	9,680	7,260	5,808	4,840	3,630
42 (3.5 ft)	74,674	37,337	24,891	18,669	14,934	12,446	10,668	9,334	8,297	6,223	4,978	4,149	3,111
48 (4 ft)	65,340	32,670	21,780	16,335	13,068	10,890	9,334	8,167	7,260	5,445	4,356	3,630	2,722
60 (5 ft)			17,424	13,068	10,454	8,712	7,467	6,534	5,808	4,356	3,485	2,904	2,178
72 (6 ft)			14,520	10,890	8,712	7,260	6,223	5,445	4,840	3,630	2,904	2,420	1,815
84 (7 ft)			12,446	9,334	7,467	6,223	5,334	4,667	4,149	3,111	2,489	2,074	1,556
96 (8 ft)			10,890	8,167	6,534	5,445	4,667	4,084	3,630	2,722	2,178	1,815	1,361

TABLE 8. CRITICAL PERIODS OF WATER NEED FOR VEGETABLE CROP

Crop	Critical Period
Asparagus	Brush
Beans, Lima	Pollination and pod development
Beans, Snap	Pod enlargement
Broccoli	Head development
Cabbage	Head development
Carrots	Root enlargement
Cauliflower	Head development
Corn	Silking and tasseling, ear development
Cucumbers	Flowering and fruit development
Eggplants	Flowering and fruit development
Lettuce	Head development
Melons	Flowering and fruit development
Onions, Dry	Bulb enlargement
Peppers	Flowering and fruit development
Potatoes (Irish)	Tuber set and tuber enlargement
Radishes	Root enlargement
Southernpeas	Seed enlargement and flowering and English
Squash, Summer	Bud development and flowering
Sweetpotato	Root enlargement
Tomatoes	Early flowering, fruit set, and enlargement
Turnips	Root enlargement

TABLE 9. AVAILABLE WATER-HOLDING CAPACITY BASED ON SOIL TEXTURE

Soil Texture	Available Water Holding Capacity (water/inches of soil)
Coarse sand	0.02–0.06
Fine sand	0.04–0.09
Loamy sand	0.06–0.12
Sandy loam	0.11–0.15
Fine sandy loam	0.14–0.18
Loam and silt loam	0.17–0.23
Clay loam and silty clay loam	0.14–0.21
Silty clay and clay	0.13–0.18

TABLE 10. SOIL INFILTRATION RATES BASED ON SOIL TEXTURE

Soil Texture	Soil Infiltration Rate (inch/hour)
Coarse sand	0.75–1.00
Fine sand	0.50–0.75
Fine sandy loam	0.35–0.50
Silt loam	0.25–0.40
Clay loam	0.10–0.30

SEED STORAGE AND HANDLING

Both high temperature and relative humidity will reduce seed germination and vigor of stored seed. Do not store seed in areas that have a combined temperature and humidity value greater than 100 [e.g., 50°F + 50% relative humidity]. In addition, primed seed does not store well after shipment to the buyer. Therefore, if you do not use all the primed seed ordered in the same season, have the seed tested before planting in subsequent seasons.

Corn, pea, and bean seed are especially susceptible to mechanical damage due to rough handling. Bags of these seed should not be dropped or thrown because the seed coats can crack and seed embryos can be damaged, resulting in a nonviable seed. When treating seed with a fungicide, inoculum, or other chemical, use only gentle agitation to avoid seed damage.

PLANT POPULATIONS

For vegetable seed sizes and plant populations see Tables 6 and 7.

IRRIGATION

Basic Principles. Vegetables are 80 to 95% water. Maintaining proper soil moisture levels is important in order to maximize the productivity of vegetable crops. Plant stress caused by too much or too little soil moisture can lead to decreased size and weight of individual fruit and to defects such as: toughness; strong flavor; poor tipfill and podfill; cracking; blossom-end rot; and misshapen fruit. Saturated soil conditions can reduce soluble solids in cantaloupes and other small melons as well as capsaicin in hot peppers.

It is imperative that soil moisture level be maintained near field capacity at all times during the growing season. Field capacity is the soil moisture *status/content/tension* when water will no longer drain due to the force of gravity. To maintain field capacity at all times requires good soil drainage (both surface and subsurface), and that your irrigation system is capable of making uniform, *frequent*, and precisely timed applications (time/length of irrigation determines the amount/depth applied). More than one irrigation cycle per day may be needed to ***maintain*** field capacity. This is particularly true for fast growing crops grown in soils with little water holding capacity, such as sandy loams.

Different soil types have different moisture holding capacities. It is important that irrigation events be scheduled properly and based on measured soil moisture contents throughout the soil profile. In some cases, water supplies might not be adequate to meet the crop's peak demand. In these cases, it is a better use of the available water to irrigate only a portion of the planting and sacrifice the remaining area, rather than practicing deficit irrigation on the entire planting. Vegetable crops have a high peak water requirement. To prevent plant stress, irrigation systems should be able to apply a minimum of 2.0 inches per week over the entire field area (6 gpm/acre if operated 24/7).

For sprinkler systems used on vegetable crops, droplet size and application rate are also important. Large droplets resulting from low pressure at the sprinkler head can cause damage to young vegetable plants and can contribute to soil crusting when the soils dry. Water is more readily held in clay soils; however, clay soils have a lower water infiltration rate as compared to sandy soils. Irrigation rate is dependent on soil type, and application rates should follow values in Table 10. Depending on the soil structure, high application rates will result in irrigation water running off the field, contributing to erosion and fertilizer runoff particularly on heavy clay soils.

Even relatively short periods of inadequate soil moisture can adversely affect many crops. Thus, irrigation is beneficial in most years, since rainfall is rarely uniformly distributed even in years with above-average precipitation. Moisture deficiencies occurring early in the crop cycle may delay maturity and reduce yields. Shortages later in the season often lower quality and yield. Over-irrigating, however, especially late in the season, can reduce quality and postharvest life of the crop. Table 8 shows the critical periods of crop growth when an adequate supply of water is essential for the production of high-quality vegetables.

Applying the proper amount of water at the correct time is critical for achieving the optimum benefits from irrigation. The crop water requirement, termed evapotranspiration, or *ET*, is equal to the quantity of water lost from the plant (transpiration) plus water that evaporated from the soil surface. The ET rate is important in effectively scheduling irrigations. Numerous factors must be considered when estimating ET. The amount of solar radiation, which provides the energy to evaporate moisture from the soil and plant surfaces, is the major factor. Other factors include: crop growth stage; day length; air temperature; wind speed; and humidity level.

Plant factors that affect ET are crop species; canopy size and shape; leaf size, and shape. Soil factors must also be considered. Soils having high levels of silt, clay, and organic matter have greater water-holding capacities than sandy soils or compacted soils (Table 9). Soils with high water-holding capacities require less frequent irrigation than soils with low water-holding capacities. When such soils are irrigated less frequently, a greater amount of water must be applied per application.

TABLE 11. HOURS REQUIRED TO APPLY 1" WATER BASED ON ROW SPACING.

Drip Tube Flow Rate		Row Spacing (Ft.)				
gph/100 ft.	*gpm/100 ft.*	*4*	*5*	*6*	*8*	*10*
11.4	0.19	21.9	27.3	32.8	43.7	54.7
13.2	0.22	18.9	23.6	28.3	37.8	47.2
20.4	0.34	12.2	15.3	18.3	24.4	30.6
27.0	0.45	9.2	11.5	13.9	18.5	23.1
40.2	0.67	6.2	7.8	9.3	12.4	15.5
80.4	1.34	3.1	3.9	4.7	6.2	7.8

TABLE 12. MAXIMUM APPLICATION TIME IN MINUTES FOR DRIP IRRIGATED VEGETABLES.

	Drip Tubing Flow Rate (*gpm/100 ft.*)				
	0.2	0.3	0.4	0.5	0.6
Available Water Holding Capacity[1] *Inch Of Water/Inch Soil Depth*	Maximum Number of Minutes per Application[2]				
0.02	20	14	10	8	7
0.04	41	27	20	16	14
0.06	61	41	31	24	20
0.08	82	54	41	33	27
0.10	102	68	51	41	34
0.12	122	82	61	49	41
0.14	143	95	71	57	48
0.16	163	109	82	65	54
0.18	183	122	92	73	61

[1] Refer to Table 9 for Available Water Holding Capacity based on soil texture.

[2] Assumes a 10-inch deep root zone and irrigation at 25% soil moisture depletion.

Another soil factor influencing irrigation practices is the soil infiltration rate. Water should not be applied to soils at a rate greater than the rate at which soils can absorb water. Table 10 lists the typical infiltration rates of several soil types.

Without the use of soil moisture monitoring devices, there is no way to accurately schedule irrigation because all the above factors interact to determine water loss. The following factors should be kept in mind when deciding when and how much to irrigate:

Soils vary greatly in their water-holding capacities and infiltration rates. Silt and clay soils and those high in organic matter can hold much more available water than sandy soils, low in organic matter.

Water loss from plants is much greater on clear, hot windy days than on cool, overcast days. During periods of hot, dry weather, ET rates may reach 0.25 inch per day or higher. ET can be estimated by the use of a standard evaporation pan. Check with your local Extension office for information on how to use evaporation pans.

Recent research indicates that maintaining soil moisture levels in a narrow range, just slightly below field capacity (75% to 90% available soil moisture), maximizes crop growth. This may mean that more frequent irrigations of smaller amounts are better than delaying irrigations until the soil moisture reaches a lower level (40% to 50% available soil moisture) and then applying a heavy irrigation.

Plastic mulches reduce evaporation from the soil but also reduce the amount of rainwater that can reach the root zone. Thus, the much of the natural precipitation should be ignored when scheduling irrigations for crops grown under plastic mulch.

Drip Irrigation. *Drip irrigation is used to* ***maintain*** *soil moisture whereas other types of irrigation are used more to* ***replace*** *depleted soil moisture*. Drip irrigation is a method of slowly applying water directly to the plant's root zone. Water is applied frequently, often daily, to maintain favorable soil moisture conditions. Even so, field operations can continue uninterrupted. Water is applied without wetting the foliage, thereby decreasing evaporative losses and decreasing disease pressure due to damp foliage. Additionally, the use of drip irrigation can limit waste and potential contamination from overuse (or unnecessary use) of agricultural chemicals. In most cases, drip irrigation is considerably more uniform and efficient in its distribution of water to the crop than other irrigation methods. Still, drip irrigated crops can require up to 10% more water than sprinkler or furrow irrigated crops because of increased plant vigor, larger canopies, and heavier fruit setting. In addition, fertilizers applied through the drip irrigation system are conserved.

Drip irrigation is used on a wide range of fruit and vegetable crops. It is especially effective when used with mulches; on sandy soils; and on high value crops, such as cantaloupes, watermelons, squash, peppers, eggplants, and tomatoes. Drip irrigation systems have several other advantages over sprinkler and surface irrigation systems. Low flow rates and operating pressures are typical of drip systems. These characteristics lead to lower energy costs. Once in place, drip systems require little labor to operate, can be automatically controlled, and can be managed to apply the precise amount of water and nutrients needed by the crop. These factors also reduce operating costs. The areas between rows remain dry reducing weed growth between rows and reducing the amount of water lost to weeds.

There are several potential problems unique to drip irrigation systems. Most drip systems require a higher level of management than other irrigation systems. Moisture distribution in the soil is limited with drip systems. In most cases, a smaller soil water reserve is available to plants. Under these conditions, the potential to stress plants is greater than with other types of irrigation systems. *In order to use drip irrigation successfully, the system must be carefully managed and maintained*.

The equipment used for drip irrigation systems must be routinely monitored and maintained in order to prevent any challenges. Drip irrigation tape and tubing can be damaged by insects, rodents, and laborers, and often has a higher initial investment cost than other irrigation system types. Pressure regulation and filtration require equipment not commonly used with sprinkler or surface systems. The drip system, including a pump, headers, filters, and various connectors, must be checked and be ready to operate *before* planting. Failure to have the system operational could result in costly delays, poor plant survival, and irregular stands, reducing yield.

Calculating the length of time required to apply a specific depth of water with a drip irrigation system is more difficult than with sprinkler systems. Unlike sprinkler systems, drip systems apply water to only a small portion of the total crop acreage. Usually, a fair assumption to make is that the mulched width approximates the extent of the plant root zone. Although the root zone is confined, the plant canopy is vigorous and water use and loss from evapotranspiration (*Et*) can far exceed the water applied if application is based on a banded or mulch width basis. Table 11 calculates the length of time required to apply 1-inch of water with drip irrigation based on the drip tape flow rate and crop row spacing. The use of this table requires that the drip system be operated at the pressure recommended by the manufacturer.

Excessive application of water can move nutrients, water and pesticides below the plant root zone. Table 12 has been prepared to calculate the maximum recommended irrigation period for drip irrigation systems. The irrigation periods listed are based on the assumption that 25 percent of the available water in the plant root zone is depleted. Soil texture directly influences the water-holding capacity of soils and the consequential depth reached by irrigation water.

In drip tape systems, water is carried through plastic tubing (which expands when water flows through it) and distributed along the drip tape through built-in outlets or devices called emitters. The pressure-reducing flow path also allows the emitter to remain relatively large, allowing particles that could clog an emitter to be discharged.

Although modern emitter design reduces the potential for trapping small particles, emitter clogging can be a common occurrence with drip irrigation systems. Clogging can be attributed to physical, chemical, or biological contaminants. Proper filtration is a must and occasional water treatment might be necessary in order to keep drip systems from clogging. Further information on drip irrigation systems can be obtained from manufacturers, dealers, and your local Extension office.

Chlorination. Bacteria can grow inside drip irrigation tapes, forming a slime that can clog emitters. Algae present in surface waters can also clog emitters. Bacteria and algae can be effectively controlled by chlorination of the drip system. Periodic treatment **before** clogs develop can keep the system functioning efficiently. The fre-

quency of treatments depends on the quality of the water source. Generally two or three treatments per season are adequate. Irrigation water containing high concentrations of iron (greater than 1 ppm) can also cause clogging problems due to a type of bacteria that "feeds" on iron. In consuming the dissolved (ferrous) form of iron, the bacteria secrete a slime called ochre, which may combine with other solid particles in the drip tape and plug emitters. The precipitated (ferric) form of iron, known commonly as rust, can also physically clog emitters. In treating water containing iron, chlorine will oxidize the iron dissolved in water, causing the iron to precipitate so that it can be filtered and removed from the system.

Chlorine treatment **should take place upstream of filters** in order to remove the precipitated iron and microorganisms from the system. Chlorine is available as a gas, liquid, or solid. Chlorine gas is extremely dangerous and caution should be exercised if this method of treatment is chosen. Solid chlorine is available as granules or tablets containing 65% to 70% calcium hypochlorite but might react with other elements in irrigation water to form precipitates which could clog emitters. Liquid chlorine is available in many forms, including household bleach (sodium hypochlorite), and is the easiest and often safest form to use for injection. **Stock solutions can be bought that have concentrations of 5.25%, 10%, or 15% available chlorine. Use chlorine only if the product is labeled for use in irrigation systems.**

Since chlorination is most effective at pH 6.5 to 7.5, some commercial chlorination equipment also injects buffers to maintain optimum pH for effective kill of microorganisms. This type of equipment is more expensive, but more effective than simply injecting sodium hypochlorite solution.

The required rate of chlorine injection is dependent on the amount of microorganisms present in the water source, the amount of iron in the irrigation water, and the method of treatment being used. To remove iron from irrigation water, start by injecting 1 ppm of chlorine for each 1 ppm of iron present in the water. For iron removal, **chlorine should be injected continuously**. Adequate mixing of the water with chlorine is essential. For this reason, be certain to mount the chlorine injector a distance upstream from filters. An elbow between the injector and the filter will ensure adequate mixing.

For treatment of algae and bacteria, a chlorine injection rate that results in the presence of 1 to 2 ppm of "free" chlorine at the end of the furthest lateral will assure that the proper amount of chlorine is being injected. Free, or residual, chlorine can be tested using an inexpensive DPD (diethyl-phenylene-diamine) test kit. A swimming pool test kit can be used, but only if it measures free chlorine. Many pool test kits only measure total chlorine.

If a chlorine test kit is unavailable, one of the following schemes is suggested as a starting point:

For iron treatment:

- Inject liquid sodium hypochlorite continuously at a rate of 1 ppm for each 1 ppm of iron in irrigation water. In most cases, 3 to 5 ppm is sufficient.

For bacteria and algae treatment:

- Inject liquid sodium hypochlorite continuously at a rate of 5 to 10 ppm where the biological load is high.
- Inject 10 to 20 ppm during the last 30 minutes of each irrigation cycle where the biological load is medium.
- Inject 50 ppm during the last 30 minutes of irrigation cycles two times each month when biological load is low.
- Superchlorinate (inject at a rate of 200 to 500 ppm) once per month for the length of time required to fill the entire system with this solution and shut down the system. After 24 hours, open the laterals and flush the lines.

The injection rates for stock solutions that contain 5.25%, 10% and 15% can be calculated from the following equations:

FOR 5.25% STOCK SOLUTION:

Injection rate of chlorine, gph = [(Desired available chlorination level, ppm) x (Irrigation flow rate, gpm)] divided by 875.

FOR A 10% STOCK SOLUTION:

Injection rate of chlorine, gph = [(Desired available chlorination level, ppm) x (Irrigation flow rate, gpm)] divided by 1,667.

FOR A 15% STOCK SOLUTION:

Injection rate of chlorine, gph = [(Desired available chlorination level, ppm) x (Irrigation flow rate, gpm)] divided by 2,500.

It is important to note that chlorine will cause water pH to rise. This is critical because chlorine is most effective in acidic water. If your water pH is above 7.5 before injection, it must be acidified for chlorine injection to be effective.

IMPORTANT NOTES.

- Approved backflow control valves, low pressure drains, and interlocks must be used in the injection system to prevent contamination of the water source.

- Chlorine concentrations above 30 ppm may kill plants.

Fertilization. Before considering a fertilization program for mulched-drip irrigated crops, be sure to have the soil pH checked. If a liming material is needed to increase the soil pH, the material should be applied and incorporated into the soil as far ahead of mulching as practical. For most vegetables, adjust the soil pH to around 6.5. When using drip irrigation in combination with mulch, apply the recommended amount of preplant fertilizer and incorporate it 5 to 6 inches into the soil before laying the mulch. If equipment is available, apply the preplant fertilizer to the soil area that will be covered by the mulch. This is more efficient than a broadcast application to the entire field.

The most efficient method of fertilizing an established mulched crop is through a drip irrigation system, which is installed during the mulching operation. Due to the very small holes or orifices in the drip tape, high quality liquid fertilizers, or water-soluble fertilizers must be used. Since phosphorous is a stable non-mobile soil nutrient and can cause clogging of the drip tape emitters, it is best to apply 100% of the crop's phosphorous needs pre-plant. Additionally, apply 20 to 40% of the crops's nitrogen and potassium needs pre-plant. The remainder of the crop's nutrient needs can be applied through the drip system with a high quality liquid fertilizer such as 8–0–8, 7–0–7, or 10–0–10. Generally, it is not necessary to add micronutrients through the drip system. Micronutrients can be best and most economically applied pre-plant or as foliar application if needed.

The amount of nutrients to apply through the drip system depends upon the plant's growth stage. In general, smaller amounts of nutrients are needed early in the plant's growth with peak demand occurring during fruit maturation. The frequency of nutrient application is most influenced by the soil's nutrient holding capabilities. Clay soils with a high nutrient holding capacity could receive weekly nutrient applications through the drip system while a sandy soil with low nutrient holding capacity will respond best with a daily fertigation program. Fertigation rates are provided under crop specific recommendations later in this handbook.

MULCHES AND ROW COVERS

Mulches. The most widely used mulches for vegetable production are black, white on black, clear and metalized polyethylene mulches. Black mulch is most widely used for spring applications where both elevated soil temperatures and weed control are desired. Clear plastic mulch is used when maximum heat accumulation is desired and weed control is not as critical. White on black plastic (with white-side of plastic facing up) is used for late spring and summer plantings where the benefits of moisture retention and weed control are valued and heat accumulation may be detrimental. Growers often will apply white latex paint to black mulch when double cropping.

Metallized mulch, commonly referred to as reflective or silver mulch, is used to combat aphids and thrips that vector viral diseases. Metalized mulch should reflect a recognizable image (that is, be mirror-like) to be most effective.

Organic mulches such as straw, pine straw, compost, and coarse hay provide weed control and moisture retention and keep soils cooler than bare ground. Using hay often introduces weeds into a field. One benefit of using organic mulches is that they add organic matter to the soil when incorporated after the growing season. When using these mulches, supplemental nitrogen may be needed to compensate for the nitrogen that is lost to soil microbes in the process of breaking down the organic mulch.

Bed formation and moisture are critical to the success of growing vegetables with plastic mulch. Beds should be smooth, free of clods and sticks, and of uniform height. Black plastic mulch warms the soil by conduction, so as much contact as possible should be made between the mulch and soil. Raised beds allow the soil to drain and warm more quickly. Drip tape is commonly laid under the plastic in the same field operation. The soil should be moist when the plastic is applied since it is difficult to add enough water to thoroughly wet the width of the bed when using drip irrigation. Steep slopes may limit row length when using drip tape, normally row lengths should not exceed 300 to 600 feet depending on the specifications of drip tape.

Follow label directions for fumigants and herbicides used with plastic mulches. Fumigants have a waiting period before seeds or transplants can be planted. Transplanters and seeders are available to plant through plastic mulch. In fields with a history of nutsedge, appropriate measures must be taken in order to reduce or eliminate infestations as plastic mulches cannot control nutsedge. Nutsedge will compromise plastic mulch by piercing it.

Fertilization. Vegetables produced on plastic mulch, but without the ability to supply nutrients through the drip system, should have all of their required fertilizer incorporated into the beds prior to applying the mulch. Broadcasting the fertilizer before bedding has been shown to be an effective method of application since the bedding process moves most of the fertilizer into the bed. Growers using fertigation should follow the recommendations for each specific crop. Fertigation schedules are listed for cantaloupe, cucumber, eggplant, okra, pepper, summer squash, tomato, and watermelon later in this handbook. Also, refer to the previous section for further information on fertilization.

Double cropping. Growers frequently grow two crops on black plastic mulch. The spring crop is killed and removed, then the plastic is generally painted with white latex paint diluted with water (1 part paint to 5 parts water). After painting, a second crop is planted through the mulch. The new crop should be planted into new holes and fertilizer added based on soil test results and the new crop's nutrient requirements.

Degradable mulches. Photodegradable and biodegradable plastic mulches are available, but usually cost more than conventional films. This additional expense is offset to an extent by reduced disposal costs. They have many of the properties and provide the usual benefits of standard polyethylene mulches. Photodegradable mulches begin to break down after the film has received a predetermined amount of sunlight. When a photodegradable film has received sufficient light, it becomes brittle and develops cracks, tears, and holes. Small sections of film may tear off and be blown around by the wind. Finally, the film breaks down into small flakes and disappears into the soil. **The edges covered by the soil retain their strength and break down very slowly.**

Biodegradable plastic mulches are weakened by exposure to sunlight, but are designed to degrade in the soil by microorganisms when soil moisture and temperatures are favorable for biological activity. Biodegradable film will usually be retained on the surface of the soil rather than be blown away from the application site. In addition, all of the biodegradable film will eventually decompose, including the tucked edges buried in the soil. It is recommended that biodegradable mulch be incorporated into the soil at the end of the harvest or growing season. Cover crops can be planted the next day after biodegradable plastic mulch has been rototilled into the soil.

Plastic Mulch Removal and Disposal

Commercial mulch lifters are available. Plastic can be removed by hand by running a coulter down the center of the row and picking the mulch up from each side. Sanitary landfills may accept plastic mulch in some areas. There are a few recycling projects which accept plastic mulch. Some states allow burning of mulch with a permit.

Row covers. Row covers are used to hasten the maturity of the crop, exclude certain insect pests, and provide a small degree of frost protection. There are two main types of row covers: vented clear or translucent polyethylene that is supported by wire hoops placed at regular (5 to 6 ft) intervals, and floating row covers that are porous, lightweight spunbonded materials placed loosely over the plants. In addition, plastic can be placed loosely over the plants with or without wire supports. Floating covers are more applicable to the low-growing vine crops. Upright plants like tomatoes and

peppers have been injured by abrasion when the floating row cover rubs against the plant or excess temperatures build-up. Erratic spring temperatures require intensive management of row covers to avoid blossom shed and other high temperature injuries.

In particular, clear plastic can greatly increase air temperatures under the cover on warm sunny days, resulting in a danger of heat injury to crop plants. Therefore, vented materials are recommended. Even with vents, clear plastic has produced heat injury, especially when the plants have filled a large portion of the air space in the tunnel. This has not been observed with the translucent materials.

Usually, row covers are combined with plastic mulch.

High Tunnels. High tunnels are unheated polyethylene covered greenhouse structures that provide a larger degree of frost protection than row covers. A properly built high tunnel with one or two layers of plastic, should afford 5-8 °F of frost protection for growers. As with row covers, high tunnels require intensive management to ensure that they are vented properly when warm spring temperatures can cause excessive heat to build up in tunnels, resulting in damage to the crop. Tomatoes are commonly produced in high tunnels as well as a variety of leafy greens crops, due to the premium prices obtained. Row covers are often combined with the use of high tunnels and plastic mulch.

In some northern regions, high tunnels can provide 3-4 weeks of season extension for spring and fall crops such as tomatoes as well as year-round production of cole crops and lettuce. High tunnels can reduce the incidence of certain diseases and insects due to protection from rain and changes in light interception, respectively, inside the tunnel; however, traditional greenhouse pests, such as leaf mold, aphids, spider mites, and white flies may be more prevalent in high tunnels. In many states high tunnels are considered a greenhouse structure for the application of pesticides, which may reduce the number of chemicals available compared to field production. Be sure to determine if the pesticides you are applying are acceptable for use in high tunnels in your state.

Extensive information regarding construction, specifics of crop production, soil management, and economics of production for many fruit, vegetable, and cut flowers grown in high tunnels can be found at http://www.hightunnels.org/.

Considerations for Using Mulch, Drip Irrigation, and Row Covers. Each grower considering mulches, drip irrigation, and/or row covers must weigh the economics involved. The long-term versus short-term opportunities must be considered.

Does the potential increase in return justify the additional costs?

Are the odds in favor of the grower getting the most benefit in terms of earliness and yield from the mulch, drip irrigation, and/or row covers?

Does the market usually offer price incentives for early produce? Will harvesting early allow competition against produce from other regions?

For planting on 5 to 6-foot centers, polyethylene mulch costs $250 to $300 per acre, respectively When using plastic mulch, drip irrigation must also be used. With 5 to 6-foot centers, drip irrigation materials will cost $300 to $350 per acre, respectively. Row covers can cost over $400 per acre. Growers must determine these costs for their situations and calculate their potential returns.

POLLINATION

Honeybees or other pollinating insects are essential for commercial production of cucurbit vine crops and may also improve the yield and quality of fruit in beans, eggplants, peas, and peppers. In other fruiting vegetables, such as okra and some legumes, pollination does not require insect visits. Lack of adequate pollination usually results in small or misshapen fruit in addition to low yields. The size and shape of the mature fruit is related to the number of seeds produced and each seed requires one or more pollen grains for normal development. Cucumbers, squash, pumpkins, and watermelons have separate male and female flowers, while cantaloupes and other specialty melons have male and hermaphroditic (perfect or bisexual) flowers. Adequate amount of the sticky pollen of the male flowers must be transferred to the female flowers to achieve fruit set. Cucurbit flowers are usually open and attractive to bees for no more than one day. Flower opening, release of pollen, and commencement of nectar secretion normally precede bee activity. Pumpkin, squash, cantaloupe, and watermelon flowers normally open around daybreak and close by or before noon; whereas, cucumbers and melons generally remain open the entire day. Pollination must take place on the day the flowers open because pollen viability, stigmatic receptivity, and attractiveness to bees lasts only that day.

European honeybees and various native wild bees may visit the flowers of flowering vegetables. However, successful pollination requires that these insects visit male and female flowers frequently for pollen transfer to occur. Some insects present in flowers may not contribute greatly to pollination. Honeybees and bumblebees move frequently from one flower to another and placing hives of these bees into a crop at the correct time will greatly enhance pollination. Even though bumblebees and other species of wild bees are excellent pollinators, populations of these native pollinators usually are not adequate for large acreages grown for commercial production. Colonies of wild honeybees have been decimated by Tracheal and Varroa mites, and possibly other environmental factors, and therefore cannot be counted on to aid in pollination. One of the best ways to ensure adequate pollination is to keep or rent strong colonies of honey bee from a reliable beekeeper. Another option for pollination is the bumblebee. Bumblebees are becoming a popular grower's choice over the past decade and are being found to be effective as a pollinator alternative to honeybees. Commercial bee attractants are available but have not proven to be effective in enhancing pollination. Growers are advised to increase numbers of honeybee or bumblebee colonies and not to rely on such attractants. Suppliers of both honeybee and bumblebee colonies need ample notice prior to when the bees are needed for a given crop. Approximately 3 to 4 months advance notice is usually sufficient to meet crop pollinator needs. A written contract between the grower and beekeeper/supplier can prevent misunderstandings and, thus, ensure better pollinator service. Pollinator contracts should specify the number and strength of colonies, the rental/purchase fee, time of delivery, and distribution of bees in the field.

Honeybee activity is determined to a great extent by weather

and conditions within the hive. Bees rarely fly when the temperature is below 55°F. Flights seldom intensify until the temperature reaches 70°F. Wind speed beyond 15 miles per hour seriously slows bee activity. Cool, cloudy weather and threatening storms greatly reduce bee flights. In poor weather, bees foraging at more distant locations will remain in the hive, and only those that have been foraging nearby will be active. Ideally, colonies should be protected from wind and be exposed to the sun from early morning until evening. Colony entrances facing east or southeast encourage bee flight. The hives should be off the ground and the front entrances kept free of grass and weeds. For best results, hives should be grouped together. A clean water supply should be available within a quarter mile of the hive.

The number of colonies needed for adequate pollination varies with location, attractiveness of crop, density of flowers, length of blooming period, colony strength, and competing blossoms of other plants in the area. In vine crops, recommendations are one to two colonies per acre, with the higher number for higher density plantings. Each honeybee hive or colony should contain at least 40,000 - 50,000 bees. Eight or more bee visits per female flower are required to produce marketable fruit. Bumblebees have some advantages compared to honeybees in that the former fly in cool, rainy, and windy weather and often visit flowers earlier in the morning than honeybees. Bumblebees are also active later in the day when temperatures cool and they have a larger body size than honeybees, thus requiring fewer visits to achieve good pollination and fruit set. Bumblebee hives are sold as a quad or four hives per quad. A quad is the minimum order that can be purchased from a supplier. Generally one bumblebee hive contains 200 to 250 bees and is equivalent to one honeybee hive; however, research that can specifically document this is lacking. Thus, one quad of bumblebees would provide good pollination for four acres of a cucurbit crop if the recommendation is to use 1 bumblebee hive per acre. In some instances, two hives per acre or more may be recommended (i.e. triploid watermelon). In this case, one quad would provide good pollination for two acres. Bumblebee hives should not be placed in direct sunlight so that the bees work more efficiently. No more than two bumblebee quads should be placed in one location so that pollination is more uniform in the field. The quad locations should be at least 650 to 700 feet from each other.

Insecticides applied while a crop is in bloom pose a serious hazard to bees visiting flowers. If insecticides must be applied, select a product that will give effective control of the target pest but pose the least danger to bees. Apply these chemicals near evening when the bees are not actively foraging and avoid spraying adjacent crops while bees are active. If insecticide spraying is necessary, give the beekeeper 48 hours of notice of when you expect to spray so that precautions can be taken. Avoid leaving puddles of water around chemical mixing areas as bees may pick up and be harmed by insecticide contaminated water. As with honeybees, one must carefully plan when to spray insecticides so that the bumblebees are not injured or killed. Because bumblebees are most active from dawn until late morning, and again from about 4 PM until sunset, the hives need to be closed around 11 AM so that the bumblebees remain in the hive and are protected during a late evening spray application.

HOW TO IMPROVE PEST CONTROL

Failure to control an insect, mite, disease, or weed pest is often erroneously blamed on the pesticide when the cause frequently lies elsewhere. Several common reasons for failure to achieve control are the following:

1. Delaying applications until pest populations become too large or damage is too advanced.
2. Poor coverage caused by insufficient volume, inadequate pressure, or clogged or poorly arranged nozzles.
3. Selecting the wrong pesticide for the target pests.
4. Contaminated or high pH water source.

SUGGESTED STEPS FOR MORE EFFECTIVE PEST CONTROL:

1. *Scout fields regularly.* Know the pest situation and any buildups in your fields. Frequent examinations (at least once or twice per week) help determine the proper timing of the next pesticide application. Do not apply a pesticide simply because a neighbor chooses to do so.
2. *Integrated Pest Management (IPM).* Use an ongoing program of biological, physical, cultural, and chemical methods in an integrated approach to manage pests. IPM involves scouts visiting fields to collect pest population data. Use this updated information to decide whether insecticide applications or other management actions are needed to avoid economic loss from pest damage. Control decisions are based on factors such as:
    - The economic action threshold level (when the cost of control equals or exceeds potential crop losses attributed to real or potential damage)
    - Other factors are listed in the Recommended Control Guidelines section that follows

To employ an IPM program successfully, basic practices need to be followed. Whether participating in a university- or grower-supported IPM program, hiring a private consultant, or doing the work personally, the grower still practices:

- frequent and regular examination of fields to assess pest populations
- applying a control measure only when the economic threshold level has been reached
- where possible, employing a cultural practice or a biological control or using a pesticide that is less harmful to natural enemies of the target pest

Resistance management. The way pesticides are used affects the development of resistance. Resistance develops because intensive pesticide use kills the susceptible individuals in a population, leaving only resistant ones to breed. Adopting the following practices will reduce the development of pest resistance:

1. Rotate crops to a nonhost crop, thus reducing the need for pesticide treatment and, thereby reducing the ratio of resistant to susceptible individuals in the breeding population.
2. Use control guidelines as an important tactic for reducing the pesticide resistance problem. For more information concern-

ing control guidelines, refer to the following section and the crop-specific sections of this handbook.

3. Spot treat when possible. Early-season insects are often concentrated in areas near their overwintering sites. Diseases often can be first detected in favorable microclimates, such as low or wet areas of the field. Perennial weeds and newly introduced or herbicide-resistant annual weeds often occur first in small numbers in a part of a field. Treating these areas, rather than the entire field, can prevent the development of resistant populations.
4. Control pests early, because seedling weeds and immature insects are more susceptible to pesticides and less likely to develop resistance compared to older and more mature crop pests.
5. Do not overspray. Attempts to destroy every pest in the field by multiple applications or by using higher than labeled rates often eliminate the susceptible pests but not the resistant pests.
6. Rotate pesticides to reduce the development of resistance, particularly with pesticides that differ in their mechanism of action. Rotation among different chemical groups is an excellent method of reducing resistance problems.
7. Use appropriate additives when recommended on the pesticide's label. For example, adding a crop oil concentrate or a surfactant to certain postemergence herbicides will increase the effectiveness of the herbicides.

Control Pests According to Recommended Control Guidelines or Schedule. Control guidelines provide a way to decide whether pesticide applications or other management actions are needed to avoid economic loss from pest damage. Guidelines for pests are generally expressed as a count of a given insect stage or as a crop damage level based on certain sampling techniques. They are intended to reflect the pest population that will cause economic damage and thus would warrant the cost of treatment. Guidelines are usually based on pest populations, field history, stage of crop's development, variety, weather conditions, life stage of the pest, parasite, and/or predator populations, resistance to chemicals, time of year, and other factors. Specific thresholds are given in this handbook for a number of pests of many crops.

Insect population sampling techniques include:

- *Visual observation*. Direct counts of any insect stages (eggs, larvae, adults, etc.) are accomplished by examining plants or plant parts (leaves, stems, flowers, fruits). Counts can be taken on single plants or a prescribed length of row, which will vary with the crop. Usually, quick moving insects are counted first, followed by those that are less mobile.
- *Shake cloth* (also known as a ground cloth). This sampling procedure consists of using a standard 3-foot by 3-foot shake cloth to assess insect populations. Randomly choose a site without disturbing the plants and carefully unroll the shake cloth between two rows. Bend the plants over the cloth one row at a time and beat the plants vigorously to dislodge insects held on stems, leaves, and branches. Count only insects that have landed on the shake cloth. The number of sampling sites per field will vary with the crop.
- *Sweep net*. This sampling procedure uses a standard 15-inch diameter sweep net to assess insect populations. While walking along one row, swing the net from side to side with a pendulum-like motion to face the direction of movement. The net should be rotated 180 degrees after each sweep and swung through the foliage. Each pass of the net is counted as one sweep. The number of sweeps per field will vary with the crop.

Weed population sampling techniques include:

- *Weed identification*. This first step is frequently skipped. Perennial weeds and certain serious annual weeds should be controlled before they can spread. Common annual weeds need only be controlled if they represent a threat to yield, quality, or harvestability. It is critical to know the weed history of a field prior to planting as many herbicides need to be applied pre-plant. Your county Extension office is an excellent resource for reliable weed identification.
- *Growth stage determination*. The ability of weeds to compete with the crop is related to size of the weed and size of the crop. Control of the weed using herbicides or mechanical methods is also dependant on weed size. A decision to control or not to control a weed must be carried out before the crop is affected and before the weed is too large to be controlled.
- *Weed population*. Weeds interfere with crop production in many ways. They may compete for light, water, nutrients, and space. The extent of this interference is dependant on population and is usually expressed as *weeds per foot of row or weeds per square meter.* Control measures are needed when the weed population exceeds the maximum tolerable population of that species.

Disease monitoring involves determining the growth stage of the crop, observing disease symptoms on plants, and/or the daily weather conditions in the field.

Disease control is often obtained by applying crop protectants on a regular schedule. For many diseases, application must begin at a certain growth stage and must be repeated every 7 to 10 days. When environmental conditions are favorable for disease development, delaying a spray program will result in a lack of control if the disease has progressed too far. For certain diseases that do not spread rapidly, fields should be scouted regularly.

Predictive systems are available for a few diseases. Temperature, rainfall, relative humidity, and duration of leaf wetness period are monitored, and the timing of fungicide application is determined by predicting when disease development is most likely to occur. One such program for Downy Mildew is available at http://cdm.ipmpipe.org/

Weather Conditions. These are important to consider before applying a pesticide. Spray only when wind velocity is less than 10 miles per hour. Do not spray when sensitive plants are wilted during the heat of the day. *If possible, make applications when ideal weather conditions prevail*.

Certain pesticides, including biological insecticides (e.g. BT's) and some herbicides, are ineffective in cool weather. Others do not perform well or may cause crop injury when hot or humid conditions are prevalent. Optimum results can frequently be achieved when the air temperature is in the 70°F range during application.

Strive for Adequate Coverage of Plants.

Improved control of aphids can be achieved by adding and arranging nozzles so that the application is directed toward the plants from the sides as well as from the tops (also see *Alkaline Water and Pesticides*, which follows). In some cases, nozzles should be arranged so that the application is directed beneath the leaves. As the season progresses, plant size increases, as does the need for increased spray gallonage to ensure adequate coverage.

Applying insecticide and fungicide sprays with sufficient spray volume and pressure is important. Spray volumes should increase as the crop's surface area increases. Sprays from high-volume-high-pressure rigs (airblast) should be applied at rates of 40 to 200 gallons per acre at 200 psi or greater. Sprays from low-volume-low-pressure rigs (boom type) should be applied at rates of 50 to 100 gallons per acre at 20 psi. The addition of a spreader-sticker improves coverage and control when wettable powders are applied to smooth-leaved plants, such as cole crops and onions.

Use a dedicated sprayer for herbicides and a different sprayer for fungicides and insecticides. Herbicide sprays should be applied at between 15 and 50 gallons of spray solution per acre using low pressure (20 to 40 psi). Never apply herbicides with a high-pressure sprayer that was designed for insecticide or fungicide application because excessive drift can result in damage to nontarget plants in adjacent fields and areas. **Do not** add oil concentrates, surfactants, spreader-stickers, or any other additive unless **specified** on the label, or crop injury is likely.

Select the Proper Pesticide. Know the pests to be controlled and choose the recommended pesticide and rate of application. When in doubt, consult your local Extension office. The herbicide choice should be based on weed species or cropping systems.

For insects that are extremely difficult to control or are resistant, it is essential to alternate labeled insecticides, especially with different classes of insecticides. Be alert for a possible aphid or mite buildup following the application of certain insecticides.

Caution: Proper application of soil systemic insecticides is extremely important. The insecticide should be placed according to the label instructions (which, in general, indicate application should be directed away from the seed) or crop injury may occur.

Be sure to properly identify the disease(s). Many fungicides control specific diseases but provide no control of others. For this reason, on several crops, fungicide combinations are recommended.

Pesticide Compatibility. To determine if two pesticides are compatible, use the following "jar test" before you tank-mix pesticides or tank-mix pesticides with liquid fertilizers:

1. Add 1 pint of water or fertilizer solution to a clean quart jar, then add the pesticides to the water or fertilizer solution in the same proportion as used in the field.
2. To a second clean quart jar, add 1 pint of water or fertilizer solution. Then add 1/2 teaspoon of an adjuvant to keep the mixture emulsified. Finally, add the pesticides to the water-adjuvant or fertilizer adjuvant in the same proportion as used in the field.
3. Close both jars tightly and mix thoroughly by inverting 10 times. Inspect the mixtures immediately and after standing for 30 minutes. If a uniform mix cannot be made, the mixture should not be used. If the mix in either jar remains uniform for 30 minutes, the combination can be used. If the mixture with adjuvant stays mixed and the mixture without adjuvant does not, use the adjuvant in the spray tank. If either mixture separates but readily remixes, constant agitation is required. If nondispersible oil, sludge, or clumps of solids form, do not use the mixture.

Note: For compatibility testing, the pesticide can be added directly or premixed in water first. In actual tank-mixing for field application, unless label directions specify otherwise, add pesticides to the water in the tank in this order: first, wettable granules or powders, then flowables, emulsifiable concentrates, water solubles, and companion surfactants. If tank-mixed adjuvants are used, these should be added first to the fluid carrier in the tank. Thoroughly mix each product before adding the next product.

Select Correct Sprayer Tips. The choice of a sprayer tip for use with many pesticides is important. Flat fan-spray tips are designed for preemergence and postemergence application of herbicides. These nozzles produce a tapered-edge spray pattern that overlaps for uniform coverage when properly mounted on a boom. Standard flat fan-spray tips are designed to operate at low pressures (20-40 psi) to produce small-to medium-sized droplets that do not have excessive drift. Flat fan-nozzle tips are available in brass, plastic, ceramic, stainless steel, and hardened stainless steel. Brass nozzles are inexpensive and are satisfactory for spraying liquid pesticide formulations. Brass nozzles are least durable, and hardened stainless steel nozzles are most durable and are recommended for wettable powder formulations, which are more abrasive than liquid formulations. When using any wettable powder, it is essential to calibrate the sprayer frequently because, as a nozzle wears, the volume of spray material delivered through the nozzle increases.

Flood-type nozzle tips are generally used for complete fertilizers, liquid N, etc., and sometimes for spraying herbicides onto the soil surface prior to incorporation. They are less suitable for spraying postemergence herbicides or for applying fungicides or insecticides to plant foliage. Coverage of the target is often less uniform and complete when flood-type nozzles are used, compared with the coverage obtained with other types of nozzles. Results with postemergence herbicides applied with flood-type nozzles may be satisfactory if certain steps are taken to improve target coverage. Space flood-type nozzles a maximum of 20 inches apart, rather than the suggested 40-inch spacing. This will result in an overlapping spray pattern. Spray at the maximum pressure recommended for the nozzle. These techniques will improve target coverage with flood-type nozzles and result in more satisfactory weed control.

Full and hollow-cone nozzles deliver circular spray patterns and are used for application of insecticides and fungicides to crops where thorough coverage of the leaf surfaces is extremely important and where spray drift will not cause a problem. They are used when higher water volumes and spray pressures are recommended. With cone nozzles, the disk size and the number of holes in the whirl plate affect the output rate. Various combinations of disks and whirl plates can be used to achieve the desired spray coverage.

Alkaline Water and Pesticides. At times applicators have commented that a particular pesticide has given unsatisfactory results. Usually, these results can be attributed to poor application, a bad

batch of chemical, pest resistance, weather conditions, etc. However, another possible reason for unsatisfactory results from a pesticide may be the pH of the mixing water.

Some materials carry a label cautioning the user against mixing the pesticide with alkaline materials. The reason for this caution is that some materials (in particular the organophosphate insecticides) undergo a chemical reaction know as "alkaline hydrolysis." This reaction occurs when the pesticide is mixed with alkaline water; that is, water with a pH greater than 7. The more alkaline the water, the greater the breakdown (i.e., "hydrolysis").

In addition to lime sulfur, several other materials provide alkaline conditions: caustic soda, caustic potash, soda ash, magnesia or dolomitic limestone, and liquid ammonia. Water sources in agricultural areas can vary in pH from less than 3 to greater than 10.

To check the pH of your water, purchase a pH meter or in most states you can submit a water sample to your state's soil or water testing lab. If you have a problem with alkaline pH, there are several products available that are called nutrient buffers that will lower the pH of your water.

There are some instances when materials should not be acidified, namely, sprays containing fixed copper fungicides, including: Bordeaux mixture, copper oxide, basic copper sulfate, copper hydroxide, etc.

BENEFICIAL INSECTS

A number of environmental factors, such as weather, food availability, and natural enemies combine to keep insect populations under control naturally. In some human-altered landscapes, such as in agricultural crop fields, the levels of natural control are often not acceptable to us, and we have to intervene in order to lower pest populations. While some environmental factors, such as weather, cannot be altered to enhance control of pests, others such as populations of natural enemies, can be effected. The practice of taking advantage of and manipulating natural enemies in order to suppress pest populations is called *biological control*.

Approaches To Biological Control. There are three general approaches to biological control: importation, augmentation, and conservation of natural enemies. Each of these techniques can be used either alone or in combination in a biological control program.

Importation: Importation of natural enemies, sometimes referred to as classical biological control, is used when a pest of exotic origin is the target of the biocontrol program. Pests are constantly being imported into countries where they are not native, either accidentally, or in some cases, intentionally. Many of these introductions do not result in establishment or if they do, the organism may not become a pest. However, it is possible for some of these introduced organisms to become pests due to a lack of natural enemies to suppress their populations. In these cases, importation of natural enemies can be highly effective.

Once the country of origin of the pest is determined, exploration in the native region can be conducted to search for promising natural enemies. If such enemies are identified, they may be evaluated for potential impact on the pest organism in the native country or alternatively imported into the new country for further study. Natural enemies are imported into the U.S. only under permit from the U.S. Department of Agriculture. They must first be placed in quarantine for one or more generations to be sure that no undesirable species are accidentally imported (diseases, hyperparasitoids, etc.). Additional permits are required for interstate shipment and field release.

Augmentation: Augmentation is the direct manipulation of natural enemies to increase their effectiveness. This can be accomplished by one of two general methods or a combination of these methods: mass production and/or periodic colonization of natural enemies. The most commonly used of these approaches is the first, in which natural enemies are produced in insectaries, then released either inoculatively or inundatively. For example, in areas where a particular natural enemy cannot overwinter, an inoculative release each spring may allow the population to establish and adequately control a pest. Inundative releases involve the release of large numbers of a natural enemy such that their population completely overwhelms the pest.

Augmentation is used where populations of a natural enemy are not present or cannot respond quickly enough to the pest population. Therefore, augmentation usually does not provide permanent suppression of pests, as may occur with importation or conservation methods. An example of the inoculative release method is the use of the parasitoid wasp, *Encarsia formosa* Gahan, to suppress populations of the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood). The greenhouse whitefly is a ubiquitous pest of vegetable and floriculture crops that is notoriously difficult to manage, even with pesticides. Releases of relatively low densities (typically 0.25 to 2 per plant, depending on the crop) of *Encarsia* immediately after the first whiteflies have been detected on yellow sticky cards can effectively prevent populations from developing to damaging levels. However, releases should be made within the context of an integrated crop management program that takes into account the low tolerance of the parasitoids to pesticides. It is important to bear in mind that *Encarsia* can provide effective control of greenhouse whitefly, but not sweetpotato whitefly. Therefore, it is critical to identify which whitefly is present before releasing *Encarsia*. Another parasitoid, *Eretmocerus californicus* has shown promise against sweetpotato whitefly.

Because most augmentation involves mass-production and periodic colonization of natural enemies, this type of biological control has lent itself to commercial development. There are hundreds of biological control products available commercially for dozens of pest invertebrates (insects, spidermites, etc.), vertebrates (deer, rodents, etc.), weeds, and plant pathogens. A summary of these products and their target pests is presented in Table 13. The efficacy of these predators and parasites is dependent on many factors. Management of the target pest is more likely than 100% control. It is critical to familiarize yourself with proper usage of these predators and parasites otherwise you may not achieve satisfactory results and obtain inconsistent results. Selection of products and suppliers should be done with care, as with purchasing any product. Review publications for guidelines on how to purchase and utilize natural enemies.

Conservation: The most common form of biological control is conservation of natural enemies which already exist in a cropping situation. Conservation involves identifying the factor(s) which

TABLE 13. PREDATORS AND PARASITES OF VEGETABLE PESTS

Predators and Parasites	Approx. # North American Species	Pest(s) Controlled or Impacted
WASPS		
Aphelinid Wasps *	1,000	Aphids on some greenhouse and vegetable crops; mummies of parasitized aphids will be black.
Aphidiid Wasps *	114	Aphid parasites; mummies turn tan or golden.
Braconid Wasps *	1,000	Caterpillars on cole crops and potatoes, leafminers in greenhouse crops.
Chalcid Wasps *	1,500	Internal and external parasite of fly and moth larvae and pupae. A few species attack beetles.
Cotesia Wasps (Braconid Family) *	200	Parasites of caterpillars including armyworms, Alfalfa caterpillar, loopers, cabbageworms.
Encarsia formosa *	1	A commercially available Aphelinid wasp, whiteflies on greenhouse/some field crops.
Encyrtid Wasps	500	Aphids on some greenhouse crops, Cabbage looper, root maggot.
Eulophid Wasps	3,400	Colorado Potato Beetle, Mexican Bean beetle, Asparagus beetle, leafminers in field crops.
Ichneumonid Wasps *	3,100	Caterpillars, eggs, and beetle larvae in: cole crops, corn, Asparagus whiteflies on cole crops and tomato.
Mymarid Egg Wasps	1,300	Lygus bug, Tarnished Plant bug, carrot weevil. Egg parasite of beetles, flies, grasshoppers, leafhoppers and many true bugs (Stink bugs, lygeids). Adults are 1/25 inch in size.
Pteromalid Wasps	3,000	Parasites of beetles, flies, and other wasps, cabbage worm, diamondback moth.
Scelionid Egg Wasps	300	Parasite of true bug and moth eggs.
Tiphiid Wasps	225	Parasites of Japanese beetles and Tiger beetles.
Trichogramma Wasps *	650	Moth eggs on cole crops, peppers, sweet corn, and tomatoes. Because only eggs are parasitized, releases must be timed to coincide with egg laying (use pheromone trap to determine timing).
Thripobius semiluteus (Eulophidae Family)*	1	Controls thrips via parasitism.
Vespid Wasps (hornets, yellowjackets, etc.)	200	Caterpillars, flies, true bugs, beetles, and other wasps are fed to Vespid larvae.
FLIES		
Aphid Flies (Chamaemyiid Flies)	36	Feed on aphids, mealybugs, and soft scales.
Bombyliid Flies (Bee Flies)	250	Internal and external parasites of various caterpillars and wasp larvae, beetle larvae, some eggs.
Nemestrinid Flies (Tangle Veined Flies)	250	Internal parasites of locusts and beetle larvae and pupae.
Phorid Flies (Humpbacked Flies)	350	Internal parasites of ants, bees, caterpillars, moth pupae, and fly larvae.
Pipunculid Flies (Big-Headed Flies)	100	Internal parasites of leafhoppers and planthoppers.
Predatory Midges (Cecidomyiid Flies)*	10	Aphids and mites on some greenhouse crops.
Pyrgotidae (Pyrgotid Flies)	5	Internal parasites of June beetles and related Scarab beetles; nocturnal and rarely seen.
Syrphid Flies	1,000	Most larvae are predaceous upon aphids, whitefly pupae, and soft-bodied small insects.
Tachinid Flies	1,300	Internal parasite of beetle, butterfly, and moth larvae, earwigs, grasshoppers and true bugs. Tachinids lay eggs directly on host or on a leaf that is then eaten by the host insect. Some species parasitize Japanese beetles.
TRUE BUGS		
Assassin Bugs (Reduviidae)	160	Generalist predators against small and soft-bodied insects, eggs, and pupae.
Big-Eyed Bug, *Geocoris* spp.	25	Generalist predators feeding on a wide variety of insect eggs and small larvae. Both immature and adults are predaceous and feed on over 60 species of other insects.
Damsel Bugs (Nabidae)	34	Mites, aphids, caterpillars, leafhoppers, and other insects, especially soft-bodied insects.
Minute Pirate Bug, *Orius insidiosis* (aka Flower Bug)*	1	Thrips, spider mites, aphids, small caterpillars small insects in sweet corn, potato, and on some green-house crops.
Predatory Stink Bug (*Perillus, Podisus* spp.)	14	Look similar to plant feeding Stink bugs, but feed on caterpillar pests, small insects and insect eggs, and Colorado Potato beetle (larvae). Effective in solanaceous crops, beans, cole crops and asparagus.
Spined Soldier Bug, *Podisus maculiventris**	1	Generalist predator on many vegetables (i.e. potato, tomato, sweet corn, cole crops, beans, eggplant, cucurbits, asparagus, onions). Attacks larvae of European Corn borer, Diamondback moth, Corn Earworm, Beet Armyworm, Fall Armyworm, Colorado Potato beetle, Cabbage Looper, Imported Cabbageworm, and Mexican Bean beetle. A pheromone to attract Spined Soldier Bug is also available.
BEETLES		
Ground Beetles (Carabid Beetles)	2,200	Both larvae and adults predaceous, nocturnal. Feed on mites and snails, soil dwelling beetle and fly eggs and pupae, some caterpillars, and other soft bodied insects. Most beneficial in cole crops, root crops, and onions.
Lady Beetles (Coccenelidae)*	400	Aphids, mites, whitefly, small insects, and insect eggs in most vegetable crops (especially potatoes, tomatoes, sweet corn and cole crops. Release purchased lady beetles in evening, in vicinity of pest, and cover with a light sheet or cloth overnight for best predator retention.
Rove Beetles (Staphylinidae)	3,100	Distinguished by short outer wings and exposed abdomens, Rove beetles feed on a variety of eggs, pupae, larvae, and soft bodied insects (aphids, mites, whitefly).
Soft-Winged Flower Beetles (Melyridae)	450	Adults and larvae feed on aphids, leafhoppers, and other immature insects. Covered in fine hairs that give the insect a velvety appearance.
Soldier Beetles (Cantharids, aka Leather-Winged Beetles)	100	All larvae, and some adults, are predaceous. Other adults feed on nectar and pollen, so can be attracted by flower plantings. Predators of eggs and larvae of beetles, butterflies moths, aphids, others. Most effective in cole crops, cucurbits, and sweet corn.
Tiger Beetles (Cicindelid Beetles)	40	Adults and larvae prey on a wide variety of insects.

* Insects marked with an asterisk represents species that are available commercially for purchase.
For a list of Biological Control (Beneficial Insects) Suppliers, see http://wiki.bugwood.org/Commercially_available_biological_controls

TABLE 13. PREDATORS AND PARASITES OF VEGETABLE PESTS (cont'd)

Predators and Parasites	Approx. # North American Species	Pest(s) Controlled or Impacted
OTHER BENEFICIAL ORGANISMS		
Praying Mantis *		Flies, crickets, bees, moths. All life stages are predatory. Commercially available mantis are usually Tenodera aridifolia, a Chinese species.
Lacewings*	27	Aphids, thrips, small caterpillars, leafhoppers, mealybugs, psyllids, whiteflies, and insect eggs. Release purchased lacewings as soon as target pest is noticed in field to achieve good results.
Parasitic nematodes*		Cutworms, beetle larvae, root maggots.
Predatory mites (Phytoseiidae & 3 other families)*	6	Releases most beneficial in strawberries and greenhouse vegetables; avoid carbamates and organophosphates to encourage natural populations in field. Primarily effective against spider mites and thrips.

* Insects marked with an asterisk represents species that are available commercially for purchase.
For a list of Biological Control (Beneficial Insects) Suppliers, see http://wiki.bugwood.org/Commercially_available_biological_controls

TABLE 13 A. RELATIVE IMPACT OF INSECTICIDES & MITICIDES ON KEY NATURAL ENEMY GROUPS

IRAC Group	Common Name	Example Product	Predaceous Mites	Lepidopteran Parasitoids	Aphid Parasitoids	Coccinellids	Lacewings	Predatory Bugs
1A	carbaryl	Sevin	M	H	H	H	H	H
	methomyl	Lannate	H	H	H	H	H	H
	oxamyl	Vydate	H	H	H	M	H	H
1B	chlorpyrifos	Lorsban	H	H	H	H	H	H
	diazinon	-	M	H	H	H	H	M
	dimethoate	-	M	H	H	H	H	H
	malathion	-	M	H	H	H	H	H
3A	bifenthrin	Brigade	H	H	H	H	H	H
	cyfluthrin	Baythroid	H	H	H	H	H	H
	fenpropathrin	Danitol	H	H	H	H	H	H
	permethrin	Pounce	L	H	H	H	H	H
	ζ-cypermethrin	Mustang Max	H	M	M	H	H	H
	λ-cyhalothrin	Karate	H	H	H	H	H	H
4A	acetamiprid	Assail	M	H	H		M	H
	clothianidin	Belay	L					
	dinotefuran	Venom	M	M/H	M/H		M/H	
	imidacloprid	Admire	M	H	H	M	M/H	H
	thiamethoxam	Actara/Platinum	L	M	L	M	H	H
4C	sulfoxaflor	Closer		M	M	L	M	M
4D	flupyradifurone	Sivanto					M	M
5	spinosad	Entrust	M	L/M	L/M	M	M	M
	spinetoram	Radiant	M		M/H	L	H	H
6	abamectin	Agri-Mek	H	H	H	M	L	H
	emamectin benzoate	Proclaim	L	L	L	L	L	L
7C	pyriproxyfen	Knack	L	L	L	L	L	L
9B	pymetrozine	Fulfill	L	L	L	L	L	L
10	etoxazole	Zeal	M	M		L	M	M
11	Bt	various	L	L	L	L	L	L
15	novaluron	Rimon	M	L	M	H	H	H
16	buprofezin	Courier	L	L	L	M	L	L
17	cyromazine	Trigard	M	L	L			
18	methoxyfenozide	Intrepid	L	L	M	L	L	L
20B	acequinocyl	Kanemite	L	H	L	L	M	L
20D	bifenazate	Acramite	L	H	L	L	M	L
21A	fenpyroximate	Portal	H	H	H	M	M	L
	tolfenpyrad	Torac	M					
22A	indoxacarb	Avaunt	L	M	L	M	L	M
23	spiromesifen	Oberon	L					
	spirotetramat	Movento	L					
25	cyflumeton	Nealta	L	L	L	L	L	L
28	chlorantraniliprole	Coragen	L	L	L	H	H	L
	cyantraniliprole	Verimark/Exirel	L	L	L	H	H	L
29	flonicamid	Beleaf	L	L	L	L	L	L
UN	azadirachtin	NeeMix	L	M	L	L	L	L

TABLE 13 A. RELATIVE IMPACT OF INSECTICIDES & MITICIDES ON KEY NATURAL ENEMY GROUPS (cont'd)

IRAC Group	Common Name	Example Product	Predaceous Mites	Lepidopteran Parasitoids	Aphid Parasitoids	Coccinellids	Lacewings	Predatory Bugs
	sulfur	various	M					
?	insecticidal soap	various	M		M	L	L	
?	kaolin	Surround	M		L	M/H		
?	spray oils	various	M		M	L	L	

Key: L = Low impact, M = Medium impact, H = High impact, Blank space = no data currently available

Sources: Washington State University, University of California, North Carolina State University, *Pest Management Science,* Intech (*http://dx.doi.org/10.5772/47244*), *Journal of Entomology and Zoology Studies, Journal of Economic Entomology,* and *Biocontrol Science and Technology*

may limit the effectiveness of a particular natural enemy and modifying these factor(s) to increase the effectiveness of natural enemies. In general, this involves either reducing factors which interfere with natural enemies or providing resources that natural enemies need in their environment. The most common factor that interferes with natural enemy effectiveness is the application of pesticides. Some cultural practices such as tillage or burning of crop debris can also kill natural enemies or make the crop habitat unsuitable. In some crops, accumulation of dust deposits on leaves from repeated tillage or a location near roadways may kill small predators and parasites and cause increases in certain insect and mite pests. In some cases, the chemical and physical defenses that plants use to protect themselves from pests may reduce the effectiveness of biological control.

An example of how conservation can work involves the diamondback moth, *Plutella xylostella* (L.). This insect has developed into the most important pest of crucifers in recent years due to the pest's development of resistance to most pesticides. Two parasitoids, the Ichneumonid wasp *Diadegma insulare* (Cresson) and the braconid wasp *Cotesia plutellae* (Kurdjunov), can help reduce diamondback moth populations if excessive pesticide applications are avoided, especially with reductions in the use of pyrethroids. BT products can work well to suit this purpose. Therefore, by simply being selective in the type of pesticide used, and by spraying only when threshold levels are reached, free control can be provided by natural enemies already present in the field.

Incorporating Biological Control Into A Pest Management Program: Biological control can be an effective, environmentally sound method of managing pests. However, when trying to make the best use of natural enemies in your crop, it may be helpful to consider the following suggestions.

First, make sure you have your pest(s) accurately identified. Extension can help with this. Consulting your local Extension office is a good practice regardless of which pest control method you use.

Second, determine if natural enemy releases are appropriate for your specific situation. Sometimes knowledge of crop and cultural practices that encourage naturally-occurring biological control agents can allow you to maximize the control they provide. By conserving these natural enemies, pesticide use (and therefore expense) can be minimized.

Usually, released natural enemies work best as a preventative pest management method. That is, if they are introduced into your crop at the *beginning* of a pest infestation, they can prevent that population from developing to damaging levels. If you wait until pests have become a problem *before* releasing natural enemies, the use of natural enemies usually will not work. Therefore, pest problems must be anticipated and planned for by carefully monitoring pest population development. Effective trapping, monitoring, and field scouting should be used to determine when pests appear, and to determine the timing of natural enemy releases.

If you decide to use commercially available biological control agents, you should choose your product and supplier carefully. Once you have received your natural enemies, handle them with care, following all instructions provided by your supplier. The number or rate of natural enemies to release can be determined through consultation with a reliable supplier, as can the timing of application. Because natural enemies are living organisms, adverse conditions (e.g. stormy weather, pesticide residues) can kill them or reduce their effectiveness. Because the actions of natural enemies are not as obvious as those of pesticides, it may be important to work with your supplier to develop a procedure to evaluate the effectiveness of your releases.

Further details of the above suggestions are provided in Table 13. Remember, just because an organism is sold as a "natural" or "biological" control does not mean it will work as you expect. For example, praying mantids are general "ambush" predators that will eat anything small enough (usually mobile insects) that pass in front of them. They do not specifically attack pests that growers are usually interested in removing. Another example is ladybeetle adults that have been "pre-conditioned." These ladybeetles will just as readily leave the area that you have treated as ladybeetles that have been collected and not pre-conditioned.

This does not mean that biological control will not work for your situation. There are a number of products and approaches that can provide very satisfactory results.

Finally, if insecticides are necessary to control a pest, choose a product that is least harmful to the beneficial(s) you are trying to preserve. Listed in Table 13A is the relative safety of different pesticides to key groups of beneficial organisms in most important in vegetable systems.

For the most current information about suppliers of organisms and related products, the purchase of natural enemies, and how to effectively use them, consult with Extension.

DIAGNOSING VEGETABLE CROP PROBLEMS

When visiting a vegetable field, follow the steps outlined below to help solve any potential problems. All vegetable problems, such as poor growth, leaf blemishes, wilts, rots, and other problems should be promptly diagnosed. This is necessary for the grower to implement prompt and effective corrective measures or to help reduce the probability of its reoccurrence in following crops or its spread to susceptible neighboring crops.

1. Describe the problem.
2. Determine whether there is a pattern of symptomatic plants in the field.
   a. Does the pattern correlate with a certain area in the field, such as a low spot, poor-drainage area, or sheltered area?
   b. Does the pattern correlate with concurrent field operations, such as certain rows, time of planting, method of fertilization, or rate of fertilization?
3. Try to trace the history of the problem.
   a. On what date were the symptoms first noticed?
   b. Which fertilizer and liming practices were used?
   c. Which pest-management practices were used to manage diseases, undesirable insects, and weeds — which chemicals (if any), were applied, at what application rates, and what was the previous use of equipment that was used for application?
   d. What were the temperatures, soil moisture conditions, and level of sunlight?
   e. What was the source of seed or planting stock?
   f. Which crops were grown in the same area during the past 3 or 4 years?
4. Examine affected plants to determine whether the problem is related to insects, diseases, or cultural practices.
   a. Do the symptoms point to **insect** problems? Insect problems are usually restricted to the crop. (A hand lens is usually essential to determine this.)
      (1) Look for the presence of insects, webbing, and frass on foliage, stems, and roots.
      (2) Look for feeding signs such as chewing, sucking, or boring injuries.
   b. Do the symptoms suggest **disease** problems? These symptoms are usually not uniform; rather, they are specific for certain crops.
      (1) Look for necrotic (dead) areas on the roots, stems, leaves, flowers, and fruit.
      (2) Look for discoloration of the vascular tissue (plant veins).
      (3) Look for fungal growth.
      (4) Look for virus patterns; often these are similar to injury from 2,4-D or other hormones and nutritional problems.
      (5) Examine roots for twisting or galling.
   c. Do the symptoms point to **cultural** problems? Look for the following:
      (1) Nutrient deficiencies. (A soil test from good areas and poor areas should be done as well as analysis of nutrient content of leaf tissue from the same areas.)
         • Nitrogen—light green or yellow foliage. Nitrogen deficiencies are more acute on lower leaves.
         • Phosphorus—purple coloration of leaves; plants are stunted.
         • Potassium— yellow or brown leaf margins and leaf curling.
         • Magnesium—interveinal chlorosis (yellowing between veins) of mid level or lower leaves.
         • Boron—development of lateral growth; hollow, brownish stems; cracked petioles.
         • Iron—light green or yellow foliage occurs first and is more acute on young leaves.
         • Molybdenum—"whiptail" leaf symptoms on cauliflower and other crops in the cabbage family.
      (2) Chemical toxicities.
         • Toxicity of minor elements—boron, zinc, manganese.
         • Soluble salt injury—wilting of the plant when wet; death, usually from excessive fertilizer application or accumulation of salts from irrigation water.
      (3) Soil problems. (Take soil tests of good and poor areas.)
         • Poor drainage.
         • Poor soil structure, compaction, etc.
         • Hard pans or plow pans.
      (4) Pesticide injury. (Usually uniform in the area or shows definite patterns, and more than one plant species, such as weeds, are often symptomatic.)
         • Insecticide burning or stunting.
         • Weed-killer (herbicide) burning or abnormal growth.
      (5) Climatic damage.
         • High-temperature injury.
         • Low-temperature (chilling) injury.
         • Lack of water.
         • Excessive moisture (lack of soil oxygen).
         • Frost or freeze damage.
      (6) Physiological damage.
         • Air-pollution injury.
         • Genetic mutations (this is rare).

In summary, when trying to solve a vegetable crop problem, take notes of problem areas, look for a pattern to the symptoms, trace the history of the problem, and examine the plants and soil closely. These notes can be used to avoid the problem in the future or to assist others in helping solve their problem. Publications and bulletins designed to help the grower identify specific vegetable problems are available from Extension.

AIR POLLUTION INJURY

The extent of plant damage by particular pollutants in any given year depends on meteorological factors leading to air stagnation, the presence of a pollution source, and the susceptibility of the plants.

Some pollutants that affect vegetable crops are sulfur dioxide (SO_2), ozone (O_3), peroxyacetyl nitrate (PAN), chlorine (Cl), and ammonia (NH_3).

Sulfur dioxide. SO_2 causes acute and chronic plant injury. Acute injury is characterized by clearly marked dead tissue between the veins or on leaf margins. The dead tissue may be bleached, ivory, tan, orange, red, reddish brown, or brown, depending on plant species, time of year, and weather conditions. Chronic injury is marked by brownish red, turgid, or bleached white areas on the leaf blade. Young leaves rarely display damage, whereas fully expanded leaves are very sensitive.

Some crops sensitive to sulfur dioxide are: squash, pumpkin, mustard, spinach, lettuce, endive, Swiss chard, broccoli, bean, carrot, and tomato.

Ozone. A common symptom of O_3 injury is small stipplelike or flecklike lesions visible only on the upper leaf surface. These very small, irregularly shaped spots may be dark brown to black (stipplelike) or light tan to white (flecklike). Very young leaves are normally resistant to ozone. Recently matured leaves are most susceptible. Leaves become more susceptible as they mature, and the lesions spread over a greater portion of the leaf with successive ozone exposures. Injury is usually more pronounced at the leaf tip and along the margins. With severe damage, symptoms may extend to the lower leaf surface.

Pest feeding (red spider mite and certain leafhoppers) produces flecks on the upper surface of leaves much like ozone injury. Flecks from insect feeding, however, are usually spread uniformly over the leaf, whereas ozone flecks are concentrated in specific areas. Some older watermelon varieties and red varieties of potatoes and beans are particularly sensitive to ozone.

Peroxyacetyl nitrate. PAN affects the under surfaces of newly matured leaves, and it causes bronzing, glazing, or silvering on the lower surface of sensitive leaf areas.

The leaf apex of broadleaved plants becomes sensitive to PAN about 5 days after leaf emergence. Since PAN toxicity is specific for tissue of a particular stage of development, only about four leaves on a shoot are sensitive at any one time. With PAN only successive exposures will cause the entire leaf to develop injury. Injury may consist of bronzing or glazing with little or no tissue collapse on the upper leaf surface. Pale green to white stipplelike areas may appear on upper and lower leaf surfaces. Complete tissue collapse in a diffuse band across the leaf is helpful in identifying PAN injury.

Glazing of lower leaf surfaces may be produced by the feeding of thrips or other insects or by insecticides and herbicides, but differences should be detectable by careful examination.

Sensitive crops are: Swiss chard, lettuce, beet, escarole, mustard, dill, pepper, potato, spinach, tomato, and cantaloupe.

Chlorine. Injury from chlorine is usually of an acute type, and it is similar in pattern to sulfur dioxide injury. Foliar necrosis and bleaching are common. Necrosis is marginal in some species, but scattered in others either between or along veins. Lettuce plants exhibit necrotic injury on the margins of outer leaves, which often extends into solid areas toward the center and base of the leaf. Inner leaves remain unmarked. Crops sensitive to chlorine are: Chinese cabbage, lettuce, Swiss chard, beet, escarole, mustard, dill, pepper, potato, spinach, tomato, cantaloupe, corn, onion, and radish.

Ammonia. Field injury from NH_3 has been primarily due to accidental spillage or use of ammoniated fertilizers under plastic mulch on light sandy soils. Slight amounts of the gas produce color changes in the pigments of vegetable skin. The dry outer scales of red onions may become greenish or black, whereas scales of yellow or brown onions may turn dark brown. In addition, chicken litter may be high in ammonia (NH_3) and ammonium (NH_4), and if sufficient time is not allowed between litter application and planting, substantial damage from ammonia toxicity may occur to seeds or seedlings.

WHAT ARE GOOD AGRICULTURAL PRACTICES (GAPS)?

Good agricultural practices (GAPs) are basic environmental and operational conditions necessary for the production of safe, wholesome fruits and vegetables. The purpose of GAPs is to give logical guidance in implementing best management practices that will help reduce the risks of microbial contamination of fruits and vegetables. Examples of GAPs include worker hygiene and health, manure use, and water quality throughout the production and harvesting process. While the United States has one of the safest food supplies in the world, media attention the past few years on food borne illness outbreaks underscores the importance of good agricultural practices.

Growers, packers, and shippers are urged to take a proactive role in minimizing food safety hazards potentially associated with fresh produce. Being aware of, and addressing, the common risk factors outlined in GAPs will result in a more effective, cohesive response to emerging concerns about the microbial safety of fresh fruits and vegetables. Furthermore, operators should encourage the adoption of safe practices by their partners along the farm-to-table food chain. This includes distributors, exporters, importers, retailers, producer transporters, food service operators, and consumers.

BASIC PRINCIPLES OF GOOD AGRICULTURAL PRACTICES (GAPS)

By identifying basic principles of microbial food safety within the realm of growing, harvesting, packing, and transporting fresh produce, growers will be better prepared to recognize and address the principal elements known to give rise to microbial food safety concerns.

1. *Prevention* of microbial contamination of fresh produce is favored over reliance on *corrective actions* once contamination has occurred.
2. To minimize microbial food safety hazards in fresh produce, growers, packers, and shippers should use good agricultural and management practices *in those areas over which they have control*.

TABLE 14. RECOMMENDED STORAGE CONDITIONS AND COOLING METHODS FOR MAXIMUM POSTHARVEST LIFE OF COMMERCIALLY GROWN VEGETABLES

Crop	Temperature °F	Temperature °C	% Relative Humidity	Approximate Storage Life	Cooling Method[1]
Asparagus	32-35	0-2	95-100	2-3 weeks	HY
Bean, green or snap	40-45	4-7	95	7-10 days	HY, FA
Bean, lima (butterbean)	37-41	3-5	95	5-7 days	HY
Bean, lima, shelled	32	0	95-100	2-3 days	ROOM, FA
Beet, topped	32	0	98-100	4-6 months	ROOM
Broccoli	32	0	95-100	10-14 days	HY,ICE
Cabbage, early	32	0	98-100	3-6 weeks	ROOM
Cabbage, Chinese	32	0	95-100	2-3 months	HY,VAC
Carrot, bunched	32	0	95-100	2 weeks	HY
Carrot, mature, topped	32	0	98-100	7-9 months	HY
Cauliflower	32	0	95-98	3-4 weeks	HY,VA
Collard	32	0	95-100	10-14 days	HY,ICE,VAC
Cucumber	50-55	10-13	95	10-14 days	HY
Eggplant	46-54	8-12	90-95	1 week	FA
Endive and escarole	32	0	95-100	2-3 weeks	HY,ICE,VAC
Garlic	32	0	65-70	6-7 months	ROOM
Greens, leafy	32	0	95-100	10-14 days	HY,ICE,VAC
Kale	32	0	95-100	2-3 weeks	HY,ICE,VAC
Kohlrabi	32	0	98-100	2-3 months	ROOM
Leek	32	0	95-100	2-3 months	HY,ICE,VAC
Lettuce	32	0	98-100	2-3 weeks	HY, VAC, ICE
Melon					
Cantaloupe, 3/4-slip	36-41	2-5	95	15 days	FA,HY
Mixed melons	45-50	6-10	90-95	2-3 weeks	FA,HY
Watermelon	50-60	10-15	90	2-3 weeks	ROOM, FA
Okra	45-50	7-10	90-95	7-10 days	FA
Onion, green	32	0	95-100	3-4 weeks	HY,ICE
Onion, dry[2]	32	0	65-70	1-8 months	ROOM
Parsley	32	0	95-100	2-2.5 months	HY,ICE
Parsnip	32	0	98-100	4-6 months	ROOM
Pea, green or English	32	0	95-98	1-2 weeks	HY,ICE
Southernpea	40-41	4-5	95	6-8 days	FA,HY
Pepper, sweet (bell)	45-55	7-13	90-95	2-3 weeks	FA, ROOM
Potato (Irish)[2]	40	4	90-95	4-5 months	HY,ROOM,FA
Pumpkin	50-55	10-13	50-70	2-3 months	ROOM
Radish, spring	32	0	95-100	3-4 weeks	HY, FA
Radish, oriental	32	0	95-100	2-4 months	ROOM
Rutabaga	32	0	98-100	4-6 months	ROOM
Spinach	32	0	95-100	10-14 days	ICE,HY,VAC
Squash, summer	41-50	5-10	95	1-2 weeks	FA,HY
Sweet corn	32	0	95-98	5-8 days	HY,ICE,VAC
Squash, winter	50	10	50-70	Depending on type	ROOM
Sweetpotato[2]	55-60	13-16	85-90	4-7 months	ROOM
Tomato, mature-green	55-70	13-21	90-95	1-3 weeks	FA,ROOM
Tomato, firm-red	46-50	8-10	90-95	4-7 days	FA,ROOM
Turnip	32	0	95	4-5 months	FA,ROOM

[1] FA = Forced-air cooling; HY = Hydrocooling; ICE = Package ice, slush ice; ROOM = Room cooling; VAC = Vacuum cooling

[2] Curing required prior to long term storage. 'Curing' of dry onions actually involves drying the outer bulb scales, reducing the fresh weight by 5-6%.

3. Fresh produce can become microbiologically contaminated at any point along the farm-to-table food chain. The major source of microbial contamination with fresh produce is associated with *human or animal feces*.
4. Whenever *water* comes in contact with produce, its source and quality dictates the potential for contamination. Minimize the potential of microbial contamination from water used with fresh fruits and vegetables.
5. Practices using *animal manure or municipal biosolid wastes* should be managed carefully to minimize the potential for microbial contamination of fresh produce.
6. *Worker hygiene and sanitation* practices during production, harvesting, sorting, packing, and transport play a critical role in minimizing the potential for microbial contamination of fresh produce.
7. Follow *all applicable local, state, and federal laws and regulations*, or corresponding or similar laws, regulations or standards for operators outside the U.S., for agricultural practices.
8. Accountability at all levels of the agricultural environment (farm, packing facility, distribution center, and transport operation) is important to a successful food safety program.
9. There must be *qualified personnel and effective monitoring* to ensure that all elements of the program function correctly and to help track produce back through the distribution channels to the producer.

More information and resources on Good Agricultural Practices can be found at the following websites or by contacting your local Extension office.

SOURCES
NC Produce Safety
http://ncfreshproducesafety.ces.ncsu.edu/

Produce Safety Alliance
http://producesafetyalliance.cornell.edu/

FDA Produce Safety Standards
http://www.fda.gov/Food/GuidanceRegulation/FSMA/ucm304045.htm

LSU AG Center Food Safety
http://www.lsuagcenter.com/en/food_health/food/safety/

FOOD SAFETY MODERNIZATION ACT'S (FSMA) PRODUCE SAFETY RULE

The Food Safety Modernization Act (FSMA) is a compilation of laws that required the Food and Drug Administration (FDA) to set comprehensive, prevention-based controls across the food supply. FSMA was passed by Congress on December 21, 2010 and signed into law on January 4, 2011. FSMA gave FDA a new public health mandate to establish standards for adoption of modern food safety prevention practices by those who grow, process, transport, and store food. It also gave FDA new mandates, authorities and oversight tools aimed at providing solid assurances that those practices are being carried out by the food industry on a consistent, on-going basis.

As part of FSMA, FDA developed "Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption". These standards are commonly referred to as the Produce Safety (PS) Rule. The PS rule sets forth procedures, processes and practices that minimize the risks for consumers of eating raw fruit and vegetables that could be contaminated with bacteria, viruses or parasitic organisms that cause food borne illness.

The PS rule was effective January 26, 2016 and has different compliance dates for produce and sprout farms. The earliest compliance date for produce farms is January 26, 2018. Inspections at farms are set to start in 2019. One important aspect of the PS rule is that it establishes training requirements for covered farms. The rule requires that at least one supervisor or responsible party for covered farms complete food safety training at least equivalent to that received under standardized curriculum recognized as adequate by the FDA. The Produce Safety Alliance Grower training course is currently the only curriculum that has been approved to meet this requirement. Produce Safety Alliance Grower trainings provide an overview of good agricultural practices and the standards set in the rule that farms must follow. For a list of Produce Safety Alliance trainings visit:

PRODUCE SAFETY ALLIANCE TRAININGS

https://producesafetyalliance.cornell.edu/training/grower-training-courses/upcoming-grower-trainings

POSTHARVEST HANDLING

Importance of Temperature Management

Once harvested, a vegetable continues life processes independent of the plant, and as a result, must utilize its own stored energy reserves. Within hours of harvest, crops held at ambient temperatures can suffer irreversible losses in quality, reducing postharvest life. Additionally, many vegetables, such as greens and lettuce, are cut at harvest, and this wound further increases stress on the tissue. The relative perishability of a crop is reflected in its respiration rate. Respiration is the process of life by which O_2 is combined with stored carbohydrates and other components to produce heat, chemical energy, water, CO_2, and other products. The respiration rate varies by commodity; those commodities with high respiration rates utilize the reserves faster and are more perishable than those with lower respiration rates. Therefore, vegetables with higher respiration rates, such as broccoli and sweet corn, must be rapidly cooled to the optimal storage temperature to slow metabolism and extend postharvest life during subsequent shipping and handling operations.

Since the introduction of hydrocooling for celery in the 1920s, rapid cooling (precooling) has allowed produce to be shipped to distant markets while maintaining high quality. Commercial cooling is defined as the rapid removal of field heat to temperatures approaching optimal storage temperature and it is the first line of defense in retarding the biological processes that reduce vegetable quality. Cooling, in conjunction with refrigeration during subsequent handling operations, provides a "cold chain" from packinghouse to supermarket to maximize postharvest life and control diseases and pests. (The term "postharvest life" is purposely used in this text, since "shelf life" has the connotation that the commodity "sits on the shelf", implying that the product requires no subsequent refrigeration.) Timeliness during handling is also essential in maintaining produce quality: timely and careful harvest and transport to the packinghouse, rapid packing and cooling, and rapid transport to the market or buyer. Everyone involved at each

of the many steps during product handling (e.g., shippers, truckers, receivers) must take care to ensure that the refrigerated cold chain is not broken.

Many shippers are well equipped to rapidly cool their crops, and a growing number are incorporating cooling or improving their existing facilities. **Simple placement of packed vegetables in a refrigerated cooler is not sufficient to maintain quality for product destined for distant markets.** Neither should non-cooled vegetables be loaded directly into refrigerated trailers. In both of these situations, the product cools very slowly, at best. Refrigerated trailers are designed to maintain product temperature during transport, and they **do not** have the refrigeration capacity to quickly remove field heat. Therefore, only produce that has been properly cooled should be loaded, and only into trailers that have been cooled prior to loading.

STORAGE REQUIREMENTS

Horticultural crops may be grouped and stored into two broad categories based on sensitivity to storage temperatures. The degree of chilling sensitivity, and therefore the lowest safe storage temperature, is crop-specific. Those crops that are chilling sensitive should be held at temperatures generally above 50°F (10°C). Storage below this threshold will give rise to a physiological disorder known as **chilling injury**. Chilling injury symptoms are characterized by development of sunken lesions on the skin, increased susceptibility to decay, increased shriveling, and incomplete ripening (poor flavor, texture, aroma, and color). Vegetables most susceptible to chilling injury include cucumber, eggplant, melons, okra, peppers, potatoes, summer squash, sweetpotatoes, and tomatoes.The extent of chilling symptoms is also dependent on the length of exposure to low temperatures. Short exposure times will result in less injury than longer exposure to chilling temperatures. Those crops not as sensitive to chilling injury may be stored at temperatures as low as 32°F (0°C).

In addition to maintaining storage rooms at proper storage temperatures, the relative humidity should also be controlled to reduce water loss from the crop. Optimal storage recommendations and precooling methods are included for a wide range of vegetable commodities in Table 14.

OPTIMIZING COMMERCIAL COOLING

COOLING CONCEPTS

Cooling is a term that is often used quite loosely. In order to be effective and significantly benefit the shipping life of the product, an appropriate definition of commercial cooling for perishable crops is: *the rapid removal of at least 7/8 of the field heat from the crop by a compatible cooling method*. The time required to remove 7/8 of the field heat is known as the *7/8 Cooling Time*. Removal of 7/8 of the field heat during cooling is strongly recommended to provide adequate shipping life for shipment to distant markets; also, 7/8 of the heat can be removed in a fairly short amount of time. Removal of the remaining 1/8 of the field heat will occur during subsequent refrigerated storage and handling with little detriment to the product.

The rate of heat transfer, or the cooling rate, is critical for efficient removal of field heat in order to achieve cooling. As a form of energy, heat always seeks equilibrium. In the case of cooling, the sensible heat (or field heat) from the product is transferred to the cooling medium. The efficiency of cooling is dependent on time, temperature, and contact. In order to achieve maximum cooling, the product must remain in the precooler for sufficient time to remove heat. The cooling medium (air, water, crushed ice) must be maintained at constant temperature throughout the cooling period. The cooling medium also must have continuous, intimate contact with the surfaces of the individual vegetables. For reasonable cooling efficiency, the cooling medium temperature should be at least at the recommended storage temperature for the commodity found in Table 14. Inappropriately designed containers with insufficient vent or drain openings or incorrectly stacked pallets can markedly restrict the flow of the cooling medium, increasing cooling time.

COOLING METHODS

The cooling rate is not only dependent upon time, temperature, and contact with the commodity; it is also dependent upon the cooling method being employed. The various cooling media used to cool produce have different capacities to remove heat.

ROOM COOLING

The simplest, but slowest, cooling method is room cooling, in which the bulk or containerized commodity is placed in a refrigerated room for several days. Air is circulated by the existing fans past the evaporator coil to the room. Vented containers and proper stacking are critical to minimize obstructions to air flow and ensure maximum heat removal. Room cooling is not considered precooling and is satisfactory only for commodities with low respiration rates, such as mature potatoes, dried onions, and cured sweetpotatoes. Even these crops may require precooling, when harvested under high ambient temperatures.

FORCED-AIR COOLING

The cooling efficiency of refrigerated rooms can be greatly improved by increasing the airflow through the product. This principle led to the development of forced-air, or pressure cooling, in which refrigerated room air is drawn at a high flow rate through specially stacked containers or bins by means of a high capacity fan. This method can cool as much as four times faster than room cooling. Forced-Air cooling is an efficient method for precooling. In many cases, cold storage rooms can be retrofitted for forced-air cooling, which requires less capital investment than other cooling methods. However, in order to achieve such rapid heat removal, the refrigeration capacity of the room may need to be increased to be able to maintain the desired air temperature during cooling. Portable systems can be taken to the field.

With either room cooling or forced-air cooling, precautions must be taken to minimize water loss from the product. The refrigeration system actually dehumidifies the cold-room air as water vapor in the air condenses on the evaporator coil. This condensation lowers the relative humidity in the room. As a result, the product loses moisture to the air. To minimize water loss during cooling and storage, the ambient relative humidity should be maintained at the recommended level for the particular crop (commercial humidification systems are available) and the product should be promptly removed from the forced-air precooler upon achieving *7/8 Cooling*. Forced-air cooling is recommended for most of the fruit-type

vegetables and is especially appropriate for vegetables such as peppers and tomatoes.

HYDROCOOLING

Hydrocooling removes heat at a faster rate than forced-air cooling. The heat capacity of refrigerated water is greater than that for air, which means that a given volume of water can remove more heat than the same volume of air at the same temperature. Hydrocooling is beneficial in that it does not remove water from the commodity. It is most efficient (and, therefore, most rapid) when individual vegetables are cooled by immersion in flumes or by overhead drench, since the water completely covers the product surfaces. Cooling becomes less efficient when the commodity is hydrocooled in closed containers, and even less efficient when containers are palletized and hydrocooled. It is important to continuously monitor the hydrocooler water and product temperatures and adjust the amount of time the product is in the hydrocooler accordingly in order to achieve thorough cooling.

Sanitation of the hydrocooling water is critical, since it is recirculated. Decay organisms present on the vegetables can accumulate in the water, inoculating subsequent product being hydrocooled. Cooling water should be changed frequently. Commodities that are hydrocooled must be sufficiently resistant to withstand the force of the water drench. The container must also have sufficient strength so as to resist the application of water. Crops recommended for hydrocooling include sweet corn, snap beans, cucumbers, and summer squash.

CONTACT ICING

Contact icing has been used for both cooling and temperature maintenance during shipping. Heat from the product is absorbed by the ice, causing it to melt. As long as the contact between the ice and produce is maintained, cooling is fairly rapid and the melted ice serves to maintain a very high humidity level in the package, which keeps the produce fresh and crisp. Non-uniform distribution of ice reduces the cooling efficiency. There are two types of contact icing: *top icing and package icing*.

Top icing involves placement of crushed ice over the top layer of product in a container prior to closure. Although relatively inexpensive, the cooling rate can be fairly slow since the ice only directly contacts the product on the top layer. For this reason, it is recommended that top icing be applied after precooling to crops with lower respiration rates such as leafy vegetables and celery but not for fruit of warm-season crops. Prior to shipping, ice is blown on top of containers loaded in truck trailers to aid in cooling and maintenance of higher relative humidity. However, care should be taken to avoid blockage of vent spaces in the load; this restricts airflow, which results in warming of product in the center of the load during shipment. Ice should also be "tempered" with water to bring the temperature to 32°F (0°C) to avoid freezing of the product.

Package Icing. Crushed ice distributed within the container is known as package icing. Cooling is faster and more uniform than for top icing, but it can be more labor intensive to apply.

A modified version of package icing utilizes a slurry of refrigerated water and finely chopped ice drenched over either bulk or containerized produce or injected into side hand holds. This "slush ice" method has been widely adopted for commodities tolerant to direct contact with water and requiring storage at 32°F (0°C). The water acts as a carrier for the ice so that the resulting slush, or slurry, can be pumped into a packed container. The rapidly flowing slush causes the product in the container to float momentarily until the water drains out the bottom. As the product settles in the container, the ice encases the individual vegetables by filling air voids, thus providing good contact for heat removal. Slush icing is somewhat slower than forced-air cooling, but it does reduce pulp temperatures to 32°F (0°C) within a reasonable amount of time and maintains an environment of high relative humidity. Container selection is critical. The container must be oversized to accommodate sufficient ice to provide cooling. Corrugated fiberboard cartons must be resistant to contact with water (usually impregnated with paraffin wax) and must be of sufficient strength so as not to deform. Shipping operations must also tolerate water dripping from the melting ice during handling and storage. Package icing is successfully used for leafy crops, sweet corn, green onions, and cantaloupes.

VACUUM COOLING

Vacuum cooling is a very rapid method of cooling, and is most efficient for commodities with a high surface-to-volume ratio such as leafy crops. This method is based on the principle that, as the atmospheric pressure is reduced, the boiling point of water decreases. Containerized or bulk product is thoroughly wetted, placed in a vacuum chamber (tube) and sealed. The pressure in the chamber is reduced until the water on the product surface evaporates at the desired precooling temperature. As water on the product surface evaporates, it removes field heat; the resultant vapor is condensed on evaporator coils within the vacuum tube to increase cooling efficiency. Any water that evaporates from the vegetable tissue is removed uniformly throughout the product. Therefore, it does not tend to result in visible wilting in most cases.

Precautions must be taken so as not to cool the products below their chilling temperature threshold. Vacuum coolers are costly to purchase and operate and are normally used only in high volume operations or are shared among several growers. Commodities that can be cooled readily by vacuum cooling include leafy crops, such as spinach, lettuce, and collards.

SUMMARY

When selecting an appropriate cooling method, several factors must be considered, including: the maximum volume of product requiring precooling on a given day, the compatibility of the method with the commodities to be cooled, subsequent storage and shipping conditions, and fixed/variable costs of the system.

Specific Crop Recommendations

For further information about Insect, Disease and Weed Control, see the appropriate control section after these specific crop recommendations.

ASPARAGUS (*Asparagus officinalis*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
ASPARAGUS									
Grande						N			
Jersey Giant [2]	A	G	K	L	M	N	S	T	V
Jersey King [2]						N			V
Jersey Knight [2]	A	G	K	L	M		S	T	V
Jersey Supreme [2]	A	G	K	L		N	S	T	V
Purple Passion	A		K	L	M	N		T	V
Millennium [2]									V
UC157 F_1	A	G	K	L					

[1] Abbreviations for state where recommended. [2] Male hybrid.

Soil Preparation. Be sure to soil test in order to determine liming and fertilizer requirements. The ideal pH for asparagus is between 6.7 and 7.0. Asparagus does not tolerate acidic soils and will not grow well at or below a pH of 6.0. Fungal diseases that contribute to asparagus decline (Fusarium Crown and Root rot) survive better at lower pH. Liming the soil 7.0 – 7.5 will reduce the survivability of Fusarium. Apply 100 lbs/acre of nitrogen. If no soil test is performed, supply sufficient phosphorus and potassium so that the soil contains 250 lbs/acre of available phosphorus and 300 lbs/acre of available potassium. Phosphorus does not move readily in the soil and cannot be incorporated into the soil after the asparagus is planted, so it must be incorporated prior to planting.

Asparagus grows and yields best in a deep, well-drained sandy loam soil, but will tolerate heavier soils as long as the soil has good internal drainage and the water table does not come within four feet of the soil surface as this would interfere with the extensive and deep root system.

Broadcast the fertilizer and plow it under when preparing the land for the planting furrows. Then, each year after harvest is complete, broadcast 100 lbs/acre nitrogen and other nutrients (if needed). Lime can also be added at this time. For the first four years, soil test yearly to determine if fertility and pH adjustments are necessary. Fertilizing in the spring before spears emerge will not benefit the developing crop since the buds on the crown were formed utilizing nutrients from the previous year. After four years, soil test every two years.

Planting. An optimal soil temperature of 50ºF is critical for rapid growth by crowns. See "Asparagus Planting Dates" table for suggested dates. Avoid planting crowns into cold soils. Prolonged exposure to cool, wet soils will make crowns more susceptible to Fusarium Crown and Root Rot. **If crowns are received before the field is ready to plant, crowns must be stored between 33 - 38ºF. Otherwise, the buds on the crowns will sprout, causing the fleshy crown roots to shrivel and die.**

Asparagus crowns and transplants are placed into furrows. Make furrows 6" deep. On a heavy soil, plant crowns no deeper than 5" and on a light textured soil, no more than 6". Apply fertilizer in the bottom of the furrow before planting crowns. Place crowns in the bottom of the furrow and cover with 1 to 2" of soil. The fertilizer will not burn the crowns. Although crown orientation is not important, crowns placed with their buds oriented upward will emerge faster. Research shows that pre-plant applications of phosphorus below the crown are an important factor in long-term asparagus production. Omitting the phosphorus placed in the bottom of the furrow will reduce yields in subsequent years as compared to not applying the additional phosphorus.

NOTE: Asparagus crowns are received in bulk or in bundles of 25 crowns per bundle. After receiving, separate the crowns by size into small, medium, or large. When ready to plant, plant all the smalls together in the same row, all the mediums together, and all the large crowns together. Do not plant a small crown next to a medium or large sized crown. This will cause the larger crown to shade the smaller one, which will then never attain its full growth potential.

Spacing. Crowns can be spaced 12" to 18" within the row. Research shows that there is no advantage of planting 9" between crowns in the row. Although a larger yield is obtained earlier with 9" spacing, after 4 or 5 years, the yield will be the same as with 18" in row spacing. Also, the closer the crowns are spaced in the row, the more crowns needed, increasing cost (for example, 18" in row x 5 feet between row = 5,808 crowns per acre; 12" crowns in row x 5 feet between row = 8,712 crowns per acre).

Asparagus crowns should not be planted in a solid block; rather, plant the field with drive rows spaced between a block of five rows. In order to obtain optimal spray coverage, an air-blast sprayer is needed to evenly apply insecticides and fungicides into the dense fern canopy from both sides of the five-row block. Boom sprayers usually cannot be set high enough to prevent the knocking over of ferns causing damage.

The furrows can be filled-in completely to soil level after planting without damaging the crowns. Do not drive on or compact the soil over the newly planted furrows, however; or emergence of the spears will be severely delayed or reduced. With good soil moisture, the new spears will break through the soil in 1-2 weeks.

ASPARAGUS PLANTING DATES

	Planting Dates		Planting Dates
AL North	2/15–4/15	NC East	2/15–3/31
AL South	1/15–3/15	NC West	4/1–5/31
GA North	2/15–4/15	SC East	2/1–3/15
GA South	3/15–4/30	SC West	3/1–4/15
MS	3/15–4/15	TN East	3/1–3/31
KY East	3/20–4/1	TN West	2/25–3/15
KY Central	3/15–3/25	VA East (coastal)	3/1-4/15
KY West	3/10–3/20	VA West (mountains)	4/1-5/31

SPECIAL NOTES FOR PEST MANAGEMENT

WEED MANAGEMENT

Weed control is critical in asparagus. If young plants compete with weeds, these young plants will become stressed preventing them from developing good fern growth. Cultivation is not recommended as there are effective herbicides labeled for use. Research shows that even the shallowest of cultivations between asparagus rows cuts and injures roots, predisposing them to Fusarium root rot fungus that eventually will kill the asparagus. Apply a pre-emergence and post-emergence herbicide over the entire field after planting crowns and again after the old fern growth is mowed each spring. Apply an herbicide three weeks prior to the emergence of new spears and ferns, so that these newly emerging spears and fern growth will not compete with weeds.

Although asparagus is highly salt tolerant and salt can be used to control weeds, salt will cause severe soil crusting; impeding water infiltration and percolation. Additionally, salts can leach horizontally through the soil killing other vegetables adjacent to the asparagus which are not as salt tolerant.

INSECTS AND DISEASES MANAGEMENT

Cutworms feed on the spear tips at night before emerging from the soil. They feed on one side of the spear, causing the tip to bend over. Cutworms can easily be managed with approved insecticides.

Asparagus Beetle adults chew on ferns reducing photosynthesis. Any reduction in leaf area causes a loss of stored food reserves in the crown which is needed for next year's crop. Asparagus beetles also lay eggs on the spears during harvest and will result in further damage. During this period, the best way to manage the beetle is to pick on a timely basis preventing any spear getting tall and spindly, or allowing them to fern out.

Cercospora Needle Blight is a fungal disease that produces spores that are wind-blown during the summer when hot and humid. Cercospora Needle Blight turns the needles of the fern yellow, then brown, and then they fall off. This severely reduces the photosynthetic capability of the ferns to manufacture carbohydrates which are critical for next year's spears. Spray an approved fungicide to manage Cercospora when reddish-brown, football-shaped lesions on the fern stalks are first noticed. Research in NC has demonstrated that spraying once every 7 days from early July through September, alternating with chlorothalonil and mancozeb weekly successfully manges Cercospora. Spray once every 7 to 10 days through September. Neglecting to spray might reduce spear yields up to 40% the following year. Burning the old ferns off instead of mowing them off and letting the residue remain on the ground will not prevent Cercospora. Be prepared to spray, regardless if the old ferns are burned or not.

Fusarium Crown and Root Rot are the major destructive diseases of asparagus and the ones that usually take fields out of production. There are no controls once the plants succumb to these diseases. The main way to prevent infection is to prevent stresses from occurring to the plant. These stresses include: overharvesting; low soil pH; low soil fertility; frost damage to spears; waterlogged soil; and insect, disease, and weed pressures.

HARVESTING AND STORAGE

During the second year about 3 weeks before the spears emerge, mow off the dead ferns and spray a tank-mix of an approved pre-emergence and post-emergence herbicide. Mow the dead ferns off as close to the ground as possible. Do not cut ferns down in the fall because the dead ferns will capture moisture in the winter and will keep the soil temperature about 5 degrees colder than the temperature of bare soil. This colder soil temperature will delay spear emergence in the early spring when warm day temperatures force the growth of new spears in bare soil causing frost injury on spears.

With air temperatures (<70ºF), harvesting might be done once every 2 to 3 days, harvesting a 7" to 9" tall spear with tight tips. Air temperatures over 70ºF will cause the tips of the spears to open up or "fern out" at a shorter height causing fiber development in the spears making them tough. Fiber development is determined by the tightness of the spear tip but has no bearing on spear toughness. Harvesting under warm temperatures forces the grower to pick shorter, 5" to 7" tall spears before the spear tips fern out. Otherwise, the spears will lack tenderness and quality. This involves harvesting in the morning and evening of the same day as spears elongate rapidly under high temperatures.

Asparagus can be harvested safely for 2 weeks during the second year (the year following initial establishment of crowns), 4 weeks during the third year, 6 weeks during the fourth year, and 8 weeks during the fifth year. It is best to determine when to stop harvesting by looking at the spear diameter. When 3/4 of the spears are pencil-sized in diameter, stop harvesting. This will take some experience to determine.

Asparagus can be harvested with a knife, below the soil, but snapping is preferred. Using a knife results in a tough and fibrous butt being produced that has to be trimmed off. Cutting below the soil with a knife increases the chances of cutting into other buds on the crown that would normally produce more spears. Snapping involves using the thumb and index finger together to gently break the spear just above the soil line. Snapped asparagus contains no fibrous butt that needs to be removed. The harvested spear is all usable.

Do not allow any small spindly spears to grow into ferns while harvesting. These ferns can provide a site for asparagus beetles to lay their eggs, develop into larvae, then into adult beetles. The field should be free of any tall, spindly spears or fern growth during harvest, except for new spears coming up or ones ready to be harvested.

Harvest asparagus in the morning when the temperatures are cool. Asparagus has a very high respiration rate, just like a fresh cut flower. Place harvested spears into plastic containers that have holes in them to let water pass through. Plunge them into ice-cold water for about 5 minutes. This will remove the field heat out of the spears. Next, allow containers to drain and put them into plastic bags. Place into refrigerated storage set at 36ºF with 95-100% RH. Storage life at 36ºF is about 2 weeks, but growers should try to sell the asparagus soon after it is picked, to let the consumer hold it for 2 weeks, if needed. See Table 14 for further postharvest information.

BEANS: LIMA/BUTTER (*Phaseolus lunatus*) AND SNAP (*Phaseolus vulgaris*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
BEANS - Lima								
***Bush** (small seeded)*								
Bridgeton	A	G		L	M	N	S	T
Dixie Butterpea	A	G			M		S	
Early Thorogreen	A	G		L	M	N	S	
Henderson Bush	A	G		L	M	N	S	
Jackson Wonder	A			L	M		S	T
Nemagreen	A	G		L	M	N	S	
***Bush** (large seeded)*								
Fordhook 242	A	G	K			N	S	T
Dixie Speckled Butterpea	A	G			M	N	S	T
***Pole** (large seeded)*								
Christmas Pole				L				
Carolina Sieva	A	G		L	M	N	S	
Florida Speckled Butter		G		L	M		S	
King of the Garden	A	G		L		N	S	T
Willow Leaf	A			L				
BEANS - Snap								
Bush (Fresh Market)								
Ambition		G						
Ambra	A					N	S	T
Baron[3]		G						
Bowie	A							
Bronco	A	G	K	L		N	S	T
Bush Blue Lake 274	A	G	K	L		N		
Caprice	A	G	K			N		T
Colter		G						T
Festina	A	G				N	S	T
Hialeah	A		K	L		N	S	
Jade	A		K			N		
Lewis	A		K					
Lynx				L		N	S	
Magnum	A	G	K		M	N		T
Momentum		G						
Pony Express	A	G						
Roma II (flat pod)	A	G	K		M	N	S	
Strike	A	G		L		N	S	
Tapia (flat pod)						N		
Tenderette	A					N		
Valentino		G		L		N		T
Pole								
Kentucky Blue			K	L	M	N		
Louisiana Purple Pole				L				
McCaslan	A	G		L				T
Rattlesnake				L	M			T
Red Noodle[2]	A				M			T
State Half Runner		G	K			N		T
Stringless Blue Lake	A	G		L		N	S	
Volunteer/Tennessee Half Runner[4]		G	K			N		T
White Seeded Kentucky Wonder 191	A	G	K	L	M	N	S	T

[1] Abbreviations for state where recommended.
[2] Yard long/Asparagus bean.
[3] Fall production only.
[4] Not for Coastal Plain areas.

Seed Treatment. To protect against root rots and damping off, use treated seed or treat with an appropriate protectant at manufacturer's recommendation. Further information on seed treatments can be found in the SEED TREATMENTS section starting on page 239. Rough handling of seed greatly reduces germination.

MARKET SNAPS PLANTING DATES

	Spring	Fall
AL North	4/1–7/15	NR
AL South	2/10–4/30	8/15–9/20
GA North	5/1–7/15	NR
GA South	2/15–4/30	7/15–9/15
KY East	5/1–7/15	NR
KY Central	4/25–7/25	NR
KY West	4/10–8/1	NR
LA North	4/1–5/15	8/15–9/15
LA South	3/1–5/31	8/15–9/15
MS North	3/30–5/10	8/15–9/1
MS South	2/10–5/1	8/15–9/20
NC East	3/20–6/15	8/1–9/15
NC West	5/1–8/15	NR
SC East	4/1–6/1	8/1–9/1
SC West	4/15–7/1	7/20–8/1
TN East	4/20–6/20	7/15–8/20
TN West	4/1–6/1	NR

PROCESSING SNAPS PLANTING DATES

	Spring	Fall
AL North	4/1–7/15	NR
AL South	2/10–4/30	8/15–9/20
GA North	5/1–7/15	NR
GA South	2/15–4/30	7/15–9/15
KY East	5/1–7/15	NR
KY Central	4/25–7/25	NR
KY West	4/10–8/1	NR
MS North	4/1–5/15	9/5–9/20
MS South	2/10–4/30	8/15–9/20
NC East	4/1–6/15	NR
NC West	5/15–7/31	NR
SC East	4/1–6/1	8/1–9/1
SC West	4/15–7/1	7/20–8/1
TN East	4/20–8/20	7/15–8/20
TN West	4/1–7/15	NR

LARGE & SMALL LIMAS PLANTING DATES

	Spring	Fall
AL North	4/1–7/1	NR
AL South	2/10–5/1	8/15–9/20
GA North	5/1–7/1	NR
GA South	3/1–5/1	7/15–9/1
KY East	5/10–7/10	NR
KY Central	5/1–7/20	NR
KY West	4/15–7/1	NR
MS North	4/1–7/25	NR
MS South	3/1–8/15	NR
NC East	4/10–6/15	7/15–8/1
NC West	6/1–7/15	NR
SC East	4/15–6/1	7/15–8/1
SC West	5/1–6/15	7/1–7/15
TN East	5/1–6/30	7/15–8/20
TN West	4/15–7/15	NR

SOIL AND FERTILITY

Snapbeans grow best on medium-textured, well drained soils, with a pH of 5.5 to 6.2. Commercial producers generally apply 65 lbs N/A by banding at planting 2 inches to each side and 3 inches below the seed. Direct contact with seed can cause injury or kill germinating seed.

SPACING

Snap Beans: With rows 30 to 36 inches apart, plant 5 to 7 seeds per foot. To increase yield plant in rows 18 to 24 inches apart with 4 to 6 seeds per foot. Calibrate planter according to seed size. Sow 1 to 1.5 inches deep in light sandy soil; shallower in heavier soil.

Lima Beans, Large Seeded: Plant in rows 30 to 36 inches apart, 2 seeds per foot, 1 to 1.5 inches deep.

Lima Beans, Small Seeded: Space rows 30 to 36 inches apart, 2 seeds per foot, 0.75 to 1.25 inches deep (deeper if soil is dry). For mechanically harvested irrigated fields: Rows 18 to 30 inches apart, 4 to 5 inches between plants.

Edamame: Edamame are green, immature soybeans sold as fresh vegetables with the seeds in the pods. Grown like bush beans, the pods are harvested when the seeds have reached full size but before the pods begin to yellow. Some commonly grown varieties include Midori Giant, Tohya, Lanco, and Envy.

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Seed Maggot: See the preceding "Seed Treatment" section, or use approved soil systemic insecticides at planting time if probability of pest outbreak is high. Also see the "Maggots" section in Soil Pests—Their Detection and Control and following "Early Season Control" section.

Experience has shown that effective insect control with systemics usually lasts from 4 to 6 weeks after application. Frequent field inspections are necessary after this period to determine pest incidence and the need for additional spray controls.

Thrips: Treatments should be applied if thrips are present from cotyledon stage to when the first true leaves are established and/or when first blossoms form.

Mites: Spot treat areas along edges of fields when white stippling along veins on undersides of leaves is first noticed and 10 mites per trifoliate are present.

Aphids: Treat only if aphids are well-distributed throughout the field (50% or more of terminals with five or more aphids), when weather favors population increase, and if beneficial species are lacking.

Leafhoppers: Treat only if the number of adults plus nymphs exceeds 1 to 2 adults per sweep.

Tarnished Plant Bug (Lygus): Treat only if the number of adults and/or nymphs exceeds 15 per 50 sweeps from the pin pod stage until harvest.

Beet Armyworm (BAW), Cabbage Looper (CL): Treat if the number of worms (BAW and CL) averages 15 per 3 feet of row.

European Corn Borer (ECB)–Snap Beans Only: Treat when moth catches in local blacklight traps average five or more per night. The first application should be applied during the bud–early bloom stage and the second application during the late bloom–early pin stage. Additional sprays may be needed between the pin spray and harvest. Consult a pest management specialist for local black- light trap information and recommended spray intervals.

Corn Earworm (CEW), Fall Armyworm (FAW): In snap beans, treat every 5 to 7 days if CEW catches in local blacklight traps average 20 or more per night and most corn in the area is mature. The use of pheromone (insect sex attractants) and blacklight traps is very helpful in detecting population build-up of various insects.

For limas, treat when CEW populations exceed one per 6 feet of row from the late flat pod stage to harvest.

For both lima bean types, treatment should be timed when 50% or more of the CEW and/or FAW populations reach a length of 1/2 inch or longer. Treating too early for young CEW/FAW populations will eliminate natural control and may result in the need for additional sprays for reinfestations. See "How to Improve Pest Control" for insect sampling techniques. Consult a pest management specialist for more refined decision-making.

Whiteflies: Treat when whiteflies exceed five adults per fully expanded leaflet.

Nematode Management. Use nematicides listed n the "Nematode Control in Vegetate Crops" table in the Disease Control section.

Soybean cyst nematode, races I and III, are present in soybeans in some areas. Snap beans are susceptible, but small seeded lima beans are resistant to this nematode. Growers who rotate snap beans with soybeans should be alert to the possibility of problems in infested fields.

WEED CONTROL

Since beans are a quickly maturing crop, early weed control is essential. Weeds can reduce yield, quality and the efficiency of the mechanical harvester. Preparing a weed-free seedbed is the first step of a weed control program. A weed-free seed bed allows the bean plants to get off to a quick start without interference from weed growth. Carefully read herbicide labels to make sure that beans can tolerate the material. Be sure to avoid planting beans after other crops for which herbicides with a long residual have been used.

MINIMUM TILLAGE

When planning to use minimum tillage practices, give consideration to bean variety, date of planting, soil fertility practices, insect control, planting equipment, cover crop, and weed species in the field. Minimum tillage might not be suited to all growing areas around the SE US. Soil type and other environmental conductions might limit its success. Consult with your local Extension office for the latest recommendations.

HARVESTING AND STORAGE

See Table 14 for postharvest information.

BEETS (*Beta vulgaris*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
BEETS									
Bull's Blood (for greens)	A	G	K	L	M	N	S	T	V
Chioggia (red and white interior)	A	G						T	V
Detroit Dark Red	A	G	K	L			S	T	V
Early Wonder Tall Top	A						S		
Red Ace	A	G	K	L		N	S	T	V
Ruby Queen	A	G	K	L		N	S	T	V
Solo			K	L				T	

[1] Abbreviations for state where recommended.

Light, well-drained soils are best for root development in beets. Beets are frost tolerant and produce the best commercial quality when grown during cool temperatures (50° to 65°F). Lighter color and wider zoning within the roots occur during periods of rapid growth in warm temperatures. If plants are exposed to 2 or 3 weeks of temperatures below 50°F after several true leaves have formed, seedstalks (undesirable because they will reduce root quality) will form. Cultivars vary in their sensitivity to this problem with newer cultivars generally being less sensitive to it.

Beets are susceptible to boron deficiency and will develop internal black spot if soil boron is not adequate. If boron is deficient, apply 2 to 3 lb. of boron per acre with broadcast fertilizer, or for smaller plantings, apply ½ oz. Borax per 100 square feet of row with initial fertilizer application.

Seeding and Spacing. Optimum germination temperature for beets ranges from 50° to 85°F, but early plantings can be made 4 to 6 weeks before the average last spring frost. Germination takes between 10-14 days, but can be hastened by soaking seed in warm water prior to planting. Sow seed ½ to 3/4 in deep at the rate of 15 to 18 seeds per foot of row. Space rows 15 to 20 inches apart; thin plants to 3 inches apart. Seeds remain viable for 2-3 years when stored properly.

BEET PLANTING DATES

	Spring	Fall
AL North	3/15–5/30	8/1–9/15
AL South	2/1–3/31	8/1–9/30
GA North	4/15–5/30	7/15–8/15
GA South	2/1–3/31	8/1–9/30
KY East	3/20–4/15	NR
KY Central	3/15–4/10	NR
KY West	3/10–4/1	NR
LA North	2/1–3/31	9/15–11/15
LA South	2/1–3/31	9/15–11/15
MS	NR	NR
NC East	3/1–4/15	8/1–9/15
NC West	4/1–5/31	7/15–8/15
SC East	2/15–3/31	8/15–9/30
SC West	3/15–5/31	7/15–8/31
TN East	3/15–4/15	9/1–9/30
TN West	3/1–4/1	9/15–10/1
VA East (coastal)	3/15-4/15	8/1-8/31
VA West (mountains)	4/1-5/31	7/15-8/15

SPECIAL NOTES FOR PEST MANAGMENT

DISEASE MANAGEMENT

Seed rot and damping-off may be a problem, especially in early spring plantings when soils are cool. Seeds should be treated with an appropriate fungicide to protect the seed.

Cercospora leaf spot is the most common disease that occurs on beets. Circular spots with reddish brown or purplish margins are the first signs. Spray every 2 to 3 weeks with an appropriate crop protectant.

INSECT MANAGEMENT

The most common insect pests of beets are aphids, leafminers, flea beetles, and webworms. Sanitation and crop rotation should be practiced to avoid pest build ups.

HARVESTING AND STORAGE

Market beets are hand-harvested when 1-3/4 to 2 inches in diameter, usually about 50-75 days after planting. Expected yield per 100 row feet is 100 lbs. See Table 14 for further postharvest information.

BROCCOLI, CABBAGE, CAULIFLOWER, COLLARDS, KALE, AND KOHLRABI (*Brassica* spp.)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
BROCCOLI									
Early									
Castle Dome	A			L	M	N	S	T	V
Packman	A	G	K	L	M	N		T	V
Windsor [10]			K					T	V
Mid-season									
Emerald Crown	A	G			M	N	S		V
Emperor	A		K	L	M	N	S		
Ironman [5]	A					N	S		V
Liberty							S		
Patron [2, 10]	A	G				N	S		
Premium Crop [10, 12]	A		K	L	M	N			
Late-season									
Arcadia [6, 10]	A	G	K	L	M	N	S	T	
BC1691 [14]	A	G				N	S		
Burney	A					N	S		
Destiny [2, 5]					M		S		
Diplomat [10]	A	G		L		N	S	T	V
DuraPak 16 [14]						N	S		
DuraPak 19	A					N	S		
Emerald Pride	A	G		L		N	S		
Fiesta						N			
Greenbelt [5, 6, 8, 10]	A	G	K				S		
Heritage							S		
Patriot [5, 10]	A	G		L					
Marathon [5, 6, 7, 10]	A		K	L	M	N			V
Pinnacle	A		K		M		S		
Triathlon [10]				L		N			
Full-season									
Bay Meadows [2]	A			L	M	N	S		
Belstar					M	N	S	T	
Gypsy [10]	A	G	K	L	M	N	S	T	V
Green Magic [2, 11]		G	K	L	M	N	S	T	V
Lieutenant [5]	A				M	N	S	T	V
CABBAGE: green									
Bayou Dynasty	A	G	K	L	M	N	S		V
Blue Dynasty [4, 6, 9]	A	G				N		T	V
Blue Thunder [4, 6, 8, 9]	A	G		L		N	S	T	V
Blue Vantage [4, 6, 8, 9]	A		K	L	M	N	S	T	V
Bravo [6, 9]	A	G	K	L	M	N	S	T	
Bronco [4, 9]		G	K			N		T	
Cheers [6, 8, 9]	A	G	K	L	M		S	T	
Emblem [4, 6, 9]				L					
Hercules		G		L					
Lynx [4, 6, 9]				L					
Platinum Dynasty [4, 6, 9]	A	G			M	N	S	T	V
Royal Vantage [4, 6, 8, 9]	A	G		L					V
Savoy Ace [4, 6, 8]	A	G	K					T	V
Solid Blue 780 [6, 9]				L	M	N	S		
Thunderhead [4, 6, 9]	A	G				N			
Vantage Point [4, 6, 8, 9]				L					V
CABBAGE: red									
Cardinal [9]	A	G		L		N	S		V
Red Dynasty [4, 6]	A	G	K			N	S	T	V
Red Rookie	A	G	K			N	S	T	

[1] Abbreviations for state where recommended.
[2] Bolting tolerant.
[3] Bolting susceptible.
[4] Tip burn tolerant.
[5] Hollow stem tolerance/resistance.
[6] Black rot tolerance/resistance.
[7] Bacterial leaf spot tolerance/resistance.
[8] Bacterial speck tolerance/resistance.
[9] Fusarium yellows tolerance/resistance.
[10] Downy mildew tolerance/resistance.
[11] Powdery mildew tolerance/resistance.
[12] Suitable for side shoot production.
[13] Dinosaur or Tuscan kale.
[14] Warm weather tolerance.
[15] Orange
[16] Purple
[17] Miniature.
[18] Fall only.

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
CABBAGE: red (cont'd)									
Ruby Perfection [6]	A	G				N			V
CHINESE CABBAGE									
Napa Cabbage									
Blues					M				
China Express	A				M				
Minuet [17]	A				M				
Rubicon				L	M	S			
Michihli									
Green Rocket	A				M				
Monument	A				M				
Choi									
Joi Choi	A			L	M				
Mei Qing Choi	A			L	M				
Shiro [18]					M				
Win Win Choi	A				M				
CAULIFLOWER									
Candid Charm	A	G	K	L					V
Cheddar [15]	A	G		L			S		
Cumberland				L					
Early Snowball	A	G				N			
Freedom	A	G							V
Fremont		G						T	V
Graffiti [16]	A	G		L			S	T	V
Incline		G		L					
Majestic			K	L					
Minuteman		G							V
Symphony		G		L					V
Snow Crown	A	G	K	L	M	N	S	T	
Super Snowball	A	G				N	S		
White Magic	A	G		L					
COLLARDS									
Blue Max [2]	A	G		L	M	N	S		
Champion			K	L		N		T	
Flash	A	G	K	L	M	N	S	T	
Georgia Southern [3]	A	G	K	L	M	N	S	T	
Morris Heading						N	S		
Top Bunch [2]	A	G	K	L		N	S	T	V
Vates	A	G	K	L	M	N	S	T	V
KALE									
Black Magic [13]	A				M	N			
Blue Scotch		G							
Darkibor	A	G					S		
Lacinato [13]	A	G				N	S	T	
Premier						N	S		
Siberian	A	G	K	L	M	N	S	T	
Squire						N	S		
Starbor							S		
Vates	A	G	K	L	M	N	S	T	V
Winterbor	A	G	K		M	N	S	T	V
KOHLRABI									
Early Purple Vienna	A	G	K	L	M	N	S	T	V
Grand Duke	A		K	L	M	N	S	T	V
Kolibri	A		K						
Kossak					M	N			
Quickstar	A		K		M		S		

[1] Abbreviations for state where recommended.
[2] Bolting tolerant.
[3] Bolting susceptible.
[4] Tip burn tolerant.
[5] Hollow stem tolerance/resistance.
[6] Black rot tolerance/resistance.
[7] Bacterial leaf spot tolerance/resistance.
[8] Bacterial speck tolerance/resistance.
[9] Fusarium yellows tolerance/resistance.
[10] Downy mildew tolerance/resistance.
[11] Powdery mildew tolerance/resistance.
[12] Suitable for side shoot production.
[13] Dinosaur or Tuscan kale.
[14] Warm weather tolerance.
[15] Orange
[16] Purple
[17] Miniature.
[18] Fall only.

Seed Treatment. Check with seed supplier to determine if seed is hot-water treated for black rot control. If not, soak seed at 122°F . Use a 20-minute soak for broccoli, cauliflower, collards, kale, and Chinese cabbage. Soak cabbage for 25 minutes. **Note**. Hot water seed treatment may reduce seed germination.

Following either treatment above, dry the seed, then treat with a labeled fungicide to prevent damping-off. Further information on seed treatments can be found in SEED TREATMENTS section starting on page 239.

BROCCOLI PLANTING DATES

	Spring	Fall
AL North	3/1–7/1	NR
AL South	2/1–3/31	8/1–9/30
GA North	3/15–7/1	7/25-8/15
GA South	2/1–3/31	8/1–9/30
KY East	4/10–4/30	7/1–7/15
KY Central	4/5–4/20	7/15–8/1
KY West	3/30–4/10	8/1–8/15
LA North	1/15–3/15	8/1–10/31
LA South	1/15–3/15	8/1–10/31
MS North	2/15–3/15	7/25–8/15
MS South	1/15–3/10	8/5–9/15
NC East	2/15–4/15	8/1–9/15
NC West	4/1–8/15	NR
SC East	3/1–4/10	9/1–9/30
SC West	3/20–4/30	8/15–9/15
TN East	3/25–4/25	8/1–8/31
TN West	3/15–4/5	8/10–8/31
VA East (coastal)	3/15–4/15	7/1–7/31
VA West (mountain)	4/1–4/20	6/20–7/20

CABBAGE PLANTING DATES

	Spring	Fall
AL North	3/15–7/1	NR
AL South	2/1–3/31	8/1–10/31
GA North	3/15–7/1	7/25-8/15
GA South	2/1–3/31	8/1–10/31
KY East	4/1–4/15	6/20–7/1
KY Central	3/15–3/25	7/1–7/15
KY West	3/01–3/15	7/15–8/01
LA North	1/15–3/15	8/1–11/30
LA South	1/15–3/15	8/1–11/30
MS North	2/5–4/1	7/25–8/15
MS South	1/15–3/15	8/5–9/15
NC East	2/15–4/15	8/1–9/15
NC West	4/1–8/15	NR
SC East	2/1–3/31	8/15–9/30
SC West	3/15–4/30	7/15–8/30
TN East	3/25–4/25	7/25–8/15
TN West	3/15–4/15	8/25–9/15
VA East (coastal)	3/15–	7/1–8/15
VA West (mountain)	4/1–	6/20–7/20

CAULIFLOWER PLANTING DATES

	Spring	Fall
AL North	3/15–7/1	NR
AL South	2/1–3/31	8/1–9/30
GA North	3/15–7/1	7/25-8/15
GA South	2/1–3/31	8/1–9/30
KY East	4/10–4/30	7/1–7/15
KY Central	4/5–4/20	7/15–8/1
KY West	3/30–4/10	8/1–8/15
LA North	2/1–3/15	7/15–10/31
LA South	2/1–3/15	7/15–10/31
MS North	2/15–3/15	7/25–8/15
MS South	1/15–3/10	8/5–9/15
NC East	2/15–4/15	8/1–9/30
NC West	4/1–8/15	NR
SC East	3/1–4/10	8/15–8/30
SC West	3/20–4/30	7/15–8/30
TN East	3/25–4/25	7/15–8/15
TN West	3/15–4/15	8/1–8/20
VA East (coastal)	NR	7/1–7/30
VA West (mountain)	4/1–4/20	6/20–7/20

COLLARDS PLANTING DATES

	Spring	Fall
AL North	2/15–6/30	7/15–10/15
AL South	1/15–5/31	7/15–10/31
GA North	3/15–7/31	7/25-8/15
GA South	2/1–3/31	8/1–10/31
KY East	3/15–4/30	7/1–7/15
KY Central	3/10–4/25	7/15–8/1
KY West	3/1–4/15	8/1–8/15
LA North	1/15–3/15	7/15–10/31
LA South	1/15–3/15	7/15–10/31
MS North	1/20–4/1	7/25–8/20
MS South	1/15–3/1	8/10–9/15
NC East	2/15–6/30	8/1–9/15
NC West	4/1–8/15	NR
SC East	2/1–6/15	8/1–10/30
SC West	3/15–6/30	8/1–9/30
TN East	3/15–5/1	7/15–8/15
TN West	2/15–4/15	8/1–8/20
VA East (coastal)	4/1–	7/1–8/31
VA West (mountain)	4/20–	7/15–8/20

KALE PLANTING DATES

	Spring	Fall
AL North	3/15–4/30	8/1–9/15
AL South	2/1–3/31	8/1–10/31
GA North	3/15–4/30	NR
GA South	2/1–3/31	8/1–10/31
KY East	4/1–4/30	7/1–7/15
KY Central	3/20–4/15	7/15–8/1
KY West	3/10–4/10	8/1–8/15
LA North	2/1–3/15	7/15–10/31
LA South	2/1–3/15	7/15–10/31
MS North	1/20–4/1	7/25–8/20
MS South	1/15–3/1	8/10–9/15
NC East	2/15–6/30	8/1–9/15
NC West	4/1–8/15	NR
SC East	2/1–6/15	8/1–10/30
SC West	3/15–6/30	8/1–9/30
TN East	3/15–5/1	8/1–9/1
TN West	2/15–4/15	8/15–9/15
VA East (coastal)	4/1–	7/1–8/31
VA West (mountain)	4/20–	7/15–8/20

KOHLRABI PLANTING DATES

	Spring	Fall
AL North	3/15–7/1	NR
AL South	2/1–3/31	8/1–9/30
GA North	3/15–7/1	NR
GA South	2/1–3/31	8/1–9/30
KY East	4/10–4/30	NR
KY Central	4/5–4/20	NR
KY West	3/30–4/10	NR
LA North	2/1–3/15	7/15–10/31
LA South	2/1–3/15	7/15–10/31
MS	2/1–3/31	8/1–9/30
NC East	2/15–6/30	8/1–9/15
NC West	4/1–8/15	NR
SC East	2/1–6/15	8/1–9/30
SC West	3/15–6/30	8/1–9/15
TN East	3/25–4/25	8/1–8/15
TN West	3/15–4/15	8/15–8/30
VA East (coastal)	3/15–4/15	7/1–7/31
VA West (mountain)	4/1– 4/20	6/25–7/15

PLASTIC MULCH

Early spring cabbage, cauliflower, and broccoli are frequently grown using plastic mulch, with black mulch used in the spring and white on black or black mulch painted white used in the fall.

Broccoli. *Field seeding:* Space raised beds 36-40 inches apart; seed twin rows per bed 6-12 inches apart within row and 12 inches between row; for bunch broccoli use the shorter within row spacing which will also require a more aggressive pest management program; for organic production single rows per bed can be used and within row spacing increased to as much 6-24 inch spacing to aide in pest prevention and maximum fertilizer management.

Transplants: Space raised beds 36-40 inches apart; set transplants on twin rows per bed 6-12 inches apart within row and 12 inches between row; for bunch broccoli use the shorter within row spacing which will also require a more aggressive pest management program; for organic production single rows per bed can be used and within row spacing increased to as much 6-24 inch spacing to aide in pest prevention and maximum fertilizer management.

Cabbage. The early cabbage crop is grown from transplants seeded at the rate of 1 ounce for 3,000 plants. Transplants are ready for field planting 4 to 6 weeks after seeding. Storage of pulled, field-grown cabbage transplants should not exceed 9 days at 32°F or 5 days at 66°F prior to planting in the field. Precision seeders can be used for direct seeding. However, seed should be sown 15 to 20 days in advance of the normal transplant date for the same maturity date. Early varieties require 85 to 90 days from seeding to harvest, and main-season crops require 110 to 115 days. Set transplants in rows 2 to 3 feet apart and 9 to 15 inches apart in the row for early plantings and 9 to 18 inches apart for late plantings, depending on variety, fertility, and market use.

Chinese Cabbage. Chinese cabbage is a diverse group of growth types of Brassica rapa. Napa and Michihli resemble romaine lettuce with densely overlapping broad leaves with flat mid veins. Napa cabbage is barrel shaped while Michihli is tall and slender. Choi types have a vase shaped growth with broad petioles of white or green with green leaves at the top of the vase. Production inputs are the same as ball head cabbage. Both types grow more quickly than ball head cabbage with most cultivars maturing in 50 days from seeding.

Cauliflower. Cauliflower can be more changeling to grown than other Brassicas in this section. Consider a small test plot to determine the best methods (planting dates, varieties, etc.) to use in your area. Start seed in greenhouse or protected frames 4 to 6 weeks before planting. Use 1 ounce of seed for 3,000 plants. Set transplants in rows 3 to 4 feet apart, and plants are set 18 to 24 inches apart in the row. Make successive plantings in the field at dates indicated in preceding table.

Collards and Kale. Seed at the rate of 2 pounds per acre and thin to desired spacing. For precision, air-assist planters use 1/3 to ½ pound per acre for twin rows on 3 foot centers, or use half of this rate for single rows on 3 foot centers. When using transplants, set plants in rows 16 to 24 inches apart and 6 to 18 inches apart within the row.

Kohlrabi. Transplants may be used for a spring crop. Seed 6 weeks before expected transplant date. Use precision seeder for hybrid varieties. Space rows 18 to 24 inches apart and 6 to 8 between plants.

Bolting. Bolting in cabbage, collards and kale, and buttoning in cauliflower, can occur if the early-planted crop is subjected to 10 or more continuous days of temperatures between 35° to 50°F. However, sensitivity to bolting depends upon the variety.

SPECIAL NOTES FOR PEST MANAGMENT

Note: The use of a **spreader-sticker** is recommended for cole crops in any case; the heavy wax coating on the leaves reduces deposition of spray materials. These adjuvants allow the spray to spread out and stick to the leaves. Multiple nozzles per row or bed will provide the under leaf coverage and high coverage rates necessary to manage caterpillar pests of cole crops.

INSECT MANAGEMENT

Aphids: The cabbage aphid can be a serious problem on these crops and should be treated immediately if noticed. Other aphid species are found on these crops and should be treated if the crop is near harvest or their level of infestation is increasing. Often parasitic wasps take out these species if broad-spectrum insecticides use is avoided.

Cabbage Root Maggot: Root maggots and other similar insects such as the seed corn maggot can be a problem in heavier soils in the Southeast especially during cool, damp times of the year. Avoid planting into soils with freshly plowed down crop residue or high levels of organic matter.

Caterpillars: A number of moth and butterfly larvae feed on cole crops. The major ones are the cabbage looper (CL), the imported cabbageworm (ICW), and the diamondback moth (DBM) referred

to as the cabbageworm complex. Other caterpillars found on cole crops are the cross-striped cabbageworm, corn earworm, armyworms, and webworms. Webworms often damage the bud of the young plants and should be treated immediately; very young larvae are much more easily managed than older ones.

Scouting and using a threshold for spray applications is a cost effective method of managing these pests. Broad-spectrum insecticides that reduce the natural enemies in the field should be avoided if at all possible. If the cabbageworm complex is the major group of pests, a threshold of 1 cabbage looper equivalent (CLE) per 10 plants can be used. A cabbage looper equivalent relates the feeding amounts of the three caterpillars. One cabbage looper is equivalent to 1.5 imported cabbageworms or 5 diamondback moth larvae. (**Example**: 10 DBM larvae per 10 plants would be like 2 CLEs per 10 plants; this level would require treatment.) In other areas of the South where armyworms are common pests of cole crops, a threshold of 1 caterpillar (regardless of the kind) per 3 plants has been effectively used as a threshold. The use of a threshold to determine the need for treatment usually reduces the number of sprays per crop without loss of crop quality and improves the profit margin.

Note: *Bacillus thuringiensis* (BT) preparations are effective against most of these pests but must be eaten by the larvae. Thorough coverage of the plant particularly the undersurface of the leaf is essential, and the use of a **spreader-sticker** is strongly recommended.

Note: Several of these insects are prone to develop resistance to insecticides. Growers must rotate among classes of insecticides for each pest generation. See the section on resistance management.

Nematode Management. Use nematicides listed in the "Nematode Control in Vegetate Crops" tables in the Disease Control section.

HARVESTING AND STORAGE

Fresh market cabbage should be harvested when heads are firm and weigh 2.5 to 3.0 pounds. Most markets require one to three wrapper leaves to remain. The heads should be dense and free of insect damage. Cabbage for slaw or kraut usually has much larger heads and weighs 3 to 12 pounds.

Broccoli should be harvested when the beads (flower buds) are still tight, but a few outer beads have begun to loosen. The stalks should be 7 inches long from top of the crown to the butt. Broccoli is usually bunched in 1.5 pound bunches with 2 to 3 heads per bunch. Secure bunches with a rubber band or twist tie.

Kohlrabi should be harvested when the bulbs are 2 to 3 inches in diameter and before internal fibers begin to harden.

Cauliflower is harvested while the heads are pure white and before the curds become loose and ricey. Heads are blanched by tying outer leaves over the heads when heads are 3 to 4 inches in diameter. Blanching takes about 1 week in hot weather and 2 weeks in cooler weather.

Kale is harvested by cutting off the entire plant near ground level, or lower leaves may be stripped from plant. Collards may be harvested at any stage of growth. See Table 14 for further postharvest information on these crops.

CARROTS (*Daucus carota*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
CARROTS									
Apache [3]	A	G		L	M	N	S		V
Bolero [4]								T	V
Danvers 126 [5]	A			L		N	S		V
Deep Purple [2, 3]	A			L		N			
Maverick [6]		G		L					V
Purple Haze [2, 3]	A	G		L	M	N	S	T	
Scarlet Nantes[4]							S		
Sugarsnax 54	A	G	K	L		N		T	V
Yellow Bunch [3, 7]	A			L		N			

[1] Abbreviations for state where recommended.
[2] Purple.
[3] Imperator type: 7-8 inches long w/ long conical shape and narrow shoulders.
[4] Nantes type: Smooth, cylindrical over entire length w/ a blunt end.
[5] Danvers type: Tapering root w/ a semi-blunt tip.
[6] Nantes x Imperator type.
[7] Yellow.

Seeding Dates. Small carrot seedlings up to six leaves cannot withstand hard freezes but are somewhat frost tolerant. Optimum temperatures are in the range of 60-70°F, with daytime highs of 75°F and nighttime lows of 55°F ideal. Although the crop can be grown outside this range with little or no effect on tops, temperatures differing drastically from the above can adversely affect root color, texture, flavor, and shape. Lower temperatures in this range may induce slow growth and make roots longer, more slender and lighter in color. Carrots with a root less than one inch in diameter are more susceptible to cold injury than larger roots. Soil temperatures should be above 40°F and below 85°F for best stand establishment.

CARROT PLANTING DATES

	Spring	Fall
AL North	3/1–4/15	NR
AL South	NR	8/1–11/30
GA North	3/1–4/15	NR
GA South	NR	8/1–11/30
KY East	4/1-4/30	NR
KY Central	3/20-4/15	NR
KY West	3/10-4/10	NR
LA North	1/15–2/28	9/15–10/15
LA South	1/15–2/28	9/15–10/15
MS North	2/15–4/1	NR
MS South	1/15–3/15	NR
NC East	2/15–3/31	6/15–8/15
NC West	4/1–6/15	7/21-8/15
SC East	2/1–3/15	9/1–9/15
SC West	2/15–3/31	8/1–9/15
TN East	3/15-5/1	NR
TN West	3/1-4/30	NR
VA East (coastal)	3/15–4/30	6/1–7/31
VA West (mountain)	4/1– 6/15	7/1–7/31

SPACING

Spatial arrangements for planting can differ markedly. Carrots can be planted with vacuum, belt, or plate seeders. Often a special attachment called a scatter plate or spreader shoe is added to the plate planters to scatter the seed in a narrow band. Carrots should be spaced 1½ to 2 inches apart within the row. Carrot seed should be planted no deeper than ¼-½ inch. A final stand of 14 to 18 plants per foot of twin row is ideal. Ideal patterns are twin rows that are 2½ -3½ inches apart. Three or four of these twin rows are situated on one bed, depending on the width of the bed. One arrangement is to plant three twin rows on beds that are on 72-inch centers. Another arrangement is to plant four twin rows on a 92-inch bed (center to center). The sets of twin rows are 14 to 18 inches apart. Beds on 72-inch centers will have approximately 48 inches of formed bed. Row spacing wider than 18 inches will reduce total plant stand per acre and thus, will reduce total yield. Ideal plant populations should be in the range of 400,000 for fresh market carrots and 250,000 for processing carrots.

PLANTING AND LAND PREPARATION

Beds that are **slightly** raised are advantageous because they allow for good drainage. Beds should be firmed and not freshly tilled before planting and soil should be firmed over the seed at planting. A basket or roller attachment is often used to firm the soil over the seed as they are planted. Light irrigation will be required frequently during warm, dry periods for adequate germination.

Windbreaks are almost essential in areas with primarily sandy soils. Sand particles moved by wind can severely damage young carrot plants, reducing stands. Small grain strips planted between beds or at least planted between every few beds can help reduce this sandblasting injury.

Begin by deep turning soils to bury any litter and debris and breaking soils to a depth of 12-14 inches. Compacted soils or those with tillage pans should be subsoiled to break the compacted areas. If uncorrected, compact soil or tillage pans can result in restriction of root expansion. It is best to apply lime after deep turning to prevent turning up acid soil after lime application. Prepare a good seedbed using bed-shaping equipment. Do not use disks or rototiller to avoid soil compaction. Carrots should be planted on a slightly raised bed (2-3 inches) to improve drainage. After beds are tilled and prepared for seeding, it is best to allow the beds to settle slightly before planting. Avoid other tillage practices that can increase soil compaction. **Following in the same tracks for all field operations will help reduce compaction in planting areas.**

SPECIAL NOTES FOR PEST MANAGEMENT

DISEASE MANAGEMENT

Root-Knot Nematode: By far, the most destructive problem in carrots is root-knot nematodes. Root-knot nematodes are small eel-like worms that live in the soil and feed on plant roots. Since the root of the carrot is the harvested portion of the plant, no root-knot damage can be allowed. Root-knot causes poor growth and distorted or deformed root systems which results in a non marketable root. Root-knot damage also allows entry for other diseases such as Fusarium, Pythium, and Erwinia.

If any root-knot nematodes are found in a soil assay, treatment is recommended. Good success has been obtained using field soil fumigation to eradicate root-knot nematodes in the root zone of carrots. Use nematicides or fumigants listed in the "Nematode Control in Vegetate Crops" tables in the Disease Control section.

SOIL-BORNE ROOT DISEASES

Depending on the cropping history of the field, Pythium, Southern Blight, and Sclerotinia may cause problems. It is advisable to avoid fields where these diseases have been identified in the previous crop. Deep turning is also necessary to help prevent root diseases.

Pythium Blight: is usually characterized by flagging of the foliage indicating some root damage is occurring. Under wet conditions, Pythium may cause serious problems to the root causing a white mycelium mat to grow on the infected area which rapidly turns to a watery soft rot. Forking of the root system is also a common symptom associated with Pythium infection. Rotation is considered a major factor in reducing Pythium along with the use of fungicides.

Southern Blight: Southern blight causes serious damage to carrots. This disease is usually associated with carrots remaining in the field after the soil begins to warm in the spring. This disease causes a yellow top to develop with a cottony white fungal growth associated with the upper part of the carrot root. The top of the root and the surrounding soil may be covered with a white mycelium with tan sclerotia developing as the disease progresses. Southern Blight is best controlled by using rotation and deep turning.

Sclerotinia Blight: Sclerotinia blight causes serious damage to the roots of carrots. This disease is usually worse under wet soil conditions. White mycelium forms around the infected area and later, dark sclerotia develop on the white mycelium which is a good indicator of Sclerotinia rot. This disease causes a progressive watery soft rot of the carrot root tissue and is considered a potential problem in the production of carrots. Rotation and deep turning of the soil are recommended to reduce losses to this disease.

Rhizoctonia: Rhizoctonia rot causes brown to black lesions to develop on the sides of the carrot root. The disease is much worse under cool, wet conditions. Saturated soil conditions often enhance all soil-borne diseases which are potential problems in carrot production. Rhizoctonia damage can be minimized by using rotation and good cultural practices. Soil fumigation will prevent damage with any of the soil inhabiting fungi.

FOLIAR DISEASES

Bacterial Blight: Bacterial blight causes irregular brown spots on the leaves and dark brown streaks on the petioles and stems. The lesions on the foliage begin as small yellow areas with the centers becoming dry and brittle, with an irregular halo. The bacterium affects the leaflets, stems and petioles as the disease progresses. Some of these lesions may crack open and ooze the bacteria. These bacteria may be washed down to the crown of the plant causing brown lesions on the top of the root. The earlier the infection occurs the greater the damage to the root. The bacterium is spread by splashing water and takes about 10-12 days before symptoms appear after inoculation. Disease development progresses rapidly between 77˚ and 86˚ F. Crop rotation is a major factor in controlling Bacterial blight.

Alternaria Blight: Alternaria blight causes small dark brown to black spots with yellow edges forming mostly on the leaf margins. The spot increases as the disease progresses and in some cases entire leaflets may be killed. In moist weather, the disease can move so rapidly it resembles frost injury. Such conditions can reduce the efficiency of mechanical harvesters which require strong healthy tops to remove the carrot from the soil. Alternaria may also cause damping off of seedlings and a black decay of roots. The spores and mycelium are spread by splashing rains, contaminated soil, or on cultivation tools. The disease can manifest itself in about 10 days after infection. The optimum temperature for Alternaria blight is 82˚ F.

Cercospora Leaf Blight: Cercospora blight causes lesions to form on the leaves, petioles and stems of the carrot plant. The symptoms appear to mimic that of Alternaria blight but can be separated using a compound microscope. Cercosproa blight progresses in warm, wet weather and spots appear in about 10 days after infection. The youngest leaves are usually more susceptible to Cercosproa infection.

INSECT MANAGEMENT

Soil Insects: Wireworms, white grubs, and the granulate cutworm may be partially controlled with good cultural practices. Soil should be deep turned in sufficient time prior to planting to allow destruction of previous crop residue that may harbor soil insects. When possible, avoid planting just after crops that are slow to decompose such as tobacco and corn. Avoid planting behind peanuts and root crops such as sweetpotatoes and turnips. If a field has a history of soil insect problems, either avoid these or, broadcast incorporate a soil insecticide prior to planting. Plantings in fields that were recently in permanent pasture should be avoided as should fields recently planted to sod/turf, although these are not as critical. Fields with a history of whitefringed beetle larvae should not be planted to carrots because there are no currently registered insecticides effective on this pest.

Flea beetle larvae can damage roots by feeding from the surface into the cortex. The damage will take on the appearance of narrow "s" shaped canals on the surface. Flea beetle larvae can be prevented easily with soil insecticides.

The seedcorn maggot is an opportunistic pest that takes advantage of crops that are under stress or where there is decaying

organic matter. At-planting soil insecticides will prevent the development of maggot infestations for several weeks after planting. Seedcorn maggots cannot be effectively controlled after the infestation begins. If plants become stressed during the period of high root maggot potential, preventive applications of insecticides should be sprayed every seven days until the stress is minimized.

FOLIAR INSECTS

Foliar insect pests may be monitored and insecticides applied as needed. Carrots should be scouted at least once per week for developing populations of foliage pests.

Aphids: Several species of aphids may develop on carrots. The most common aphids to inhabit carrots are the green peach aphid and the cotton or melon aphid. Often parasitic wasps and fungal diseases will control these aphids. If populations persist and colonize plants rapidly over several weeks and honeydew or sooty mold is observed readily, then foliar insecticides are justified.

Flea Beetles: Fleas beetle adults may cause severe damage to the foliage on occasion. If carrots are attacked during the seedling stage and infestations persist over time, an insecticide application may be necessary. If plants are in the cotyledon to first true leaf stage, treatments should be made if damage or flea beetles are observed on more than 5% of the plants. After plants are well established, flea beetles should be controlled only if foliage losses are projected to be moderate to high, e.g., 15% or more.

Vegetable Weevil: The adult and larvae of the vegetable weevil may attack carrots. The adult and larvae feed on the foliage. Vegetable weevil larvae often will feed near the crown of plants and, if shoulders are exposed at the soil surface, larvae will feed on tender carrots. Treatments are justified if adults or larvae and damage are easily found in several locations.

Armyworms: The armyworm can cause damage in carrots. Armyworms may move from grain crops or weeds into carrots or adults may lay eggs directly on carrot plants. Armyworms are easily managed with foliar insecticides.

Beet Armyworm: The beet armyworm infests carrots in the late spring. Usually natural predators and especially parasites regulate beet armyworm populations below economically damaging levels.

Whiteflies: The silverleaf whitefly can be a problem during the early seedling stage of fall plantings. Silverleaf whitefly migrates from agronomic crops and other vegetables during the late summer. Infestation may become severe on carrots grown in these production areas. Often whiteflies may be controlled by several natural enemies and diseases by early fall so, treatments may not be justified. However, if whiteflies develop generally heavy populations, treatment of young plantings is justified.

HARVESTING AND STORAGE

Topped Carrots: will last 4 to 5 months at 32°F and 90% to 95% relative humidity. See Table 14 for further post harvest information.

CUCUMBERS (*Cucumis sativus*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
CUCUMBERS									
Slicer / Fresh Market									
Cortez [2, 3, 5, 6, 7, 8, 9, 10]	A	G	K	L		N	S	T	V
Dasher II [2, 3, 4, 5, 6, 10]	A	G	K	L	M	N	S	T	V
General Lee [4, 5, 6, 10]	A		K	L	M	N	S		V
Impact [2, 3, 5, 6, 7, 8, 9, 10, 11, 14]	A	G							
Indy [2, 3, 4, 5, 7, 8, 9, 10]	A		K	L		N	S	T	V
Intimidator [2, 3, 4, 6, 10]		G	K	L		N	S	T	V
Poinsett 76 [2, 3, 5, 10]	A					N	S		
Rockingham [2, 3, 5, 6, 10]	A		K		M	N	S		
Slice More [2, 4, 5, 6, 10]				L		N	S		
Speedway [2, 3, 5, 6, 10]	A	G	K	L		N	S	T	V
StoneWall [2, 3, 4, 5, 6, 10]		G	K	L		N	S		V
SV 4719CS [2, 3, 4, 5, 8, 10, 14]	A	G							
SV 3462CS [2, 3, 4, 5, 8, 10, 14]	A	G							
Talladega [2, 3, 5, 9, 10]	A		K	L	M	N	S	T	V
Thunder [3, 4, 5, 6, 8, 10]	A		K	L	M	N	S	T	V
Pickling Types - Multiple Harvest									
Calypso [2, 3, 4, 5, 6, 10]	A	G	K	L	M		S	T	V
Colt [2, 3, 4, 5, 6, 10]	A					N	S		
Eureka [2, 3, 4, 5, 6, 7, 8, 9, 10]									V
Fancipak [2, 3, 4, 5, 6, 10]	A	G					S	T	V
Pickling Types - Multiple or Once-over Harvest									
Arabian [2, 3, 4, 5, 6, 10]	A					N			
Expedition [2, 3, 5, 6, 10]	A					N	S		V
Lafayette	A					N	S		V
Sassy [2, 3, 5, 6, 7, 8, 9, 10]									V
Parthenocarpic Types - Seedless Pickling									
Gershwin	A					N	S		
Puccini [2, 3, 6, 10]	A								V
Stravinsky	A					N	S		
GREENHOUSE CUCUMBERS									
Long Dutch/English Types									
Bologna [5, 10, 11]	A		K	L	M		S	T	
Camaro [5, 13, 14]	A		K	L	M		S	T	
Cumlaude [3, 5, 10, 14]	A		K	L	M		S	T	V
Discover [3, 5, 10, 14]	A		K	L	M		S	T	V
Kasja [5, 10, 11]	A		K						
Verdon [5, 6, 10, 11, 12]	A		K	L	M			T	
Beit Alpha/Mini Types									
Delta Star [5, 6, 10, 11, 12]	A		K	L	M		S	T	
Jawell [5, 6, 14]	A		K	L	M		S	T	
Katrina [5, 6, 12]	A		K	L	M		S	T	
Manar [5, 6, 14]	A		K	L	M		S	T	
Picowell [5]	A		K	L	M		S	T	
Sarig [5]	A		K						

[1] Abbreviations for state where recommended.
[2] Anthracnose tolerance/resistance.
[3] Angular Leaf Spot tolerance/resistance.
[4] Downy Mildew tolerance/resistance.
[5] Powdery Mildew tolerance/resistance.
[6] Cucumber Mosaic Virus tolerance/resistance.
[7] Papaya Ring Spot Virus tolerance/resistance.
[8] Zucchini Yellows Mosaic Virus tolerance/resistance.
[9] Watermelon Mosaic Virus tolerance/resistance.
[10] Scab and gummosis tolerance/resistance.
[11] Target spot tolerance/resistance.
[12] Cucumber vein yellowing virus tolerance/resistance.
[13] Low light tolerant.
[14] All female (gynoecious).

Field Production. For earlier cucumber production and higher, more concentrated yields, use gynoecious varieties. A gynoecious plant produces only female flowers. Upon pollination female flowers will develop into fruit. To produce pollen, 10% to 15% pollinizer plants must be planted; seed suppliers add this seed to the gynoecious variety. Both pickling and slicing gynoecious varieties are available. For machine harvest of pickling cucumbers, high plant populations (55,000 per acre or more) concentrate fruit maturity for increased yields.

Planting Dates. For earliness container-grown transplants are planted when daily mean soil temperatures have reached 60°F but

most cucumbers are direct seeded. Consult the following table for planting dates for transplants in your area. Early plantings should be protected from winds with hot caps or row covers. Growing on plastic mulch can also enhance earliness.

CUCUMBER *SLICERS* PLANTING DATES

	Spring	Fall
AL North	4/1–7/15	8/1–8/30
AL South	3/1–4/30	8/1–9/15
GA North	4/15–7/15	8/1–8/30
GA South	3/1–4/30	8/1–9/15
KY East	5/10-6/1	6/1-6/15
KY Central	5/5-6/1	6/1-7/1
KY West	4/25-5/15	5/15-7/15
LA North	3/15–5/15	7/15–8/31
LA South	3/1–5/15	8/1–9/15
MS North	4/1–5/15	7/25–8/21
MS South	3/15–5/1	8/14–9/14
NC East	4/15–5/15	7/15–8/15
NC West	5/15–7/31	NR
SC East	3/15–5/15	8/1–8/30
SC West	4/15–6/5	8/1–8/30
TN East	5/5-6/15	7/1-8/10
TN West	5/1-6/1	7/25-8/25
VA East (coastal)	4/15-6/15	7/1-7/31
VA West (mountains)	5/15-6/30	6/15-7/31

CUCUMBER *PICKLING* PLANTING DATES

	Spring	Fall
AL North	4/15–7/15	8/1–8/30
AL South	3/1–4/30	8/1–9/15
GA North	4/15–7/15	NR
GA South	3/1–4/30	8/1–9/15
KY East	5/10-6/1	6/1-6/15
KY Central	5/5-6/1	6/1-7/1
KY West	4/25-5/15	5/15-7/15
LA North	4/1–5/15	7/15–8/31
LA South	3/15–5/15	8/1–9/15
MS South	4/1–4/15	NR
NC East	4/20–5/20	7/15–8/15
NC West	5/25–7/31	NR
SC East	3/15-5/15	8/1–8/30
SC West	4/15–6/15	8/1–8/30
TN East	5/5-6/15	7/1-8/10
TN West	5/1-6/1	7/25-8/25
VA East (coastal)	4/15-6/15	7/1-7/31
VA West (mountains)	5/15-6/30	6/15-7/31

Spacing. *Slicers:* Space rows 3 to 4 feet apart with plants 9 to 12 inches apart. *Pickles*: For hand harvest, space 3 to 4 feet apart; for machine harvest, space three rows 24–28 inches apart on a bed. Plants for hand harvest should be 6 to 8 inches apart in the row; 2 to 4 inches apart for machine harvest. Close spacing increases yields, provides more uniform maturity and reduces weed problems, but require slightly higher fertilizer rates. *Seeding for slicers*: 1.5 pounds per acre. *Seeding for pickles*: 2 to 5 pounds per acre.

Bitterness. Bitterness can be a common problem in cucumber. Cucumbers (and all other cucurbits) produce a group of chemicals called cucurbitacins which can cause bitterness to develop. As cucurbitacin concentrations increase, the more bitter the cucumber will taste. Generally, the amount of cucurbitacin in a cucurbit fruit is low and cannot be tasted. Mild bitterness results from higher levels of cucurbitacin often triggered by environmental stresses, including high temperatures, wide temperature swings, or too little water. Uneven watering practices (too wet followed by too dry), low soil fertility, and low soil pH are also possible factors. Over-mature or improperly stored cucumbers may also develop a mild bitterness, although it is not usually severe.

Mulching. Fumigated soil aids in the control of weeds and soilborne diseases. Black plastic mulch laid before field planting conserves moisture, increases soil temperature, and increases early and total yield. Plastic and fumigant should be applied on well-prepared planting beds 2 to 4 weeks before field planting. Plastic should be placed immediately over the fumigated soil. The soil must be moist when laying the plastic. Fumigation alone may not provide satisfactory weed control under clear plastic. Herbicides labeled and recommended for use on cucumbers may not provide satisfactory weed control when used under clear plastic mulch on nonfumigated soil. Black plastic can be used without a herbicide. Fertilizer must be applied during bed preparation. At least 50% of the nitrogen (N) should be in the nitrate (NO_3) form.

Foil and other reflective mulches can be used to repel aphids that transmit viruses in fall-planted (after July 1) cucumbers. Direct seeding through the mulch is recommended for maximum virus protection. Fumigation will be necessary when there is a history of soilborne diseases in the field. Growers should consider drip irrigation with plastic mulch. For more information, see the section on "Irrigation".

SUGGESTED FERTIGATION SCHEDULE FOR CUCUMBER* (N:K,1:2)

Days after planting	Daily nitrogen	Daily potash	Cumulative Nitrogen	Cumulative Potash
	(lb / A)			
Preplant			25.0	45.0
0-14	0.9	1.8	37.6	75.2
15-63	1.5	3.0	110.3	196.6
64-77	0.7	1.4	120.1	216.6

ALTERNATIVE FERTIGATION SCHEDULE FOR CUCUMBER* (N:K,1:1)

Days after planting	Daily nitrogen	Daily potash	Cumulative Nitrogen	Cumulative Potash
	(lb / A)			
Preplant			24.0	24.0
0-7	1.0	1.0	31.0	31.0
8-21	1.5	1.5	52.0	52.0
22-63	2.0	2.0	136.0	136.0
64-70	1.5	1.5	150.0	150.0

*Adjust based on tissue analysis.

Greenhouse Cucumber Production. If you plan on growing cucumbers to maturity in the greenhouse, you need to select a greenhouse variety. This is because these varieties have been bred specifically for greenhouse conditions – lower light, higher humidity and temperature, etc., and they have better disease resistance than field types.

Nearly all greenhouse cucumber varieties are gynecious, parthenocarpic hybrids. This means that these varieties produce only female flowers and the fruit are seedless. Since they are all female, no pollination is needed. The seedless characteristic makes

the fruit very tender to eat. Greenhouse cucumbers are also thin skinned which makes them more desirable than field varieties. While non-greenhouse types would grow in the greenhouse, the yield and quality would be reduced, and therefore they may not be profitable.

Variety selection is based on yield, fruit size, uniformity, disease resistance, and lack of physiological disorders, as well as the market demand for the type grown. In some markets the long, European types sells better, while in others, the small beit alpha types, also referred to as "minis", are preferred. For suggestions on varieties, see the variety table above. Insect and disease control methods for greenhouse vegetables can be found in Tables 2-10 (in the Insect section) and 3-11 (in Disease section), respectively.

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Cucumber Beetle: Cucumber beetles can transmit bacterial wilt; however, losses from this disease vary greatly from field to field and among different varieties. Pickling cucumbers grown in high-density rows for once-over harvesting can compensate for at least 10% stand losses. On farms with a history of bacterial wilt infections and where susceptible cultivars are used, foliar insecticides should be used to control adult beetles before they feed extensively on the cotyledons and first true leaves. Begin spraying shortly after plant emergence and repeat applications at weekly intervals if new beetles continue to invade fields. Treatments may be required until stems begin vining (usually about 3 weeks after plant emergence), at which time plants are less susceptible to wilt infections.

Pickleworm, Melonworm: Make one treatment prior to fruit set, and then treat weekly.

Aphids: Aphids transmit several viruses (CMV, WMV, PRSV, etc.) and can delay plant maturity. Thorough spray coverage beneath leaves is important. For further information on aphid controls, see the preceding "Mulching" section. Treat seedlings every 5 to 7 days or as needed.

Mites: Mite infestations generally begin around field margins and grassy areas. CAUTION: DO NOT mow or maintain these areas after midsummer because this forces mites into the crop. Localized infestations can be spot-treated. Begin treatment when 50% of the terminal leaves show infestation. ***Note:*** Continuous use of pyrethroids may result in mite outbreaks.

DISEASE MANAGEMENT

Cucurbit Downy Mildew Forecasting System: Cucurbit downy mildew (CDM) is a devastating foliar cucurbit disease. While difficult, if not impossible to control, CDM can be prevented by using effective IPM practices. A useful tool for prevention of CDM is the CDM forecasting system. This program depends on the accurate reporting of CDM in the field as well as the monitoring of over 50 strategically placed sentinel plots. These plots are monitored by Plant Pathologists at multiple Land Grant Universities throughout the United States and Canada. Forecasts of the epidemic movement of the disease are generated 3 times a week. Risk maps are produced from these forecasts. For forecasts, maps, local contacts and other helpful information please visit our website, http://cdm.ipmpipe.org. If you think you have CDM, please contact your local Extension office.

Phytophthora Blight: To minimize the occurrence of this disease, fields should be adequately drained to ensure that soil water does not accumulate around the base of the plants. Just before plants begin vining, subsoil between rows to allow for faster drainage following rainfall.

Belly Rot: Belly rot is a soil-borne disease. Application of appropriate crop protectant at last cultivation may be helpful.

Weed Management: See the previous "Mulching" section for futher information on weed control under clear plastic mulch.

Nematode Management. Use nematicides listed in the "Nematode Control in Vegetate Crops" tables in the Disease Control section.

POLLINATION

Bees are critical for insuring that pollination and cucumber fruit set occurs. Supplementing a field with bee hives can be especially helpful when native bee populations are low or lacking. Having sufficient bees provides the opportunity to maximize cucumber yields and quality. Lack of sufficient pollination can result in a variety of misshapen fruits; dogbone, crooks, nubs, etc.

Rented honeybee hives are often placed in cucumber fields as plants begins to flower. The timing of hive placement is important because cucumber flowers are not that attractive to honeybees. If the honeybee hives are placed by cucumber fields prematurely before the crop flowers, the honeybees may forage to wild flowers nearby which are more attractive due to their higher nectar and pollen supply. If this occurs, the honeybees may be predisposed to visit these wild flowers even though cucumber flowers are in full bloom a few days later. Assuming that the honeybee hive is a healthy hive, one hive per acre is recommended for hand-harvested pickling and slicing cucumbers with recommended plant populations of approximately 25,000 to 30,000 plants per acre. For mechanical or once-over harvested pickling cucumbers, the recommended plant populations are generally 55,000 to 60,000 plants per acre. Therefore, two honeybee hives should be placed per acre to account for the increased number of flowers from the increased plant population used for mechanically harvested cucumbers. When hybrid cucumbers are grown at high plant populations for machine harvest, flowers require 15 to 20 visits for maximum fruit set. Generally, as the number of visits increase, there will be an increase in the numbers of fruit set and an increase in number of seed per fruit, as well as improved fruit shape and fruit weight.

Bumblebees are an effective pollinator alternative to honeybees in cucumber production. Bumblebees have some advantages compared to honeybees; flying under more adverse weather conditions in which it is cool, rainy or windy. They will also visit flowers earlier in the morning than honeybees, and fly later in the afternoon and early evening when the temperatures cool. Because bumblebees have a larger body size than honeybees, fewer flower visits are required by bumblebees in order to achieve good pollination and fruit set.

As with honeybees, bumblebees should be placed in the cucumber field shortly after the crop begins to flower. Bumblebees will typically last for 6 to 12 weeks and will meet the pollination needs of 2 to 3 sequentially planted cucumber crops.

Bumblebee hives are sold as a quad or four hives per quad. A quad is the minimum order that can be purchased from a supplier. Generally one bumblebee hive contains 200 to 250 bees and is equivalent to one honeybee hive. Thus, one quad of bumblebees (minimum order, contains 4 bumblebee hives) would provide good pollination for four acres of hand-harvested cucumbers. For machine-harvest pickling cucumbers, one quad would provide good pollination for every two acres. Bumblebee hives should not be placed in direct sunlight so that the bees work more efficiently. No more than two bumblebee quads should be placed in one location so that pollination is more uniform in the field. As with honeybees, one must carefully plan when to spray insecticides so that the bumblebees are not killed. Because bumblebees are most active from dawn until late morning and from about 4 PM to sunset, the hives need to be closed around 11 AM so that the bees in the hive remain protected during a late evening spray application. Bumblebee quads should be located a minimum of 650 to 700 feet away from the other quads in order to maximize pollinator efficiency.

See the section on "Pollination" in the General Production Recommendations for additional information.

HARVESTING AND STORAGE

See Table 14 for postharvest information.

EGGPLANT (*Solanum melongena*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
EGGPLANT									
Asian									
Black Shine [2, E]					M				
Calliope [3, O]	A	G		L	M	N	S	T	V
Cambodian Green Giant [7, R]	A	G		L					
Ichiban [2, E]	A	G	K	L	M	N	S	T	V
Kermit [6, R]	A	G		L		N	S	T	V
Pingtung Long [7, E]	A	G				N			
Italian									
Black Bell [2, GL]				L	M			T	
Classic [2, GL]	A	G	K	L	M	N	S	T	V
Dusky [2, GL]	A		K	L	M	N	S	T	V
Epic [2, GL]	A	G	K	L	M	N	S	T	V
Night Shadow [2, GL]	A	G					S	T	V
Santana [2, GL]	A	G	K	L		N	S	T	V
Miniature/Specialty									
Casper [4, E]	A	G			M		S	T	V
Fairy tale [5, E, M]	A	G	K	L	M	N		T	
Ghostbuster [4, OL]	A	G	K		M		S	T	
Gretel [4, E, M]	A	G	K		M		S	T	V
Hansel [2, E, M]	A	G	K			N	S	T	V
Little Fingers [2, E, M]	A		K		M	N		T	
Rosita [7, T]	A	G	K		M	N			

[1] Abbreviations for state where recommended.
[2] Purple/black exterior.
[3] White exterior with purple streaks.
[4] White exterior.
[5] Purple exterior with white stripes.
[6] Green and white exterior.
[7] Lavender exterior.
[R] Round fruit.
[E] Elongated fruit.
[M] Miniature fruit.
[T] Tear drop fruit.
[O] Oval fruit.
[OL] Long, oval fruit.
[GL] Large, oval fruit.

Eggplant is a warm-season crop that makes its best growth at temperatures between 70° to 85°F. Temperatures below 65°F result in poor growth and fruit set.

Seed Treatment. Soak seed in hot water at 122°F for 25 minutes. Dry seed, then treat with an appropriate fungicide to prevent damping-off. Further information on seed treatments can be found in SEED TREATMENTS section starting on page 239.

EGGPLANT PLANTING DATES

	SPRING	FALL
AL North	4/1–7/15	NR
AL South	3/1–4/30	7/15–8/31
GA North	4/15–7/15	NR
GA South	3/1–4/30	7/15–8/31
KY East	5/15-6/1	NR
KY Central	5/10-6/15	NR
KY West	5/1-7/1	NR
LA North	4/15–5/15	7/1–8/15
LA South	3/15–5/15	7/1–8/30
MS North	4/15-6/15	NR
MS South	3/1-4/30	8/1-8/31
NC East	4/15–5/10	8/1–8/15
NC West	5/15–7/15	NR
SC East	4/1–4/30	8/1–8/31
SC West	5/1–6/30	NR
TN East	4/25-7/15	NR
TN West	4/15-6/15	NR

EGGPLANT PLANTING DATES (cont'd)

	SPRING	FALL
VA East (coastal)	5/1-6/30	NR
VA West (mountains)	5/15-6/30	NR

Spacing. *Rows:* 4 to 5 feet apart; plants: 2 to 3 feet apart in the row.

Staking. Staking eggplant improves quality and yield, while reducing decay. Use a 5 foot tomato stake between every other plant and place string along each side of the plants as they grow. This is described in detail in the tomato section of this guide. Side branches of eggplant should be pruned up to the first fruit and 2 main stems should be used. If additional stems grow too large remove them. The first fruit should be pruned off until the flower is at least 8 inches above the ground, this will allow for straight fruit to form.

Transplant Production. Sow seed in the greenhouse 8 to 10 weeks before field planting. Three to 4 ounces of seed are necessary to produce plants for 1 acre. Optimum temperatures for germination and growth are 70° to 75°F. Seedlings should be transplanted to 2-inch or larger pots or containers anytime after the first true leaves appear, or seed can be sown directly into the pots and thinned to a single plant per pot. Control aphids on seedlings in greenhouse before transplanting to field.

Transplanting Dates. Harden plants for a few days at 60° to 65°F and set in field after danger of frost and when average daily temperatures have reached 65° to 70°F.

Drip Irrigation and Fertilization. After mulching and installing the drip irrigation system, the soluble fertilizer program should be initiated using the following table. On low to low-medium boron soils, also include 0.5 pound per acre of actual boron.

The first soluble fertilizer application should be applied through the drip irrigation system within a week after field-transplanting the eggplant. Continue fertigating until the last harvest.

SUGGESTED FERTIGATION SCHEDULE FOR EGGPLANT* (high soil potassium)

Days after planting	Daily nitrogen	Daily potash	Cumulative	
			Nitrogen	Potash
	(lb / A)			
Preplant			50.0	100.0
0-22	0.5	0.5	60.5	110.5
22-49	0.7	0.7	80.1	130.1
50-70	1.0	1.0	101.1	151.1
71-91	1.1	1.1	124.2	174.2
92-112	1.0	2.0	145.2	195.2

ALTERNATIVE FERTIGATION SCHEDULE FOR EGGPLANT* (low soil potassium)

Days after planting	Daily nitrogen	Daily potash	Cumulative	
			Nitrogen	Potash
	(lb / A)			
0-22	0.5	0.5	60.5	111.0
22-49	0.7	1.4	80.1	150.2
50-70	1.0	2.0	101.1	192.5
71-91	1.1	2.2	124.2	238.7
92-112	1.0	2.0	145.2	280.7

*Adjust based on tissue analysis.

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Colorado Potato Beetle (CPB), Flea Beetles (FB): CPB has the ability to rapidly develop resistance to insecticides. Refer to "Eggplant" insecticide section for management options. The use of row covers can be highly effective for flea beetle management early in the season.

Silverleaf Whitefly: Treat when an average of 5 or more adults are found per leaf.

Weed Management. See "Mulching" section for further information on weed control under clear plastic mulch.

RATOONING EGGPLANT: PRODUCING A FALL CROP FROM A SPRING PLANTED CROP

Ratooning eggplants can be done after the first crop is complete to allow a second crop to develop. Depending on the location, the first crop may be completed by June or July. Plants at this point will appear "topped out," not producing any more flowers and any subsequent fruits. Mow plants 6 to 8 inches above the soil line, being sure to leave two to three leaf axils. Next, fertilize with 50 to 60 pounds of nitrogen per acre and 80 to 100 pounds of potash per acre (K_2O). This combination will produce vigorous re-growth and stimulate flowering. Plants will begin producing fruit 4 to 6 weeks after ratooning and should produce eggplants until frost.

HARVESTING AND STORAGE

Eggplant may be harvested once the fruit has reached one-half to full size for a given variety. However, harvesting prior to full size may reduce potential yields.

Harvest-ready fruit have a glossy appearance and are firm, without wrinkles. Harvest eggplant fruit before they become over mature. When over mature, the fruit is dull in color, seeds are hard and dark, and the flesh is characteristically spongy. Although the fruit can often be "snapped" from the plant, they should be clipped with a sharp knife or scissors to prevent damage. When harvesting, cut the stem approximately 1/4 inch from the fruit. Eggplant skin is tender and easily bruised, so handle with care. See Table 14 for further postharvest information.

GARLIC (*Allium sativum*) AND ELEPHANT GARLIC (*A. ampeloprasum*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
GARLIC									
California Early [2, 5]		G							
Chesnok Red [4, 6]						N			
Creole [5]				L					
Duganski [4, 6]	A								
Elephant (also called Tahiti) [3, 5]	A	G	K	L	M	N	S	T	V
German Extra Hardy [4, 7]	A		K			N	S	T	V
Italian [2, 5]				L					V
Korean Red [4, 6]	A								
Lokalen [2, 5]	A								
Music [4, 5]						N			
New York White Neck [2, 5]	A					N	S	T	V
Spanish Roja [4, 5]						N			

[1] Abbreviations for state where recommended.
[2] Softneck.
[3] *Allium ampeloprasum* (Broadleaf Wild Leek)
[4] Hardneck.
[5] White cloves.
[6] Purple stripped cloves
[7] White outer skin, red cloves.

Most garlic that is available from retail markets tends to be softneck types. When selecting softneck garlic for planting be sure to secure a strain of softneck garlic from a local grower who has had success with fall-planted garlic. Unlike many strains sold commercially, such a strain should be well adapted to your area to overwinter. Avoid planting the Creole types of softneck garlic in the northern range (also called Early, Louisiana, White Mexican, etc.), because they are not very winter-hardy and do not keep well. Both the Italian and Creole types have a white outer skin covering the bulb, but the Italian type has a pink skin around each clove, whereas the skin around each Creole clove is white. Elephant-type garlic (milder than regular garlic and up to four times larger) may not yield very well when fall-planted in areas with severe cold or extensive freezing and thawing cycles, which cause heaving. Elephant garlic has performed well, however, in western North Carolina when it is well-hilled with soil or mulched with straw. The Italian and Elephant types take about 220 days to mature.

Many of the most productive Italian garlic strains produce seed heads prior to harvest. Whether removed as they form or left intact, they have produced satisfactory yields.

Research in Kentucky and North Carolina has shown that hardneck types of garlic produce superior yields and are more winter-hardy than softneck types. Unlike softneck types, which will produce large numbers of small cloves per bulb; hardneck garlic will produce bulbs with 7-10 large cloves. Hardneck types have a hard "seedstalk" (called a "scape") that is typically removed prior to harvest. Scapes are sometimes sold at farmers markets as a specialty item.

Seed pieces for hardneck garlic are often more expensive and harder to find than softneck types, but improved winter hardiness and bulb quality in the spring in Kentucky suggests that these are preferred for production at more northern latitudes. Results from these states might not translate to all areas of the southeastern US. Consult with your local Extension office to find appropriate cultural information for your area.

Soil Fertility. Maintain a soil pH of 6.2 to 6.8. Fertilize according to soil test recommendations for garlic. In moderately fertile soils, apply about 75 pounds nitrogen (N) per acre, 150 pounds phosphate (P_2O_5) per acre and 150 pounds potash (K_2O) per acre and disk about 6 inches deep before planting. When plants are about 6 inches tall (about March 15), topdress with 25 pounds per acre nitrogen and repeat the top dressing about May 1. Apply all top dressings to dry plants at midday to reduce chance of fertilizer burn.

Because sulfur may be partially associated with the extent of pungency, you may wish to use ammonium sulfate for the last top dressing (May 1). If ammonium sulfate is used, make sure pH is 6.5 to 6.8.

Garlic is commonly grown on muck, sandy, or fine textured soils as long as they are loose and friable. Use of organic matter or cover cropping is important.

Planting. Garlic cloves should be planted during the fall because a chilling requirement must be met for good bulb development. Plant according to the times listed in the following table to ensure that good root systems are established prior to winter. Final bulb size is directly related to the size of the cloves that are planted. Avoid planting the long, slender cloves from the center of the bulb and cloves weighing less than 1 gram.

GARLIC PLANTING DATES

	Planting Dates		Planting Dates
AL North	9/15–11/10	MS	9/15–10/30
AL South	10/1–11/30	NC East	9/15–11/10
GA North	9/15–11/10	NC West	8/15–10/15
GA South	10/1–11/30	SC East	10/1–11/30
KY East	9/1-10/1	SC West	8/15–10/15
KY Central	9/10-10/15	TN East	9/1-11/1
KY West	9/15-11/1	TN West	9/15-11/1
LA North	9/1–11/30	VA East (coastal)	9/15-11/15
LA South	9/1–11/30	VA West (mountains)	9/1-9/30

Spacing. Garlic should be planted 4 by 4 inches apart in triple rows or multiple beds 16 to 18 inches apart. Between-row spacing depends on the equipment available. Clove tops should be covered with 1 to 1.5 inches of soil. The cloves must not be so deep that the soil will interfere with the swelling of the bulbs, nor so shallow that rain, heaving from alternate freezing and thawing, and birds will dislodge them. Vertical placement of cloves by hand gives optimal results. Cloves dropped into furrows are likely to lie in all positions and may produce plants with crooked necks. Garlic has also been grown successfully in Kentucky using plastic mulch as this helps reduce weed pressure during the long growing season.

INSECT MANAGEMENT

Thrips: During hot, dry weather, the population of thrips increases following harvest of adjacent alfalfa or grain. Thrips could therefore present the most serious insect problem on garlic. (See "Onions" in the Insect Control section of this publication). Read and follow specific label directions for use on garlic; if not listed, do not use. Treat if thrips counts exceed an average of 5 thrips per plant.

HARVESTING AND STORAGE

Garlic is ready for harvest in mid-May to mid-June—it must be harvested when around 30% of foliage is starting to yellow or the bulbs will split and be more susceptible to disease. When a few tops fall over, push all of them down and pull a sample. There are only about 10 days to 2 weeks for optimal garlic harvest. Before then, the garlic is unsegmented; much after that period the cloves can separate so widely that the outer sheath often splits and exposes part of the naked clove. Picked at the proper time, each clove should be fully segmented and yet fully covered by a tight outer skin.

Run a cutter bar under the bulbs to cut the extensive root system and partially lift them. The bulbs are usually pulled and gathered into windrows. Tops are placed uppermost in the windrow to protect bulbs from the sun, and the garlic is left in the field for a week or more to dry or cure thoroughly. Curing can also be accomplished in a well-ventilated shed or barn. The bulbs must be thoroughly dried before being shipped or stored. Outdoor curing is not recommended where morning dew can keep it too damp. Bring in for drying immediately from field. Emphasize gentle handling. Cure for about 6 weeks.

After curing garlic, discard diseased and damaged bulbs. Clean the remaining bulbs to remove the outer loose portions of the sheath, and trim the roots close to the bulb. Do not tap or bang bulbs together to remove soil. Braid or bunch together by the tops of the bulbs, or cut off the tops and roots and bag the bulbs like dry onions.

When properly cured, garlic keeps well under a wide range of temperatures. Storage in open-mesh sacks in a dry, well-ventilated storage room at 60° to 90°F is satisfactory. However, garlic is best stored under temperature and humidity conditions required for onions [32°to 35°F and 65% relative humidity]. Garlic cloves sprout quickly after bulbs have been stored at temperatures near 40°F, so avoid prolonged storage at this temperature. Garlic stored at above 70% relative humidity at any temperature will mold and begins to develop roots.

Marketing. New growers should develop a local retail market (roadside stands, night markets, gourmet restaurants), wholesale shipper, or processing market before planting. The demand for garlic is increasing due to recent reports about the health and medical benefits of garlic. The main markets are New York, Philadelphia, Pittsburgh, Washington, D.C., Chicago, and St. Louis.

The markets of the northern and eastern United States will take the bulbs trimmed like dry onions and known as "loose garlic." Frequently, 30 to 50 bulbs are tied in bunches. Bulbs should be graded into three sizes—large, medium, and small. Each string or bunch should contain bulbs of uniform size and of the same variety.

First-class garlic bulbs must be clean and have unbroken outer sheaths. Many of the larger vegetable markets, such as the large chain stores, could retail garlic in the form of clean, uniform cloves, two dozen to a mesh bag. Processors are not particular about having the cloves enclosed in a neat sheath and occasionally accept sprouted bulbs.

Garlic-growing can be very profitable when freshness is stressed and if the tops are braided, tied together, or placed into long, narrow, plastic mesh bags so they can be effectively displayed at roadside or night-market stands

GREENS: MUSTARD (*Brassica juncea*) AND TURNIP (*Brassica rapa* var. *rapa*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
MUSTARD								
Florida Broadleaf	A	G	K	L	M	N	S	T
Garnet Red	A				M			
Green Wave	A		K	L				T
Savannah[2]	A	G	K	L	M		S	T
Southern Giant	A	G	K	L	M	N	S	T
Tendergreen[2]	A	G	K	L	M	N	S	T
TURNIP GREENS								
Alamo	A	G	K	L	M		S	T
All Top	A	G	K	L		N	S	T
Just Right	A				M	N	S	
Purple Top White Globe	A	G	K	L	M	N	S	T
Seven Top	A	G	K	L		N	S	T
Shogoin	A			L		N	S	
Southern Green	A	G	K		M	N	S	
Top Star	A	G						T
Topper			K	L	M		S	T
Tokyo Cross		G		L			S	T

[1] Abbreviations for state where recommended. [2] Spinach-mustard.

Seeding. Greens can be succession seeded throughout the indicated times liated in the table below. The next seeding date should be made when the previous crop is 50% emerged. Seeds emerge in 3-12 days: emergence is temperature dependent, with rapid emergence in warm weather (fall planting) and slower in cool temps (spring planting). Rows should be 12-24 inches apart and in-row spacing should be 1-2 inches.

Soils. Loamy soils will produce greatest yields, but many soil types are suitable. Sandy soils are preferred for cool season and overwintering production. Greens grown in sandy soils are easier to pull from the soil, and easier to clean off soil residue, than those grown in clay soils. Soil pH of 6.0 to 6.5 is desirable.

Fertilizers. Quality greens require quick, continuous growth. A continual supply of nitrogen is essential for good color and tenderness. Applications of nitrogen at planting followed by additional sidedress applications during the growing season, are essential to produce consistent, high quality greens.

Cultivation. In addition to adequate nutrition, consistent irrigation is necessary for good leaf formation. Overhead irrigation should be avoided as it causes favorable conditions for the development of several diseases.

MUSTARD AND TURNIP PLANTING DATE

	Spring	Fall
AL North	2/1–4/30	8/1–9/15
AL South	2/1–5/15	8/1–10/31
GA North	3/15–4/30	8/1–9/15
GA South	2/1–5/15	8/1–10/31
KY East	3/15-4/30	7/1-7/15
KY Central	3/10-4/25	7/15-8/1
KY West	3/1-4/15	8/1-8/15
LA North	2/1–3/15	7/15–10/31
LA South	2/1–3/15	7/15–10/31
MS North	1/20–4/1	7/25–8/20
MS South	1/15–3/1	8/10–9/15

MUSTARD AND TURNIP PLANTING DATES (cont'd)

	Spring	Fall
NC East	2/15–6/30	8/1–9/15
NC West	4/1–8/15	NR
SC East	2/1–6/15	8/1–10/15
SC West	3/15–9/15	NR
TN East	4/1-5/30	7/1-7/30
TN West	2/15-4/15	8/1-8/31

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Aphids: These insects can be serious pests of greens crops. Frequent examinations of the crops are necessary to avoid undetected infestations. Broad-spectrum insecticides used for caterpillar management can lead to aphid infestations.

Caterpillars: Many of the same caterpillars that feed on the large cole crops (cabbage, collard, etc.) will feed on greens. Action thresholds for greens crops are currently lacking, but low levels of caterpillars can be tolerated during the early stages of growth. The use of BTs and other soft materials are encouraged in order to maintain natural enemy populations in the crops.

Flea Beetles: These small insects can be serious pests of greens crops. They are often associated with heavier soils and weedy areas. BTs are ineffective against beetle pests. These materials are generally ineffective against these insects although the new neonictinoid insecticides work well with little effect on natural enemies. Treatment should begin when the infestation is first noticed. Frequent use of broad-spectrum insecticides for flea beetle management often leads to resurgence of other pests. Reflective mulches have been found to be effective in repelling flea beetles.

HARVESTING AND STORAGE

See Table 14 for postharvest information.

BASIL (*Ocimum basilicum*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
BASIL									
Sweet									
Eleonora [4]									V
Genovese [2]	A	G	K	L	M	N	S	T	
Italian Large Leaf [3]	A	G	K	L	M	N	S	T	
Nufar [2,3]	A	G	K	L	M	N	S	T	
Aroma II [2,3]	A	G	K	L	M	N	S	T	
Purple Ruffles	A	G	K	L	M	N	S	T	
Specialty									
Mrs. Burns' Lemon	A	G		L	M	N	S	T	
Sweet Thai (Horapha, Hun Que)	A	G	K	L	M	N	S	T	
Cinnamon	A	G		L	M	N	S		

[1] Abbreviations for state where recommended. [2] Fusarium tolerance/resistance. [3] Suitable for High Tunnel production [4] Downy mildew tolerance.

Cultivation. Sow seed 1/8 inch deep. Basil is an easy to grow tender annual. Plant basil in *late spring after all danger of frost is past*. Grow in full sun in warm, well-drained soil, preferably in raised beds. A light sand to silt loam with a pH of 6.4 is best. Basil may be grown in the field from seed or transplants. Trim transplants to encourage branching and plant in the field when about six inches tall (4 to 6 weeks old).

Double-row plantings on 2 to 4 foot wide beds increase yields per acre and helps to shade out weeds. Planting dates may be staggered to provide a continuous supply of fresh leaves throughout the growing season. For fresh-cut basil production, the use of black plastic mulch is highly recommended. Basil will not tolerate moisture stress; provide a regular supply of water through drip or overhead irrigation.

Fertilization. Do not over fertilize basil. It is generally suggested that 100 pounds each of N, P_2O_5, and K_2O per acre be broadcast and incorporated at time of planting or follow guidelines for fertilization of salad greens. If more than one harvest is made, sidedress with 15 to 30 pounds N per acre shortly after the first or second cutting.

Pest Control. There are few agricultural chemicals registered for use on basil. To keep weed pressure down, use high plant populations, shallow cultivation, and/or mulch. BT products can be used to control various worms and caterpillars. Genovese, Italian Large Leaf, and lettuce leaf varieties are susceptible to Japanese beetles. Japanese beetle traps set about 20 feet away from the basil will help prevent damage. Reflective mulches, beneficial insects, insecticidal soaps, traps, and handpicking may give some level of control of other insect pests. Keep foliage as dry as possible by watering early in the day, or by using drip irrigation to reduce fungal disease. Rotate herbs to different parts of the field each year and remove and destroy all plant debris to reduce soil borne disease.

Fusarium Wilt. Plants infected with this disease usually grow normally until they are 6 to 12 inches tall, then they become stunted and suddenly wilt. Fusarium wilt may persist in the soil for 8 to 12 years. Growers should use Fusarium wilt tested seed or resistant or tolerant varieties.

Basil Downy Mildew. Use clean seed and less susceptible varieties as they become available. Minimize leaf wetness as much as possible. Learn what the disease symptoms look like.

To ensure protection, consider applying fungicides proactively when your Extension agent or agricultural advisor indicates that Cucurbit downy mildew is active in your area. Although these are distinctly diseases, active Cucurbit downy mildew indicates that conditions are favorable for Basil downy mildew development. You can also monitor conditions for Cucurbit downy mildew at http://cdm.ipmpipe.org/

Harvesting and Storage. Leaf yields range from 1 to 3 tons per acre dried or 6 to 10 tons per acre fresh. Foliage may be harvested whenever four sets of true leaves can be left after cutting to initiate growth, but when harvesting for fresh or dried leaves, always cut prior to bloom. Presence of blossoms in the harvested foliage reduces quality. Frequent trimming helps keep plants bushy. For small-scale production of fresh-market basil, the terminal 2- to 3-inch long whorls of leaves may be cut or pinched off once or twice a week. This provides a high-quality product with little stem tissue present. Basil can also be cut and bunched like fresh parsley. A sickle bar type mower with adjustable cutting height is commonly used for harvesting large plantings for fresh and dried production. The optimum storage temperature for fresh basil is 40° to 45° F with a high relative humidity.

PARSLEY (*Petroselinum crispum*) AND CILANTRO (*Coriandrum sativum*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
PARSLEY									
Curly Leaf									
Banquet	A	G	K	L	M	N	S	T	V
Forest Green	A			L		N	S	T	V
Moss Curled	A					N	S		V
Flat Leaf									
Dark Green Italian	A			L			S		
Giant of Italy	A			L		N			V
Plain Italian Green	A	G	K	L	M	N	S	T	V
CILANTRO									
Calypso[2, 3]	A					N			
Jantar Long Standing[3]	A	G		L	M	N	S	T	V
Leisure									V
Marino									V
Tubro II[4]									V
Santo[3]	A		K	L		N	S	T	V

[1] Abbreviations for state where recommended. [2] Fusarium resistance. [3] Suitable for High Tunnel production. [4] Heat tolerant/slow bolting.

Parsley is a biennial grown as an annual. There are two varietal types of parsley: flat-leaf and curled leaf. Flat leaf parsley tends to be more aromatic than the curled leaf and is used for flavoring in cooking. Curled leaf parsley is more attractive and is primarily used as a garnish. Cilantro is a fast growing annual that is cultivated for its fresh leaves. The seeds of the cilantro plant are referred to as the spice coriander. Parsley and cilantro are best cultivated as cool season crops in the southeast.

Seeding and Spacing. Neither parsley nor cilantro transplant well due to their taproots which are typical of plants in the Apiaceae. Direct seeding is recommended and is best achieved when using a precision seeder. Multiple plantings every 1-3 weeks are necessary for a season-long supply. Parsley seed is slow to germinate (12-25 days, temperature dependent). Seed is viable for 3-5 years but its percentage germination reduces quickly after 1 year.

Seed is sown 1/3 to ½ inches deep in a well-prepared seed bed. Seeding rates are from 16 to 24 pounds per acre (1/4 oz. per 100 row feet) for parsley and 15 to 50 pounds per acre (1-2 oz. per 100 row feet) for cilantro. Spacing between single rows is 15 to 18 inches. Parsley and cilantro can be precision seeded into raised beds with 3 to 4 rows per bed. Final in-row spacing should be 6 to 8 inches for parsley and 2 to 5 inches for cilantro. Research has shown that maximum yields can be achieved with more closely spaced plants.

PARSLEY/CILANTRO PLANTING DATES

	Spring	Fall
AL North	3/15–5/30	NR
AL South	2/1–3/31	8/1–9/30
GA North	3/15–5/30	NR
GA South	2/1–3/31	8/1–9/30
KY East	5/10-7/10	NR
KY Central	5/1-7/20	NR
KY West	4/15-7/1	NR
LA North	2/15–4/15	9/15–10/31
LA South	2/1–4/15	9/15–10/31

PARSLEY/CILANTRO PLANTING DATES (cont'd)

	Spring	Fall
MS	NR	8/1–9/30
NC East	2/15–4/15	8/1–9/30
NC West	4/1–8/15	NR
SC East	NR	9/1–11/15
SC West	NR	8/15–9/30
TN East	4/1-8/1	NR
TN West	4/1-5/30	8/1-9/1
VA East (coastal)	3/15-5/15	8/1-9/15
VA West (mountains)	4/15-8/15	NR

Cultivation. Parsley and cilantro grow best in a well-drained, organic loam soil with soil pH between 6.5 and 7.5. Overhead irrigation is essential for stand establishment. Irrigation during the germination period and the 2-3 weeks following emergence are critical. Too little water at any point will result in diminished leaf yield. Long, warm periods with too little water results in bolting which is undesirable since the plants are grown for their leaves. In addition, bolting reduces the amount, quality, and flavor of the leaves.

Cilantro cultivars are divided into "temperature sensitive" and "slow-bolt" groups. When high temperatures and daylight greater than twelve hours occur, temperature sensitive cultivars tend to set flowers in as little as three weeks following germination. Cilantro responds well to growth stimulators (gibberellic acid, folcyteine, extracts of marine algae) to maximize leaf production. Premature bloom can be delayed through the use of these foliar sprays.

Both parsley and cilantro are weak competitors with other plants. Weed control is critical throughout the season and will also make harvest more efficient.

SPECIAL NOTES FOR PEST MANAGEMENT

There are few agricultural chemicals cleared for use on parsley and cilantro. Weed control is important and can best be obtained by using black plastic mulch and cultivation. Parsley and cilantro

are prone to leaf blights, leaf spots, and mildews. Any approved fungicides should be sprayed as soon as symptoms appear. Cultural controls include the use of drip irrigation, crop rotation, and limited movement through the fields during wet conditions.

Root and crown rot of parsley is best controlled by a two-year crop rotation with non-susceptible plants. Swallowtail caterpillars feed on parsley and are present in large numbers in late summer months. Row covers while swallowtail butterflies are present may reduce damage by blocking butterfly access to plants for egg laying.

Harvesting and Storage. Parsley and cilantro are usually harvested by hand and bunched with rubber bands or twist ties in the field. Cutting entire plants 1.25 to 3 inches above the crown may result in secondary growth sufficient to allow for another harvest. Average yield for both parsley and cilantro is 30-40 pounds per 100 row feet of row. Maximum biomass usually occurs at 40-45 days after germination for cilantro and at 75-90 days for parsley. Multiple harvests are more likely with parsley than cilantro. Store parsley and cilantro at 32° F with high humidity. See Table 14 for further postharvest information.

HOPS (*Humulus lupulus*)

HOPS (*Humulus lupulus*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
HOPS								
Cascade	A				M	N		
Canadian Red Vine						N		
Chinook						N		
Columbus [2]						N		
Comet								
Galena						N		
Nugget						N		
Zeus [2]						N		

[1] Abbreviations for state where recommended. [2] Also know as CTZ. There is evidence that Columbus, Tomahawk and Zeus are closely related.

Hops (*Humulus lupulus*) are a new crop for the Southeastern U.S. Most hops in the United States are grown in the Pacific Northwest in Washington, Oregon, and Idaho. Hops are photoperiod sensitive plants (short-day plants). Commercial hops varieties produce the highest yields in the most northern states.

In short-day areas (below the 35th latitude), flowering occurs too soon when the required number of nodes for a particular variety are produced. As a result, yields are not maximized. In longer day areas (above 35th latitude), vegetative growth is maximized prior to the point where day length begins to shorten in mid- to late summer.

Yields noticeably decrease the further south the plants are grown, particularly below the 35th latitude. Breeding efforts are underway to produce varieties specifically for the Southern U.S. In the meantime, there are cultural practices that can be used to increase yields in Southern hop yards. Most of the information currently available for hops production pertains to large-scale production in the Pacific Northwest or from the emerging industries in the Great Lakes and the Northeast. That information can be helpful, but the differences in photoperiod, disease incidence, lack of infrastructure for processing, and scale of production require adapting it to suit conditions in the Southeast.

Hops are herbaceous perennials with long-lived underground crowns. Each year the plants send up multiple shoots (called bines) which bear papery cones (flowers) that are the plant parts that are harvested for making beer and herbal products. When mature, the cones contain bright yellow, sticky lupulin glands that contain the fragrance and bittering compounds that hops are valued for. Each year the bines can grow to be up to 25 feet long, so they need to be trellised. Hops have male and female plants, but only female plants are grown commercially so the cones do not contain seeds.

Hops are an expensive crop to establish because of the need for a permanent, tall trellis system. Short hop varieties are being bred, but at this time the common varieties need to be grown on tall trellises. There are several trellis designs available that are suitable for production in the Southeast. Most trellises are 16 to 18 feet tall and composed of locust or cedar posts and wire. The bines are trained to strings (often coir twine that is replaced annually) suspended from the top wires of the trellis.

Hops require a well-drained, fertile soil with a pH of 6.0 to 6.5. Hops are heavy feeders and soil tests should be taken annually to determine how to provide adequate nutrition. Hops also require irrigation which is usually supplied as drip-irrigation.

Varieties. Cascade is the variety that has proven to be most reliable throughout the Southeast. It is an aroma hop and is used by most brewers. Growers are encouraged to talk to their customers to identify other varieties to experiment with. Growers in the Southeast have not been very successful growing the Noble varieties.

Pruning. To encourage flowering at the proper time for increased yields, emerging hop shoots are often cut to the ground in the spring until late April. Then several shoots are selected to be trained to each string. The remaining emerging shoots are kept pruned away. The foliage from the lower four feet or so of the plant is mechanically or chemically removed to encourage good air movement around the plants.

Harvesting. Cones are harvested in mid to late summer. Small-scale growers often hand-pick cones multiple times during the season. As the hop yard expands, however, this becomes impractical and most growers move to a one-time harvest which involves cutting the bines, removing them from the yard, and running them through a mechanical harvester which separates the cones from the foliage, bines, and strings.

Cones can be sold as fresh (wet), whole cones to brewers for making seasonal ales. More commonly, hops are dried in a dryer called an oast. A few brewers use whole dried cones, but most brewers require dried hop pellets. Hops quality is determined by chemical analysis which includes alpha and beta acids and essential oils. Most brewers will want these numbers before purchasing hops. How the hops are grown, when they are harvested, and how they are handled after harvesting and stored will greatly affect these values.

SPECIAL NOTES FOR PEST MANAGEMENT

Disease, insect, and weed control strategies for the Southeast are still being developed. Downy mildew is the primary disease that growers need to be prepared to manage and should be a major consideration when choosing varieties. There are many other diseases, including viruses and viroids, that affect hops and that a grower should be scouting for. The major insects are spider mites, Japanese beetles, leafhoppers, and comma butterflies. Weed control should be planned for in advance and may include use of herbicides, landscape fabric, and other mulches. A good air-blast sprayer will be needed to provide good spray coverage up to the top of the trellis.

LEEKS (*Allium porrum*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
LEEKS								
Alcazar	A					N	S	T
Chinook	A							
Lancelot	A	G				N	S	T
Tadorna	A					N	S	

[1] Abbreviations for state where recommended.

Transplants. Transplants are used for early spring plantings. For summer planting, sow in seed beds as indicated in following table. About 2 pounds of seed are required to provide enough plants to set an acre. Seed should be planted 1/3 to 1/2 inch deep 8 to 12 weeks before field setting. Plants will be ready to set in early August. Plug cells have worked well.

LEEK PLANTING DATES

	Spring	Fall
AL North	3/15–4/30	9/15-10/31
AL South	2/1–3/31	NR
GA North	3/15–4/30	9/15–10/31
GA South	2/1–3/31	NR
KY East	4/1-6/15	NR
KY Central	3/25-7/1	NR
KY West	3/15-7/15	NR
MS	NR	NR
NC East	2/15–6/30	NR
NC West	4/1–8/15	NR
SC East	2/1–6/15	NR
SC West	3/15–6/30	NR
TN East	4/1-6/30	NR
TN West	3/15-8/1	NR

Field Spacing. *Rows:* 20 to 30 inches apart; *plants:* 4 inches apart in the row. Set plants in trenches 3 to 4 inches deep.

Culture. Leeks grow slowly for the first 2 or 3 months. To develop a long white stem, start to gradually fill in trenches and then hill soil around stems to 3 or 4 inches.

There has been limited success growing leeks in Alabama, Louisiana, Kentucky and Tennessee. They can be grown for direct market sales, but wholesale production is not currently recommended. At this time there are no varieties recommended for these states.

HARVESTING AND STORAGE

Spring-transplanted leeks are ready for harvest in July. Fall-transplanted leeks are ready to harvest by July. Fall-planted leeks are ready by November and can be overwinterted. See Table 14 for postharvest information.

LETTUCE (*Lactuca sativa*), ENDIVE (*Cichorium endivia*), AND ESCAROLE (*C. endivia*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
LETTUCE								
Green Leaf								
Grand Rapids		G	K	L		N	S	
Green Star	A							T
Nevada	A			L		N		
Salad Bowl	A	G	K	L	M	N		T
Sierra	A			L				
Slobolt	A					N	S	T
Tango	A		K	L		N		T
Tehama[3]				L		N	S	
Two Star	A			L	M	N	S	
Red Leaf								
New Red Fire[4]	A	G	K	L	M	N	S	T
Red Express[4]						N	S	
Red Sails[4]	A		K	L		N		T
Ruby[4]				L		N		T
Cos / Romaine								
Coastal Star	A							T
Green Forest	A		K	L		N	S	T
Green Towers	A	G	K	L		N	S	T
Ideal Cos			K	L		N	S	T
Parris Island Cos	A		K	L			S	T
Ridgeline				L				
Sunbelt[2]	A	G				N	S	
Valley Heart[2]	A					N	S	
Winter Destiny[3, 5]		G						
Butterhead								
Adriana	A			L		N		T
Buttercrunch	A	G	K	L		N	S	T
Caliente				L				
Ermosa	A		K	L		N	S	
Esmeralda	A	G	K	L		N	S	T
Harmony				L				
Nancy	A		K			N		T
ENDIVE								
Galia Frisse	A	G				N	S	
Salad King	A	G	K	L		N	S	T
ESCAROLE								
Full Heart Batavian	A		K	L		N	S	T
Full Heart 65	A					N	S	

[1] Abbreviations for state where recommended.
[2] Recommended for fall production only (bolting susceptible).
[3] Bolting resistant.
[4] Red.
[5] Bibb-Romaine type.

Lettuce and endive are cool-season crops. Properly hardened lettuce transplants can tolerate temperatures as low as 20° to 25°F. Temperatures above 85°F for several days will cause seed stalk formation and bolting in lettuce. Temperatures below 70°F during the seedling stage promote premature stalk formation in endive and escarole.

Due to a number of factors such as length of time to harvest, the production of head lettuce is not recommended in the regions covered by this handbook.

Seeding and Transplanting. *Spring crop*. Lettuce transplants are started in frames or greenhouses. Seed for the lettuce crop is sown in heated greenhouses in November to February at the rate of 4 to 6 ounces of seed for 1 acre of plants.

Direct-seeded lettuce is sown in prepared beds as early in the spring as the ground can be worked. Seed should be sown shallow—some of the seed will actually be uncovered and visible. Pelleted seed should be watered at night during high-temperature periods (soil temperatures above 80°F) until germination occurs.

LETTUCE *LEAF AND BUTTERHEAD* PLANTING DATES

	Spring	Fall
AL North	4/15–5/30	8/1–9/30
AL South	2/1–4/15	8/1–10/15
GA North	4/15–5/30	8/1–8/30
GA South	2/1–4/15	8/1–10/15
KY East	4/1-4/30	NR
KY Central	3/25-4/15	NR
KY West	3/15-4/1	NR
LA North	1/15–3/15	9/15–10/30
LA South	1/15–3/15	9/15–10/30
MS North	3/15-4/30	8/1-9/30
MS South	2/1-4/15	8/1-10/15
NC East	2/1–4/20	8/25–10/1
NC West	3/1-8/25	NR
SC East	2/1–4/15	9/15–11/1
SC West	3/1–5/15	NR
TN East	3/15-4/30	8/1-9/1
TN West	3/1-4/15	8/15-9/15

LETTUCE *COS / ROMAINE* PLANTING DATES

	Spring	Fall
AL North	4/15–5/30	8/1–9/15
AL South	2/1–3/31	8/1–9/30
GA North	4/15–5/30	NR
GA South	2/1–3/31	8/1–9/30
KY East	4/1-4/30	NR
KY Central	3/25-4/15	NR
KY West	3/15-4/1	NR
LA North	1/15–3/15	9/15–10/30
LA South	1/15–3/15	9/15–10/30
MS	NR	NR
NC East	2/1-4/10	8/25-9/15
NC West	3/15-8/1	NR
SC East	2/1-4/15	9/15-11/1
SC West	3/1-5/15	NR
TN East	3/15-4/30	8/1-9/1
TN West	3/1-4/15	8/15-9/15

ENDIVE/ESCAROLE PLANTING DATES

	Spring	Fall
AL North	4/15-5/30	8/1-9/15
AL South	2/1-3/31	8/1-9/30
GA North	4/15-5/30	NR
GA South	2/1-3/31	8/1-9/30
KY East	4/1-4/30	NR
KY Central	3/25-4/15	NR
KY West	3/15-4/1	NR
LA North	1/15–3/15	9/15–10/30
LA South	1/15–3/15	9/15–10/30
MS	NR	NR
NC East	3/20-6/15	8/1-9/15
NC West	5/1-8/15	NR
SC East	2/1-4/15	9/15-11/1
SC West	3/1-5/15	NR
TN East	3/15-4/30	8/1-9/1
TN West	3/1-4/15	8/15-9/15

Mulching. Using polyethylene mulch can be very beneficial for all types of lettuce and endive, in that the plastic reduces the amount of soil that gets inside the leaves. Use white plastic when air temperature exceeds 85°F. Most leaf lettuce varieties can be planted in 3 or 4 rows to the 30 inch bed top. In row spacing should be 9 to 12 inches and between row spacing should be 9 to 12 inches. Romaine types do best with 2 or 3 rows per bed and 12 to 15 inches in row spacing.

SPACING

Lettuce: Leaf and Butterhead type lettuce are planted 3 to 4 rows per bed with beds spaced 66 to 72 inches on centers. Space plants 9 to 12 inches apart in the row. Use black plastic in spring and white plastic when mean daily temperature at planting is >85°F.

Endive/Escarole: Plant three to four rows per bed and space beds 66 to 72 inches on centers. Space plants 9 to 15 inches apart in the row.

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Keep lettuce fields isolated from endive and escarole for spray purposes.

Thrips: Scout for thrips and begin treatments when observed. Do not produce vegetable transplants with bedding plants in the same greenhouse.

Leafhopper: Control of leafhoppers will prevent spread of lettuce yellows. In the spring, spray when plants are one-half inch tall; repeat as needed. In the fall, spray seedlings 4-5 times at 5-day intervals.

Corn Earworm (CEW): **Note.** Head lettuce seedlings, in the 7 to 18 leaf stage, are vulnerable to CEW attack in August to September. Control must be achieved before center leaves start to form a head (15 to 18 leaf stage).

Tarnished Plant Bug: This insect can cause serious damage to the fall crop; it is usually numerous where weeds abound.

HARVESTING AND STORAGE

See Table 14 for postharvest information.

MELONS (*Cucumis melo*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
CANTALOUPES and MIXED MELONS								
Eastern								
Accolade [4, 5, 7, 8, 9, 11]							S	
Avatar [2, 4, 5, 7, 8, 9]	A		K				S	T
Ambrosia [2, 3, 6]	A			L	M	N	S	T
Aphrodite [4, 5, 7, 8, 9, 11]		G	K	L	M	N		T
Astound [4, 5, 7, 8, 9, 11]							S	
Atlantis [2, 4, 5, 7, 8, 9]	A		K			N	S	T
Athena [4, 5, 7, 8, 9, 11]	A	G	K	L	M	N	S	T
Magenta [14]						N		
Majus [4, 5, 7, 8, 9, 14]			K					
Sunny Dee [7, 8, 9]			K				S	
Timeless Gold [7, 8, 9, 12]			K				S	
Tirreno [4, 5, 7, 8, 9, 14]	A		K					
Proteo [14]	A					N		
Western								
Caribbean Gold [12]	A	G				N	S	T
Fiji [4,5,7,9,12]	A					N	S	
Infinite Gold [5,7,8,9,12]	A					N	S	
Mission [6]	A				M			
Origami [4, 5, 7, 8, 9, 12]	A	G				N	S	T
Samoa [4, 5, 7, 8, 9, 12]	A	G	K			N	S	T
Honeydew								
Dew Dream [4, 5, 7, 8, 9]	A						S	
Honey Yellow	A	G				N	S	T
Santa Fe						N	S	
Saturno [6, 7, 9]	A					N	S	
Summer Dew [4, 5, 8, 9, 10]		G	K			N	S	T
Temptation [13]			K					T
Galia								
Esmeralda						N		
Galia [4]	A	G				N	S	T
Honey Ace [6, 10]	A	G				N	S	
Juan Canary								
Golden Beauty [6]	A	G	K			N		T
Sunbeam [4, 5, 7, 8, 9]	A	G				N	S	
Oriental (Asian type)								
Sprite (Crisp flesh type)	A	G	K			N	S	T

[1] Abbreviations for state where recommended.
[2] Local markets only.
[3] Downy Mildew tolerance/resistance (DM).
[4, 5] Powdery Mildew race 1 or 2 tolerance/resistance (PM).
[6] Powdery Mildew tolerance/resistance (non-race specific).
[7, 8, 9] Fusarium Wilt race 0,1, or 2 tolerance/resistance (FW).
[10] Fusarium Wilt tolerance/resistance (non-race specific).
[11] Tolerant to sulphur.
[12] Extended shelf-life type.
[13] Orange-fleshed honeydew.
[14] Tuscan/Italian netted type.

Melon Types. Most growers and consumers are familiar with cantaloupes and honey dew melons. Cantaloupes turn beige and slip from the vine when ripe and have an orange, sweet flesh. Cantaloupes are typically separated into two categories; eastern and western. Eastern types are sutured, larger and generally have a shorter shelf life (a few days) than western types. Many eastern types are only suited for local markets, while improved eastern varieties such as 'Athena' have a longer shelf life and can be shipped to more distant markets. Western types typically are not sutured, are round with a corky beige netting, and usually have a two-week shelf life.

Honeydew melons generally have smooth rinds with some corky striations becoming obvious as the fruit nears or becomes ripe. These fruit do not slip like cantaloupe. Rind color can vary among varieties. Most are an off-white or beige but some have a yellow rind. Flesh color is typically light green, firm, and honey dews are sweeter than cantaloupes. Honey dew melons are typically grown in the southwestern United States in arid, dry climates. In the southeastern United States, honey dew fruit are more susceptible to cracking or splitting open. This is due to the uneven, high moisture conditions often encountered in the southeastern United States.

Other specialty melons include Galia, Juan Canary, and oriental crisp-flesh types. The Galia type melon rind normally turns from green to golden yellow and will slip from the vine when ripe. The flesh is soft and white to light green, and the fruit produces a strong odor. The Juan Canary melons have a bright yellow rind when ripe but will not slip from the vine. Flesh color is white to very pale green. The oriental crisp-flesh melons have a crispy white flesh and have white and/or yellow rinds. Some types are more bland, while others are more sweet like the variety Sprite.

Plant Production. Transplants should be grown in pots or cells that provide a space of *at least* 1.5 inches by 1.5 inches for each plant.

Smaller pots or cells will restrict root growth and provide less protection to the newly set transplant. If the seed is of good quality with a high germination test, one seed per pot is sufficient. One ounce of melon seed contains 950 to 1,250 seeds.

The required amount of seed can then be estimated using Tables 6 and 7 and knowing how many seeds make up an ounce of the desired variety.

Planting and Spacing. Transplant or seed when daily mean temperatures have reached 60°F. Temperatures below 45°F can stunt plant growth. Consult the following table for planting dates in your area. Early plantings should be protected from wind with row covers or rye strips. Plantings can continue until about 100 days before first frost.

Normal in-row spacing for melons is 1.5 to 2 feet on plastic mulch and 2 to 4 feet on bare ground. Typically, an average of 7.5 to 15 ft^2 should be allocated per plant on plastic mulch. On bare ground, 20 to 25 ft^2 should suffice per plant.

MELON PLANTING DATES

	Spring	Fall*
AL North	4/15–6/15	8/1–8/30
AL South	3/1–6/30	8/1–9/15
GA North	4/15–6/15	NR
GA South	3/1–4/30	8/1–9/15
KY East	5/15-6/15	NR
KY Central	5/10-7/1	NR
KY West	4/25-7/15	NR
LA North	4/1–6/30	7/1–7/31
LA South	3/15–6/30	7/1–8/15
MS North	4/1–4/10	NR
MS South	3/1–3/15	NR
NC East	4/15–5/15	7/1–7/15
NC West	5/15–7/31	NR
SC East	3/15–5/15	7/1–7/30
SC West	4/15–6/5	NR
TN East	5/5-6/15	NR
TN West	4/15-6/1	NR

*Use transplants for later season plantings.

Drip Fertilization. Before mulching, adjust soil pH to 6.5 and in the absence of a soil test apply fertilizer to supply 25 pounds per acre of N, P_2O_5 and K_2O, (some soils will require 50 pounds per acre of K_2O), then thoroughly incorporate into the soil. After mulching and installing the drip irrigation system, the soluble fertilizer program should then be initiated according to that described in the table below. On low to low-medium boron soils, also include 0.5 pound per acre of actual boron. The first soluble fertilizer application should be applied through the drip irrigation system within a week after field transplanting or direct seeding the muskmelon. Continue fertigating until the last harvest.

SUGGESTED FERTIGATION SCHEDULE FOR MELON* (low potassium soil)

Days after planting	Daily nitrogen	Daily potash	Cumulative Nitrogen	Cumulative Potash
	(lb / A)			
Preplant			25.0	50.0
0-28	0.9	1.8	50.2	100.4
29-49	1.3	2.6	77.5	155.0
50-77	1.5	3.0	119.5	239.0
78-91	0.7	1.4	129.3	258.6

SUGGESTED FERTIGATION SCHEDULE FOR MELON* (high potassium soil)

Days after planting	Daily nitrogen	Daily potash	Cumulative Nitrogen	Cumulative Potash
	(lb / A)			
Preplant			25.0	50.0
0-28	0.9	0.9	50.2	75.2
29-49	1.3	1.3	77.5	102.5
50-77	1.5	1.5	119.5	144.5
78-91	0.7	0.7	129.3	154.5

*Adjust based on tissue analysis.

Plastic Mulch. The use of plastic mulch is especially beneficial when growing melons. It reduces the amount of fruit rots and often results in significant increases in yields than if the crop is grown on bare ground. Black embossed plastic mulch is generally used to increase soil temperatures in the spring as well as provide weed control, and fertilization and irrigation efficiency. Fruit maturation is usually quickened with the use of plastic. White plastic can be used instead of black plastic mulch when air temperatures exceed 85°F to reduce excessive heat that can occur under black plastic at the later planting dates. Spacing on plastic mulch is typically 5 to 6 feet between rows and 18 to 30 inches in-row. Marketable yields will generally range between 7,000 to 10,000 fruit per acre when grown on black plastic mulch.

SPECIAL NOTES FOR PEST MANAGEMENT

DISEASE MANGEMENT

Cucurbit Downy Mildew Forecasting System: Cucurbit downy mildew (CDM) is a devastating foliar cucurbit disease. While difficult, if not impossible to control, CDM can be prevented by using effective IPM practices. A useful tool for prevention of CDM is the CDM forecasting system. This program depends on the accurate reporting of CDM in the field as well as the monitoring of over 50 strategically placed sentinel plots. These plots are monitored by Plant Pathologists at multiple Land Grant Universities throughout the United States and Canada. Forecasts of the epidemic movement of the disease are generated 3 times a week. Risk maps are

produced from these forecasts. For forecasts, maps, local contacts and other helpful information please visit our website, http://cdm.ipmpipe.org. If you think you have CDM, please contact your local Extension office.

INSECT MANAGEMENT

Seed Corn Maggot (SCM): Use insecticide treated seed or at-planting soil-insecticide treatments to avoid SCM in the early season. SCM problems subside with later plantings.

Cucumber Beetle: Cucumber beetles transmit bacterial wilt, and most cultivars of muskmelons are highly susceptible to this disease. Also adult beetles can cause direct feeding injury to young plants. Foliar insecticides should be used to control adult beetles before they feed extensively on the cotyledons and first true leaves. Begin spraying shortly after plant emergence and repeat applications at weekly intervals if new beetles continue to invade fields. Treatments may be required until vining, at which time plants are less susceptible to wilt infections.

Pickleworm, Melonworm: Make one treatment prior to fruit set, and then treat weekly.

Aphids: Aphids can delay plant maturity. Thorough spray coverage beneath leaves is important. For further information on aphid controls, see the preceding section on "Mulches and Row Covers." Treat seedlings every 5 to 7 days or as needed.

Squash Bug: Begin treatments shortly after vining. Treat every 7 to 10 days or as needed.

Leafhoppers: High numbers of potato leafhoppers cause leaf yellowing (chlorosis) known as hopper burn, which will result in yield loss.

POLLINATION

Honeybees are important for pollination, high yields, and quality fruit. Populations of pollinating insects may be adversely affected by insecticides applied to flowers or weeds in bloom. Apply insecticides only in the evening hours or wait until blooms have closed before application. See section on "Pollination" in the General Production Recommendations.

HARVESTING AND STORAGE

Cantaloupes should be harvested at quarter-to half-slip for shipping. Healthy vines and leaves must be maintained until melons are mature to obtain high-quality melons. Harvest daily or twice daily in hot weather. See Table 14 for further postharvest information. Many other types of melons do not slip and judging maturity can be difficult. Many melons will change their water not color. It is critical to be familiar with the unique character of each melon.

OKRA (*Abelmoschus esculentus*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
OKRA								
Annie Oakley II[2]	A	G	K	L	M	N	S	T
Cajun Delight	A	G	K	L	M	N	S	T
Clemson Spineless 80	A	G	K	L	M	N	S	T
Emerald	A	G		L		N	S	
Gold Coast				L				
Jambalaya	A							
Lee	A					N	S	
North and South	A				M			T

[1] Abbreviations for state where recommended. [2] Dwarf cultivar.

Okra is a tropical annual which is widely adapted, however, it is very sensitive to frost and cold temperatures and should not be planted until soil has warmed in the spring.

Seeding and Spacing. Generally only one planting is made. For cooler areas, seed in the greenhouse in cells and transplant to the field through black plastic mulch.

For dwarf varieties, space the rows about 3.5 feet apart; for medium and tall varieties, 4 to 4.5 feet apart. Drill seeds 1 to1.5 inch deep, with 3 or 4 seed per foot of row (5 to 7 pounds per acre). Thin plants when they are 5 inches high. Dwarf varieties should be spaced 12 to 15 inches apart in the row; plants of tall varieties should be spaced 18 to 24 inches apart.

OKRA PLANTING DATES

	Spring	Fall
AL North	4/15–6/15	7/15–8/15
AL South	3/1–4/30	8/1–8/30
GA North	5/1–7/15	7/15–8/15
GA South	3/15–4/30	8/1–8/30
KY East	5/15-7/1	NR
KY Central	5/10-7/15	NR
KY West	4/20-8/1	NR
LA North	4/15–5/31	7/1–7/31
LA South	3/15–5/31	8/1–7/31
MS	4/15–6/1	8/1–9/1
NC East	5/1–5/30	8/1–8/30
NC West	5/25–7/31	NR
SC East	5/1-6/30	NR
SC West	5/15–7/15	NR
TN East	5/15-6/15	7/1-7/31
TN West	4/15-6/15	7/25-8/25

Ratooning Okra: Producing a Fall Crop from a Spring Planting. Market price for okra typically declines sharply as the summer progresses. After the market price drops, consider ratooning or cutting back your okra. Ratooning okra will allow the plants to rejuvenate and produce a crop in the fall, when okra prices are generally higher. Cut plants back using a mower, leaving 6 to 12 inches of each plant above the ground. Re-fertilize with 15-0-14, 8-0-24, or 13-0-44 to encourage re-growth and the development of side branches. Fall yields of cutback okra will often exceed that of spring crops or the yields of a crop that is not cut back.

Drip Fertilization. Before mulching, adjust soil pH to 6.5 and in the absence of a soil test apply fertilizer to supply 25 pounds per acre of N, P_2O_5 and K_2O, (some soils will require 50 pounds per acre of K_2O), then thoroughly incorporate into the soil. Apply 1 to 2 pound per acre of actual boron. After mulching and installing the drip irrigation system, the soluble fertilizer program should then be initiated according to that described in the tables below. The first soluble fertilizer application should be applied through the drip irrigation system within a week after field transplanting or direct seeding the okra. Continue fertigating until the last harvest.

SUGGESTED FERTIGATION SCHEDULE FOR OKRA* (low potassium soil)

Days after planting	Daily nitrogen	Daily potash	Cumulative	
	(lb / A)		Nitrogen	Potash
Preplant			25.0	50.0
0-14	0.9	1.8	50.2	100.4
15-28	1.3	2.6	77.5	155.0
29-84	1.5	3.0	119.5	239.0
85-91	0.7	1.4	129.3	258.6

SUGGESTED FERTIGATION SCHEDULE FOR OKRA* (high potassium soil)

Days after planting	Daily nitrogen	Daily potash	Cumulative	
	(lb / A)		Nitrogen	Potash
Preplant			25.0	50.0
0-14	0.9	0.9	50.2	75.2
15-28	1.3	1.3	77.5	102.5
29-84	1.5	1.5	119.5	144.5
85-91	0.7	0.7	129.3	154.5

*Adjust based on tissue analysis.

Plastic Mulching. Polyethylene (black plastic) mulch can offer growers several advantages. Drip irrigation systems must be used with plastic mulch. On plastic mulch, transplant at the three-to four-leaf stage into staggered double rows spaced 15 to 18 inches apart between the double rows. Place plants 12 inches apart.

HARVESTING AND STORAGE

An okra pod usually reaches harvesting maturity 4 to 6 days after the flower opens. The pods are 3 to 3.5 inches long at this stage and are tender and free of fiber.

Pick pods at least every second day to avoid the development of large, undesireable pods. Okra should be kept at temperatures between 50° to 55°F and of 85% to 90% relative humidity. Okra pods are subject to chilling injury below 50°F.

ONIONS (*Allium cepa*) AND GREEN ONIONS (*A. cepa*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
GREEN ONIONS								
Beltsville Bunching [2]	A				M	N	S	
Crystal White Wax				L				
Evergreen Bunching [2]	A		K	L			S	
Ishikura Improved	A		K		M	N	S	
Parade							S	
Southport [2]							S	
White Spear				L			S	
ONIONS (Short Day)								
Amelia (WI-129)		G**						
Century		G**		L				
DP Sweet 1407		G**						
Georgia Boy		G**		L				
Goldeneye	A	G**						
Granex Yellow PRR	A	G**		L		N	S	T
Honeybee		G**						
Miss Megan		G**		L				
Mr. Buck		G**		L				
Red Burgundy [4]				L				
Red Hunter [4]	A						S	
Ringo		G**						
Sapelo Sweet		G**						
Savannah Sweet	A	G**					S	
Solar Candy Ann (SS 2005)		G**						
Sweet Agent		G**						
Sweet Caroline	A	G**		L				
Sweet Harvest		G**						
Sweet Jasper		G**						
Sweet Vidalia	A	G**		L	M			
Texas Early Grano 502				L		N	S	
Texas Grano 1015Y	A			L	M	N	S	
Yellow Granex [3]				L				
ONIONS (Intermediate Day)								
Candy			K	L	M			T
Hiball						N		
Super Star (white)			K	L		N		
Tough Ball						N		

[1] Abbreviations for state where recommended.

[2] Bulbing type.

[3] Also designates a "type" of onion and performance may vary.

[4] Red

**** Georgia Growers note:** To be marketed as "Vidalia," varieties must be on the Georgia Department of Agriculture's "Recommended Vidalia Onion List" and grown in the Vidalia area. All of these varieties can be used for green onions.

Planting and Seeding Dates. In the northern range of the Southeast for dry bulb onions, sets and seed can be planted as soon as soil conditions are favorable in the spring. Plant transplants for bulb onions as indicated in the following table.

Seed for bunching onions can be planted as soon as soil conditions are favorable in the spring and successive plantings can be made throughout the summer in the cooler parts of the Southeast.

On-farm transplant production can be performed in most conditions for dry bulb onion production. In the northern range of the Southeast it may be preferable to purchase transplants. Transplant production should begin by seeding plantbeds from late August to the end of September. A common method of producing transplants is to seed in high density plantings with 30-70 seed per linear foot. Four to five rows are planted 12-14 in. apart on beds prepared on six-foot centers.

For dry bulb onion production from transplants follow planting dates recommended in the following table. Onion production from sets has not worked as well because it is difficult to mechanically orient the sets with the growing point up. Hand planting sets, however, works well for smaller operations.

Direct seeding dry bulb onions can save money on labor and materials. See seeding dates in table below. It is recommended that

coated or encrusted seed be used with a vacuum planter to insure good seed singulation. It is critical that the beds be properly prepared without any previous plant debris. Preplant fertilizer application of 1/5 to 1/4 of required amount with proper bed moisture is recommended. Care should be taken so that the seed is singulating properly, soil is not clogging the seeder, and planting depth is correct (~ 0.25 in.). Watering is required to insure germination and emergence. It may be necessary to apply water more than once a day during periods of hot, dry weather.

Seeding dates for green onions are listed in the table below. Green onions during winter production will require 12-14 weeks. Spring production may be shorter. Green onions can also be produced from transplants.

ONION *DIRECT SEED* PLANTING DATES

	Green Onions	Onions (dry)
AL North	NR	NR
AL South	8/15-10/15	10/5-10/25
GA North	NR	NR
GA South	8/15–10/15	10/5–10/25
LA North	9/15–10/31	9/15–10/31
LA South	10/1–10/31	10/1–10/31
MS North	2/15-3/30	9/15-10/15
MS South	10/15–2/15	9/15-10/30
NC East	8/1–6/15	9/15–10/31
NC West	4/1–8/15	9/1–9/30
SC East	2/15–10/15	9/15–11/15
SC West	3/15–7/30	NR
TN East	9/1-9/30	NR
TN West	NR	NR

ONION *TRANSPLANT* PLANTING DATES

	Onions (dry)		Onions (dry)
AL North	11/1-12/31	MS North	12/15–3/1
AL South	11/1–1/31	MS South	10/1–2/15
GA North	11/1-12/31	NC East	10/1–3/1
GA South	11/1–1/31	NC West	9/15–10/15
KY East	4/1-6/15	SC East	10/1–11/15
KY Central	3/25-7/1	SC West	9/15–10/15
KY West	3/15-7/15	TN East	9/15/10/15
LA North	12/15–1/31	TN West	3/1-3/30
LA South	12/15–1/31		

Spacing. A typical planting arrangement for dry bulb onions is to plant four rows, 12-14 in. apart on beds prepared on six-foot centers. In-row spacing should be 4-6 inches. Row spacing up to 24 in. can be used. For direct seeded onions, set the planter to sow seed with a 3-4 in. in-row spacing.

For green onions, space rows 12 to 16 in. apart and space seed 0.75 to 1.5 inches apart (2-6 pounds per acre). A vacuum planter with a double row planter or a scatter shoe will work well. Seed depth should be 0.25-0.5 inches. Place transplants or sets 1.5 to 2.5 inches deep.

Cultivation. For bunching onions, hill with 1 to 2 inches of soil to ensure white base.

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Soilborne pests are often controlled with a preplant application of a soil insecticide.

Seedcorn Maggot: An early season problem that is common following winter injury to plants or in fields where planting occurs soon after a cover crop has been plowed under.

Cutworms: See cutworm section in Soil Pests-Their Detection and Control.

Thrips: Use a threshold of 5 thrips per plant.

HARVESTING AND STORAGE

See Table 14 for postharvest information

PARSNIP (*Pastinaca sativa*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
PARSNIP								
All American	A	G				N	S	
Harris Model	A		K			N	S	
Javelin						N	S	

[1] Abbreviations for state where recommended.

Seeding and Spacing. Seed as indicated in the following table. Seeds germinate very slowly (taking up to 18 days). Seed more than one-year-old will not germinate. Parsnips need 120 to 180 days to mature and need to mature during cool weather.

Seed 3 to 5 pounds per acre at a depth of ¼ to 3/8 inch in rows 18 to 30 inches apart. Adjust seeder to sow 8 to 10 seeds per foot of row. Thin seedlings to 2-4 inches apart in the row. This will result in parsnips of similar shape and size to a plump carrot. To produce the huge roots popular in some areas, provide a much greater spacing of up to 12" between plants. Do not transplant parsnips.

Cultivation. Cultivate parsnips in a similar manner as to carrots. Do not let the roots dry out too much, as this will lead to cracked, unmarketable roots and bitter flavor.

Yield. Expected yield is 50-75 pounds per 100 row feet or 4 to 4.5 tons per acre.

Harvesting and Storage. Roots are ready for harvest when tops start to die back in autumn. Parsnips may be dug, topped, and then stored at 32°F at 90 to 95% relative humidity. Roots can be stored up to 6 months. Parsnips left in the ground over winter should be removed before growth starts in the spring. See Table 14 for further postharvest information.

Note: Many people develop a rash after contact with the juice that parsnip leaves exude when crushed or torn, especially when handling leaves in the sun. Consider wearing gloves during harvest and handling; do not display parsnips with leaves still attached as is common for fresh market carrots.

PARSNIP PLANTING DATES

	Spring	Fall
AL North	3/15–4/30	8/1–9/15
AL South	2/1–5/15	8/1–9/30
GA North	3/15–4/30	8/1–9/15
GA South	2/1–5/15	8/1–9/30
KY East	4/1–6/1	NR
KY Central	3/20–6/15	NR
KY West	3/10–7/1	NR
LA	NR	NR
MS	NR	NR
NC East	2/15–4/15	8/1–9/30
NC West	4/1–8/15	NR
SC East	2/1–3/31	8/15–10/15
SC West	3/15–4/30	7/15–9/30
TN East	NR	NR
TN West	NR	NR

Harvesting and Storage. Parsnips may be dug, topped, and stored at 32°F at 90% to 95% relative humidity. Storage can be up to 6 months. Parsnips left in the ground over winter should be removed before growth starts in the spring. See Table 14 for further postharvest information.

PEAS (ENGLISH/GARDEN) (*Pisum sativum*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
ENGLISH/GARDEN PEAS								
Green Arrow	A	G	K	L		N	S	T
Knight		G		L			S	T
Novella					M	N		
Oregon Sugar Pod II [2, 3]	A	G	K	L	M	N	S	T
Sugar Ann [3]		G	K	L		N	S	T
Sugar Bon [3]	A			L		N		
Sugar Snap [3]	A	G	K	L		N	S	T
Tall Telephone (Alderman)				L	M	N		

[1] Abbreviations for state where recommended. [2] Flat podded - snow pea. [3] Edible pod type.

Garden peas thrive in cool weather and are frost tolerate . Early plantings can be made as soon as soil can be tilled in the spring. Inoculation of seed can enhance early nodule formation and improve plant development.

Seed Treatment. Use seed already treated with an approved seed treatment, or treat seed with a slurry or dust that contains an approved fungicide.

Seeding and Spacing. For Garden peas and processing peas, plant 3-4 seeds per foot in rows 6-8 inches apart, requiring seed 80-120 pounds per acre in 30 inch rows. Seed at a depth of no more than one inch unless soil is dry. Use press wheel drill or seeder to firm seed into soil.

Seedlings will emerge in 6 to 14 days, weather dependent. Harvesting usually begins 50-75 days after emergence. Average yield of Garden peas is approximately 20 pounds per 100 row feet.

Cultivation. Avoid overfertilization. Too much nitrogen will reduce yields. Garden peas need some type of support structure for best performance and speedier picking. Garden peas should not follow beans or another Legume crop.

Harvesting and Storage. Harvest often. Picking is labor intensive and may need to happen almost daily during peak production periods. Allowing Garden peas to get too large on the vines will greatly reduce production. Larger acreages of Garden peas require mechanical harvesting to be profitable. Leafless type Garden peas, with more tendrils than true leaves, are easier to harvest. Cool Garden peas as soon as possible after picking as their sugars convert to starch at higher temperatures. See Table 14 for further postharvest information.

ENGLISH/GARDEN PEAS PLANTING DATES

	Spring	Fall
AL North	3/15–4/30	8/1–8/31
AL South	2/1–3/31	8/1–9/30
GA North	3/15–4/30	8/1–8/31
GA South	2/1–3/31	8/1–9/30
KY East	3/15-4/15	NR
KY Central	3/1-4/1	NR
KY West	2/20-3/20	NR
LA North	11/15–2/1	NR
LA South	11/15–2/1	NR
MS North	2/10-4/25	NR
MS South	1/25-4/5	NR
NC East	2/15–4/15	8/1–9/30
NC West	4/1–6/15	NR
SC East	2/1–3/15	8/15–11/30
SC West	3/1–4/15	8/15–10/30
TN East	3/15-4/30	NR
TN West	2/15-3/30	NR

PEPPERS (*Capsicum annuum* and related species)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
PEPPER (open pollinated)									
Bell									
Capistrano	A			L	M	N	S		
Jupiter	A			L	M	N	S	T	
Purple Beauty[9]	A				M	N			
Frying type									
Cubanelle	A	G	K			N	S	T	
Sweet Banana	A	G	K	L		N	S	T	
HOT/PUNGENT TYPES (open pollinated)									
New Mexican/Anaheim type									
Anaheim	A	G	K	L		N		T	V
Cayenne type									
Carolina Cayenne[10]						N	S		
Charleston Hot[10]				L	M	N	S		
Large Red Thick				L					
Long Slim Cayenne	A	G			M	N	S		
Habenero / Scotch Bonnet type									
Habañero	A	G	K	L		N	S	T	V
Wax type									
Long Hungarian Wax	A	G	K	L		N	S	T	V
Jalapeño type									
Jalapeño M	A	G		L	M	N	S	T	
Tula[4]	A	G		L		N	S	T	
PEPPER (Hybrid)									
Bell									
Alliance[4, 8 b-f, 11, 13, 14, 15]	A		K			N	S	T	V
Antebellum[3, 8 a-k, 16]		G							
Aristotle[4, 8 b-d]	A	G	K	L		N	S	T	V
Bastille[5, 8 b-k, 15]			K						
Currier[2, 4, 5, 8 b-d, 11, 15]			K						
Karisma[4, 8 b-d, 11, 13, 15]			K						
Camelot X3R[8 b-d]	A		K	L	M	N	S	T	
Declaration[2, 3, 8 b-f, 11]	A	G	K	L		N		T	V
Enterprise[8 b-d]	A						S		
Excursion II[4, 8 b-d, 13]	A		K	L		N		T	
Flamingo[12, 13]	A					N			
Flavorburst[7]	A		K	L		N			
Green Machine[3, 8 a-k, 16]	A	G							
King Arthur[4, 6, 8 c, 13]	A		K	L	M	N	S	T	V
Mecate[4, 7, 8 b-d, 13, 15]	A					N			V
Paladin[2, 13]	A	G	K	L		N			V
Patriot[4, 8 b-f]			K			N	S	T	
Plato[3, 4, 8 b-d]	A			L		N	S		
Polaris[8 b-d]			K			N		T	
PS 09942815[3, 8 b-k]	A	G							
PS 09979325[8 a-k, 16]		G							
Red Knight[4, 8 b-d]		G	K			N	S		V
Red Lion	A					N			V
Revolution[2, 8 b-f, 11]	A		K	L	M	N		T	V
SDY 48[8 a-k]		G							
SV 3255PB[8 a-k, 16]		G							
Sirius[3, 7, 8 b-c]	A								
Tequila[9, 13]	A			L	M	N		T	
Valencia[7, 13]					M	N	S		V

[1] Abbreviations for state where recommended.

[2] Phytophthora Root Rot tolerance/resistance.

[3] Tomato Spotted Wilt Virus tolerance/resistance (TSWV).

[4] Potato Virus Y tolerance/resistance (PVY).

[5] Tomato Mosaic Virus tolerance/resistance (ToMV).

[6] Tobacco Etch Virus tolerance/resistance (TEV).

[7] Mature Yellow fruit or Mature Orange fruit.

[8a, b, c, d, e, f, g, h, i, j, k] Bacterial Leaf Spot resistance for races 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, respectively.

[9] Mature Purple fruit.

[10] Nematode resistance (N).

[11] Cucumber Mosaic Virus tolerance/resistance (CMV).

[12] Fruit mature from White to Red.

[13] Tobacco Mosaic Virus (TMV) tolerance/resistanace.

[14] Pepper Yellow Mosaic virus tolerance/resistance (PYMV).

[15] Pepper Mottle Virus tolerance/resistance (PMV).

[16] Tobamovirus tolerance/resistance (TM).

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
PEPPER (Hybrid)									
Bell (cont'd)									
Vanguard [2, 8 b-f, 11]	A					N	S		V
Wizard [4, 8 b-d]	A	G	K			N	S	T	
Frying type									
Aruba	A	G							V
Banana Supreme	A	G	K	L		N	S	T	
Biscayne	A	G			M	N	S		V
Gypsy	A	G	K	L	M	N			
Key Largo	A	G			M	N	S		V
Ancho/Poblano									
Ancho 101	A								
San Juan	A					N			
San Martin	A		K			N		T	V
Tiburon	A	G			M			T	V
HOT/PUNGENT TYPES (Hybrid)									
Serrano type									
Nazas [5]	A					N			
Cayenne type									
Mesilla [4, 6]								T	V
Super Cayenne II [8 c, 13]	A					N	S		
Habenero / Scotch Bonnet type									
Tiger Paw NR [10]							S		
Jalapeño type									
Compadre [5, 8 c, f]	A	G							
El Rey [8 b-d]	A	G	K	L	M	N		T	V
Inferno	A	G		L		N			
Ixtapa [4, 8 b-d]	A	G	K		M			T	
Mitla [4]	A	G		L	M	N	S	T	
Tormenta [4, 6, 8 b-d]	A			L				T	

[1] Abbreviations for state where recommended.
[2] Phytophthora Root Rot tolerance/resistance.
[3] Tomato Spotted Wilt Virus tolerance/resistance (TSWV).
[4] Potato Virus Y tolerance/resistance (PVY).
[5] Tomato Mosaic Virus tolerance/resistance (ToMV).
[6] Tobacco Etch Virus tolerance/resistance (TEV).
[7] Mature Yellow fruit or Mature Orange fruit.
[8a, b, c, d, e, f, g, h, i, j, k] Bacterial Leaf Spot resistance for races 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, respectively.
[9] Mature Purple fruit.
[10] Nematode resistance (N).
[11] Cucumber Mosaic Virus tolerance/resistance (CMV).
[12] Fruit mature from White to Red.
[13] Tobacco Mosaic Virus (TMV) tolerance/resistanace.
[14] Pepper Yellow Mosaic virus tolerance/resistance (PYMV).
[15] Pepper Mottle Virus tolerance/resistance (PMV).
[16] Tobamovirus tolerance/resistance (TM).

Peppers are a warm-season crop that grow best at temperatures of 70° to 75°F. This crop is sensitive to temperature extremes. Poor fruit set and blossom drop can be expected when night temperatures drop below 60° or day temperatures rise above 85°F.

Seed Treatment. If seed is not treated in order to minimize the occurrence of bacterial leaf spot, dip seed in a solution containing 1 quart of household bleach and 4 quarts of water plus 1 teaspoon of surfactant for 15 minutes. Provide constant agitation. Use at the rate of 1 gallon of solution per pound of seed. Prepare a fresh solution for each batch of seed. Wash seed in running water for 5 minutes and dry seed thoroughly. Plant seed soon after treatment. Further information on seed treatments can be found in SEED TREATMENTS section starting on page 239.

Planting and Spacing. Space rows 4 to 5 feet apart. Set plants 12 to 18 inches apart in double rows. Select fields with good drainage. Plant on raised, dome-shaped beds to aid in disease control.

To minimize sunscald when growing pepper on sandy soils and on plastic mulch without drip irrigation, plant varieties that have excellent foliage. To optimize production, peppers should be staked.

PEPPER PLANTING DATES

	Spring	Fall
AL North	5/15–6/30	7/1-8/1
AL South	3/1–5/15	7/15–8/30
GA North	5/15–6/30	7/1-8/1
GA South	3/1–4/30	7/15–8/30
KY East	5/20-6/15	NR
KY Central	5/10-7/1	NR
KY West	5/1-7/15	NR
LA North	4/1–5/15	6/15–7/31
LA South	3/1–5/15	6/15–7/31
MS North	4/20–6/30	NR
MS South	3/1–4/30	8/1–8/15
NC East	4/15–5/10	8/1–8/15
NC West	5/15–7/15	NR
SC East	4/1–5/15	7/10–8/1
SC West	5/1–6/30	NR
TN East	5/15-7/1	NR
TN West	4/20-6/30	NR
VA East (coastal)	4/1-4/30	7/1-8/1
VA West (mountain)	5/1-6/15	NR

Drip Fertilization. Before mulching, adjust soil pH to 6.5, and in the absence of a soil test, apply enough fertilizer to supply 50 pounds per acre of N, P_2O_5 and K_2O, (some soils will require 100 pounds per acre of K_2O) then thoroughly incorpotrate into the soil. After transplanting the soluble fertilizer program should then be initiated following that described in the following table. On soils testing low-medium for boron, also include 0.5 pound per acre of actual boron. The first soluble fertilizer application should be applied through the drip irrigation system within a week after transplanting the peppers. Continue fertigating until the last harvest.

SUGGESTED FERTIGATION SCHEDULE FOR PEPPER* (low soil potassium)

Days after planting	Daily nitrogen	Daily potash	Cumulative	
			Nitrogen	Potash
	(lb / A)			
Preplant			50.0	100.0
0–14	0.5	0.5	57.0	107.0
15–28	0.7	1.4	66.8	126.6
29–42	1.0	2.0	80.8	154.6
43–56	1.5	3.0	101.8	196.6
57–98	1.8	3.6	177.4	347.8

SUGGESTED FERTIGATION SCHEDULE FOR PEPPER* (high soil potassium)

Days after planting	Daily nitrogen	Daily potash	Cumulative	
			Nitrogen	Potash
	(lb / A)			
Preplant			50.0	100.0
0–14	0.5	0.5	57.0	107.0
15–28	0.7	0.7	66.8	116.8
29–42	1.0	1.0	80.8	130.8
43–56	1.5	1.5	101.8	151.8
57–98	1.8	1.8	177.4	227.4

*Adjust based on tissue analysis.

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Green Peach and Melon Aphid: For best green peach aphid control during periods of drought, apply insecticide 2 to 3 days after irrigation. Thorough spray coverage beneath leaves is critical.

Pepper Maggot: Pepper maggot flies are active from June 1 to mid-August.

Pepper Weevil (PW): PW is a pest occasionally imported on older transplants or transplants with flowers or fruit.

European Corn Borer (ECB): European Corn Borer (ECB). The use of pheromone insect traps is recommended, treat when more than ten moths per trap per week are found. Follow table in Insect Control section of this publication.

Nematode Management. Use nematicides listed in the "Nematode Control in Vegetate Crops" tables in the Disease Control section.

VIRUSES

Aphid-transmitted Viruses (TMV, PVX, CMV, TEV, PVY): Use tolerant or resistant varieties to control these viruses when available and provided that the fruit quality is consistent with market demands. Use these varieties in areas where these viruses have been prevalent or when high aphid pressure is expected. Generally, these viruses cannot be adequately controlled with insecticide applications, but symptom expression can be delayed through their use combined with the use of reflective mulches.. Because aphids transmit these virus, growers may wish to use yellow trap pans containing water to determine when mass flights of winged aphids occur.

Thrips-transmitted Virus (Tomato Spotted Wilt Virus, TSWV): Use tolerant or resistant varieties. TSWV can be severe on peppers during both greenhouse production of transplants and during field production of the crop. The virus is spread to peppers by thrips. During transplant production, thrips transmit the virus from infected ornamental plants (flowers). Be sure not to grow any ornamental bedding plants in the same greenhouse as pepper transplants. Monitor greenhouses and scout fields for thrips. Begin an insecticide program BEFORE a problem is observed.

HARVESTING AND STORAGE

See Table 14 for postharvest information.

POTATOES (IRISH) (*Solanum tuberosum*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
POTATOES									
Atlantic [4, 5, 9]	A	G	K	L	M	N	S	T	V
Dark Red Norland [4, 7]	A		K	L		N	S	T	
Harley Blackwell [4, 8]						N			
Katahdin [5]						N	S		V
Kennebec [6, 8]		G	K	L		N	S	T	
La Chipper [5, 6, 7]				L					
La Rouge [4]	A			L		N		T	V
Mountain Rose [3]						N	S		
Norchip [4]			K			N	S	T	
Purple Majesty [2]						N	S		
Red LaSoda [5]	A	G	K	L	M	N	S	T	V
Red Pontiac [5]		G	K			N	S	T	V
Superior [4, 8]		G	K			N			V
Vivaldi [5]						N			V
Yukon Gold [5, 7, 9]	A	G	K	L	M	N	S	T	V
Fingerling Types									
Evnol [5]									V
French Fingerling		G	K			N	S	T	V
Russian Banana [4]		G	K			N	S	T	V

[1] Abbreviations for state where recommended.
[2] Purple flesh when mature.
[3] Red flesh when mature.
[4] Tolerant/resistant to scab.
[5] Susceptible to scab.
[6] Late blight tolerance/resistance.
[7] Ozone sensitive.
[8] Tolerant to heat necrosis.
[9] Susceptible to heat necrosis.

Planting and Spacing. The recommended planting dates for potatoes are in the following table.

POTATO PLANTING DATES

	Spring	Fall
AL North	2/15–4/30	NR
AL South	1/15–3/31	NR
GA North	3/15–4/30	NR
GA South	2/1–3/31	NR
KY East	3/20-6/15	NR
KY Central	3/15-7/1	NR
KY West	3/15-7/15	NR
LA North	1/15–2/28	7/15-9/1
LA South	1/15–2/28	7/1-9/15
MS North	1/20–3/15	NR
MS South	1/20–3/1	NR
NC East	2/15–3/31	NR
NC West	4/1–6/15	NR
SC East	2/1–3/31	NR
SC West	3/15–4/30	NR
TN East	3/20-4/30	NR
TN West	2/15-3/31	NR
VA East (coastal)	3/10-4/5	NR
VA West (mountains)	4/1-6/15	NR

Space seed 7 to 12 inches apart in 34- or 36- inch rows. Use closer spacing for large, cut seed pieces and wider spacing for whole (B-size) seed. Use close spacing for potatoes being marketed in 5- and 10-pound consumer packs and for Katahdin and Kennebec, which tend to set few tubers and produce oversize tubers.

Seed-Piece Treatment. Use certified seed. Warm potato seed 65°F to 70°F for a period of 2 to 3 weeks before planting to encourage rapid emergence. Do not use seed pieces that weigh less than 1.5 oz each. Plant seed pieces immediately after cutting or store under conditions suitable for rapid healing of the cut surfaces (60° to 70°F plus high humidity). Dust seed pieces immediately after cutting with fungicide. Some fungicide seed-piece treatments are formulated with fir or alder bark. Bark formulations have been effective treatments to reduce seed piece decay. Further information on seed treatments can be found in SEED TREATMENTS section starting on page 239.

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Colorado Potato Beetle (CPB): Rotation to non-solanaceous crops (crops other than potato, tomato, eggplant, and pepper) is extremely important in reducing CPB problems.

The further fields can be planted from last year's solanaceous crop, the more beneficial it will be in reducing CPB problems. Avoid the application of late-season sprays to prevent the buildup of insecticide-resistant beetles.

Beginning at plant emergence, sample fields weekly for CPB to determine the need to spray. Select at least 10 sites per field along a V- or W-shaped path throughout the field. At each site, select one stem from each of five adjacent plants and count and record all adults, large larvae (more than half-grown), and small larvae (less than half-grown). As a general guideline, if more than 25 adults or 75 large larvae or 200 small larvae are counted per 50 stems, a treatment is recommended. The amount of yield loss as a result of CPB feeding depends on the age of the potato plant. The Superior variety (short season) cannot compensate for early season defoliation by overwintered beetles, but, during the last 30 days of the season, Superior can withstand up to 50% defoliation without yield loss.

Note: Several insecticides may no longer be effective in certain areas due to CPB resistance. Alternate insecticide classes from one year to the next to avoid resistance. Check with the county Extension agent in your area for the most effective control.

Flea Beetles and Leafhoppers: Treatment is suggested if leafhopper counts exceed three adults per sweep or one nymph per 10 leaves.

European Corn Borer (ECB): Continued treatment for ECB may significantly increase CPB insecticide resistance. However, for proper timing of ECB sprays, consult your local county Extension office for further information.

Potato Aphid and Green Peach Aphid: Insecticide treatments are recommended when aphid counts exceed two per leaf prior to bloom, four aphids per leaf during bloom, and 10 aphids per leaf within two weeks of vine kill.

Potato Tuberworm: Treat when foliage injury is first noted. Potato tuberworms are primarily a problem with late potatoes, in cull piles, or potatoes in storage. Sanitation is very important.

Cutworms: See "Cutworms" section in Soil Pests-Their Detection and Control. Cutworms are especially troublesome to tubers where soil cracking occurs. Variegated cutworms feed on lower leaves and petioles.

Wireworms: Wireworms are a generic term used for the larvae of several species of click beetles, which burrow into potato tubers. In the Southeast U.S., wireworms attacking potato are typically the corn wireworm, or one of five species in the genus *Conoderus*. Wireworm problems are most prevalent when potatoes follow corn, any cereal crop, sod, or pasture. Wireworms do not move quickly from one field to the next, but can remain as larvae in a field for 2-5 years, depending on the species. Since it is difficult and laborious to monitor for a pest that lives in the ground, field history is an important tool for determining the need to treat for wireworms. Treatment must begin at or before planting to be effective. Options include preplant broadcast or at-planting furrow application of an appropriate insecticide. There is no control for wireworms once they have infested potato tubers.

DISEASE MANAGEMENT

Early Blight: Fungicide applications can slow the spread of early blight, but cannot eliminate it, and will be effective only when application begins when airborne spores are first present. Spore formation is most prevalent during repeated wet/ dry cycles, such as caused by overhead irrigation or frequent dew. Minimizing plant stress can reduce damage caused by early blight, especially in younger plants. Early blight spreads more rapidly in young plants than mature ones. If a field is infested with early blight, potatoes may still be harvested if adequate time between vine kill and harvest allows the skins to set and great care is taken not to bruise the tubers in the field. Tubers can be infected during the harvest process, and will decay more rapidly in storage than non- infected tubers. There are some potato cultivars resistant to early blight.

White Mold: High fertility and frequent rain or overhead irrigation are conditions conducive to white mold, caused by the fungus *Sclerotinia sclerotiorum*. This organism can survive in the soil for three or more years, and impacts other produce crops such as lettuce, beans, broccoli, peppers, and others. Fungicides should be applied as a protectant in fields with a history of white mold. In addition, eliminate canopy wetness by reducing overhead irrigation or aligning rows with prevailing winds to promote rapid evaporation of water in the canopy. Avoid fields with poor air movement or poor drainage. Rotate with a non-susceptible crop for three yields after a heavy infestation of white mold.

Common Scab: Common scab is characterized by brown lesions on tuber skin that may be slightly raised or sunken in relation to surrounding surface. The causal agent is a bacteria (*Streptomyces* spp.), which can be seedborne or soilborne. Scab occurs most commonly in warm dry soils with pH 5.5 to 7.5, and does not affect yield. If lesions are significant, marketability and quality are affected. Scab is difficult to manage. In addition to seed treatments at planting, management strategies include rotation out of the field for 3-4 years, maintaining low soil pH, using resistant varieties, and maintaining high soil moisture during tuber formation.

Late Blight: Caused by the fungal pathogen Phytophthora infestans, late blight is the disease responsible for the potato famine and continues to plague potato crops worldwide. Environmental conditions that favor late blight include frequent rainfall (or overhead irrigation), cool weather (50-75°F), and high humidity. Spread is usually quite rapid and complete defoliation can occur within 2-3 weeks of initial infestation. Infection can occur at any growth stage, and in any plant part including the tuber. Fungicides should be applied protectively; after infection, only systemic fungicides (those that penetrate plant tissue) can inhibit the spread of the disease. Additional management strategies include reducing periods of leaf wetness by decreasing overhead irrigation or increasing air movement. Use resistant cultivars when they are available. A critical strategy is reducing the initial amount of inoculum available in the field. Use certified disease-free tubers, and dispose of infected tubers and volunteer vines in a pit with at least 2 ft soil coverage to avoid sprouting. Consider fungicide treatment of seed pieces.

In recent years, forecasting and reporting for this disease have become available, particularly valuable since Phytophthora spores can travel long distances on air currents. One such model is http://www.usablight.org. Use late blight modeling to forecast when disease pressure is most likely to be present and time fungicide sprays accordingly for most efficient use of chemicals.

HARVESTING AND STORAGE

Harvest indicators: Tuber formation of potatoes ends when soil temperatures are consistently over 80°F, regardless of whether or not vine tops have died back. For most "new" potatoes, tubers will be well developed between 65-75 days. Flowering is not a reliable indicator of tuber formation, as some varieties may flower little or not at all. Check for readiness by hand harvesting a few tubers for evaluation.

Vine Kill: Also known as desiccation, many growers chemically (labeled herbicide application) or physically (rotobeating or chopping) defoliate potato vines once optimum marketable size of tubers has been achieved. This allows the tuber skin to set and mature and helps minimize skinning prior to digging. This technique provides benefits including efficiency in harvest, better control over harvest timing, skin set to reduce harvest injury, and reducing impact of diseases like late blight. Vine killing halts the translocation of nutrients and sugar accumulation from the leaves, triggering the conversion of tuber sugars to starch for storage. Vine killing also weakens the juncture of the tuber and stolon, making tubers fall from the plant more easily. If vine killing is used, harvest of tubers should occur at 2-3 weeks after vines are completely dead. Harvest before this and tuber skin may not have had adequate time to set, while harvesting later increases the chance for rotting organisms to attach the crop in the ground. Care should be taken to monitor this period and harvest at the optimum time to minimize mechanical damage and breakdown. See Table 14 for further postharvest information.

PUMPKINS AND WINTER SQUASH (*Cucurbita* spp.)

VARIETIES[1]	AL	AR	GA	KY	LA	MS	NC	SC	TN	VA
PUMPKIN										
Miniature <2 lbs										
Apprentice [B, H, R]	A		G				N		T	V
Baby Boo [H, V, W, FL]	A		G	K			N		T	V
Bumpkin [H, S, FL, PM]	A		G				N	S	T	V
Crunchkin [B, H, FL]	A						N			V
Gold Dust [H, SB, FL, PM]	A						N		T	
Gooligan [H, V, W, FL]	A		G	K					T	
Jack-Be-Little [V, H, FL]	A		G	K	L		N		T	V
Jill-Be-Little [V, H, FL, PM]							N			
Lil Pump-ke-mon [H, B, FL, W w/ orange stripes]	A		G	K			N		T	V
Lil Ironsides [B, H, R]	A	R	G	K			N	S	T	V
Munchkin [V, H, FL]	A	R	G		L	M	N	S	T	V
WeeeeOne [B, R, PM] (carvable)	A								T	V
Small 2-6 lbs										
Blanco [S, W, R, PM]							N			
Cannon Ball [V, P, PM]	A		G	K			N		T	V
Darling [V, H, O, PM]	A				L					
Early Abundance [S, H, R, PM]	A				L					
Field Trip [SV, FL-R, PM]	A			K			N		T	V
Gargoyle [B, WA, R, PM]	A								T	V
Iron Man [V, H, R, PM]	A	R	G	K			N	S	T	V
Little Giant [S, H, R]	A									V
Prankster [S, H, R, PM]	A		G							
Small Sugar [V, O]	A		G		L		N			V
Sunlight [V, Y, R, PM]	A				L					
Medium 6-12 lbs										
Autumn Gold [S, R]	A					M	N			
Cotton Candy [V, W, R]	A		G	K			N		T	V
Goosebumps II [V, WA, R]	A			K			N		T	V
Grey Ghost [V, BL]							N			
Hijinks [S, H, R]	A						N		T	
Hybrid Pam [B, H, R]				K			N		T	V
Jamboree [V, BL, FL-O, CMV, PRSV]	A								T	
Jarrahdale [V, BL, FL]	A	R	G	K			N		T	V
Long Island Cheese [V, BU, FL]	A			K			N		T	V
Lumina [V, W, FL-R]	A		G	K			N		T	
Mystic Plus [V, FL-R, PM]	A		G				N		T	V
Neon [SB, R]	A		G			M	N			
Orange Bulldog [V, H, O-R, PM]	A		G							
Rouge Vif D' Etampes [V, RS, FL]	A			K			N		T	V
Large 12-20 lbs										
Appalachian [SB, R-O]	A		G	K	L				T	
Aspen [SB, R-O]	A		G		L		N		T	
Big Autumn [SB, O]			G	K	L	M				
Blue Bayou [V, BL, DM, PM]							N			
Blue Doll [V, BL, DM, PM]							N			
Cinderella [V, RS, FL]	A	R	G		L		N		T	
Dependable [V, R-O, PM]	A		G				N		T	
Fairytale [V, BU, FL]	A		G				N		T	

[1] Abbreviations for state where recommended.

Growth habit:
- [B] Bush growth habit.
- [SB] Semi-bush growth habit.
- [S] Semi-vining growth habit.
- [V] Vining growth habit.

Skin features:
- [BL] Blue skin.
- [BU] Buff skin.
- [G] Green skin.
- [H] Hardshell.
- [W] White skin.
- [WA] Warts.
- [RS] Red Skin.
- [VR] Variegated.
- [Y] Yellow skin.

Shape:
- [FL] Flat (Cinderella, pancake).
- [O] Oblong.
- [R] Round.
- [P] Pie pumpkin - suitable for cooking.

Disease Tolerance/Resistance:
- [DM] Downy mildew tolerance/resistance.
- [F] Fusarium tolerance/resistance.
- [PH] Phytophthora tolerance/resistance.
- [PM] Powdery mildew tolerance/resistance.
- [VT] Virus tolerance (non-specific).
- [CMV] Cucumber Mosaic Virus.
- [WMV] Watermelon Mosaic Virus (Strain 2).
- [ZYMV] Zucchini Yellows Mosaic Virus.
- [PRSV] Papaya Ringspot Virus.

VARIETIES[1]	AL	AR	GA	KY	LA	MS	NC	SC	TN	VA
PUMPKIN (cont'd)										
Large 12-20 lbs										
Gold Medal [S, W, R]	A		G		L				T	V
Knuckle Head [S, WA, R-O]				K			N		T	
Magic Lantern [S, R, PM]	A	R	G	K			N	S	T	V
Magic Wand [S, R-FL, PM]	A		G	K			N		T	V
Magician [S, R, PM, ZYMV]	A	R	G	K			N	S	T	V
Merlin [S, R, PM]	A		G	K						
Racer Plus [S, H, R, PM]							N			
Sorcerer [S, R]	A		G		L		N	S	T	V
20 Karat Gold [SB, R]				K			N		T	
Extra Large 20-50 lbs										
Aladdin [SV, R-O, PM]	A		G	K	L		N	S	T	V
Apollo [S, O, PM]	A						N		T	V
Big Max [V, R-O]	A		G		L	M	N		T	
Camaro [V, R, PM]	A			K		M	N	S	T	
Cronus [V, R, PM (poor performer under high temps)]	A						N	S	T	V
Gladiator [S, R, PM]	A		G	K			N			V
Gold Medallion [V, R-O]	A		G			M			T	
Gold Rush [V, R]	A		G			M			T	
Howden Biggie [V, O]	A		G	K		M			T	V
Kratos [S, H, FL-R, PM]							N		T	
Mammoth Gold [V, R]	A									
Mustang [S, R, PM]	A			K			N	S	T	
Phantom [V, R-O]			G							
Rhea [V, H, FL-R, PM]	A						N		T	
Super Herc [V, R-O, PM]	A		G	K					T	
Warlock [V, H, R-O, PM]			G	K			N		T	
Giant >50 lbs +										
Atlantic Giant [V, R-O]	A			K	L		N		T	V
Big Moose [V, H, R]							N		T	
First Prize [V, O-R]			G				N			V
Full Moon [V, W, R]	A		G	K			N		T	
New Moon [V, O-R]	A		G				N		T	V
Prizewinner [V, RS (red-orange skin), FL-R]	A		G	K	L		N		T	V
WINTER SQUASH										
Acorn										
Autumn Delight [SB, PM]	A						N	S	T	V
Celebration [B, PM]	A						N	S	T	V
Table Ace [SB]			G	K	L		N	S	T	V
Table Queen [V]	A		G	K	L	M	N	S	T	V
Taybelle PM [SB, PM]	A		G	K	L	M	N	S	T	V
Buttercup										
Buttercup [V]	A		G				N	S	T	V
Butternut										
Atlas [SV]			G							
Avalon [V]	A								T	V
Butterfly [SB, PM]							N			
Betternut 900 (local markets only) [SB, PM]							N			
Butternut Supreme [S]	A		G	K			N	S	T	V
Early Butternut [SB]	A				L			S		
Polaris [V, BU]							N			

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- [WMV] Watermelon Mosaic Virus (Strain 2).
- [ZYMV] Zucchini Yellows Mosaic Virus.
- [PRSV] Papaya Ringspot Virus.

VARIETIES[1]	AL	AR	GA	KY	LA	MS	NC	SC	TN	VA
WINTER SQUASH										
Hubbard (cont'd)										
Quantum [V, BU]							N			
Ultra [V]	A						N			V
Waltham Butternut [V]	A		G	K	L	M	N	S	T	V
Golden Hubbard [V]	A		G				N		T	V
True Green Improved Hubbard [V]	A		G							V
Spaghetti										
Primavera [S]	A						N	S		V
Pinnacle [SB]	A						N	S		V
Stripetti [V, VR]	A		G				N	S		V
Small Wonder [R, V]							N			
Vegetable Spaghetti [V]	A		G	K		M	N	S	T	V
Miscellaneous Types										
Bush Delicata [B, PM]	A			K			N			V
Cushaw Green Striped [V]	A			K	L		N		T	V
Cushaw Orange Striped [V]							N		T	V
Gold Nugget [B]							N			
Golden Delicious [V]	A									
Kabocha										
Sweet Mama [S]	A		G	K		M	N	S	T	V
Calabaza										
La Estrella [V]	A		G	K		M	N	S	T	V
Sunshine [S, FL-R]							N			

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- [VR] Variegated.
- [Y] Yellow skin.

Shape:
- [FL] Flat (Cinderella, pancake).
- [O] Oblong.
- [R] Round.
- [P] Pie pumpkin - suitable for cooking.

Disease Tolerance/Resistance:
- [DM] Downy mildew tolerance/resistance.
- [F] Fusarium tolerance/resistance.
- [PH] Phytophthora tolerance/resistance.
- [PM] Powdery mildew tolerance/resistance.
- [VT] Virus tolerance (non-specific).
- [CMV] Cucumber Mosaic Virus.
- [WMV] Watermelon Mosaic Virus (Strain 2).
- [ZYMV] Zucchini Yellows Mosaic Virus.
- [PRSV] Papaya Ringspot Virus.

Seeding and Spacing. Research around the SE U.S. has demonstrated that fruit size can vary for each variety among locations due to a number of environmental factors. To best determine how well a variety performs in your area, trial it before planting out a large acreage. Seed in the field as indicated below:

Bush types: Rows–5 to 6 feet apart; plants–2 to 3 feet apart in row; seed–4 to 6 pounds per acre.

Semi-vine types: Rows- 6 to 8 feet apart; plants–2 to 4 feet apart in row; seed–2 to 4 pounds per acre.

Vine types: Rows–8 to 10 feet apart; plants–4 to 5 feet apart in row; seed–2 to 4 pounds per acre.

PUMPKIN/WINTER SQUASH PLANTING DATES

	Halloween	Winter Squash
AL North	6/15–7/15	4/15–6/15
AL South	6/15–7/15	3/15–5/15
AR North	6/15-7/5	5/15-6/30
AR South	6/15-7/5	4/15-6/30
GA North	5/1–6/15	4/15–6/15
GA South	6/15–7/15	3/15–5/15
KY East	5/10-6/1	5/15-6/15
KY Central	5/5-6/15	5/10-7/10
LA North	6/15-7/15	4/15–5/15
LA South	6/15-7/15	3/15–5/15

PUMPKIN/WINTER SQUASH PLANTING DATES (cont'd)

	Halloween	Winter Squash
MS North	6/20–7/5	4/15-6/15
MS South	6/20–7/5	3/15-5/15
NC East	6/15–7/10	4/15–5/20
NC West	5/25–6/30	5/25–6/30
SC East	NR	3/20–5/1
SC West	NR	4/15–6/15
TN East	6/1-7/15	5/15-6/30
TN West	5/15-6/15	4/25–6/30
VA East (coastal)	6/15-7/15	5/1-5/20
VA West (mountain)	6/15-7/5	5/15-6/15

For Soil Strips between Rows of Plastic Mulch. Use the following land preparation, treatment, planting sequences, and herbicides labeled for pumpkins or squash or crop injury may result.

1. Complete soil preparation and lay plastic and drip irrigation (optional) before herbicide application. In some cases, overhead irrigation can be used if small holes are punched into the plastic.
2. Spray preemergence herbicides on the soil and the shoulders of the plastic strips in bands before weeds germinate. DO NOT APPLY HERBICIDE TO THE SURFACE OF THE PLASTIC. Herbicides may wash from a large area of plastic into the plant hole and result in crop injury.

3. Incorporate preemergence herbicide into the soil with 0.5 to 1 inch of rainfall or overhead irrigation within 48 hours of application and BEFORE PLANTING OR TRANSPLANTING.
4. Apply selective postemergence herbicides broadcast or in bands to the soil strips between mulch to control susceptible weeds.

Minimum Tillage. No-tillage is the most commonly used minimum tillage practice with pumpkins. No-till planters currently in use with row crop production will plant pumpkin seed but seed plates or feed cups need to match up with seed size. Improper seed plates or cups will break pumpkin seed. Type of winter cover crop residue can affect pumpkin seed depth. Inspect seed placement and adjust for correct depth. Early spring planting with no-tillage in pumpkin may delay growth and days to harvest. Planting after soils warm in the spring will improve vigor (pumpkins are normally planted after soil warms so this may not be a management problem). Use of small grain cover residue may require additional nitrogen fertilizer (20 to 30 lbs N/acre in addition to the normal recommendation) if cover crop is fairly mature when killed. Normal pumpkin nitrogen fertilizer recommendations can be used if a legume cover crop (hairy vetch, winter peas, or crimson clover) is used as residue.

SPECIAL NOTES FOR PEST MANAGEMENT

DISEASE MANGEMENT

Cucurbit Downy Mildew Forecasting System: Cucurbit downy mildew (CDM) is a devastating foliar cucurbit disease. While difficult, if not impossible to control, CDM can be prevented by using effective IPM practices. A useful tool for prevention of CDM is the CDM forecasting system. This program depends on the accurate reporting of CDM in the field as well as the monitoring of over 50 strategically placed sentinel plots. These plots are monitored by Plant Pathologists at multiple Land Grant Universities throughout the United States and Canada. Forecasts of the epidemic movement of the disease are generated 3 times a week. Risk maps are produced from these forecasts. For forecasts, maps, local contacts and other helpful information please visit our website, http://cdm.ipmpipe.org. If you think you have CDM, please contact your local Extension office.

INSECT MANAGEMENT

Cucumber Beetle: Cucumber beetles cause direct feeding damage to the foliage. Young plants need to be protected with insecticide as soon as they emerge or are transplanted. Cucumber beetles also cause direct damage to pumpkin and winter squash rinds. Fall treatments with foliar insecticides to prevent feeding damage may also reduce incidence of bacterial wilt. While Hubbard squash, butternut squash and processing pumpkins are susceptible to bacterial wilt, Jack-o-lantern pumpkins and most other varieties of squash are rarely susceptible to bacterial wilt.

Squash Vine Borer: Pheromone baited sticky traps can be used soon after planting to monitor the activity of the adult moths. Start inspecting plants closely for squash vine borer eggs (1mm [1/25 inch] diameter oval, flattened, dull-red to brownish) as soon as moths are caught in the traps. The first application of insecticide should occur when eggs begin to hatch or just prior to hatching. Applications should be made in afternoons or evenings after flowers close to reduce the spraying of valuable pollinators, especially bees. If pheromone traps are not used, a preventive treatment should be applied when vines begin to run. Re-apply insecticide every seven days for four weeks. Continue monitoring the pheromone traps into August to detect the emergence of the new moths. When moths are caught, inspect plants for second-generation eggs, and begin the insecticide applications when eggs first begin to hatch or just prior to hatching.

Aphids: Aphid feeding can delay plant maturity. Thorough spray coverage, especially on the underside of the leaves is important. Treat seedlings every five to seven days, or as needed. The transmission of plant viruses by aphids has the potential to be the most damaging to the crop. Unfortunately, insecticide use for aphids does not reduce the spread of virus. A better approach is the application of Stylet Oil to fill tiny grooves between the leaf cells. When the aphid probes the leaf surface, its stylet must pass through a layer of oil. This reduces the infectivity of the virus resulting in less disease in the squash plant. The application of Stylet Oil can delay virus infection, but requires application every other day, thorough coverage and high pressure sprays. Also, refer to the preceding "Mulches" section for information on metallized reflective mulch used to repel or disorient aphids that can spread viruses.

Squash Bug: Begin scouting shortly after plant emergence. Treat every 7 to 10 days when adults or nymphs appear. The control of squash bugs is particularly important where yellow vine disease occurs since squash bugs vector the pathogen responsible for this disease.

Spider Mites: Mite infestations generally begin around field margins and grassy areas. CAUTION: DO NOT mow these areas after midsummer because this forces mites into the crop. Localized infestations can be spot-treated. **Note:** Continuous use of pyrethroid sprays may result in mite outbreaks.

POLLINATION

Honey bees are important for pollination, high fruit yields, fruit size, and quality. Populations of pollinating insects may be adversely affected by insecticides applied to flowers or weeds in bloom. Use one hive per acre to get good pollination. Apply insecticides only in the evening hours or wait until blooms have closed before application. See section on "Pollination" in the General Production Recommendations.

HARVESTING AND STORAGE

Use clean storage bins and sanitize. Be sure to thoughly clean and santize bins prior to usage and subsequent storage.

Harvest as soon as fruits are mature and prior to frost. Use care in handling fruit to prevent wounds. Cure after harvest at temperatures between 80° to 85°F with a relative humidity of 75% to 80% for 10 days.

Temperatures below 50°F cause chilling injury. The hard-shelled varieties, such as Butternut, Delicious, and the Hubbard strains, can be stored for several months. Store at 55°F and 55% relative humidity. See Table 14 for further postharvest information.

RADISHES (*Raphanus sativus*), RUTABAGAS (*Brassica napus*), AND TURNIPS (*Brassica rapa* var. *rapa*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
RADISH: Salad, Daikon, and Icicle Types								
Cherriette [2]	A	G				N	S	T
Cherry Belle [2]	A		K	L	M	N	S	T
Champion [2]	A	G			M	N		
Crunchy Royal [2]						N	S	T
Easter Egg [2] (mixture of 5 - 6 root colors)			K			N		T
Early Scarlet Globe [2]	A		K		M	N		T
Fireball							S	
Ostergruss Rosa [2, 3]							S	
Red Boy	A					N		
Red Jewel [2, 7, 8]	A							
Red Pearl [2, 7, 8]	A							
Red Silk							S	
Sparkler [2] (half red, half white root)	A				M	N		
White Icicle [4]	A	G	K		M	N		T
Watermelon [2, 9]	A			L		N	S	
RADISH: Storage Types								
April Cross [3]	A	G	K			N		
Everest [3]	A		K			N		
Omny [3]	A				M	N		
Long Black Spanish [5]	A				M	N		T
Round Black Spanish [5]	A				M	N		T
RUTABAGAS								
American Purple Top	A	G				N	S	
Laurentian	A	G				N	S	
TURNIPS								
Hakurei [6]			K					T
Purple Top White Globe	A	G	K	L	M	N	S	T
Royal Crown		G		L				T
Scarlet Queen Red Stems [6]	A		K	L				T
Shogoin	A				M	N	S	
Tokyo Cross	A		K	L	M	N	S	T
White Egg						N	S	
White Lady				L	M		S	T

[1] Abbreviations for state where recommended.
[2] Garden radish.
[3] Daikon radish.
[4] Icicle radish.
[5] Spanish radish.
[6] Small root type; best when harvested at 2" to 3" diameter.
[7] Downy mildew tolerance/resistance.
[8] Fusarium wilt tolerance/resistance.
[9] White exterior with red interior.

Seed Treatment. Soak seed in hot water at 122°F. Soak rutabagas for 20 minutes and turnips for 25 minutes. Dry the seed, then dust with a labeled fungicide to prevent damping-off. Further information on seed treatments can be found in SEED TREATMENTS section starting on page 239.

SPACING AND SEEDING

Radishes: *Salad or garden radish* roots are normally red skinned, round, less than two inches in diameter and grow rapidly, generally taking less than one month from seeding to harvest. *Icicle* types are elongated root forms of garden radishes. *Daikon radishes* are Asian storage radishes that produce large, white cylindrical roots which can exceed twelve inches in length and can weigh over one pound. *Spanish radishe*s have round or elongated large storage roots with black skin. *Storage radishes* can take up to ninety days from seeding to harvest.

Radishes are a quick-growing, cool-season crop producing its best quality when grown at temperatures of 50° to 65°F. Many radish types are ready for harvest 23 to 28 days after sowing. Radishes must be grown with an adequate moisture supply; otherwise, when growth is checked radishes become hot, tough, and pithy. Warm temperature and longer day-lengths induce seedstalk formation.

Seed radish as early in the spring as soil can be worked, then in order to maintain a continual supply make additional plantings at 8- to 10-day intervals. Space rows 8 to 15 inches apart and sow 12 to 15 seed per foot within a row. This will require 10 to 15 pounds of seed per acre.

RADISH PLANTING DATES

	Spring	Fall
AL North	2/15–5/15	8/1–10/15
AL South	1/15–3/31	8/1–10/31
GA North	3/15–5/15	8/1–9/15
GA South	2/1–3/31	8/1–10/15
KY East	3/15-5/15	8/1-9/1
KY Central	3/10-5/10	8/15-9/15
KY West	3/10-4/1	9/15-10/1
LA North	2/1–3/15	8/1–10/30
LA South	1/15–3/15	8/1–10/30
MS North	3/5-4/30	8/1-9/15
MS South	2/1-3/31	8/1-9/30
NC East	2/15–6/30	8/1–9/15
NC West	4/1–8/15	NR
SC East	2/1–6/15	8/1–9/30
SC West	3/15–6/30	8/1–9/15
TN East	4/1-5/30	8/1-9/15
TN West	3/1-5/1	8/1-9/30

Rutabagas: A cool-season crop that develops best at temperatures of 60° to 65°F. Usually considered a fall crop, it can be grown in the spring. Seed at least 90 days before the early freeze date in the fall. Sow 1.5 to 2 pounds of seed per acre at a depth of 1 inch in rows 30 to 36 inches apart. Thin to 4 to 8 inches in the row when plants are 2 to 3 inches tall.

RUTABAGA PLANTING DATES

	Spring	Fall
AL North	2/15–5/15	8/1–9/15
AL South	1/15–3/31	8/1–10/15
GA North	3/15–5/15	8/1–9/15
GA South	2/1–3/31	8/1–10/15
KY East	3/15-5/15	NR
KY Central	3/10-5/10	NR
KY West	3/10-4/1	NR
LA North	2/1–3/15	7/15–10/30
LA South	1/15–3/15	7/15–10/30
MS	NR	NR
NC East	2/15–4/15	8/1–9/30
NC West	4/1–8/15	NR
SC East	2/1–3/31	8/15–10/15
SC West	3/15–4/30	7/15–9/30
TN East	3/15-5/15	NR
TN West	3/10-4/1	NR

Turnips: Seed as early in the spring as soil can be worked or at least 70 days before the early freeze date in the fall. Seed in rows 1 to 2 pounds per acre, 0.25 to 0.5 inch deep, in rows 14 to 18 inches apart. Plants should be 2 to 3 inches apart in the row. Seed can also be broadcast at the rate of 2.5 pounds per acre.

TURNIP (ROOTS) PLANTING DATES

	Spring	Fall
AL North	2/15–5/15	8/1–10/15
AL South	1/15–3/31	8/1–10/30
GA North	3/15–5/15	8/1–9/15
GA South	2/1–3/31	8/1–10/15
KY East	3/15-4/15	7/1-7/15
KY Central	3/10-4/10	7/15-8/1
KY West	3/1-4/1	8/1-8/15
LA North	2/1–3/15	7/15–10/31
LA South	1/15–3/15	7/15–10/31
MS North	1/20–4/1	7/25–8/20
MS South	1/15–3/1	8/10–9/15
NC East	2/15–6/30	8/1–9/15
NC West	4/1–8/15	NR
SC East	2/1–4/1	8/1–9/30
SC West	3/15–4/30	8/1–9/15
TN East	3/15-5/30	7/15-8/10
TN West	3/1-5/1	8/1-8/25

HARVESTING AND STORAGE

Rutabagas: Pull and trim tops in field. Bruised, damaged, or diseased rutabagas will not store well. Wash rutabagas in clean water, spray-rinse with clean water, then dry as rapidly as possible before waxing and shipping. Rutabagas can be stored 2 to 4 months at 32°F and at 90% to 95% relative humidity.

Turnips: The crop is dug mechanically and either bunched or topped. Turnips can be stored at 32° to 35°F and at 90% to 95% relative humidity.

For further postharvest information on radish, rutabaga, and turnip, see Table 14.

SOUTHERNPEAS (*Vigna unguiculata*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
SOUTHERNPEAS								
Blackeyes								
Bettergro Blackeye [2, 4]	A	G					S	
California Blackeye #5 [2, 5]	A	G				N	S	
Magnolia Blackeye [5]	A			L	M			
Queen Anne [2, 5]	A	G	K	L	M	N		T
Pinkeyes								
Coronet [2, 5]	A						S	
Pinkeye Purple Hull [4]		G		L		N	S	T
Pinkeye Purple Hull - BVR [4]	A	G		L	M	N		T
QuickPick Pinkeye [2, 5]	A	G		L	M	N	S	T
Texas Pinkeye	A			L				
Top Pick Pinkeye [2]	A	G		L	M			
Creams								
Big Boy (cream/browneye) [5]							S	
Elite [2, 5]				L				T
Mississippi Cream [2, 5]				L	M			T
Tender Cream [2, 5]							S	
Texas Cream 8		G			M		S	T
Texas Cream 12	A	G						
Top Pick Cream	A	G		L				T
White Acre-BVR	A	G						
Crowders								
Clemson Purple						N	S	
Colossus 80 [2, 5]						N	S	
Dixie Lee				L		N		T
Hercules	A	G				N	S	T
Knuckle Purple Hull		G				N	S	
Mississippi Purple [3]	A	G	K	L	M	N	S	T
Mississippi Shipper [2, 3]	A	G		L	M	N	S	T
Mississippi Silver [3]	A	G	K	L	M	N	S	T
Purple Tip Crowder							S	T
Top Pick Crowder	A	G		L		N		
Zipper Cream [4]	A	G		L	M	N	S	T

[1] Abbreviations for state where recommended.
[2] Suitable for mechanical harvest.
[3] Semi-vining.
[4] Vining
[5] Bush.

Southernpeas originated in India in prehistoric times and moved to Africa, then to America. In India, southernpeas are known by 50 common names and in the United States are called "Field peas", "Crowder peas", "Cowpeas" and "blackeyes", but southernpeas is the preferred name. Southernpeas require relatively warms soils for good germination.

Seeding and Spacing. Sow when soil temperature reaches 60°F and continue sowing until 80 days before fall frost. Seeding too early causes poor stands and you may need to replant. Bush types should be seeded 4 to 6 per foot or 30 to 50 pounds of seed per acre. Vining types should be seeded 1 to 2 per foot or 20 to 30 pounds of seed per acre. Plant seeds 3/4 to 1 1/4 inch deep in rows spaced 20 to 42 inches apart depending on cultivation requirements.

Fertility. Most soils will produce a good crop, but medium fertility with pH of 5.8 to 6.5 is desirable. High fertility produces excessive vine growth and poor yields. Inoculants of specific N fixing bacteria may increase yield especially in soils where southernpeas have not been grown. Crop rotation or fumigation is important for nematode control.

SOUTHERNPEA PLANTING DATES

	Spring	Fall
AL North	4/15–7/31	NR
AL South	3/15–6/15	7/15–8/30
GA North	5/15–7/15	NR
GA South	3/15–5/15	7/15–8/30
KY East	5/10-6/15	NR
KY Central	5/5-7/1	NR
KY West	4/20-7/15	NR
LA North	4/15–7/31	7/1–7/31
LA South	4/1–5/31	7/15–8/15
MS North	4/15–7/15	NR
MS South	3/15–6/15	8/1–8/30

SOUTHERNPEA PLANTING DATES (cont'd)

	Spring	Fall
NC East	3/25–6/15	8/1–8/30
NC West	4/15–7/15	NR
SC East	4/1–6/15	7/15–8/1
SC West	4/15-7/15	NR
TN East	5/10-7/15	NR
TN West	4/15-7/31	NR

Insect Management. Cowpea Curculio: At first bloom, make three insecticides applications at five-day intervals for curculio control.

Harvesting and Storage. Depending on variety and weather, harvest will begin 65 to 80 days after seeding and continue for 3 to 5 weeks. Begin harvest when a few pods are beginning to change color and harvest only pods with well formed peas. This is the best stage for shelling and eating.

Southernpeas are sold in bushel hampers or mesh bags. Do not use burlap sacks because they are not properly ventilated. Southernpeas weigh 22 to 30 pounds per bushel. One person can harvest 12 to 20 bushels per day if yields are average. Average production is 60 to 200 bushels per acre. See Table 14 for further postharvest information.

SPINACH (*Spinacia oleracea*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	OK	SC	TN
SPINACH									
Baker [5]							O		
Bloomsdale Long Standing [2, 5]	A	G	K			N			T
Bolero [5]						N	O		
Crescent [7]							O		
Early Hybrid #7 [2, 4, 6]	A	G				N		S	
F91- 415 [4, 7]							O		
F97- 154 [4, 7]							O		
Greyhound [3, 4]				L					
Olympia [4, 5]							O		
Regal [4, 5, 7]							O		
Teton [4, 5]							O		
Tigercat [4]				L					
Tyee [3, 4]	A	G	K	L		N		S	T
Unipak 151 [3, 4, 5, 6]				L					
Whale [2, 4, 5]								S	

[1] Abbreviations for state where recommended.
[2] Savoy type.
[3] Semi-savoy.
[4] Downy mildew tolerance/resistance.
[5] Bolting tolerant.
[6] Cucumber Mosaic Virus tolerance/resistance.
[7] White Rust tolerance/resistance.

Spinach may be divided by use into fresh and processed types. Spinach cultivars are either upright or spreading in habit and can be further subdivided by leaf type into savoy (wrinkled), crushed, crumpled, long-season, semi-savoy, and smooth varieties. The processing types are usually smooth leaved; the semi-savoy types can be used for both purposes; while the fresh market prefers the savoy types. In addition spinach cultivars can be classified as being fast bolters or slow bolters. Spinach usually matures in 30 to 50 days.

Geographic/Climate Requirements. Since spinach is a hardy, cool season plant growing best where temperatures are moderate. Spinach is frost tolerant and cold hardy to 20°F. Germination is maximized at 41°F (5°C) with emergence taking 23 days. Higher temperatures reduce germination. Spinach may be an early spring, late fall, or winter crop, where the conditions permit surviving winter killing temperatures. Longer day length triggers bolting.

SPINACH PLANTING DATES

	Spring	Fall
AL North	3/15–4/30	8/1–9/15
AL South	2/1–3/31	8/15–9/30
GA North	3/15–4/30	8/1–9/15
GA South	2/1–3/31	8/1–9/30
KY East	3/10-4/10	8/1-8/15
KY Central	3/1-4/1	8/15-9/1
KY West	2/15-3/15	9/1-9/15
LA North	2/1–3/15	9/1–11/15
LA South	2/1–3/15	9/15–11/15
MS	NR	NR
NC East	2/15–6/30	8/1–9/15
NC West	4/1–8/15	NR
OK	2/15–4/15	9/1–12/30
SC East	2/1–4/1	8/15–10/15
SC West	3/15–4/15	8/1–9/30
TN East	2/1-3/31	8/15-10/15
TN West	2/1-3/31	8/15-10/15

Soil and Fertilizer Requirements. Spinach is sensitive to acidic soils, preferring a pH range of from 6.0 to 7.5. Warmer sandy soils are preferred for overwintering spinach. Fertilizer is more important during the slower growing winter periods. Before any fertilizer is worked into a spinach field, careful soil sampling and analysis should be obtained to determine the levels of P and K.

Cultural Practices. Spinach is usually direct seeded in rows using either precision methods and coated seed or regular drilled uncoated seed. In some areas spinach is simply broadcast on beds. The rate of germination fluctuates widely depending on methods of seeding but also upon the risk of damping-off. Despite the size of spinach seed, it is sown fairly shallowly, 0.8 to 1 inch (2 to 3 cm), in soil moisture conditions ranging from slightly above permanent wilting to field capacity.

Where spinach is pulled by hand for harvest, it is possible to select the larger, more vigorous plants, leaving space for the slower, crowded plants to grow. Seeding rates for non-clipped: 10 to 14 pounds/acre and for clipped: 18 to 25 pounds/acre. Spacing within rows is generally 12 inches. For smaller stands, sow 1 oz. of seed per 100 row feet. For smaller stands, average yields are 40 lb/100 row feet, 152 cwt/ acre.

Irrigation and Drainage. The spinach plant is shallow rooted and therefore may become water-stressed if irrigation is not available between rain showers. More often than not the first irrigation is necessary to germinate the spinach seed. Since spinach is sensitive to overwatering or waterlogging, provision for drainage either through seedbed preparation or tiling is essential. The large transpiring leaf surface of maturing spinach plants coupled with warm temperatures can readily deplete the available moisture reserves.

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Insect pests of spinach include: Aphids, Leaf miners, Cabbage loopers, mites, and Sweet corn maggots. Control methods include crop rotation, destruction of crop residues, and the use of pesticides.

Seed Corn Maggot: To prevent maggot damage to spring-seeded plants, treat seed with an approved commercially available insecticide or use a broadcast application of a soil-incorporated insecticide. See the "Maggots" section in Soil Pests- Their Detection and Control.

DISEASE MANAGEMENT

Spinach is vulnerable to attacks by blight (CMV), downy mildew, leaf spot, damping-off, seed rot, nematodes, and root rot. Resistant or tolerant cultivars help to ward off diseases. Where possible the use of the right seed dressing will protect the germinating seed and developing roots. Fumigation may sometimes be necessary, coupled with good rotational practices.

WEED MANAGEMENT

Weed management is especially important in young spinach stands to reduce competition. Spinach competes poorly with many weeds, and the presence of weeds can significantly reduce yield. Growers should include both cultural and chemical controls for weed management, as no one practice consistently provides control.

Cultural controls include choosing a planting site that has low weed pressure, sanitation, and crop rotation. If field cultivation is necessary prior to planting, it should be shallow so as not to expose buried weed seeds to the sun. Consumer tolerance for weeds in bagged spinach is low; cultivation and hand-weeding are sometimes employed in addition to other controls. Hand-weeding is costly but is often the only option as the plants mature.

As with other leafy greens, herbicide options after seedlings have emerged are limited. I n addition, spinach is sensitive to damage from certain herbicides, and should not be planted if residues may be present in the soil. Preplant application of an appropriate herbicide is recommended. Proper identification of the weeds present in the field is crucial to selection of the best herbicide for the location, as there are few options, and none that address all the weed types that may be present.

Some growers have been able to reduce weed pressure with pre-irrigation, saturation of the field before the spinach seed is planted. This causes a flush of weeds to emerge, which can be eliminated by burning or herbicide application. The spinach seed is planted after the weedy plants have been removed with the expectation of less competition.

HARVESTING AND STORAGE

See Table 14 For further postharvest information.

SUMMER SQUASH (*Cucurbita pepo*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
SUMMER SQUASH								
Yellow Crook Neck								
Destiny III [3, 4, 5, 6]	A	G	K	L		N	S	T
Dixie	A			L		N	S	T
Gentry	A	G	K	L	M	N	S	T
Gold Star [6, 8]	A	G				N		
Prelude II [3, 4, 5]	A	G	K	L		N	S	T
Supersett [2, 4, 5]	A			L	M	N	S	T
Yellow Straight Neck								
Cheetah [2, 4, 8]	A			L		N	S	T
Conqueror III [3, 4, 5, 6, 7]	A	G	K					T
Cougar [4, 5, 7]	A		K	L		N	S	T
Daisey	A							
Enterprise	A	G				N	S	T
Fortune [2]			K			N		T
Goldbar	A				M	N	S	T
Lioness [4, 5, 6, 7]		G	K	L		N		T
Multipik [2, 4, 5]	A		K	L		N	S	T
Solstice [4, 5]	A	G		L		N	S	T
Superpik [2, 4, 5]	A			L		N	S	T
Zucchini								
Cashflow						N		T
Desert [6, 9]							S	
Elite	A					N	S	T
Esteem [4,5,7,8]	A							
Goldie [9]	A	G					S	
Judgement III [3, 4, 5, 6]	A	G	K			N		T
Justice III [3, 4, 5, 6]	A	G	K			N		
Leopard [4, 7]						N	S	T
Lynx [4, 5, 7]								T
Paycheck [4, 5, 6, 8]	A	G	K			N		T
Payroll [4, 5, 6, 7]	A	G	K		M	N	S	T
Payload [4, 5, 6, 8]	A	G				N	S	T
President							S	
Sebring [8, 9]	A			L				
Senator	A			L	M		S	T
Spineless Beauty	A		K		M	N	S	T
Spineless Perfection [4, 5, 8]	A	G				N	S	
SV6009YG [4, 5, 6, 8]	A	G				N	S	
Tigress [4, 5, 7]	A		K		M	N	S	T
Zephyr [2] (bi-color)	A	G	K	L		N		T
Grey Zucchini								
Ishtar	A	G						T
Scalloped								
Patty Green Tint	A			L		N	S	
Peter Pan	A		K			N	S	T
Scallopini	A	G		L		N		
Sunburst	A	G	K	L		N	S	T
Total Eclipse	A							T

[1] Abbreviations for state where recommended.
[2] *Py* - Precocious yellow gene; has a prominent yellow stem.
[3] Transgenic.
[4] Zucchini Yellows Mosaic virus tolerance/resistance.
[5] Watermelon Mosaic virus tolerance/resistance.
[6] Cucumber Mosaic Virus tolerance/resistance.
[7] Papaya Ringspot Virus tolerance/resistance.
[8] Powdery mildew tolerance/resistance.
[9] Yellow zucchini.

Seed Treatment. Check with seed supplier to determine if seed has been treated with an insecticide and/or fungicide. Information on seed treatments can be found in SEED TREATMENTS section starting on page 239.

Seeding, Transplanting, and Spacing. Use 4 to 6 pounds of seed per acre. Seed or container-grown transplants are planted when daily mean temperatures have reached 60°F. Seed as indicated in following table. Early plantings should be protected from winds with row covers, rye strips, or wind breaks. Space rows 3 to 6 feet apart with plants 1.5 to 2.5 feet apart in the row.

SUMMER SQUASH PLANTING DATES

	Spring	Fall
AL North	4/15–8/15	8/1–8/30
AL South	3/1–4/30	7/15–9/15
GA North	5/1–8/15	NR
GA South	3/1–4/30	7/15–9/15
KY East	5/15-7/15	NR
KY Central	5/10-8/1	NR
KY West	4/20-8/15	NR
LA North	3/15–5/15	7/15–8/31
LA South	3/1–5/15	8/1–9/15
MS North	4/15–6/15	7/25–8/14
MS South	2/15–5/1	8/14–9/14
NC East	4/1–5/30	7/15–8/15
NC West	5/15–7/31	NR
SC East	3/15-7/30	8/1–8/30
SC West	4/15–7/30	7/30–8/15
TN East	5/10-8/1	NR
TN West	4/15-7/15	NR

Mulching. Plastic mulch laid before field planting conserves moisture, increases soil temperature, reduces mechanical damage to fruit, and increases early and total yield. Plastic should be applied on well-prepared planting beds. The soil must be moist when laying the plastic. Black plastic mulch can be used without a herbicide. In most situations, 50 percent of the nitrogen(N) should be in the nitrate (NO_3) form.

Reflective, plastic mulches can be used to repel aphids that transmit viruses in fall-planted (after July 1) squash. Direct seeding through the mulch is recommended for maximum virus protection.

Growers should consider drip irrigation. See the section on "Irrigation" in this handbook.

SUGGESTED FERTIGATION SCHEDULE FOR SUMMER SQUASH* (N:K;1:2)

Days after planting	Daily nitrogen	Daily potash	Cumulative	
			Nitrogen	Potash
	(lb / A)			
Preplant			24.0	24.0
0–14	0.9	1.8	36.6	49.2
8–28	1.3	2.6	54.8	85.6
29–63	1.5	3.0	107.3	190.6

* Adjust based on tissue analysis.

ALTERNATIVE FERTIGATION SCHEDULE FOR SUMMER SQUASH* (N:K,1:1)

Days after planting	Daily nitrogen	Daily potash	Cumulative	
			Nitrogen	Potash
	(lb / A)			
Preplant			24.0	24.0
0–7	1.0	1.0	31.0	31.0
8–21	1.5	1.5	52.0	52.5
22–63	2.0	2.0	136.0	136.5

*Adjust based on tissue analysis.

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Cucumber Beetle: Cucumber beetles cause direct feeding damage to the foliage. Young plants need to be protected with insecticide as soon as they emerge or are transplanted.

Squash Vine Borer: Pheromone baited sticky traps can be used soon after planting to monitor the activity of the adult moths. Start inspecting plants closely for squash vine borer eggs (1mm [1/25 inch] diameter oval, flattened, dull-red to brownish) as soon as moths are caught in the traps. The first application of insecticide should occur when eggs begin to hatch or just prior to hatching. Applications should be made in afternoons or evenings after flowers close to reduce the spraying of valuable pollinators, especially bees. If pheromone traps are not used, a preventive treatment should be applied when vines begin to run. Re-apply insecticide every seven days for four weeks. Continue monitoring the pheromone traps into August to detect the emergence of the new moths. When moths are caught, inspect plants for second-generation eggs, and begin the insecticide applications when eggs first begin to hatch or just prior to hatching.

Aphids: Aphid feeding can delay plant maturity. Thorough spray coverage, especially on the underside of the leaves is important. Treat seedlings every five to seven days, or as needed. The transmission of plant viruses by aphids has the potential to be the most damaging to the crop. Unfortunately, insecticide use for aphids does not reduce the spread of virus. A better approach is the application of Stylet Oil to fill tiny grooves between the leaf cells. When the aphid probes the leaf surface, its stylet must pass through a layer of oil. This reduces the infectivity of the virus resulting in less disease in the squash plant. The application of Stylet Oil can delay virus infection, but requires application every other day, thorough coverage and high-pressure sprays. Also, refer to the preceding "Mulches" section for information on metallized reflective mulch used to repel or disorient aphids that can spread viruses.

Squash Bug: Begin scouting shortly after plant emergence. Treat every 7 to 10 days when adults or nymphs appear. The control of squash bugs is particularly important where yellow vine disease occurs since squash bugs vector the pathogen responsible for this disease.

Spider Mites: Mite infestations generally begin around field margins and grassy areas. CAUTION: DO NOT mow these areas after midsummer because this forces mites into the crop. Localized in-

festations can be spot-treated. **Note:** Continuous use of pyrethroid sprays may result in mite outbreaks.

DISEASE MANGEMENT

Cucurbit Downy Mildew Forecasting System: Cucurbit downy mildew (CDM) is a devastating foliar cucurbit disease. While difficult, if not impossible to control, CDM can be prevented by using effective IPM practices. A useful tool for prevention of CDM is the CDM forecasting system. This program depends on the accurate reporting of CDM in the field as well as the monitoring of over 50 strategically placed sentinel plots. These plots are monitored by Plant Pathologists at multiple Land Grant Universities throughout the United States and Canada. Forecasts of the epidemic movement of the disease are generated 3 times a week. Risk maps are produced from these forecasts. For forecasts, maps, local contacts and other helpful information please visit our website, http://cdm.ipmpipe.org. If you think you have CDM, please contact your local Extension office.

Viruses (CMV, WMV, PRSV and ZYMV): Plant infection by viruses often causes squash fruit to be distorted or off-color rendering them unmarketable. Certain yellow-fruited varieties contain the precocious (*Py*) gene. The varieties are distinguished by their yellow stem. Varieties with the *Py* gene should be used for late spring or summer plantings since viruses are more prevalent in the summer than spring plantings. The *Py* varieties can normally mask virus fruit symptoms of certain viruses for several harvests. Use resistant varieties where possible, but even these may not escape virus.

WEED MANAGEMENT

See the previous "Mulching" section for further information on weed control under clear plastic mulch.

For Seeding into Soil without Plastic Mulch. Stale bed technique: Prepare beds 3 to 5 weeks before seeding. Allow weed seedlings to emerge and spray with paraquat a week prior to seeding. Then seed beds without further tillage.

For Soil Strips between Rows of Plastic Mulch. Use the following land preparation, treatment, planting sequences, and herbicides labeled for squash, or crop injury may result.

1. Complete soil preparation and lay plastic and drip irrigation before herbicide application.

2. Spray preemergence herbicides on the soil and the shoulders of the plastic strips in bands before weeds germinate. DO NOT APPLY HERBICIDE TO THE BED SURFACE OF THE PLASTIC. Herbicides may wash from a large area of plastic into the plant hole and result in crop injury.

3. Incorporate herbicide into the soil with1/2 to 1 inch of rainfall or overhead irrigation within 48 hours of application and BEFORE PLANTING OR TRANSPLANTING.

4. Apply selective postemergence herbicides broadcast or in bands to the soil strips between mulch to control susceptible weeds.

POLLINATION

Honey bees are important for producing high yields and quality fruit. Populations of pollinating insects may be adversely affected by insecticides applied to flowers or weeds in bloom. Apply insecticides only in the evening hours or wait until bloom is completed before application. See section on "Pollination" in the General Production Recommendations.

HARVESTING AND STORAGE

See Table 14 for postharvest information.

SWEET CORN (*Zea mays*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN
CORN, SWEET								
White - Early								
Silver Princess (se)	A					N		T
Sweet Ice (se)	A	G	K			N	S	
White Out (se)								T
White - Mid-Season								
Argent (se)		G	K	L		N		T
Avalon (se)	A		K					T
Biscayne (sh_2)	A		K			N	S	
Devotion (sh_2)	A					N		T
Ice Queen (sh_2)	A	G	K	L			S	
Munition (sh_2)	A		K			N	S	
WH0809 (sh_2) [2]		G						T
Xtra-Tender Brand 372A (sh_2)	A	G					S	T
Xtra-Tender Brand 378A (sh_2)		G				N	S	T
White - Late season								
Silver King (se)	A					N	S	T
Silver Queen (su)	A	G	K	L	M	N	S	T
WSS 0987 (sh_2) [2]		G		L		N		T
Yellow - Early								
Bodacious (se)					M	N	S	T
Mirai 130Y (sh_2)	A	G			M	N	S	T
Seneca Horizon (su)	A	G		L	M	N		T
Xtra-Tender XT 372A (sh_2)	A				M		S	
Yellow - Mid-Season								
Golden Queen (su)							S	
GH0851 (se) [2]	A	G	K			N	S	T
GSS 0966 (sh_2) [2]	A	G		L		N	S	
Honey Select (se)	A	G	K					T
Incredible (se)				L	M	N	S	T
Merit (su)	A	G	K	L	M	N	S	T
Passion (sh_2)	A	G						
Passion II (sh_2) [2, 3]	A	G	K			N		
Summer Sweet 7210R (sh_2)	A				M	N		
Vision (sh_2)	A				M		S	T
Bicolor - Early								
Lancelot (se)	A					N	S	T
Precious Gem (se)	A			L		N	S	T
Temptation (se)	A					N	S	T
Temptation II (se) [2, 3]	A					N		
Xtra-Tender Brand 270A (sh_2)							S	
Bicolor - Mid-Season								
Awesome XR (sh_2)	A	G				N		T
BC 0805 (sh_2)[2]		G	K					T
BSS 0977 (sh_2)[2]	A	G	K	L		N	S	T
BSS 0982 (sh_2)[2]		G	K	L				
Cameo (sh_2)[2]			K	L				T
Mirai 301BC (sh_2)			K	L	M		S	T
Mirai 350 BC (sh_2)	A				M			
Montauk (sh_2)			K					T
Obsession (sh_2)	A	G	K			N	S	T
Obsession II (sh_2) [2, 3]	A	G	K	L	M	N	S	T
Providence (sh_2)			K					T
Rainier (sh_2) [2]	A							
Sweet Chorus (se)	A	G				N		T
Sweet G90 (su)				L	M	N	S	T
Sweet Rhythm (se)	A	G					S	
Xtra-Tender Brand 281A (sh_2)	A				M	N	S	

[1] Abbreviations for state where recommended. [2] BT sweet corn (transgenic). [3] RoundUp Ready sweet corn (transgenic).

There are three primary genes contributing to sweetness in sweet corn. They are; normal sugary (*su*), sugary enhanced (*se*), and supersweet or shrunken-2 (sh_2).

Normal sugary sweet corn (*su*) has been enjoyed for many years. *Su* sweet corn is known for its creamy texture and mild sugars; however, sugars in these cultivars are rapidly converted into starch if not cooked the day of harvest. These cultivars are commonly sold in farmer's markets and roadside stands. Examples of cultivars of the normal sugary sweet corn are 'Silver Queen' (white kernel), 'Merit' (yellow kernel) and 'Butter and Sugar' (bicolor kernel).

The sugary enhanced (*se*) sweet corn gene, known under trade names such as Everlasting Heritage have varying degrees of increased sugar content with a creamier kernel texture as compared to *su* sweet corn types. This translates into increased sweetness with a smoother kernel texture. Another advantage is that *se* sweet corn types maintain their quality for a longer period of time than normal sugary sweet corn types (*su*).

Cultivars of "Supersweet" or "shrunken" sweet corn (sh_2) derive their name from the appearance of the dried kernel which is much smaller than kernels of *su* or *se* sweet corn types. Recently germination of sh_2 sweet corn cultivars has been improved and is now comparable with the su and se types. Seed of supersweet (sh_2) sweet corn cultivars should be handled very gently and the use of plateless planter is recommended to prevent damage to seed. Many older supersweet cultivars require warm soil (70°F or higher) to germinate since they are less vigorous than the *se* or *su* genotypes. Supersweet sweet corn (sh_2) cultivars have a crunchier kernel, are sweeter than su and se cultivars, and will delay the conversion of sugar to starch extending their shelf life.

Xtra-tender, *Ultrasweet*, and *Triplesweet* are names for the latest development in sweet corn cultivars. These new types of sweet corn combine the genetics of sh_2, *se*, and *su* genotypes. These cultivars are high in sugar levels, hold well in storage, and have a pericarp which is tender (this improves the eating quality of the sweet corn). Plant these cultivars using the same recommendations as those of the sh_2 types of sweet corn.

Isolation requirements for the sweet corn genotype are important in order to obtain the highest quality sweet corn. Supersweet (sh_2) sweet corn must be isolated by a distance of 300 feet or 12 days difference in silking date to avoid cross pollination from field corn, pop corn, normal sugary (*su*), and/or sugar enhanced (*se*) types. Failure to properly isolate the sh_2 genotype will result in it producing starchy, tough kernels. Isolation of sugary enhanced from normal sugary sweet corn types is recommended to maximize quality; however, quality is usually very minimally affected should cross pollination occur. It is recommended that augmented sweet corn types be isolated from all other sweet corn types for best quality.

Another important development in sweet corn cultivar development is the incorporation of the *BT* gene (called *BT* sweet corn). *BT* sweet corn has been genetically modified by incorporating a small amount of genetic material from another organism through modern molecular techniques. In sweet corn, the incorporated *BT* genes is particularly effective in providing protection against European corn borer and corn earworm. The protein produced by the *BT* gene is very selective, generally not harming insects in other orders (such as beetles, flies, bees, or wasps) but more importantly this protein is safe for consumption by humans, other mammals, fish, and birds. Syngenta Seeds has incorporated the *BT* gene into several sweet corn cultivars that are sold commercially under the trade name of *Attribute* followed by a series of numerals to identify the cultivar. Certain restrictions such as isolation, minimum acreage requirements, and destruction of the crop are part of the terms of contract when purchasing *BT* sweet corn seed.

In general, when selecting a cultivar, be sure to evaluate its acceptance in the market. Plant small acreages of new cultivars to test market their acceptance.

Seed Treatment. Check with seed supplier to ensure seed was treated with an insecticide and fungicide. Information on seed treatments can be found in SEED TREATMENTS section starting on page 239.

Seeding and Spacing. Seed is sown as early as February in more southern regions on light, sandy soils. Use a high vigor seed variety for early plantings. Seed is drilled in the field about 1 inch deep. Varieties are spaced 30 to 42 inches apart between rows depending on cultural practices, equipment, and seed size. In-row spacings range from 6 to 12 inches apart, with small-eared, early seasons varieties planted closest.

SWEET CORN PLANTING DATES

	Spring	Fall
AL North	4/15–5/30	NR
AL South	2/1–4/30	7/15-8/15
GA North	4/15–4/30	NR
GA South	2/1–3/31	7/15–8/15
KY East	5/1-6/15	NR
KY Central	4/20-7/10	NR
KY West	4/10-7/20	NR
LA North	3/1–5/15	NR
LA South	2/15–5/1	NR
MS North	3/20–4/9	NR
MS South	2/21–3/14	NR
NC East	3/15–4/30	NR
NC West	4/15–6/15	NR
SC East	3/1–4/15	NR
SC West	3/30–5/30	NR
TN East	4/15-6/30	NR
TN West	4/15-6/15	NR

Mulching. The use of clear plastic mulch will improve stands, conserve moisture, and produce earlier maturity. Corn is seeded in the usual manner, except 10 to 20 days earlier in double rows 14 inches apart and on 5- to 6-foot centers. Apply herbicide and then cover with clear, 4-foot-wide plastic. Allow plastic to remain over plants for 30 days after emergence, then cut and remove plastic from field. Plants can then be cultured in the usual manner. A nematode assay is recommended before using this system. If nematodes are present in the soil, control measures are necessary before planting. Use a high vigor seed variety to avoid uneven and reduced stand.

Minimum Tillage. No-tillage is the most commonly used minimum tillage practice with sweet corn. No-till planters currently in use with row crop production will plant sweet corn seed with minimal modifications. Type of winter cover crop residue can affect sweet corn seed depth. Inspect seed placement and adjust for

correct depth. Early spring planting with no-tillage in sweet corn may delay growth and days to harvest. Planting after soils warm in the spring will improve vigor. Use of small grain cover residue may require additional nitrogen (20 to 30 lbs N/acre in addition to the normal recommendation) if cover crop is fairly mature when killed. No additional nitrogen above recommendations is required if a legume cover crop (hairy vetch, winter peas, or crimson clover) is used as residue.

SPECIAL NOTES FOR PEST MANAGEMENT

(listed as "Corn, Sweet" in the Pest Management section)

INSECT MANAGEMENT

Corn Earworm (CEW): CEW initiates egg laying when the plants begin to silk and ends when the silks wilt. Eggs are laid singly on the fresh silks. Begin to control CEW when 10% of the ears are silked. Repeat sprays at three to five day intervals until 90% of the silks have wilted. Control is more difficult late in the season. Direct sprays toward the middle third of the plant. Corn hybrids having a long, tight-fitting shuck appear to suffer less damage than those with loose shucks.

Another management tactic for CEW and European corn borer (ECB) control is the use of BT sweet corn. These hybrids produce their own natural insecticide for control of these pests. However, under high pressure, supplemental sprays may be needed to achieve damage-free ears. Minimum acreage and resistance management practices are required with BTs sweet corn. Some markets may not accept these hybrids.

Corn Flea Beetle: Flea beetles transmit a bacterial wilt disease, known as Stewart's Wilt, and these beetles are numerous after mild winters. Treat susceptible varieties at spike stage when 6 or more beetles per 100 plants can be found. Repeat every 3 to 5 days as needed. **Note:** Soil-applied insecticides may be ineffective during the first week of plant growth if soil temperatures are cool. Foliar applications of an insecticide may be necessary during this period.

European Corn Borer (ECB): Thorough spray coverage in whorls and on plants is essential. Many insecticides are highly toxic to bees. Granular formulations, if applied over the whorl, are generally more effective than liquid formulations for ECB control.

Sap Beetle (SB): Loose-husked varieties tend to be more susceptible to sap beetle attack. Ears damaged by other insects attract SB. Begin sampling at pollen shed and treat when 5% of the ears have adults and/or eggs. **Note:** Insecticides used for worm control at silk may not control SB infestations.

Fall Armyworm (FAW): Direct granules over the plants so that they fall into leaf whorls when FAW first appear and repeat application, if necessary. For foliar spray applications, high-spray gallonage (50 to 75 gallons per acre) is necessary for effective FAW control.

INSECT MANAGEMENT DECISION-MAKING

Whorl/Tassel Infestation: In general, insect larval feeding (ECB and FAW) during the whorl stage of sweet corn development has a greater impact on early planted, short-season varieties. For ECB on early plantings, apply first spray or granular application when 15% of the plants show fresh feeding signs. Additional applications may be necessary if infestation remains above 15%. An early tassel treatment is usually more effective than a whorl treatment because larvae are more exposed to the chemicals.

The impact of infestation on mid-and late-season plantings depends on the stage of the plants when the infestation occurs. Treat for FAW during the early whorl stage when more than 15% of the plants are infested. During mid- to late-whorl stages, treatment for both FAW and ECB may be necessary if more than 30% of the plants are infested. Treat fields in early tassel stage if more than 15% of the emerging tassels are infested with ECB, FAW, or young corn earworm (CEW) larvae.

Ear Infestation: Direct sampling for CEW, FAW, and ECB during silking is not practical because of the low thresholds for ear damage. Begin treatment when 10% of the ears show silk. If CEW populations are heavy, it may be necessary to begin treatments when the very first silks appear. Silk sprays should continue on a schedule based on area blacklight and pheromone trap counts, geographical location, and time of year. Early in the season, silk sprays may be required on a 3- to 6-day schedule. When CEW populations are heavy, it may be necessary to treat on a 1-to 3-day schedule. Applications during low populations can end up to 5 days before last harvest. During heavy populations and high temperatures, treatments will need to be made according to the legal "days to harvest" of the chemical.

For best control during heavy populations, maximize the gallonage of water per acre, use a wetting agent, and make applications with a high pressure sprayer (200+ psi) with drop nozzles directed at the silks.

HARVESTING AND STORAGE

See Table 14 for postharvest information.

SWEETPOTATO (*Ipomoea batatas*)

VARIETIES[1]	AL	GA	KY	LA	MS	NC	SC	TN	VA
SWEETPOTATO									
Beauregard [2, 5, 6, 8, 9, 11]	A	G	K	L	M	N	S	T	V
Bayou Belle [2, 6, 7, 8, 8, 11]	A			L	M		S		
Bonita [3, 6, 7, 8, 9, 12]	A			L	M	N	S		V
Burgundy [2, 6, 7, 8]						N			V
Carolina Ruby [2, 6, 8]						N		T	V
Covington [2, 6, 7, 11]	A	G	K		M	N	S		V
Evangeline [2, 5, 6, 7, 8, 11]		G		L	M	N			V
Hernandez [2, 6, 7, 8, 11]	A	G	K			N	S		
Japanese/Grand Asia [4, 7, 11]						N			
Jewel [2, 7, 8, 9, 10, 11]	A	G	K		M	N	S		V
Murasaki [4, 6, 7, 8, 9, 11]	A		K			N			
O' Henry [3, 5, 6, 8, 9, 11]	A		K		M	N			V
Orleans [2, 6, 8, 9, 11]	A			L	M	N	S		V
White Hayman [3]	A					N			

[1] Abbreviations for state where recommended.
[2] Red or copper skin, orange flesh.
[3] Tan or cream, white flesh.
[4] Purple skin, white flesh.
[5] Sclerotial blight resistance.
[6] Soil rot resistance.
[7] Root knot resistance.
[8] Fusarium wilt resistance.
[9] Rhizopus resistance.
[10] Bacterial soft rot resistance.
[11] Fusarium root rot resistance.
[12] Suitable choice for organic production.

Variety Selection. Selection of a variety depends on the intended market. Most varieties require 90 to 150 days to produce maximum yields. Sweetpotatoes are cold sensitive and should not be planted until all danger of frost is past. The optimum temperature to achieve the best growth of sweetpotatoes is between 70°F and 88°F, although they can tolerate temperatures as low as 55°F and as high as 105°F.

Soil. Well-drained sandy and sandy loam soils will produce the best-shaped sweetpotatoes. Avoid using heavy soils. Soils with high levels of organic matter can promote scurf. Use long rotations to decrease the incidence of scurf and infection from Fusarium wilt. Avoid fields that have produced a crop of sweetpotatoes in the past two years and fields that have high nematode populations and are seriously eroded or grassy. Select a soil that is well drained but not prone to drought. Waterlogged, poorly drained soils prevent roots from obtaining sufficient oxygen, which can cause "souring" of roots.

Fertilizer and Lime. Get a soil test. The optimum pH range is 5.8 to 6.2. If your soil needs lime, incorporate the appropriate amount several months before planting. This will allow sufficient time for the lime to increase your soil's pH.

Broadcast or band half of the required nitrogen (N) before planting and then sidedress the remainder at layby when the vines begin to run. An appropriate total seasonal rate of N range for sweetpotato is between 40 and 80 pounds per acre. When applying N, apply between 150 to 200 pounds of potash per acre for the growing season. Some varieties require less N fertilizer than others. For the variety Beauregard, 50 pounds per acre per growing season is sufficient while for the variety Covington, 80 pounds per acre in preferred. Follow the recommended rate of fertilizer because high fertilizer concentrations may result in salt burn and plant damage. Additionally, applying surplus fertilizer can cause excessive vine growth and be a waste of resources due to added costs that will not result in higher yields.

CROP ESTABLISHMENT

Propagating. Sweetpotatoes are propagated from sprouts or slips (vine cuttings). Only purchase certified, disease-free seed stock or slips. Select seed (the word *seed* refers to the roots used for slip production), that is free from insect and disease damage, that has a uniform flesh with variety appropriate skin color, and that is free from veins. Your profitability depends on starting with the highest quality seed stock available. Using quality roots for seed is essential for producing quality sweetpotatoes. Quality sweetpotatoes are not produced from poor-quality seed.

In most years, it is not possible to purchase sufficient certified seed stock to produce slips for your entire planned production. Thus, seed must be saved from each year's crop. When possible, isolate your seed planting from that of your commercial planting to minimize viruses. Save seed from the highest quality roots that you produce. Carefully inspect roots for defects (no off-types), disease, insect damage, etc., as listed above. Each year purchase a portion of your required seed stock for slip production as certified seed, supplementing your total need with seed from the previous year's crop. Certified slips are available from several growers in around the Southeastern US. Consult your local Extension office for information.

Presprouting. Presprouting is a technique that produces two to three times more slips than seed stock that is not presprouted. Some refer to presprouting as "waking up" the sweetpotatoes after they have been in storage. Presprouting encourages more prolific sprouting in roots. This can decrease production costs by decreasing the amount of seed stock required. In addition to increasing the number of slips produced, presprouting produces slips faster. Conditions required for presprouting are similar to those required

for curing sweetpotatoes. Presprouting involves placing seed stock in a controlled storage area, such as a curing room. You must be able to control temperature and relative humidity and be able to provide ventilation. Be sure that you are able to replace the air one to two times per day because the roots require a significant amount of oxygen to facilitate presprouting. A rule of thumb: if there is not enough oxygen for a match to stay lit, there is likely not enough oxygen for the sweetpotatoes. To presprout, place seed stock in a presprouting room for 21 to 35 days at 70 to 80°F with 90% relative humidity. Spraying the walls and floors with water two times per day can help maintain relative humidity. Mechanical humidifiers (automatic humidifiers, misting systems) can help establish and maintain the required relative humidity. Avoid humidity near 100 percent or wetting of the surface of the roots as this can lead to the development of rots.

Bedding. Provide 4 to 5 pounds of 8-8-8 or 10-10-10 type fertilizer per 100 square feet of bed area. Treat seed with appropriate fungicides to prevent bedding root decay. After presprouting, place roots into beds, being careful not to damage them. Be sure to cover roots completely with 2 to 3 inches of soil. Do not be concerned if a few sprouts are above the soil line. Keep beds moist but not wet. After planting roots, cover beds immediately with black or clear plastic to warm the soil. Punch holes in plastic for ventilation as needed. Slips are ready to harvest when they have 6 to 10 leaves (8 to 12 inches long) and adventitious roots are initiated (roots projected from the nodes or joints of the stem). Slips from presprouted roots are generally ready one week earlier.

Preparing Slips for Transplanting. To harvest, cut the slips about 1 inch above the bed surface. Cutting is preferred to pulling slips. Always pull the knife up and away from the soil to prevent contamination from the seedbeds from moving into the production field. Clean knives frequently by dipping them into a 1:1 (v/v) solution of bleach and water. This will also prevent the spread of diseases from the seedbed into the field. Set the slips in the field within three days after harvesting them from the plant beds. About 500 slips can be produced from one bushel of seed. One bushel of seed requires 20 to 30 square feet of bed area.

Transplanting. Avoid planting slips until all danger of frost is past because they are very frost sensitive. Beds should be 4 to 8 inches high and as wide as equipment will allow. Narrow beds tend to dry quickly and may reduce overall yields. High beds will aid in promoting drainage, thus preventing water damage to roots. The most economical method to set a large number of plants is with a mechanical transplanter. Space slips 6 to 16 inches apart within rows spaced 3½ to 4 feet apart on row centers. The number of slips needed per acre will depend on your desired spacings. Be sure to manage water carefully to avoid transplant shock. Slips set more widely apart in-row will facilitate root enlargement, while closer in-row spacing results in increased competition and delay root sizing.

SWEETPOTATO PLANTING DATES

AL North	5/1–6/30	NC East	5/1–7/15
AL South	3/15–5/15	NC West	5/25–6/30
GA North	5/15–6/15	SC East	4/15–6/15
GA South	4/1–6/15	SC West	5/1–6/15
KY East	5/20-6/1	TN East	5/15-6/30
KY Central	5/10-6/10	TN West	5/1-6/30
KY West	5/1-7/15	VA East (coastal)	5/15-6/30
LA North	5/1–6/30	VA West (mountains)	6/1-6/20
LA South	4/15–6/30		
MS	4/25–5/20		

SPECIAL NOTES FOR PEST MANAGEMENT

INSECT MANAGEMENT

Lepidoptera Larvae: Sweetpotato hornworm, corn earworm, southern armyworm, yellowstriped armyworm, beet armyworm, fall armyworm, and soybean looper all feed on foliage leaving small to large holes. In plant beds and newly set fields, damage may be serious. Mid to late season foliar feeding may reduce yields or delay sizing of roots when coupled with plant stress. After harvest, larvae may continue feeding on sweetpotatoes left in the field and in storage. Apply insecticide to plant beds and in fields as needed. Cuttings should be free of insects before planting. Where worms are abundant at harvest, spray fields 2 to 3 days before digging. Remove harvested sweetpotatoes from the field immediately.

Cucumber Beetles (rootworms): Adults and larvae of the banded cucumber beetle, *Diabrotica balteata*, and the spotted cucumber beetle, *Diabrotica undecimpunctata* feed on sweet potato. Both species are highly mobile and will also feed on several other host plants including, various vegetable plant species, soybeans, and corn. Adult beetles feed on sweet potato foliage, creating irregular holes in the leaves. Adult beetles lay eggs in the soil and larvae developing in the soil feed on developing sweet potato roots. Feeding on the roots can occur throughout the production season, but damage from these insects increases late season. Feeding injury results in unsightly blemishes on the roots at harvest. The larval stage lasts from 8-30 days depending on the temperature and food supply. Pupae are found just below the soil surface. Adults will emerge in approximately one week. Numerous generations of these insects can develop and injure sweet potatoes throughout the production season. Soil applied insecticides can reduce damage from these insects if applied close to planting. Adults should be scouted weekly during the production season and labeled insecticides should be applied when the number of beetles sampled reaches or exceeds the treatment threshold of 2 beetles/100 sweeps.

Tortoise Beetle: Generally, damage by tortoise beetles threatens newly set plants or plants under stress. Leaves of infested plants are riddled with large, round holes. Adults and larvae which feed on sweetpotato foliage include: mottled tortoise beetle, striped tortoise beetle, and argus tortoise beetle, blacklegged tortoise, and golden tortoise beetle. Isolate plant beds and control morningglory. Monitor movement of ornamental sweetpotatoes which often contain tortoise beetles and other insects. Apply insecticides to young plants if needed. Control beetles in plant beds and fields.

Sweetpotato Weevil: This is the most serious worldwide pest of sweetpotatoes. Adults and larvae feed on foliage, but prefer stems and roots. Infested sweetpotatoes are riddled with small holes and galleries especially in the stem end. They turn bitter and are unfit for consumption by either humans or livestock. Use only "seed" and plants produced in approved and trapped weevil-free areas. All purchased roots/plants, including those produced out-of-state, must be certified. Use pheromone traps in plant beds, greenhouses, and in fields to detect sweetpotato weevil. Some varietal tolerance exists. Chemical control with weekly or biweekly sprays is difficult. South Carolina has a strict monitoring and quarantine program in place to maintain these weevil-free production areas.

Sweetpotato Flea Beetle: Adult beetles overwinter in debris, along fence rows, and at the edges of wooded areas. In the spring, eggs are laid in the soil near host plants. There are several generations per year. Adults feed on foliage leaving channels on the upper leaf surfaces. Larvae feed on roots etching shallow, winding, sunken trails on the surface, which enlarge, darken and split. Monitor adults with yellow sticky cups. Control morningglories and weeds along field margins and plow under crop debris. Use resistant or tolerant varieties. Beauregard is very susceptible to flea beetles. In fields with a history of infestation use a preplant or a side-dressed soil insecticide over the foliage up to the last cultivation. Control adults with insecticides.

Whitefringed Beetle: Larvae feed on roots causing damage similar to that of wireworms and white grubs. Only flightless, female adults occur and feed at the base of plants leaving scars on the stem. They also feed and notch leaves. They are most active in July and August and produce eggs in groups without mating. Avoid infested fields and rotate crops. Only grasses are not suitable as hosts. Monitor for adults or leaf notching. Limited control may be achieved by using tolerant varieties, foliar insecticides applied every two weeks and soil insecticides. Record whitefringed beetle sites and do not plant sweetpotatoes in these locations.

Wireworms: Tobacco wireworm, southern potato wireworm, corn wireworm leave small, irregular, shallow or deep holes in the surface of sweetpotato roots. Larvae are identified by differences in their last abdominal segment. Wireworm adults (click beetles) lay their eggs in grassy, undisturbed soil. Adults feed on weed seeds (pigweed) and corn pollen. Avoid land previously in sod or fallow. Wireworms may be detected prior to planting using corn, wheat, or oatmeal bait stations. If necessary, broadcast and incorporate a preplant insecticide, or use a granular material at root swell. Timed foliar sprays are of limited value, as adults do not feed on sweetpotato and are only controlled when sprays contact adults or larvae move into a treated area. Control weeds and do not allow them to mature to seed. Resistant varieties are available. Avoid planting in fields with corn wireworm. Avoid planting behind corn, grain, and grain sorghum. Tobacco wireworm adults can be monitored with yellow sticky cups. Wireworm adults are attracted to black-light insect traps.

White Grubs: These can cause large, shallow, irregular damage on the surface of sweetpotatoes. Species include Japanese beetle, spring rose beetle, and green June beetle. Adults lay eggs in grassy areas (also see section on wireworms). Pheromone traps are under evaluation. Japanese beetles are attracted to traps. White bucket traps attract spring rose beetles. Use a preplant insecticide and foliar sprays when adults are active.

Fruit Fly: Fruit flies may be a nuisance in storage houses when sweetpotatoes decay due to other causes such as souring, chilling, and Rhizopus soft rot. Fruit flies feed on decaying vegetables. Maggots may be seen in decaying roots. Fruit flies may become established in cull piles and spread to the storage house. They do not cause rots. Harvest, cure and store only sound sweetpotatoes. Dispose of culls, inspect the storage house and use traps. If necessary, spray with an appropriate insecticide.

HARVESTING AND STORAGE

A 3 to 4 month growing season is required for root development. After the roots are dug, they should be cured in the storage house at 80° to 85°F and 90% relative humidity for 6 to 8 days. After curing, temperature should be lowered to 55°F, but relative humidity should be maintained at 85%. Temperature should never go below 50°F or chilling injury may result, depending on length of exposure. Above 60°F, sprouting will occur and root weight decrease. See Table 14 for further postharvest information.

TOMATOES (*Solanum lycopersicum*)

VARIETIES[1]	AL	AR	GA	KY	LA	MS	NC	SC	TN
TOMATOES									
Fresh Market									
Amelia VR [2, 10, 11, 12, 14, 15, 18]	A	R	G	K	L	M	N	S	T
Applause [8, 10, 11, 15, 25]	A					M			
Bella Rosa [2, 3, 8, 10, 11, 15, 18]	A		G		L	M			
BHN 589 [10, 11, 18, 20, 25]	A					M			
BHN 602 [2, 10, 11, 12, 18]	A		G	K	L	M	N	S	T
BHN 640 [2, 10, 11, 12, 18]	A		G	K	L	M	N	S	T
Big Beef [8, 10, 11, 14, 15, 18, 20]		R		K	L	M			
Carolina Gold [10, 11, 17, 18]	A		G	K	L	M	N	S	T
Celebrity [10, 11, 14, 18, 25]	A	R			L		N		T
Crista [2, 10, 11, 12, 14, 18]	A		G	K	L	M	N	S	T
Defiant PhR [10,11,18,19,24]	A	R					N	S	T
Florida 47R [8, 10, 11, 15, 18]	A		G	K	L	M	N	S	T
Florida 91 [3, 8, 10, 11, 15, 18]					L	M			T
Mountain Glory [2, 10, 11, 18]	A			K			N		T
Mountain Magic [9, 10, 11, 18, 19, 24]	A	R	G	K	L	M	N	S	T
Mountain Majesty [2,10,11,18,25]	A		G				N	S	T
Mountain Merit [2, 9, 10, 11, 14, 18, 24]	A								
Mountain Rouge [14, 24]	A				L	M	N	S	
Mountain Spring [10, 11, 15, 18, 25]	A		G	K	L	M	N	S	T
Phoenix [3, 8, 10, 11, 15, 18]	A		G	K	L		N		T
Primo Red [2, 10, 11, 18, 20]	A						N		T
Red Bounty [2, 3, 10, 11, 14, 15, 18]	A		G					S	
Red Defender [2, 8, 10, 11, 15, 18, 25]	A	R	G	K	L				T
Redline [2, 10, 11, 12, 15, 18]	A		G		L				
Red Deuce [10, 11, 15, 16, 18, 25]				K					
Red Morning [2, 10, 11, 18, 20]	A								T
Red Mountain [2, 10, 11, 12, 14, 18]	A		G						T
Rocky Top [10, 11, 12, 15, 18, 25]	A			K		M	N	S	
Solar Fire (Fall only) [3,10,11,12,15]	A		G			M	N	S	
Tribute [2, 3, 8, 10, 11, 15, 18, 21]	A				L				
Cherry Types									
Matt's Wild Cherry [19, 24]								S	
Mountain Belle [10, 18]	A		G	K	L	M	N	S	T
Sun Gold [10, 11, 16, 17]	A	R			L	M	N		T
Sun Sugar [17, 20]	A				L	M	N	S	
Grape Types									
Cupid [8, 10, 15, 28]	A		G						T
Elfin [7]	A		G				N	S	
Jolly Elf [11, 18]	A		G			M	N	S	T
Mountain Honey [2, 7, 10, 11, 12, 18, 24]	A						N		T
Smarty [10, 11, 18]	A						N	S	T
Roma Types									
BHN 410 [10, 11, 15, 18, 28]	A		G				N	S	T
Granadero [2, 9, 10, 14, 18, 20, 27]	A							S	
Mariana [8, 10, 11, 14, 15, 18]	A						N		T
Picus [2, 8, 10, 15, 18]	A							S	
Plum Crimson [10, 11, 12, 18]	A		G	K			N		T

[1] Abbreviations for state where recommended.
[2] Tomato Spotted Wilt Virus resistance (TSWV).
[3] Heat set (heat tolerance).
[7] Determinant or short internode grape tomato.
[8] Alternaria Stem Canker tolerance/resistance (ASC).
[9, 10, 11, 12] Fusarium Wilt race 0, 1, 2, 3 tolerance/resistance (F).
[13] Fusarium Crown Root Rot tolerance/resistance (FCRR).
[14] Nematode resistance (N).
[15] Gray Leaf Spot resistance (St).
[16] Tobacco Mosaic Virus resistance (TMV).
[17] Yellow fruit.
[18] Verticillium Wilt resistance (V).
[19] Early Blight tolerance/resistance.
[20] Tomato Mosaic Virus resistance (ToMV).
[21] Tomato Yellow Leaf Curl Virus resistance (TYLCV).
[22] Orange fruit.
[23] Salad size (Campari type).
[24] Late blight tolerance/resistance.
[25] Suitable for high tunnel production.
[26a-e] Tomato leaf mold race A,B,C,D,E tolerance/resistance.
[27] Powdery mildew tolerance/resistance.
[28] Bacterial speck tolerance/resistance (BSK-0).

VARIETIES[1]	AL	AR	GA	KY	LA	MS	NC	SC	TN
TOMATOES (cont'd)									
Roma Types									
Plum Regal [2, 10, 11, 18, 19, 24]	A	R		K	L		N	S	T
Pony Express [10, 11, 12, 14, 18, 20, 28]				K					T
Greenhouse Types – Beefsteak									
Big Dena [10, 11, 13, 16, 18]	A				L	M			
Beorange [10, 11, 13, 18, 20, 22, 26a-e]				K					
Geronimo [11, 13, 16, 18, 26a-e, 27]	A			K	L	M			T
Starbuck [10, 13, 18, 20, 26a-e]	A				L	M			
Torero [11, 13, 16, 18, 26a-e, 27]	A				L	M			
Trust [11, 13, 16, 18, 26a-e]	A	R	G	K		M	N	S	T

[1] Abbreviations for state where recommended.
[2] Tomato Spotted Wilt Virus resistance (TSWV).
[3] Heat set (heat tolerance).
[7] Determinant or short internode grape tomato.
[8] Alternaria Stem Canker tolerance/resistance (ASC).
[9, 10, 11, 12] Fusarium Wilt race 0, 1, 2, 3 tolerance/resistance (F).
[13] Fusarium Crown Root Rot tolerance/resistance (FCRR).
[14] Nematode resistance (N).
[15] Gray Leaf Spot resistance (St).
[16] Tobacco Mosaic Virus resistance (TMV).
[17] Yellow fruit.
[18] Verticillium Wilt resistance (V).
[19] Early Blight tolerance/resistance.
[20] Tomato Mosaic Virus resistance (ToMV).
[21] Tomato Yellow Leaf Curl Virus resistance (TYLCV).
[22] Orange fruit.
[23] Salad size (Campari type).
[24] Late blight tolerance/resistance.
[25] Suitable for high tunnel production.
[26a-e] Tomato leaf mold race A,B,C,D,E tolerance/resistance.
[27] Powdery mildew tolerance/resistance.
[28] Bacterial speck tolerance/resistance (BSK-0).

Seed Treatment. To minimize the occurrence of bacterial canker, bacterial spot, and bacterial speck, seed should be treated with chlorine. If seed is not treated with chlorine by the seed company, then dip seed in a solution containing 1 quart of household bleach and 4 quarts of water plus one-half teaspoon of surfactant for 1 minute. Provide constant agitation. Use 1 gallon of solution per pound of seed. Prepare a fresh solution for each batch of seed. Wash seed in running water for 5 minutes and dry seed thoroughly. The final rinse should be done with acidified water (1 oz. vinegar per gallon of water). Further information on seed treatments can be found in SEED TREATMENTS section starting on page 239.

TOMATO PLANTING DATES

	Spring	Fall
AL North	4/15–6/15	7/1-8/1
AL South	3/1–4/30	7/15–8/15
AR North	5/15-6/20	7/15-7/30
AR South	4/15-6/15	8/1-8/15
GA North	4/15–6/15	7/1-8/1
GA South	3/1–4/30	7/15–8/30
KY East	5/15-6/1	NR
KY Central	5/5-6/15	NR
KY West	4/20-7/1	NR
LA North	3/15–6/30	7/1–8/10
LA South	3/1–6/30	7/15–8/15
MS North	4/20–6/30	NR
MS South	3/1–3/15	NR
NC East	4/15–5/10	8/1–8/15
NC West	5/15–7/15	NR
SC Coastal Island	3/1-4/30	7/1-7/15
SC East	3/15–4/30	7/1–7/15
SC West	5/1–6/30	NR
TN East	5/1-6/30	NR
TN West	4/20-6/20	NR

Hardening Transplants. It is usually desirable to harden tender tomato seedlings before planting them in the field. Recent research has shown that hardening tomato plants by exposure to cool temperatures (60° to 65°F/day and 50°to 60°F/night) for a week or more causes catfacing. Harden plants by withholding water. Allow plants to wilt slightly between light waterings. Do not harden transplants by withholding fertilizer.

Drip Fertilization. Before mulching, adjust soil pH to 6.5 and, in the absence of a soil test, apply enough fertilizer to supply 50 pounds per acre of N, P_2O_5 and K_2O, (some soils will require 100 pounds per acre of K_2O) then thoroughly incorporate into the soil.

After mulching and installing the drip irrigation system, the soluble fertilizer program should be initiated according to that described in the following table. On soils testing low to low-medium boron, also include 0.5 pound per acre of actual boron.

The first soluble fertilizer application should be applied through the drip irrigation system within a week after field-transplanting the tomatoes. Continue fertigating until the last harvest.

SUGGESTED FERTIGATION SCHEDULE FOR TOMATO* (low soil potassium)

Days after planting	Daily nitrogen	Daily potash	Cumulative	
			Nitrogen	Potash
	(lb / A)			
Preplant			50.0	125.0
0–14	0.5	0.5	57.0	132.0
15–28	0.7	1.4	66.8	151.6
29–42	1.0	2.0	80.8	179.6
43–56	1.5	3.0	101.8	221.5
57–77	2.2	4.4	148.0	313.9
78–98	2.5	5.0	200.5	418.9

SUGGESTED FERTIGATION SCHEDULE FOR TOMATO* (high soil potassium)

Days after planting	Daily nitrogen	Daily potash	Cumulative	
			Nitrogen	Potash
	(lb / A)			
Preplant			50.0	125.0
0–14	0.5	0.5	57.0	132.0
15–28	0.7	0.7	66.8	141.8
29–42	1.0	1.0	80.8	155.8
43–56	1.5	1.5	101.8	176.5
57–77	2.2	2.2	148.0	223.0
78–98	2.5	2.5	200.5	275.5

*Adjust based on tissue analysis.

Fresh Market. Yield, fruit size, and fruit quality of fresh market tomatoes are increased by the use of black plastic mulch in combination with drip irrigation. When air temperature exceed 85F use white on black plastic mulch, or paint black plastic with a 5:1 (v/v) mixture of exterior, flat white latex paint and water. Form-raised, dome-shaped beds to aid in disease control. Lay black plastic mulch tightly over the beds.

See the "Drip Irrigation" section of General Production Recommendations for detailed recommendations on fertilizing tomatoes grown with plastic mulch and drip irrigation. Lay black plastic mulch tightly over the beds.

Grafting and Diseases. In recent years, grafted tomato plants have emerged as a strategy to combat soilborne diseases, particularly in heirloom varieties. Grafting is used against diseases such as Bacterial wilt, Fusarium wilt, and Verticillium wilt. Grafted plants are more expensive per transplant. For more information, see the section Grafting in Vegetable Crops on pages 15 and 16 in this handbook.

Greenhouse Tomatoes. While there are thousands of tomato varieties on the market, only a few are suitable for growing in greenhouses. If you plan on growing tomatoes to maturity in the greenhouse, you need to select a greenhouse variety. This is because these varieties have been bred specifically for greenhouse conditions – lower light, higher humidity and temperature, etc., and have better disease resistance than field types. Nearly all greenhouse varieties are indeterminate hybrids so that they will yield over a long harvest season. While non-greenhouse types would grow in the greenhouse, the yield and quality would be reduced, and therefore they may not be profitable.

Variety selection is based on yield, fruit size, uniformity, disease resistance, and lack of physiological disorders, as well as the market demand for the type of tomato grown. For suggestions on varieties, see the variety table in this section above. Insect and disease control methods for greenhouse vegetables can be found in Tables 2-22 and 3-39 through 3-43 (in Disease section), respectively. For further information on greenhouse tomato production, see http://msucares.com/pubs/publications/p1828.pdf

Ground Culture. Space *determinate* varieties in rows 4 to 5 feet apart with plants 15 to 24 inches apart in the row. For *indeterminate* varieties, space rows 5 to 6 feet apart with plants 24 to 36 inches apart in the row.

Stake Culture. Staking tomatoes is a highly specialized production system. The following recommendations are for the short-stake cultural system using determinate cultivars that grow 3 to 4 feet in height or for indeterminate varieties that grow 6 to 7 feet in height. Use between row spacings of 5 to 6 feet with in-row spacings of 18 to 24 inches. See state specific guides for a full description of staking.

Pruning: Pruning is practiced to establish a desired balance between vine growth and fruit growth. Little to no pruning results in a plant with a heavy load of smaller fruit. Moderate pruning results in fewer fruits that are larger and easier to harvest. Pruning can result in earlier maturity of the crown fruit and improves spray coverage and pest control.

Removing all suckers up to the one immediately below the first flower cluster is adequate for most determinate cultivars. Removing the sucker immediately below the first flower cluster or pruning above the first flower cluster can result in severe leaf curling and stunting of the plant and should be avoided.

Prune when the suckers are no more than 2 to 4 inches long. A second pruning may be required to remove suckers that are too small to be easily removed during the first pruning and to remove ground suckers that may develop. Pruning when suckers are too large requires more time and can damage the plants, delay maturity, and increase disease incidence. Do not prune plants when they are wet to avoid spread of diseases. Pruning should be done before the first stringing because the string can slow the pruning process. Pruning is variety-and fertility-dependent.

Less-vigorous determinate cultivars generally require less pruning. Growers should experiment with several degrees of pruning on a small scale to determine pruning requirements for specific cultivars and cultural practices.

***Staking*:** Staking improves fruit quality by keeping plants and fruit off the ground and providing better spray coverage. Staked tomatoes are easier to harvest than ground tomatoes.

Staking tomatoes consists of a series of wooden stakes with twine woven around the stakes to train the plants to grow vertically off the ground. Stakes 4 to 4.5-feet long by 1-inch square are driven about 12 inches into the soil between the plants.

Vigorous cultivars may require larger and longer stakes. A stake placed between every other plant is adequate to support most determinate varieties. Placing an additional stake at an angle and tied to the end stake of each section will strengthen the trellis system. Stakes can be driven by hand with a homemade driving tool or with a commercially available, power-driven stake driving tool. Drive stakes to a consistent depth so that spray booms can be operated in the field without damaging the trellis system.

Select "tomato twine" that is resistant to weathering and stretching and that binds well to the wooden stakes. Tomato twine is available in 3- to 4-pound boxes. Approximately 30 pounds of twine is required per acre. To make tying convenient, use a homemade stringing tool. This tool can be made from a length of metal conduit, schedule 40PVC pipe, broom handle, or wooden dowel. With conduit, the string is fed through the pipe. With a broom handle or wooden dowel, two small parallel holes, each about 1 inch from the end, must be drilled to feed the string through one hole along the length of the tool and through the other hole. The

tool serves as an extension of the worker's arm (the length cut to the worker's preference) and helps to keep the string tight.

Proper stringing consists of tying the twine to an end stake passing the string along one side of the plants, and then looping the twine around each stake until the end of a row or section (100-foot sections with alleys may be helpful for harvesting) is reached. The same process is continued on the other side of the row. The string tension must be tight enough to hold the plants upright. **Note:** If strings are too tight, they can make harvesting fruit difficult and can scar fruit.

The first stringing should be strung 8 to 10 inches above the ground when plants are 12 to 15 inches tall and before they fall over. Run the next string 6 to 8 inches above the preceding string before plants start to fall over. Three to four stringings are required for most determinate varieties. Stringing should be done when the foliage is dry to prevent the spread of diseases.

Heirloom Tomatoes. Heirloom tomatoes are varieties that have been available for 50 years or more, are open pollinated, and grow "true to type" from seed saved from fruit each year. They are generally indeterminate, requiring trellising and constant pruning. Most varieties have little disease resistance. The fruit are usually thin-skinned, soft, and tend to crack. Consumers are attracted to heirloom tomatoes because many varieties are very flavorful, colorful, come in many sizes and shapes, and have interesting names. For the growers, heirloom tomatoes are challenging to produce and difficult to ship, but can bring high prices on the local market.

There are hundreds of varieties of heirloom tomatoes available. Some of the most popular varieties include Brandywine, German Johnson, Mr. Stripey, Cherokee Purple, and Green Zebra.

Because most heirloom tomatoes are indeterminate, they must be grown on a tall, strong trellis. A trellis can be constructed of 3 inch diameter, or larger, posts set 10-15 feet apart within the row. Use 7-8 ft. long posts, leaving 6-7 ft. above ground. Run a stout wire (12 gauge) across the tops of the posts and secure it with staples. Pieces of twine, long enough to reach the ground, should be tied to the top wire above each plant. The twine can be anchored with a loop to each plant or to a bottom line of twine that is strung about 6 in. off the ground and secured to the posts. Some growers use the standard string and weave-staked culture system for heirloom tomatoes, as described for the determinate tomatoes, but they use 6-ft. long stakes instead of the normal 4-ft. long stakes.

In a trellis system, plants are usually spaced 8-10 in. apart within the row and pruned to a single stem system. A two stem system may also be used, in which the plants should be spaced 18-30 in. apart within the row. If using a standard staking system, plants should be spaced 18-24 in. apart. Once the plants are established, suckers must be removed several times a week. If the main growing point is broken off, a sucker can be trained to take its place.

Because most heirloom tomatoes have little disease resistance, it is important to maintain a good fungicide spray schedule. For organic production, it might be necessary to grow heirloom tomatoes under high tunnels, especially in areas with high disease pressure. Grafting heirloom varieties onto diseases resistant rootstocks might also increase your success at growing organically.

TOMATO DISORDERS

Your local county Extension office has bulletins that describes fruit disorders in detail. Here are several common disorders of tomato and their causes: **catfacing** (cool day and/or night temperatures or very hot dry days), **internal browning, graywall and blotchy ripening**, (tobacco mosaic virus, overcast cloudy environment, high N, low K or soil compaction), **yellow shoulder** (direct sun exposure, worse on green shouldered varieties), **sunburn and sunscald** (direct rapid exposure to the sun), **weathercheck** (fruit exposed to dew), **blossom end rot** (low soil calcium and/or soil moisture), **cracking** (variety, irregular water, growth, and/or nutrition).

SPECIAL NOTES ON PEST MANAGEMENT

INSECT MANAGEMENT

Colorado Potato Beetle (CPB), Flea Beetles (FB): While flea beetles are a common pest of tomato throughout the southeastern US, Colorado potato beetle are most common in areas where significant acreage of potatoes is also grown. Flea beetles are primarily a problem early in the season shortly after planting, and are usually controlled by insecticides applied for other insects. Adults feed on foliage, resulting in small round holes on leaves. In most situations this damage does not affect early season growth or subsequent yields, but control may be necessary when populations are high (20-30% defoliation).

Colorado potato beetle adults and larvae feed on tomato foliage and can cause extensive defoliation if not controlled. CPB feed only on solanaceous plants, and populations tend to be concentrated in areas where potato, eggplant and tomato have previously been grown. Consequently, rotation to non-solanaceous crops is very effective in helping to avoid infestations. Thoroughly scout fields and spray only when necessary. Treatment should be made if populations exceed 15 adults per 10 plants or a combination of 20 CPB larvae and/or adults per 10 plants. Insecticide sprays should be made after most egg masses have hatched, but before larvae become large. CPB have developed resistance to many different insecticides, so knowledge of the resistance status of populations is essential in choosing which insecticides to use.

Tomato Fruitworm: The tomato fruitworm, also known as the corn earworm and cotton bollworm, is potentially the most damaging pest of tomato. However, there are many insecticides that provide excellent control. The key to controlling this insect is to ensure that there is a toxic pesticide residue on the plant during egg laying periods so that larvae are killed shortly after hatching, because larvae feed on leaf tissue for only a short time before boring into fruit. Tomato fruitworm moth activity can be monitored with pheromone traps and serves as a measure of the adult population within an area. Corn that is in the silking stage is a preferred host of fruitworm, but when corn silks begins to dry, moths will switch egg laying to other hosts, including tomato.

Armyworms: At least three species of armyworms are potential pests of tomato, including the beet armyworm, southern armyworm and yellowstriped armyworm. Infestations are usually sporadic in the more northern regions of the southeastern US, but are an annual problem in more southern areas. In contrast to tomato

fruitworm, armyworms will also feed extensively on foliage as well as fruit, and the presence of feeding damage on leaves can help differentiate between fruitworm and armyworm damage. Beet armyworm is notorious for exhibiting resistance to a wide range of insecticides, but the recent registration of newer insecticides has greatly aided the management of this pest.

Tomato Pinworm: The tomato pinworm is more common in the southern compared with northern regions of the southeast, but late-season infestations are common in northern areas. Moths lay eggs on foliage, and larvae feed within leaves, creating blotchy mines. As larvae increase in age they bore into stems and/or fruit. The use of pheromone-based mating disruption is an effective control method. Initiate mating disruption at the first sign of mines on foliage. Numerous insecticides also control pinworm.

Stink Bugs: The green and brown stink bug can be important direct pests of tomato, but they are sporadic in occurrence. Stink bugs are most common in smaller fields (i.e., 5 acres or less) that are surrounded by weedy borders, or fields that are adjacent to soybeans. In fact, chemical control of stink bugs is often not necessary in fields that do not fit the previous description. Unfortunately, there is not a good sampling method to assess population densities before damage occurs, and preventive strategies are used. Depending on the surrounding habitat and abundance of stink bugs within an area, one to three applications of an insecticide are necessary to prevent damage.

Thrips: Thrips can cause direct damage to tomato fruit by their feeding or oviposition scars on small fruits, and are also indirect pests of tomato due to their ability to transmit tomato spotted wilt virus (TSWV). The tobacco thrips and western flower thrips are vectors of tomato spotted wilt virus. The majority of virus infections are the result of primary spread (thrips transmitting the virus from surrounding weeds directly to tomatoes or greenhouse infections), and insecticides do not kill thrips quickly enough to prevent inoculation. However, an aggressive early insecticide control program early in the season (3 to 4 weeks after transplanting) and the use of reflective mulches have helped to reduce the incidence of TSWV in tomatoes. Thrips can also cause direct damage to tomato fruit. This is the result of thrips feeding and/or laying eggs in small fruits before stamens are shed from flowers. This damage appears as small dimples in fruit. Sample thrips in tomato flowers by placing a white index card below flowers and tapping the flowers with a finger. An average of 1 thrips per flower has worked well as a treatment threshold level.

Whiteflies: The greenhouse whitefly and silverleaf whitefly can both infest tomatoes in the southeast. Generally, the silverleaf whitefly is more common in the southern region and the greenhouse whitefly is more common in the northern region of the southeast. Once whitefly populations of either species become established on a crop, they are very difficult to control. Therefore, preventive control is usually necessary for effective, season-long management. Preventive control can be achieved with soil-applied systemic insecticides applied to the soil or at planting, or the application of other insecticides when populations are low.

Mites: Mites have become an increasingly important problem on tomatoes and other vegetables grown in the southeast. Twospotted spider mite is the most common mite pest, but the broad mite and carmine spider mite can also infest tomatoes. Mites overwinter on weeds and move into tomatoes in the spring as weeds die. Mites can also move from other crops (including other tomato fields) into tomatoes throughout the season. Localized infestations can be spot treated, but thorough coverage of foliage is important. Mites can be sampled by using a sample of 10 leaflets (terminal leaflet on a leaf from the upper one-third of the plant), from a minimum of 5 sample sites per field. When mites reach an average of 2 mites/leaflet, a miticide should be applied. Note that certain pesticides, such as pyrethroids and some neonictinoids, aggravate mite populations and can lead to high mite densities.

DISEASE MANAGEMENT

Damping-Off: *Plantbed:* Use seed treatment and plant in a disease-free mix.

VIRUSES

Aphid-transmitted Viruses (TMV, PVX, CMV, TEV, PVY): Use tolerant or resistant varieties to control these viruses when available and provided that the fruit quality is consistent with market demands. Use these varieties in areas where these viruses have been prevalent or when high aphid pressure is expected. Generally, these viruses cannot be adequately controlled with insecticide applications, but symptom expression can be delayed through their use combined with the use of reflective mulches.. Because aphids transmit these virus, growers may wish to use yellow trap pans containing water to determine when mass flights of winged aphids occur.

Thrips-transmitted Viruses (Tomato Spotted Wilt Virus, TSWV): Use tolerant or resistant varieties. TSWV can be severe on tomatoes during both greenhouse production of transplants and during field production of the crop. The virus is spread to tomatoes by thrips. During transplant production, thrips transmit the virus from infected ornamental plants (flowers). Be sure not to grow any ornamental bedding plants in the same greenhouse as tomato transplants. Monitor greenhouses and scout fields for thrips. Begin an insecticide program BEFORE a problem is observed.

Nematode Management. Use nematicides listed in the "Nematode Control in Vegetate Crops" tables in the Disease Control section.

HARVESTING AND STORAGE

See Table 14 for postharvest information.

WATERMELON (*Citrullus lanatus*)

VARIETIES[1]	AL	AR	GA	KY	LA	MS	NC	SC	TN
WATERMELONS									
Diploid, Open-pollinated									
AU Producer [A, IR]	A		G		L				
Crimson Sweet [MS]	A		G		L	M	N	S	T
Jubilee II [IR]	A	R	G		L	M	N	S	T
Diploid, Hybrid									
Estrella [A, R]	A		G				N	S	
Jamboree [A, IR]			G		L		N	S	T
Lemon Krush [A, 2, IR, PM]	A		G			M		S	
Mardi Gras [A, IR]	A		G				N	S	T
Nunhems 800 [A, R]	A						N	S	
Nunhems 860 [A, R]	A						N	S	
Regency [A, IR]	A		G		L		N		
Royal Sweet [A, IR]	A	R	G	K	L	M	N	S	T
Sangria [A, IR]	A		G	K	L		N	S	
Sentinel [S]							N		
Starbrite [A, S]	A	R	G	K	L	M	N	S	T
Summer Gold [2, 4]	A				L		N		
Top Gun [A, IR]	A		G				N	S	
Icebox									
Mickey Lee [R]	A		G		L	M	N	S	
Sugar Baby [S]		R		K	L				T
Triploid/Seedless									
Affirmed	A			K			N	S	
Bottle Rocket (7112) [R]	A		G				N	S	
Buttercup [2, S]	A						N	S	T
Captivation	A		G				N	S	
Crunchy Red [A,S]	A	R	G	K			N	S	T
Exclamation [A, IR]	A		G	K			N	S	
Fascination [A, IR]	A		G	K			N	S	T
Liberty [S]	A				L		N	S	T
Joy Ride [R]	A		G				N	S	
Maxima				K				S	
Melody [A]	A		G	K		M	N	S	
Orange Crisp [3]	A						N	S	
Road Trip [A, R]	A		G				N	S	
Superseedless 7167 [A]	A		G	K				S	
Superseedless 6177 [R]	A		G				N	S	
Superseedless 7177HQ [A]	A		G	K				S	
Superseedless 7187HQ [A, S]	A		G	K			N	S	
Superseedless 7197HQ [A]	A		G	K				S	
Sweet Dawn	A		G				N	S	
Sweet Gem	A			K				S	
Sweet Polly [A, IR]	A						N	S	
Traveler [A]	A	R	G				N	S	T
Treasure Chest [2, 4]	A			K	L				
Tri-X 313 [A, S]	A			K	L	M	N	S	T
Troubadour [A]	A	R	G				N	S	T
Triploid Mini/Seedless Mini									
Extazy [S]	A		G				N	S	T
Leopard [S]				K			N		T
Mielheart [S]	A		G				N	S	
Sweet Bite [S]	A		G				N	S	

[1] Abbreviations for state where recommended.
[2] Yellow flesh fruit.
[3] Orange flesh fruit.
[4] Local markets only.
[A] Anthracnose tolerance/resistance.
[MS] Moderately susceptible to Fusarium wilt race 1.
[IR] Intermediate resistance to Fusarium wilt race 1.
[S] Susceptible to Fusarium wilt race 1.
[R] Resistant to Fusarium wilt race 1.
[PM] Powdery mildew tolerance/resistance.

Seed Treatment. Check with seed supplier to determine if seed has been treated with an insecticide or fungicide. Be sure that seeds have been assayed for bacterial fruit blotch. Further information on seed treatments can be found in SEED TREATMENTS section starting on page 239.

Direct Seeding & Transplant Production. *Direct-seeded:* Seed when soil temperatures reach 55°F. Seed 3 - 5 pounds of seed per acre. The recommended spacing for watermelons is 6 - 10 feet between rows with 24 - 30 square feet per plant.

Direct-seeding for Diploids Only: Seed when soil temperatures reach 65 - 70°F. The recommended spacing for watermelons is 3 - 10 feet between rows providing 24 - 30 square feet per plant.

Transplant Production for Triploids: For seedless watermelons, transplants should be grown in containers that provide a space of at least 1.5 inches by 1.5 inches for each plant. Smaller pots or cells will restrict root growth and provide less protection to the newly set transplant. If the seed is of good quality with high germination, one seed per pot is sufficient. The seed coat of seedless watermelons tends to adhere to the seedling as it emerges, at times slowing growth or reducing stand.

Seedless watermelon seed must be planted with the point of the seed facing up (root end). Temperatures in the greenhouse should be maintained at 80° to 90°F. Growing media should be kept slightly drier than normal until 10 to 15% emergence, then resume normal watering. The required amount of seed can be estimated using Table 6.

Planting. *Transplants:* Transplant container-grown plants into plastic mulch when daily mean temperatures have reached 60°F. Planting dates vary, so consult the following table for your area. Early plantings should be protected from winds with row covers, rye strips, or windbreaks.

Seedless watermelons must be transplanted since these seed require a specific environment in order to achieve a high percentage of germination. (Seedless watermelons produce inadequate pollen, so a "pollenizer" variety is required to ensure good pollination of seedless watermelons.) Seeded (diploid) or specialized "pollenizers" must be used for seedless watermelon production.

Several seed companies have developed new varieties for use soley as a pollenizer. These pollenizers can be interplanted into a field totally devoted towards the production of triploid watermelons. Unique, compact growth habits prevent these pollenizers from competing for space with triploid plants.

Grafting and Diseases. In recent years, grafted watermelon plants have emerged as a strategy to combat soil-borne diseases. Grafting is used against Fusarium wilt. Grafted plants are more expensive per transplant. For more information, see the section Grafting in Vegetable Crops on pages 15 and 16 in this handbook.

POLLINATION AND PLANTING ARRANGEMENT WITH TRIPLOIDS

Fruit set and enlargement in watermelon is dependent upon growth regulators from pollen grains and from embryos in the developing seeds within the fruit. Inadequate pollination results in triploid watermelon fruit that are triangular in shape and of inferior quality. Additionally, inadequate pollination increases the incidence of hollowheart. Triploid watermelon flowers do not produce sufficient, viable pollen which is required to induce fruit set and development. Therefore, pollen from a "normal" (i.e., diploid/seeded) or a special pollenizer watermelon variety must be present. Fields should be interplanted with pollenizer plants or diploid watermelon plants in order to provide sufficient, viable pollen using one of the following methods.

There are two methods that can be used to incorporate pollenizer plants into the field. *Method 1: Use of a Dedicated Pollenizer Row.* Dedicated row pollenizer plantings place the pollenizer variety in the outside row and then every third or fourth row throughout the field. When using *Method 1*, it is important to use a pollenizer variety that is marketable because up to one-third of all watermelons produced in the field will be from this seeded variety. The rind pattern and/or shape of the fruit from the pollenizer must be easily distinguished from that of the fruit from the seedless variety in order to reduce confusion at harvest.

Method 2: Planting Pollenizer Within Each Row. A second method is to plant the pollenizer between every third or fourth plant within each row without changing the plant spacing of the seedless/triploid watermelons. When this method is chosen, the use of a special pollenizer is recommended. However, growers can use a normal diploid/seeded watermelon as a pollenizer. In this case, saleable watermelons are produced from the pollenizer requiring a market. The use of standard diploid variety when using *Method 2* might decrease the overall yields of the triploid plants. When selecting a diploid/seeded pollenizer variety that will also be harvested, growers must take into account market demand, plant vigor, pollen production, disease resistance, and environmental conditions.

Special pollenizer varieties have been developed solely for pollen production and most do not produce marketable fruit. The use of special pollenizers with *Method 2* allows the field to be dedicated to the production of seedless watermelons. Many growers prefer special pollenizers because they do not have markets for seeded watermelons. In addition, using a special pollenizer makes harvesting easier for crews who can more easily distinguish between fruit produced from the seeded, special pollenizer and fruit from the seedless watermelon varieties.

With *Method 2*, fruit of most special pollenizers are easily distinguishable from fruit produced by triploids in terms of size. If mini-seedless watermelons are planted; however, their rind pattern must be used to distinguish between fruit produced by the pollenizer and fruit produced by the mini seedless watermelons.

Special Dedicated Pollenizers found to work well in the southeast include:

	AL	GA	KY	LA	MS	NC	SC	TN	VA
Pollenizers for Triploid Watermelon									
Edible Diploids									
Mickey Lee [MS]	A	G	K		M	N	S		V
Nunhems 800	A		K	L	M	N	S		V
Stargazer	A	G					S		V
Estrella	A				M	N	S		V
Crimson Sweet	A		K		M	N			V
Regency	A		K		M	N			
Sangria [A,IR]	A		K	L					V
Special Pollenizer (Non-edible)									
Accomplice	A	G	K		M	N	S		V
Ace [S]	A	G			M	N	S		V
Jenny	A	G			M	N	S		V

	AL	GA	KY	LA	MS	NC	SC	TN	VA
Pollenizers for Triploid Watermelon									
Special Pollenizer (Non-edible) (cont'd)									
Minipol	A	G			M	N	S		
Pollen Pro	A	G	K		M	N	S		V
Polimax	A	G	K		M	N	S		
SideKick	A	G	K		M	N	S		V
SP-6 [A,IR]	A	G	K		M	N	S		V

Be sure to follow the seed suppliers' instructions when using a special pollenizer. New, improved specialized pollenizer varieties are continually being developed with better germination, flowering habit, and/or disease resistances/tolerances. **Do not plant your pollenizer variety and seedless (triploid) varieties in separate or adjacent blocks. Plant your pollenizer variety within 10 to 15 feet of triploid varieties to assure good pollination. Specialized pollenizer varieties should be placed within 10 feet of triploids as these varieties tend to have less aggressive vining than normal seeded pollenizers.**

It is important that pollen from the diploid pollenizer variety be available when the female blossoms on the triploid plants are open and ready for pollination. As a general rule, the pollenizer variety should be seeded on the same day that the triploid seed is seeded in the greenhouse. Smaller seeded, slower to germinate pollenizers such as SP-6; however, should be planted one week prior to planting triploid seed.

Honeybees are important for high fruit yields and quality. Populations of pollinating insects may be adversely affected by insecticides applied to flowers or weeds in bloom. Apply insecticides only in the evening hours or wait until bloom is completed before application. See section on "Pollination" in the General Production Recommendations for further information.

WATERMELON PLANTING DATES

AL North	5/15–6/15	LA North	3/10–6/30
AL South	3/1–6/30	LA South	3/1–7/5
AR North	5/15-6/20	MS North	4/15–5/15
AR South	4/15-6/15	MS South	2/15–5/1
GA North	5/15–6/15	NC East	4/15–6/30
GA South	3/1–6/30	NC West	5/25–6/30
KY East	5/15-6/15	SC East	4/1–4/30
KY Central	5/5-7/1	SC West	4/15–6/15
KY West	4/20-7/15	TN East	5/5-6/30
		TN West	4/25-5/30

Drip Fertilization and Mulching. Before mulching, adjust soil pH to 6.5, and in the absence of a soil test, apply enough fertilizer to supply 50 pounds per acre of N, P_2O_5 and K_2O, (some soils will require 100 pounds per acre of K_2O) then thoroughly incorporate into the soil.

After mulching and installing the drip irrigation system, the soluble fertilizer program should then be initiated according to that described in the following table. On soils testing low to low-medium boron, also include 0.5 pound per acre of actual boron.

The first soluble fertilizer application should be applied through the drip irrigation system within a week after field transplanting or direct-seeding the watermelons. Continue fertigating until the last harvest.

SUGGESTED FERTIGATION SCHEDULE FOR WATERMELONS*

Growth Stage [1]	Days after planting	Daily nitrogen	Daily potash	Cumulative nitrogen	Cumulative potash
		(lb / A)			
Preplant				35.0	35.0
Planting to Vining	0 - 14	0.5	0.5	42.0	42.0
Vining to Flowering	15 - 28	1.0	1.0	56.0	56.0
Flowering to Fruit Set	29 - 49	1.5	1.5	86.0	86.0
Fruit Set to Initial Ripening	50 - 77	2.0	2.0	140.0	140.0
Harvest	78 - 91	1.0	1.0	153.0	153.0

*Adjust based on tissue analysis.

[1] Growth Stage can vary from season to season. For optimal results, fertigate watermelons based on their growth stage as opposed to days after planting.

MINI SEEDLESS WATERMELON

The mini seedless watermelon was introduced in 2003 and the demand for this product is year around. These fruit generally range from 3 to 7 pounds and offer an attractive alternative for the consumer that has limited refrigerator space or a small family. Besides the smaller size, some mini melons have a thinner fruit rind and are marketed as PureHeart. Although there is more edible flesh in mini watermelons marketed under the PureHeart label, these thinner rind mini watermelons might have a higher incidence of internal bruising. These fruit must be handled carefully to minimize bruising. Some varieties of mini seedless watermelons are grown under specific labels such as "PureHeart" but are only available under a contract basis. The varieties Bambino, Extazy, Leopard, Meilhart, Sweet Bite, and Vanessa are readily available to watermelon producers and are recommended for production in certain states. These varieties have performed well either commercially or in University trials.

Spacing trials have also been conducted with mini watermelons at various locations across the southeastern US. Generally, a mini watermelon plant requires 10 to 12 square feet per plant. For example, if rows are spaced on 8 ft. centers, mini watermelon plants should be spaced 15 inches apart within the row.

SPECIAL NOTES FOR PEST MANAGEMENT

DISEASE MANGEMENT

Cucurbit Downy Mildew Forecasting System: Cucurbit downy mildew (CDM) is a devastating foliar cucurbit disease. While difficult, if not impossible to control, CDM can be prevented by using effective IPM practices. A useful tool for prevention of CDM is the CDM forecasting system. This program depends on the accurate reporting of CDM in the field as well as the monitoring of over 50 strategically placed sentinel plots. These plots are monitored by Plant Pathologists at multiple Land Grant Universities throughout the United States and Canada. Forecasts of the epidemic movement of the disease are generated 3 times a week. Risk maps are produced from these forecasts. For forecasts, maps, local contacts and other helpful information please visit our website, http://cdm.ipmpipe.org. If you think you have CDM, please contact your local Extension office.

Fusarium Wilt: Fusarium wilt of watermelon is widespread throughout the southeastern US. Most varieties of watermelon, other than heirloom varieties, are resistant to race 0. Many seeded (diploid), hybrid varieties are resistant to race 1, while all round, seedless (triploid) varieties are susceptible to race 1.

All commercial watermelon varieties are susceptible to race 2, which is present in parts of Florida, Georgia, and South Carolina. The superscripts "S" for susceptible, "MS" for moderately susceptible, "IR" for intermediate resistance, and "R" for resistant are listed next to each recommended variety. These superscripts indicate the reaction of commonly grown diploid and triploid varieties to race 1 of Fusarium wilt. Growers should choose resistant varieties whenever possible, including the pollenizers that they select for seedless watermelon production.

INSECT MANAGEMENT

Cucumber Beetle: Watermelons are resistant to bacterial wilt; however, control may be needed to prevent feeding damage to seedlings. Treat when an average of two beetles per plant is found.

Aphids: Aphids can delay fruit maturation. Thorough spray coverage beneath leaves is important. For further information on aphid controls, see the preceding "Drip Fertilization and Mulching" section. Treat seedlings every 5 to 7 days or as needed.

Mites: Mite infestations generally begin around field margins and grassy areas. CAUTION: DO NOT mow or maintain these areas after midsummer because this forces mites into the crop. Localized infestations can be spot-treated. **Note:** Continuous use of pyrethroids may result in mite outbreaks.

HARVESTING AND STORAGE

See Table 14 for postharvest information.

Soil Pests—Their Detection and Control

WIREWORMS

Wireworms injure vegetable crops by killing seeds or seedlings and tunneling and scarring tubers, roots, or bulbs.

Detection: The above injury to young plants or tubers frequently is sufficient evidence to warrant control measures. Further evidence can be obtained by sampling, using either of the following methods:

Method 1

A technique using baits has been developed for evaluating wireworm potential before planting. The bait stations should be established 2 to 3 weeks before the anticipated planting date. Fields where small grain or grasses have been grown the preceding 2 or 3 years are the best candidates for bait stations.

Because wireworm infestations are often localized within a field, it will be necessary to place the bait stations randomly throughout the field such as placing two bait stations at the highest elevation in the field, then two stations on a slope and finally two stations in the lowest point in the field. One bait station per acre is desirable.

Follow this procedure for baiting:

1. Mix 1 cup of wheat, corn, or oat seed at each station.
2. Bury the bait about 4 inches deep. Cover the ground over each bait station with an 18-inch square of black plastic. The plastic collects solar heat and speeds germination of the corn and wheat, which entices overwintering wireworms.
3. Mark each station with a flag or stake.
4. Dig up the bait stations in 10 to 14 days and count the number of wireworms.

Method 2

1. Be sure the soil temperature at the 6-inch depth ranges between 45° and 85°F and that soil moisture is equivalent to that desired for planting.
2. Collect soil samples from 20 scattered sites per acre. Each sample should represent a soil profile 12 inches deep and 6 inches in diameter.
3. Sift soil and count wireworms.

Control: If you find an average of one wireworm per bait station (Method 1) or if you find five or more wireworms in 20 soil samples (Method 2), a labeled soil insecticide should be used. In some instances, several wireworms may be found in one bait station and none in others. Wireworm infestations tend to concentrate in some locations. It may be possible to limit treatment to areas of the field where the wireworm concentration is heaviest.

When to apply: Insecticides can be applied either in the spring or fall when the soil temperature at the 6-inch depth is at least 50°F and soil moisture is equivalent to that desired for planting. Frequently, the insecticide is applied immediately before planting. When early spring planting is required, a fall treatment is suggested.

What to Use: See the crop protectant section for each crop for appropriate chemical to use.

How to apply: When intended as a broadcast application, use a low-gallonage sprayer or granule distributor designed for low dosages. Immediately after application, mix insecticide with soil to a depth of at least 6 inches by disking twice in opposite directions.

In a band treatment as with potatoes, apply an appropriate soil insecticide at planting 3 to 6 inches deep along both sides of the row.

GARDEN CENTIPEDES (SYMPHYLANS)

Garden centipedes are arthropods that are related to insects. They feed on germinating seed and fibrous roots of many plants, including most vegetable species, and on decaying plant material. They are often associated with moist areas of a field and typically establish in spots or field edges. Rotation does not appear to be an effective control. If a spot becomes established, the crops planted into that area have a difficult time growing out of the damage, because the symphylans are continuously grazing on the fibrous roots.

Detection: The first symptom is an area or patch of poorly developing plants, similar to other root problems. Check the soil in these areas so that treatment can be made before planting the next crop, as there is no practical post-planting control. A common practice is to flag off the spot and treat that area with soil insecticides in the following fall or spring. Soil solarization has not been an effective control. It is reasonable to assume that symphylans can be transported in soil on field equipment. Dig up the soil and look for small, slender (less than 0.25 inch) white centipede-like animals that move quickly and try to avoid light. Another method of sampling is to drop the soil into a bucket of water. The symphylans will float to the top. Symphylans have 12 pairs of legs on 14 body segments. Do not confuse the symphylans with true centipedes—centipedes eat other arthropods and are considered beneficial. Symphylans have beaded antennae. Centipedes are not typically white in color and have large Chilicerae with venomous fangs. Dry or cold [less than 45°F] soil will reveal few, if any, symphylans.

When to treat: If samples are taken in the spring, control is generally warranted if there is an average of over two symphylans per shovelful of soil. Samples taken in September or October may average four or five per shovelful and will warrant treatment before the next crop. Insecticides are generally applied before spring planting, and fumigant treatments are usually made in the fall. Note: Effectiveness of soil-applied insecticides decreases as soil temperature decreases below 55°F.

What to use: See the crop protectant section for each crop for appropriate materials to apply. Apply fumigants in the same manner as described in the in the "Nematode Control in Vegetate Crops" tables in the Disease Control section. Follow all label directions and restrictions when using these materials.

CUTWORMS

There are a number of cutworm species that attack vegetable plants. Some attack the tuber, spear, or fruit by chewing the edible portion, rendering them unmarketable. Others attack the seedlings or transplants, killing them outright or causing them to be unproductive. Cutworms are attracted to light and can lay eggs on transplants growing in greenhouses that are lighted at night. The cutworm eggs and larvae may be accidentally transferred to the field with the plants.

Most cutworms are night feeders and hide under sod clumps, stones, decaying vegetation, etc., during the day. Weedy, minimum-tillage fields or field coming our of pasture are especially attractive egg-laying sites for cutworm adults (moths). During periods of drought, low-lying areas in fields are more subject to attack than other areas, presumably because of more desirable conditions.

Control: Where cutworms are suspected, a broadcast incorporation treatment may be necessary just before planting. This treatment should be worked into the soil immediately after applying and just before planting.

Even if a broadcast treatment is used, fields should be scouted for cutworm damage within a week of planting or plant emergence. If cutworms are actively cutting plants, a postplanting contact treatment maybe necessary. The following procedures may help improve control when a contact insecticide treatment is used:

1. Direct sprays at the base of the plants where cutworms are actively feeding.
2. Increase the amount of water used to at least 30 gallons per acre, especially in dry weather.
3. Spray between midnight and 5 A.M., when cutworms are most active.
4. Cultivate after insecticide application to improve contact with cutworms, especially in dry weather. In all cases, consult the label for application details.

GRUBS

Grubs are the larvae of Scarab beetles and can be serious soil pests in vegetable crops. Most vegetables can be attacked, and serious problems have occurred in potatoes, sweetpotatoes, beans, corn and spinach. Grubs cause damage by feeding on the roots and underground parts of the plant from one to several inches below the soil surface. The plants may yellow and wilt, which causes a pattern of patchy growth in fields where plants are dead or dying. If injured plants are pulled up, the roots will be found to have been eaten off, and usually the curve-bodied grubs can be found in the soil.

Adult beetles lay eggs in the soil during June and July. As the soil cools in the fall, the grubs work their way deep into the soil and return to the surface the following spring. Depending on the insect, grubs may take from 1 to 3 years to become adults and may cause problems year after year.

Control: Grub damage is usually associated with grassy or weedy fields. Cleaning fields may help prevent serious grub damage. Problems may often occur in crops planted to fields that were previously in sod or turfgrass.

No effective insecticides are labeled for grub control in vegetables. However, soil insecticides that are applied for wireworm control may also be effective in reducing grub populations.

MAGGOTS

The two most important maggots can become significant pests during the growing season. The adult of the maggot (a fly) fluctuates in abundance in different areas in different years; because it is impossible to determine when and where maggots will attack and because nothing can be done once the injury is noted, preventive controls are good insurance before planting if there were previous maggot problems.

Seed Corn Maggot: Seed attacked by seed maggots usually fails to sprout or, if it does, it is weak or sickly. Injury is most severe in wet, cold springs and on land high in organic matter. Manure and other organic matter should be thoroughly worked into the soil in the fall so is not as attractive to the egg laying seed corn maggot flies in the spring.

Control: Best control is achieved by using a seed treatment. Seed treatment options are listed in the insect control section.

Cabbage Root Maggot: Plants whose roots are attacked by the root maggot will appear riddled with maggot tunnels, and underground fleshy parts of these plants rot. Above ground, plants appear off-color, will wilt, and will seldom reach full growth.

Control: Seed treatments, transplant water treatments, in-furrow treatments, preplant broadcast, and post-plant treatments may be recommended depending on the crop. Refer to the insect control section for specific recommendations.

SLUGS

Slugs are not insects, but are related to snails. All slugs require damp or humid surroundings for development. During the day, slugs seek shelter under protective debris and will avoid the drying effects of sun and wind. As a result, weed control is a useful management tool to any slug problem.

Control: Iron phosphate baits are often used. Beer traps can be effective in small areas. Place 1/2 inch of beer in a shallow flat pan. Slugs are attracted to the beer and drown upon entering the pan. Baits are often the most effective means of control. Consult your local Extension office for treatment options.

NEMATODES

Determine the degree of infestation *before* applying a nematicide. To do this, collect soil and root samples and submit these samples to your state's Plant Diagnostic Laboratory or Nematode Detection Laboratory.

Procedures for submission and sampling are noted below. Contact your local Extension office for specific information on how to submit your samples.

HOW TO COLLECT SOIL AND ROOT SAMPLES FOR NEMATODE DETECTION

Whenever nematode damage is suspected, an examination of both soil and roots is necessary to determine to what extent nematodes are involved.

The following suggestions are made so that samples will be collected properly and arrive at the laboratory in good condition.

Collecting: If a large area in a field is believed to be involved, collect samples from edges of the affected area. Take a mixture of roots and soil from at least 10 separate sites within the root zone or under at least 10 plants. This can be accomplished by unearthing each plant with a shovel and taking a handful of soil and roots or by using a soil sampling tube (3/4-inch diameter) until 1 quart of soil is obtained.

Samples collected after the host plant is plowed down are very misleading and should not be used. Send only a single blended sample from each field. Do not mix samples from several fields.

Handling: After collecting and mixing a composite soil and root sample, place it in a plastic freezer bag and close the bag tightly to prevent the sample from drying out. Protect the samples from high or freezing temperatures.

Submitting. Consult your state's diagnostic lab for its procedure and form required. The following information may be necessary so that control recommendations, if any, can be made.

Include with each sample:

1. Date collected.
2. Crop to be planted, present crop, and history of affected area.
3. Name and address of person submitting the sample and grower.
4. Plant symptoms.

**Be sure to mark samples: "For Nematode Detection."

Selecting a Nematicide: Dosage, restrictions, and crop specificity are listed on the manufacturer's label and must be carefully followed to ensure satisfactory results.

Rates for nematicides and multipurpose soil fumigants are provided in the NEMATODE CONTROL IN VEGETABLE CROPS section of this handbook.

A plastic film seal is needed when methyl bromide or certain other fumigants are used as noted on the product label. These plastic films increase the efficiency of treatments.

Apply fumigant-type nematicides to a depth of 6 to 8 inches. Immediately after application, soils should be dragged, rolled, or cultipacked to delay loss of fumigant. A light irrigation through sprinklers will also delay gas escape.

At least 2 to 3 weeks should intervene between the application of the nematicide and the time a crop is planted. See manufacturer's label recommendations for specific crops and waiting times. There are many fumigants and nematicides available, consult the disease control section of this handbook for a list of options.

One week after application, work soil to a depth of several inches so that gases may escape. Severe injury or death of sensitive plants, such as tomato, may occur on heavy soils following heavy rains or if increased rates of a fumigant are used.

Because of a reduction of nitrifying bacteria by the nematicide, at least 50% of the nitrogen in the initial fertilizer application should be in the nitrate form.

Calibrating Chemical Application Equipment

PURPOSE

To determine if the proper amount of chemical is being applied, the operator must measure the output of the application equipment. This technique is known as *calibration*. Calibration not only ensures accuracy, a critical factor with regard to many chemicals, but it can also save time and money and benefit the environment.

GETTING STARTED

Careful and accurate control of ground speed is important for any type of chemical application procedure. From large self-propelled sprayers and spreaders to small walk-behind or backpack units, precise ground speed is a key for success. Ground speed can be determined by one of two methods. The first method requires a test course and stopwatch. For this procedure, measure a suitable test course in the field and record the time it takes to cover the course with the equipment. The course should be between 100 and 300 feet long. Drive or walk the course at least twice, once in each direction and average the times for greater accuracy. Calculate the speed with Equation 1 below.

Equation 1. Ground Speed (MPH) =

$$\frac{\text{Distance} \times 60}{\text{Seconds} \times 88}$$

The second method is to use a true ground speed indicator such as a tractor-mounted radar or similar system. Do not rely on transmission speed charts and engine tachometers. They are not accurate enough for calibration.

CALIBRATING A SPRAYER:

PREPARING TO CALIBRATE

For calibration to be successful, several items need to be taken care of before going to the field. Calibration will not be worthwhile if the equipment is not properly prepared. Whenever possible, calibration should be performed using water only. If you must calibrate using spray mixture, calibrate the equipment on a site listed on the chemical label and with wind speeds less than 5 MPH. Follow the steps outlined below to prepare spraying equipment for calibration.

1. Inspect the sprayer. Be sure all components are in good working order and undamaged. On backpack sprayers, pay particular attention to the pump, control wand, strainers, and hoses. On boom sprayers, pay attention to the pump, control valves, strainers, and hoses. On airblast sprayers, be sure to inspect the fan and air tubes or deflectors as well. Be sure there are no obstructions or leaks in the sprayer.
2. Check the label of the product or products to be applied and record the following:
    - *Application Rate*, Gallons per Acre (GPA)
    - *Nozzle Type*, droplet size and shape of pattern
    - *Nozzle Pressure*, Pounds per Square Inch (PSI)
    - *Type of Application*, broadcast, band, or directed
3. Next, determine some information about the sprayer and how it is to be operated. This includes:
    - *Type of Sprayer:* backpack, boom, or airblast. The type of sprayer may suggest the type of calibration procedure to use.
    - *Nozzle Spacing (inches):* for broadcast applications, nozzle spacing is the distance between nozzles.
    - *Nozzle Spray Width (inches):* For broadcast applications, nozzle spray width is the same as nozzle spacing—the distance between nozzles. For band applications, use the width of the sprayed band if the treated area in the band is specified on the chemical label; use nozzle spacing if the total area is specified. For directed spray applications, use the row spacing divided by the number of nozzles per row. Some directed spray applications use more than one type or size of nozzle per row. In this case, the nozzles on each row are added together and treated as one. Spray width would be the row spacing.

In most cases, a backpack sprayer uses a single nozzle. Some sprayers use mini-booms or multiple nozzles. The spray width is the effective width of the area sprayed, being sure to account for overlap. If you are using a sweeping motion from side to side, be sure to use the full width sprayed as you walk forward. If you are spraying on foliage in a row, use the row spacing. Dyes are available to blend with the spray to show what has been covered.

- *Spray Swath (feet):* The width covered by all the nozzles on the boom of a sprayer. For airblast or other boomless sprayers, it is the effective width covered in one pass through the field.
- *Ground Speed, miles per hour (MPH).* When using a backpack sprayer, walk a comfortable pace that is easy to maintain. Slow walking speeds will take longer to complete the task while high speeds may be tiresome. Choose a safe, comfortable speed that will enable you to finish the job in a timely manner. On tractor-mounted sprayers, select a ground speed appropriate for the crop and type of sprayer used. Slow speeds will take longer to complete the task, while high speeds may be difficult to control and unsafe. Choose a safe, controllable speed that will enable you to finish the job in a timely manner. Ground speed can be determined from Equation 1.

4. The *discharge rate,* gallons per minute (GPM), required for the nozzles must be calculated in order to choose the right nozzle size. Discharge rate depends on the application rate; ground speed; and nozzle spacing, spray width, or spray swath.

For applications using nozzle spacing or nozzle spray width (inches), use Equation 2.

Equation 2. Discharge Rate =

$$\frac{\text{Application Rate x Ground Speed x Nozzle Spray Width}}{5{,}940}$$

For applications using the spray swath (feet):

Equation 3. Discharge Rate =

$$\frac{\text{Application Rate x Ground Speed x Spray Swath}}{495}$$

5. Choose an appropriate nozzle or nozzles from the manufacturer's charts and install them on the sprayer. Check each nozzle to be sure it is clean and that the proper strainer is installed with it.
6. Fill the tank half full of water and adjust the nozzle pressure to the recommended setting. Measure the discharge rate for the nozzle. This can be done by using a flow meter or by using a collection cup and stopwatch. The flow meter should read in gallons per minute (GPM). If you are using the collection cup and stopwatch method, the following equation is helpful to convert ounces collected and collection time, in seconds, into gallons per minute.

Equation 4. Discharge Rate =

$$\frac{\text{Ounces Collected x 60}}{\text{Collection Time x 128}}$$

7. Whenever possible, calibrate with water instead of spray solution. Do not calibrate with spray solution unless required by the chemical label. Follow all recommendations on the label. If the spray solution has a density different than water, the rate can be corrected using the procedure shown in Calibration Variables.
8. On boom sprayers or sprayers with multiple nozzles, average the discharge rates of all the nozzles on the sprayer. Reject any nozzle that has a bad pattern or that has a discharge rate 10 percent more or less than the overall average. Install a new nozzle to replace the rejected one and measure its output. Calculate a new average and recheck the nozzles compared to the new average. Again, reject any nozzle that is 10 percent more or less than the average or has a bad pattern. When finished, select a nozzle that is closest to the average to use later as your "quick check" nozzle.

On backpack sprayers or sprayers with a single nozzle, compare the discharge rate of the nozzle on the sprayer to the manufacturer's tables for that nozzle size. Reject any nozzle that has a bad pattern or that has a discharge rate 10 percent more or less than the advertised rate. Install a new nozzle to replace the rejected one and measure its output.

Once the sprayer has been properly prepared for calibration, select a calibration method. When calibrating a sprayer, changes are often necessary to achieve the application rates needed. The sprayer operator needs to understand the changes that can be made to the adjust rate and the limits of each adjustment. The adjustments and the recommended approach are:

- *Pressure:* if the error in application rate is less than 10 percent, adjust the pressure.
- *Ground speed:* if the error is greater than 10 percent but less than 25 percent, change the ground speed of the sprayer.
- *Nozzle size:* if the error is greater than 25 percent, change nozzle size. The goal is to have application rate errors less than 5 percent.

Calibration Methods

There are four methods commonly used to calibrate a sprayer:

The *basic*, *nozzle*, and *128th acre* methods are "time-based methods" which require using a stopwatch or watch with a second hand to ensure accuracy. The area method is based on spraying a test course measured in the field. Each method offers certain advantages. Some are easier to use with certain types of sprayers. For example, the basic and area methods can be used with any type of sprayer. The 128th acre and nozzle methods work well for boom and backpack sprayers. Choose a method you are comfortable with and use it whenever calibration is required.

BASIC METHOD

1. Accurate ground speed is very important to good calibration with the basic method. For tractor-mounted sprayers, set the tractor for the desired ground speed and run the course at least twice. For backpack sprayers, walk the course and measure the time required. Walk across the course at least twice. Average the times required for the course distance and determine ground speed from Equation 1.
2. Calculate the application rate based on the average discharge rate measured for the nozzles, the ground speed over the test course, and the nozzle spacing, nozzle spray width, or spray swath on the sprayer.

When using nozzle spacing or nozzle spray width measured in inches, use the following equation:

Equation 5. Application Rate =

$$\frac{\text{5,940 x Discharge Rate}}{\text{Ground Speed x Nozzle Spray Width}}$$

For spray swath applications measured in feet:

Equation 6. Application Rate =

$$\frac{\text{495 x Discharge Rate}}{\text{Ground Speed x Spray Swath}}$$

3. Compare the application rate calculated to the rate required. If the rates are not the same, choose the appropriate adjustment and reset the sprayer.
4. Recheck the system if necessary. Once you have the accuracy you want, calibration is complete.

NOZZLE METHOD

1. Accurate ground speed is very important to good calibration with the nozzle method. For tractor-mounted sprayers, set the tractor for the desired ground speed and run the course at least twice. For backpack sprayers, walk the course and measure the time required. Walk across the course at least twice. Average the times required for the course distance and determine ground speed from Equation 1.
2. Calculate the nozzle discharge rate based on the application rate required the ground speed over the test course, and the nozzle spacing, spray width, or spray swath of the sprayer. For nozzle spacing or spray width measured in inches.

Equation 7. Discharge Rate =

$$\frac{\text{Application Rate} \times \text{Speed} \times \text{Spray Width}}{5{,}940}$$

For spray swath measured in feet:

Equation 8. Discharge Rate =

$$\frac{\text{Application Rate} \times \text{Speed} \times \text{Spray Swath}}{495}$$

Set the sprayer and determine the average nozzle rate.

3. Compare the rate calculated to the average rate from the nozzles. If the two don't match, choose the appropriate adjustment and reset the system.
4. Recheck the system if necessary. Once you have the accuracy you want, calibration is complete.

128TH ACRE METHOD

1. The distance for one nozzle to cover 128th of an acre must be calculated. The nozzle spacing or spray width in inches is used to determine the spray distance. Spray distance is measured in feet. On backpack sprayers, be sure to measure the full width sprayed as you walk forward. Use Equation 9.

Equation 9. Spray Distance =

$$\frac{4{,}084}{\text{Spray Width}}$$

2. Measure the spray distance on a test course in the field. Check the ground speed as you travel across the course. Be sure to maintain an accurate and consistent speed. Travel the course at least twice and average the time to cover the course.
3. For backpack sprayers, collect the output from the nozzle for the time measured in step 2. For tractor-mounted sprayers, park the sprayer, select the nozzle closest to the average, and collect the output for the time determined in step 4. Ounces collected will equal application rate in GPA.
4. Compare the application rate measured for the nozzle to the rate determined in step 3. If the rates are not the same, choose the appropriate adjustment and reset the system.
5. Recheck the system if necessary. Once you have the accuracy you want, calibration is complete.

AREA METHOD

1. Determine the distance that can be sprayed by one tank using the full spray swath measured in feet.

Equation 10. Tank Spray Distance (ft) =

$$\frac{\text{Tank Volume (gal)} \times 43{,}560}{\text{Application Rate (GPA)} \times \text{Swath (ft)}}$$

2. Lay out a test course that is at least 10 percent of the tank spray distance from Step 1. Fill the sprayer tank with water only, mark the level in the tank, set the sprayer as recommended, and spray the water out on the course. Be sure to maintain an accurate and consistent speed.
3. After spraying the test course, carefully measure the volume of water required to refill the tank to the original level. Calculate the application rate as shown:

Equation 11. Application Rate (GPA) =

$$\frac{\text{Volume Sprayed (gal)} \times 43{,}560}{\text{Test Course Distance (ft)} \times \text{Swath (ft)}}$$

4. Compare the application rate measured to the rate required. If the rates are not the same, choose the appropriate adjustment method and reset the sprayer.
5. Recheck the system. Once you have the accuracy you want, calibration is complete.

CALIBRATING A GRANULAR APPLICATOR:

PREPARING TO CALIBRATE

Granular application calibration is usually done with the chemical to be applied. It is difficult to find a blank material that matches the granular product. Extra care should be taken in handling this product. Minimize worker exposure and take precautions against spills during calibration.

To prepare for calibration, follow these steps:

1. Before calibrating, carefully inspected the equipment to ensure that all components are in proper working order. Check the hopper, the metering rotor, the orifice, and the drop tubes. Be sure there are no leaks or obstructions.
2. Determine the type of application required for the product: ·
   - Broadcast: treats the entire area (includes band applications based on broadcast rates).
   - Band: treats only the area under the band.
   - Row: treats along the length of the row.
3. Determine the application rate needed: ·
   - Broadcast: pounds per acre. ·
   - Band: pounds per acre of treated band width. ·
   - Row: pounds per acre or pounds per 1,000 feet of row length.
4. What type of drive system does the applicator use?
   - Independent: uses PTO, hydraulic, or electric motor drive.
   - Ground Drive: uses ground driven wheel.
5. Regardless of how the application rate is expressed or type of application, calibration is easier if the rate is expressed in terms of pounds per foot of row length. Use one of the following steps to determine the correct row rate in pounds per foot.

For broadcast and row applications (Application Rate = lb/ac):

Equation 12. Row Rate, lb/ft =

$$\frac{\text{Application Rate} \times \text{Row Width (ft)}}{43{,}560}$$

For banded applications (Application Rate = lb/ac of Band Width):

Equation 13. Row Rate, lb/ft =

$$\frac{\text{Application Rate} \times \text{Band Width (ft)}}{43{,}560}$$

For directed (row) applications (Application Rate = lb per 1,000 ft):

Equation 14. Row Rate, lb/ft =

$$\frac{\text{Application Rate}}{1{,}000}$$

6. Choose a calibration distance to work with and measure a test course of this distance in the field you will be working in. Choose an area that is representative of field conditions. The calibration distance should be at least 50 feet but not more than 500 feet. Longer distances are generally more accurate.
7. Calculate the weight of material that should be collected for the calibration distance chosen.

Equation 15. Weight Collected =

Row Rate x Calibration Distance

8. Select a ground speed appropriate for the crop and type of equipment used. Slow speeds take longer to finish the task, while high speeds may be inefficient and unsafe. Consult your equipment manual for a recommended speed. Even ground-driven application equipment can be sensitive to changes in speed. Maintaining an accurate and consistent speed is very important. Choose a safe, controllable speed that will enable you to complete the job in a timely and efficient manner.
9. Set your equipment according to recommendations from the equipment or chemical manufacturer. Most equipment manufacturers and chemical manufacturers provide rate charts to determine the correct orifice setting or rotor speed for each applicator. Fill the hopper at least half full to represent average capacity for calibration.
10. Attach a suitable collection container to each outlet on the applicator. You should be able to collect all material discharged from the applicator. Locate a scale capable of weighing the samples collected in calibration. Some samples may be very small, so a low-capacity scale may be needed. An accurate scale is very important.

Calibration Methods

Two methods for calibrating granular applicators are commonly used. The first is the *distance method*. This method is preferred by many operators because it applies to any type of granular machine and is easy to perform. The second method is the *time method*. This method is similar to sprayer calibration and can be used for applicators driven by PTO, hydraulic, or electric motors.

DISTANCE METHOD

1. On the test course selected in the field, collect the output from the applicator in a container as you travel the course and weigh the material collected. Record the time required to travel the course also. Run the course twice, once in each direction, and average the results for both weight and time.
2. Determine the weight of the product that should be collected for the calibration distance.

Equation 16. Weight Collected (lb) =

Row Rate (lb/ft) x Calibration Distance (ft)

3. Compare the weight of the product actually collected to the weight expected for the calibration distance. If the rates differ by more than 10 percent, adjust the orifice, rotor speed, or ground speed and repeat. Bear in mind, speed adjustments are not effective for ground-driven equipment.
4. Repeat the procedure until the error is less than 10 percent.

TIME METHOD

1. On the test course selected in the field, record the time required to travel the course. Run the course twice, once in each direction, and average the results. Accurate ground speed is very important to good calibration with the time method.
2. With the equipment parked, set the orifice control as recommended and run the applicator for the time measured to run the calibration distance. Collect and weigh the output of the applicator for this time measurement.
3. Determine the weight of the product that should be collected for the calibration distance.

Equation 17. Weight Collected (lb) =

$$\text{Row Rate (lb/ft)} \times \text{Calibration Distance (ft)}$$

4. Compare the weight of the product actually collected during the time it took to cover the calibration distance to the weight expected for the calibration distance. If the rates differ by more than 10 percent, adjust the orifice, rotor speed, or ground speed and repeat. Bear in mind, speed adjustments are not effective for ground-driven equipment.
5. Repeat the procedure until the error is less than 10 percent.

CALIBRATING A BROADCAST SPREADER:
PREPARING TO CALIBRATE

Broadcast spreaders include machines designed to apply materials broadcast across the surface of the field. They include *drop*, *spinner*, and *pendulum* spreading devices. Calibration of a broadcast spreader is usually done using the product to be applied. Blank material is available and can be used, but may be hard to find. Use extra care and preparation when calibrating with the chemical. To begin, follow these steps:

1. Carefully inspect all machine components. Repair or replace any elements that are not in good working order.
2. Determine the type of drive system that is being used: ground drive or independent PTO. This may help determine the method of calibration.
3. Determine the application rate and the bulk density of the product to be applied.
4. Determine the spreader pattern and swath of the spreader. Check the pattern to ensure uniformity. To check the pattern, place collection pans across the path of the spreader. For drop spreaders, be sure to place a pan under each outlet. For centrifugal and pendulum spreaders, space the pans uniformly with one in the center and an equal number on each side. The pattern should be the same on each side of the center and should taper smoothly as you go to the outer edge. The swath would be set as the width from side to side where a pan holds 50 percent of the maximum amount collected in the center pan.
5. Fill the hopper half full to simulate average conditions.
6. Set the ground speed of the spreader.
7. Set the spreader according to the manufacturer's recommendations and begin calibration.

Calibration Methods

There are two common methods used to calibrate broadcast spreaders. The first method is the *discharge* method. To use this procedure, collect and measure the total discharge from the spreader as it runs across a test course. The second method, the *pan* method, is used on centrifugal and pendulum spreaders. The pattern test pans used to determine pattern shape and swath are used to determine the application rate.

DISCHARGE METHOD

1. Determine the test distance to use. Longer distances may give better accuracy but may be difficult to manage. A distance of 300 to 400 feet is usually adequate. Use shorter distances if necessary to avoid collecting more material than you can reasonably handle or weigh.
2. Set the ground speed. Be sure to maintain a constant ground speed at all times.
3. If using a ground drive spreader, attach a collection bin to the discharge chute or under the outlets and collect all the material discharged from the spreader as it runs across the test distance. If using an independent drive spreader, record the time required to run the test course. Park the spreader at a convenient location and measure the discharge from the spreader for the time measured on the test distance. The course should be run twice and the times averaged for better accuracy.
4. Calculate the application rate (pounds per acre):

Equation 18. Application Rate, lb/ac =

$$\frac{\text{Weight Collected (lb)} \times 43{,}560}{\text{Distance (ft)} \times \text{Swath (ft)}}$$

5. Compare the application rate measured to the rate required. Adjust and repeat as necessary.

PAN METHOD

1. Place pans in the field across the swath to be spread. Pans should be uniformly spaced to cover the full swath. One pan should be at the center of the swath with equal numbers of pans on each side. Use enough pans, 11 or more, to get a good measurement.
2. Make three passes with the spreader using the driving pattern to be used in the field. One pass should be directly over the center pan and the other passes at the recommended distance, lane spacing, to the left and right of the center pass.
3. Combine the material collected in the pans and determine the weight or volume collected. Divide by the number of pans used to determine the average weight or volume per pan.
4. Calculate the application rate.

If you are measuring the weight in the pans in grams:

Equation 19. Application Rate, lb/ac =

$$\frac{13{,}829 \times \text{Weight (grams)}}{\text{Pan Area (inches}^2\text{)}}$$

If you are measuring the volume in the pans in cubic centimeters (cc):

Equation 20. Application Rate, lb/ac =

$$\frac{13{,}829 \times \text{Bulk Density (lb/ft}^3\text{)} \times \text{Volume (cc)}}{\text{Pan Area (inches}^2\text{)} \times 62.4}$$

5. Compare the rate measured to the rate required.

CALIBRATION VARIABLES

Several factors can affect proper calibration. The ground speed of any type of PTO-powered machine can make a difference. On the other hand, ground-driven machines are usually only slightly affected by changes in ground speed. If using dry or granular material, product density will affect the discharge rate and may change the pattern for broadcast spreaders. For liquids, calibration can be affected by pressure, nozzle size, density and viscosity of the liquid, and application type—band or broadcast. The following adjustments may help in adjusting these variables.

SPEED

For PTO-powered equipment or other equipment in which the discharge rate is independent of ground speed, Equation 10 is useful.

Equation 21. New Application Rate =

$$\text{Old Application Rate} \times (\text{Old Speed}/\text{New Speed})$$

For ground-driven equipment, there should be little or no change in application rate when speed is changed.

PRESSURE

For liquids in sprayers, the discharge rate changes in proportion to the square root of the ratio of the pressures.

Equation 22. New Discharge Rate =

$$\text{Old Discharge Rate} \times \sqrt{\frac{\text{New Pressure}}{\text{Old Pressure}}}$$

DENSITY

For liquids in sprayers, the discharge rate changes if the specific gravity (S.G.) of the liquid changes. Use water for calibration and adjust as shown below. Calibrate with spray solution only if recommended by the supplier.

Equation 23. Water Discharge Rate =

$$\text{Spray Discharge Rate} \times \sqrt{\text{S.G. of Spray Solution}}$$

BAND APPLICATION VERSUS BROADCAST APPLICATION

Some pesticide application recommendations are based on area of cropland covered. Other recommendations are based on area of land treated in the band covered. Check the label for the product you are using to see how it is listed.

Broadcast application is based on area of cropland covered. Nozzle spacing is the distance between nozzles. Band applications in which the area of covered cropland is used for calibration and those applications in which multiple nozzles per row are used are both treated like broadcast applications. Divide the row spacing by the number of nozzles used per row to get a nozzle spacing for calibration.

For band applications in which area of treated land—not cropland covered—is specified, use the width of the band at the ground as the spacing for calibration.

DETERMINING UPPER AND LOWER LIMITS

Upper and lower limits provide a range of acceptable error. To set these limits for a given sample size, use the equations below. First, however, you must decide upon the degree of accuracy you wish to achieve. Select a percent error: 2 percent, 5 percent, 10 percent, or any other level of accuracy.

Equation 24. Upper Limit =

$$\text{Target Rate} \times (1 + \text{Percent Error}/100\%)$$

Equation 25. Lower Limit =

$$\text{Target Rate} \times (1 - \text{Percent Error}/100\%)$$

Registered Fungicides, Insecticides, And Miticides For Vegetables

Recommendations of specific chemicals are based upon information on the manufacturer's label and performance in a limited number of trials. Because environmental conditions and methods of application by growers may vary widely, performance of the chemical will not always conform to the safety and pest control standards indicated by experimental data.

Recommendations for the use of agricultural chemicals are included in this publication as a convenience to the reader. The use of brand names and any mention or listing of commercial products or services in this publication does not imply endorsement by Auburn University, Clemson University, Louisiana State University, Mississippi State University, North Carolina State University, Oklahoma State University, Texas A&M, University of Florida, University of Georgia, University of Kentucky, University of Tennessee, and Virginia Tech nor discrimination against similar products or services not mentioned. Individuals who use agricultural chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage regulations and examine a current product label before applying any chemical. For assistance, contact your local county Extension office.

BE SURE TO CHECK THE PRODUCT LABEL BEFORE USING ANY PESTICIDE.

RESISTANCE MANAGEMENT AND THE INSECTICIDE RESISTANCE ACTION COMMITTEE (IRAC) CODES FOR MODES OF ACTION OF INSECTICIDES

Many insecticides affect a particular chemical involved in the function of an insect's nervous, digestive, respiratory, or other system. Some broad-spectrum insecticides affect chemicals that occur in many places within the insect and have a wide ranging effect on the insect. Usually, these are older insecticides that have been in use for many years. The chemicals that these insecticides affect are often found in other animals as well. This can result in the insecticide having undesirable effects on these other animals (non-target effects). Also, non-target effects and persistence in nature have contributed to concerns about these older insecticides.

Many new insecticides have been developed over the last decade, specifically to minimize non-target effects and reduce persistence in the environment compared to older insecticides. This limited persistence in the environment also reduces the potential for non-target effects. However, the primary means of reducing non-target effects has been to make these newer insecticides very specific for a particular chemical (usually an enzyme produced by a single gene) found only in certain insects or groups of insects; thus making the insecticide selective for a particular type of insect. Unfortunately, there is a negative aspect to this specificity. Because only one enzyme is affected, the natural process of **mutation** can result in genetic modifications that alter the enzyme so that it is unaffected by the insecticide. Insects possessing the modified gene will not be affected by the particular insecticide. These insects will reproduce and, in time with continued exposure to the insecticide, will produce a population of insects that is **resistant** to the insecticide. Since most of the new insecticides have been developed to be very specific, resistance will develop much more quickly than with previous insecticides.

Different insecticides affect different enzymes, and insecticides are placed into classes based on which enzymes are affected. These classes are called **Modes of Action (MOA)**. Although insecticides may have different names, they can have the same mode of action and affect the same enzyme or system. It is the mode of action to which the insect will become resistant. Because of this, an insect management program **MUST** rotate the modes of action of the insecticides used during the cropping cycle. To prevent the development of resistance, it is important not to apply insecticides with the same mode of action to successive generations of the same insect. Insect development time can vary by species and environmental conditions, and generations often overlap in the field; proper scouting is necessary to determine when modes of action should be rotated. To make it easier to determine an insecticide's mode of action, the **IRAC** has developed a numerical code with a different number corresponding to each mode of action. New packaging has been developed with a colored banner on the top of the package and label giving the **IRAC code.** For example, the insecticide, Movento®, has a new mode of action and the package says:

GROUP 23 INSECTICIDES

Growers can now easily identify the mode of action of a specific insecticide. This will help them to plan their rotation of materials to avoid rapid development of insecticide resistance and help prolong the life of these important new crop protection materials while providing adequate management of their pest problems. More information about insecticide resistance and a concise chart of all of the **IRAC codes** can be found at the website: www.irac-online.org.

GENERAL INFORMATION

LAWS AND REGULATIONS

Be sure to check current state and federal laws and regulations regarding the proper use, storage, and disposal of pesticides before applying any chemicals. For restricted-use pesticides, an applicator is required to be certified or to work under the direct supervision of a certified individual. dditional information on Worker Protection Standards (WPS) can be found at http://www.epa.gov/agriculture/htc.html.

CERTIFICATION–PESTICIDE APPLICATORS

The Federal Insecticide, Fungicide, and Rodenticide Act of 1972 (FIFRA) requires each state to set up a program to certify. This certification is designed to show that users of pesticides know how to use pesticides safely in order that they do not endanger the user, fellow humans, or the environment. Users of pesticides are classified as either private applicators or commercial applicators. The certification process is somewhat different for each group. The definitions of private and commercial applicators are as follows:

Private Applicator: Any person who uses, or supervises the use of a restricted-use pesticide for the purpose of raising some type of agricultural commodity. The application can be done on land owned or rented by the applicator or the applicator's employer. However, any applications done on a "for-hire" basis are considered commercial applications. Examples of private applicators are dairy farmers, vegetable or fruit growers, greenhouse growers, and ranchers.

Commercial Applicator: Any person who uses, or supervises the use of, pesticides on a "for-hire" basis; any person who applies pesticides for nonagricultural purposes; any person who applies pesticides as a part of his or her job with any governmental agency (public operator). Examples of commercial applicators are: exterminators; landscapers; tree services; aerial applicators; weed-control firms; and owners of apartments, motels, nursing homes, restaurants, etc., who do their own pest control work.

For detailed information on certification of pesticide applicators, call your state's Department of Agriculture or your local Extension office for information.

HANDLING PESTICIDES

Before opening a pesticide container, all applicators should carefully read the label, and accurately follow all directions and precautions specified on the labeling. In order to handle and apply pesticides safely, it is essential to use the proper personal protective equipment (PPE). For the custom or professional applicator, which includes both private and commercial applicators, safety equipment should at least consist of the PPE listed on the product label.

Your physician should be advised of the types of pesticides used in your work. Before the start of the spray season, each applicator should have a baseline blood cholinesterase level determined if you will be applying any organophosphate or carbamate insecticides.

When applying pesticides, be sure to have a decontamination site as required by the EPA's Worker Protection Standards (WPS) and a supply of clean water and liquid detergent available for drenching and washing in case of an accident. A single drop of certain pesticides in the eye is extremely hazardous. Be prepared to wash a contaminated eye with clean water for 15 minutes.

Only an experienced applicator wearing the protective clothing and safety equipment required by the manufacturer should handle highly toxic pesticides, such as Guthion, Lannate, and Temik.

APPLYING PESTICIDES

Before using a pesticide, read and obey all labeling instructions. Always have the label readily available when applying a pesticide.

Do **not** handle or apply pesticides if you have a headache or do not feel well. **Never smoke, eat or drink while using pesticides. Avoid inhaling pesticide sprays, dusts, and vapors.**

If hands, skin, or other body parts become contaminated or exposed, wash the area immediately with clean water and a liquid detergent. If clothing becomes contaminated, remove it immediately. Wash contaminated clothing separately. After each spraying or dusting, bathe and change clothing; always begin the day with clean clothing.

Always have someone present or in close contact when using highly toxic pesticides -those with the signal word **DANGER** plus the skull and crossbones symbol.

APPLY THE CORRECT DOSAGE

- To avoid excessive residues on crops for feed and food
- To achieve optimum pest control and minimum danger to desirable organisms
- To avoid chemical damage to the crops
- To obtain the most economical control of pests.

Use pesticides for only those crops specified on the label, and use only those that have state and federal registration. Avoid drift to nontarget areas. Dusts drift more than sprays; airblast sprays drift more than boom sprays. When cleaning or filling application equipment, **do not contaminate** streams, ponds, or other water supplies. Keep a record of all pesticides used.

TREATED AREAS

Be sure all treated areas are posted so as to keep out unauthorized personnel. This should be a regular procedure for greenhouse operators.

REENTRY PERIOD

Persons must not be allowed to enter the treated area until after sprays have dried or dusts have settled and until sufficient time has passed to ensure that there is no danger of excessive exposure. This time period is listed on the pesticide label as the Restricted Entry Interval (REI). In no case during the reentry period are farm workers allowed to enter the treated area to engage in activity requiring substantial contact with the treated crop. PPE is required for any early entry into the treated area and is only allowed for trained applicators.

FARM WORKER SAFETY

Federal pesticide legislation sets an interval during which unprotected persons may not reenter areas treated with certain pesticides to ensure that there is no danger to excessive exposure. These intervals (days to reentry) are listed on each pesticide's label. Points for special attention are:

1. No pesticide shall be applied while any person not involved in the application is in the field being treated.
2. No owner shall permit any worker not wearing protective clothing (that is, PPE) to enter a field treated with pesticides until sprays have dried or dusts have settled, unless they are exempted from such. **Protective clothing:** hat or head covering; woven, long-sleeved shirt and long-legged pants; and shoes and socks. Additional safety equipment may be needed.
3. Pesticides classified in EPA Category 1 have a reentry time of at least 24 hours.
4. If the label states a longer reentry time or has more stringent requirements than indicated here, the label restrictions must be followed. Existing safety standards specified on the label remain in force.
5. When workers are expected to be working in the vicinity of a field treated or to be treated with a pesticide, a timely (written or oral) warning to such workers shall be given.
    a. For all pesticides, workers must be warned by posting a bulletin board at all point(s) where workers might assemble. This bulletin board should include a map of the farm which designates the different areas of the farm that might be treated and listing of the following information:
        i. Location and name of crop treated
        ii. Brand and common chemical name of pesticide applied.
    b. Date of application
    c. Date of safe reentry into treated area
    d. When a pesticide having a reentry time greater than 7 days is applied, warning signs must be posted for the duration of the reentry time. The signs must be clearly readable at a distance of 25 feet and printed in English and the language of the worker, if other than English.
    e. The sign must contain the words:

        Danger

        Name of the pesticide

        Treatment date

        Do not enter until _____
6. The sign must not be removed during the reentry time, but must be removed before workers are allowed to have contact with the treated plants.

For additional information on these and other state farm worker safety regulations, contact the Pesticide Control Program office or the Cooperative Extension pesticide office in your state.

STORAGE

Pesticides should always be stored in their original containers and kept tightly closed. For the protection of others, especially firefighters, the storage area should be posted as *Pesticide Storage* and kept securely locked.

Herbicides, especially hormone-like weedkillers such as 2,4-D, should not be stored with other pesticides—primarily insecticides and fungicides—to prevent the accidental substitution of the herbicide for these chemicals.

Store the pesticides in a cool, dry, well-ventilated area that is not accessible to children and others who do not know and understand the safe and proper use of pesticides. Pesticides should be stored under lock and key. Special precautions may be needed in case of a fire in these storage areas.

Any restricted use pesticide (RUP) or container contaminated by restricted pesticides **must** be stored in a secure, locked enclosure while unattended. This enclosure **must** bear a warning that pesticides are stored there. In many states, it is illegal to store any pesticide in any container other than its original container.

Keep an inventory of all pesticides held in storage and locate the inventory list in an accessible place away from the storage site so that it may be referred to in case of an emergency at the storage site.

Keep your local fire department informed of the location of all pesticide storages. Fighting a fire that includes smoke from burning pesticides can be extremely hazardous to firefighters. Firefighters should be cautioned to avoid breathing any smoke from such a fire. A fire with smoke from burning pesticides may endanger the people of the immediate area or community. The people of an area or community may have to be evacuated if the smoke from a pesticide fire-drifts in their direction. To obtain Prefire Planning Guides, contact the US National Response Team (NRT) at at http://www.nrt.org or at http://ipm.ncsu.edu (under "Information for Pesticide Applicators/Dealers").

Pesticide Formulation	General Signs of Deterioration
EC	Evidence of separation is such as a sludge or sediment Milky appearance does not occur when water is added.
Oils	Milky appearance does not occur when water is added.
WP, SP, WGD	Excessive lumping; powder does not suspend in water.
D, G, WDG	Excessive lumping or caking.

After freezing, place pesticides in warm storage [50°-80°F] and shake or roll container every few hours to mix product or eliminate layering. If layering persists or if all crystals do not completely dissolve, do not use the product. If in doubt, call the manufacturer.

PESTICIDE TRANSPORT

Containers must be well-secured to prevent breakage or spillage. An adequate supply of absorbent material, a shovel, and a fire extinguisher must be available. While under transport, pesticides must be stored in a separate compartment from the driver. All pesticide containers and equipment must be secured to the vehicle so as to prevent removal by unauthorized person(s) when the vehicle is unattended. The door or hatch of any service vehicle tank containing a pesticide must be equipped with a cover that will prevent spillage when the vehicle is in motion.

The above requirements do not apply if the pesticide is being transported within the application equipment tank.

For additional information on pesticide transport, contact the state Pesticide Control Program office or Extension.

DISPOSAL

Pesticides should not be disposed of in sanitary landfills or by incineration, unless these locations and equipment are especially designed and licensed for this purpose by the state.

The best method to dispose of a pesticide is to use it in accordance with current label registrations. The **triple rinse-and-drain** (see below) procedure or the **pressure-rinse procedure** (see below) is the recommended method to prepare pesticide containers for safe disposal. This method can save money as well as protect the environment.

Crush or puncture the container for disposal in a sanitary landfill or deposit in landfills that accept industrial waste, or deliver the intact container to a drum reconditioner or recycling plant. Check with the landfill operator prior to taking empty containers for disposal. For additional information on the disposal of pesticides themselves or unrinsed containers or rinsate, call the state agency responsible for hazardous wastes. See back cover for telephone numbers.

Triple Rinse–and–Drain Method. To empty a pesticide container for disposal, drain the container into the spray tank by holding the container in a vertical position for 30 seconds. Add water to the pesticide container. Agitate the container thoroughly, then drain the liquid (rinsate) into the spray tank by holding in a vertical position for 30 seconds. Repeat two more times. Puncture or otherwise create a hole in the bottom of the pesticide container to prevent its reuse.

Pressure Rinse Method. An optional method to rinse small pesticide containers is to use a special rinsing device on the end of a standard water hose. The rinsing device has a sharp probe to puncture the container and several orifices to provide multiple spray jets of water. After the container has been drained into the sprayer tank (container is upside down), jab the pointed pressure rinser through the bottom of the inverted container. Rinse for at least 30 seconds. The spray jets of water rinse the inside of the container and the pesticide residue is washed down into the sprayer tank for proper use. Thirty seconds of rinse time is equivalent to triple rinsing. An added benefit is that the container is rendered unusable.

PROTECT OUR ENVIRONMENT

- Do not burn pesticides. The smoke from burning pesticides is dangerous and can pollute air.
- Do not dump pesticides in sewage disposal or storm sewers because this will contaminate water.
- Avoid using excess quantities of pesticides. Calibrate sprayers to make sure of the output.
- Adjust equipment to keep spray on target. Chemicals off-target pollute and can do harm to fish, wildlife, honey bees, and other desirable organisms.

Keep pesticides out of ponds, streams, and water supplies, except those intended for such use. A small amount of drift can be hazardous to food crops and to wildlife. Empty and clean sprayers away from water areas (such as ponds, lakes, streams, etc.)

Protect bees and other beneficial insects by choosing the proper chemical and time of day for application. See additional precautions in section ”Protecting Our Groundwater.”

MINIMIZE SPRAY DRIFT

- Avoid spraying when there is strong wind.
- Use large orifice nozzles at relatively low pressure.
- Use nozzles that do not produce small droplets.
- Adjust boom height as low as practical.
- Do not spray at high travel speeds.
- Spray when soil is coolest and relative humidity is highest.
- Use nonvolatile pesticides.
- Use drift control additives when permitted by the pesticide label.

PESTICIDE POISONING

If any of the following symptoms are experienced during or shortly after using pesticides: headache, blurred vision, pinpoint pupils, weakness, nausea, cramps, diarrhea, and discomfort in the chest, seek medical assistance immediately. Be sure to take a copy of the pesticide label. For minor symptoms, call the appropriate Poison Control Center in your state. See back cover for emergency telephone numbers. Prompt action and treatment may save a life.

IN CASE OF AN ACCIDENT

Remove the person from exposure:

- Get away from the treated or contaminated area immediately
- Remove contaminated clothing.
- Wash with soap and clean water.
- Call a physician and the state Poison Control Center or Agency. See back cover for emergency telephone numbers.
- Be prepared to give the active ingredient name (common name)

PESTICIDE SPILLS

Keep a supply of absorbent on hand to scatter over liquid spills in the storage room. Sawdust or janitorial sweeping compound works well in absorbing the liquids in a cleanup. Use a respirator and rubber gloves to clean up spills; cover the contaminated surface with household lye, trisodium phosphate, or liquid detergent. Let it soak a couple of hours and reabsorb the solution from the floor. This procedure is recommended for cleaning truck beds that are contaminated. Specific information concerning pesticide cleanup can be obtained by calling the manufacturer directly. The phone numbers for emergencies are listed on every product label. Information can also be obtained by calling CHEMTREC at 800/424-9300. Report pesticide spills to the proper state agency. See back cover for telephone numbers.

RESPIRATORY PROTECTIVE DEVICES FOR PESTICIDES

For many toxic chemicals, the respiratory (breathing) system is the quickest and most direct route of entry into the circulatory system. From the blood capillaries of the lungs, these toxic substances are rapidly transported throughout the body.

Respiratory protective devices vary in design, use, and protective capability. In selecting a respiratory protective device, the user must first consider the degree of hazard associated with breathing the toxic substance, and then understand the specific uses and limitations of the available equipment. Select a respirator that is designed for the intended use, and always follow the manufacturer's instructions concerning the use and maintenance of that particular respirator. Different respirators may be needed for application of different chemicals or groups of chemicals. Select only equipment approved by the National Institute of Occupational Safety and Health (NIOSH). The NIOSH approval numbers begin with the letters TC. *NOTE*: The label will specify which respirator is needed for that particular pesticide.

TYPES OF RESPIRATORS

Respiratory protective devices can be categorized into three classes: air-purifying, supplied-air, and self-contained. Because most pesticide contaminants can be removed from the atmosphere by air-purifying devices, we will look at these in greatest detail.

Air-purifying devices include chemical cartridge respirators, mechanical filters, gas masks (also referred to as canister filter respirators), and battery powered respirators. They can be used only in atmospheres containing sufficient oxygen to sustain life.

- Chemical cartridge respirators provide respiratory protection against certain gases and vapors in concentrations not greater than 0.1% by volume, provided that this concentration does not exceed an amount that is immediately dangerous to life and health. They are for use only when exposure to high continual concentrations of pesticide is unlikely, such as when mixing pesticides outdoors. They are available either as halfmasks, covering only the nose and mouth, or as full-facepiece respirators for both respiratory and eye protection.
- Mechanical filter respirators (dust masks) provide respiratory protection against particulate matter such as mists, metal fumes, and nonvolatile dusts. They are available either as disposable or reusable halfmasks that cover the nose and mouth, or as reusable full-facepieces. Dust masks should never be used when mixing or applying liquids because splashed or spilled liquids, or pesticide vapors can be absorbed by the mask.
- Many respiratory protective devices are combinations of chemical cartridge and mechanical filter (prefilter) respirators. These can provide respiratory protection against both gases and particulate matter.
- Full-face piece respirators provide respiratory protection against particulate matter, and/or against certain specific gases and vapors, provided that their concentration does not exceed an amount that is immediately dangerous to life and health. Gas masks, like full-facepieces, cover the eyes, nose, and mouth, but will last longer than cartridges when continuously exposed to some pesticides. A gas mask will not, however, provide protection when the air supply is low. A special respirator with a self-contained air supply should be worn in these situations.
- Battery powered air-purifying respirators equipped with pesticide filters/cartridges are also effective in filtering out pesticide particles and vapors. They are available as halfmasks, full-face masks, hoods, and protective helmets, and are connected by a breathing hose to a battery powered filtration system. This type of filtration system has the additional advantage of cooling the person wearing it. But, like other air purifying devices, this system does not supply oxygen and must be worn only when the oxygen supply is not limited.

Chemical cartridge respirators protect against light concentrations of certain organic vapors. However, no single type of cartridge is able to remove all kinds of chemical vapors. A different type of chemical cartridge (or canister) must be used for different contaminants. For example, cartridges and canisters that protect against certain organic vapors differ chemically from those that protect against ammonia gases. Be sure that the cartridge or canister is approved for the pesticide you intend to use. Cartridge respirators are not recommended for use against chemicals that possess poor warning properties. Thus, the user's senses (smell, taste, irritation) must be able to detect the substance at a safe level if cartridge respirators are to be used correctly.

The effective life of a respirator cartridge or canister depends on the conditions associated with its use—such as the type and concentration of the contaminants, the user's breathing rate, and the humidity. Cartridge longevity is dependent on its gas and vapor adsorption capacity. When the chemical cartridge becomes saturated, a contaminant can pass through the cartridge, usually allowing the user to smell it. At this point, the cartridge must be changed immediately. There are times when the mechanical prefilter also needs to be changed. A prefilter should be replaced whenever the respirator user feels that breathing is becoming difficult. Dispose of all spent cartridges to avoid their being used inadvertently by another applicator who is unaware of their contaminated condition.

Chemical cartridge respirators cannot provide protection against extremely toxic gases such as hydrogen cyanide, methyl bromide, or other fumigants. Masks with a self-contained air supply are necessary for these purposes.

USE AND CARE OF RESPIRATORS

Respirators are worn as needed for protection when handling certain pesticides. The use of respirators is now regulated requiring a health screening prior to their use by a health professional. This is due in part to the Fumigant re-registration decisions by EPA. These prerequisites are outlined in the OSHA Respiratory Protection Act. Prior to using a respirator, read and understand the instructions on the cartridge or canister and all supplemental information about its proper use and care. Be sure the filter is approved for protection against the pesticide intended to be used. Respirators labeled only for protection against particulates must not be used for gases and vapors. Similarly, respirators labeled only for protection against gases and vapors should not be used for particulates. Remember, cartridges and filters do not supply oxygen. Do

not use them where oxygen may be limited. All respirators must be inspected for wear and deterioration of their components before and after each use. Special attention should be given to rubber or plastic parts which can deteriorate. The facepiece, valves, connecting tubes or hoses, fittings, and filters must be maintained in good condition.

All valves, mechanical filters, and chemical filters (cartridges or canisters) should be properly positioned and sealed. Fit the respirator on the face to ensure a tight but comfortable seal. Facial hair will prevent a tight seal and consequently OSHA regulations prohibit the use of a respirator when the user has a beard or facial hair. Two tests can be done to check the fit of most chemical cartridge respirators. The first test requires that you place your hand tightly over the outside exhaust valve. If there is a good seal, exhalation should cause slight pressure inside the facepiece. If air escapes between the face and facepiece, readjust the headbands until a tight seal is obtained. Readjusting the headbands may at times not be sufficient to obtain a good seal. It may be necessary to reposition the facepiece to prevent air from escaping between the face and facepiece. The second test involves covering the inhalation valve(s) by placing a hand over the cartridge(s). If there is a good seal, inhalation should cause the facepiece to collapse. If air enters, adjust the headbands or reposition the facepiece until a good seal is obtained.

Get to fresh air immediately if any of the following danger signals are sensed:

- Contaminants are smelled or tasted
- Eyes, nose, or throat become irritated
- Breathing becomes difficult
- The air being breathed becomes uncomfortably warm
- Nauseous or dizzy sensations are experienced

Cartridges or filters may be used up or abnormal conditions may be creating contaminant concentrations which exceed the capacity of the respirator to remove the contamination.

After each use of the respirator, remove all mechanical and chemical filters. Wash the facepiece with soap and warm water, and then immerse it in a sanitizing solution such as household bleach (two tablespoons per gallon of water) for two minutes, followed by a thorough rinsing with clean water to remove all traces of soap and bleach. Wipe the facepiece with a clean cloth and allow to air dry.

Store the respirator facepiece, cartridges, canisters, and mechanical filters in a clean, dry place, preferably in a tightly sealed plastic bag. ***Do not store respirators with pesticides or other agricultural chemicals.***

Handle respirators with the same care given to other protective equipment and clothing.

PROTECTING OUR GROUNDWATER

Groundwater is the water contained below the topsoil. This water is used by 90% of the rural population in the United States as their sole source of drinking water. Contamination of the water supply by pesticides and other pollutants is becoming a serious problem. One source of contamination is agricultural practices. Protection of our groundwater by the agricultural community is essential.

Groundwater collects under our soils in aquifers that are comprised of layers of sand, gravel, or fractured bedrock which, by their nature, hold water. This water comes from rainfall, snowfall, etc., that moves down through the soil layers to the aquifer. The depth of the aquifer below the surface depends on many factors. Where it is shallow, we see lakes, ponds and wetlands. In areas where it is deep, we find arid regions.

FACTORS THAT AFFECT MOVEMENT OF WATER AND CONTAMINANTS

The depth of aquifers, in conjunction with soil types, influences how much surface water reaches the aquifer. Their depth also affects how quickly water and contaminants reach an aquifer. Thus, shallow water tables tend to be more vulnerable to contamination than deeper ones.

This tendency, however, depends on the soil type. Soils with high clay or organic matter content may hold water longer and retard its movement to the aquifer.Conversely, sandy soils allow water to move downward at a fast rate. High levels of clay and/or organic content in soils also provide a large surface area for binding contaminants that can slow their movement into groundwater. Soil texture also influences downward water movement. Finer textured soils have fewer spaces between particles than coarser ones, thus decreasing movement of water and contaminants.

CHEMISTRY PLAYS A ROLE

The characteristics of an individual pesticide affect its ability to reach groundwater. The most important characteristics are solubility in water, adsorption to soils, and persistence in the environment.

Pesticides that are highly soluble in water have a higher potential for contaminating groundwater than those that are less soluble. The water solubility of a chemical indicates how much chemical will dissolve in water and is measured in parts per million (ppm). Those chemicals with a water solubility greater than 30 ppm may create problems. Be sure to read the Environmental Precautions on each pesticide label.

A chemical's ability to adhere to soil particles plays an important role. Chemicals with a high affinity for soil adsorption are less likely to reach the aquifer. Adsorption is also affected by the amount of organic matter in the soil. Soils with high organic matter content are less vulnerable than those with low organic matter content.

Finally, how persistent a chemical is in the environment may affect its ability to reach groundwater. Those that persist for a long time may be more likely to cause contamination than materials that breakdown quickly. Persistence is measured by the time it takes half of a given pesticide to degrade. This is called the chemical's half-life. Chemicals with an overall estimated half-life longer than 3 weeks pose a threat to groundwater.

HOW TO PREVENT CONTAMINATION OF GROUND WATER

Examine the chemical properties of the pesticides used. If using materials that persist for long periods of time, are very water soluble, or are not tightly held by the soil, then your groundwater

may become contaminated. Another material may be selected that has a shorter persistence, lower water solubility, or higher potential for soil adsorption. The following chart assists with these decisions.

1. Determine the local soil and geologic circumstances. If in an area with a shallow water table or the soil is low in organic matter or sandy in nature, there is a greater risk of contaminating your groundwater. In these cases, choose a pesticide that has a low water solubility and is not persistent.
2. Evaluate management practices. These practices maybe the most important factors in determining the risk of contaminating groundwater. If the same materials are used year after year, or many times a season, the potential for contamination can be increased due to the amount of pesticide in the soil. The timing of pesticide applications has an effect on groundwater contamination. If applications during periods of high rainfall or heavy irrigation are made, it is more likely that contamination may occur. Also, the water table in the spring may be higher than at other times. Early season applications, therefore, may pose a greater chance for groundwater contamination.
3. The method of application may have an effect. Direct injection, incorporation, and chemigation all increase the chance of contamination. If using these techniques, be sure to follow the procedures listed on the material's label.
4. The location of wells can be important. If the sprayer loading area or pesticide storage building is too close to a well, the risk of contamination may be greater. Wells should be located a minimum distance from all pesticide storage and loading areas. This distance differs between states but is generally between 50 and 100 ft. In the event of an accident, this distance should prevent contamination. This minimum distance should also be followed for field irrigation wells. If they are too close to application areas, contamination might occur.
5. Check the condition of any wells in the vicinity of sprayer loading areas, pesticide storage areas, or field applications. If they have cracked casings trouble is being invited. Cracks in a well casing provide a direct point of entry for pesticide-contaminated water that is in the soil.
6. Use some type of anti back-flow device in any system used for chemigation or to fill the sprayer with water. In the event of a pump shutoff or other failure, if any back-flow into the water system occurs, these devices will prevent pesticides from entering the well. Many state laws require that anti back-flow devices be placed on all sprayer water intake systems prior to the water entering the tank. The use of an air gap only is no longer acceptable in some states.
7. Care and maintenance of equipment is also an important consideration. If the equipment does not function properly, over-delivery may occur, which increases the chance of groundwater contamination. Prior to the beginning of the season, inspect all of the working parts of the sprayer or chemigation system. Check the pump to ensure that it is working properly. For both sprayers and chemigation systems, check the water lines for clogs and leaks. For sprayers, check the nozzles for wear and clogs. Clogged, leaking, or worn lines and nozzles can cause pesticides to be delivered in too high an amount or into unwanted areas. Be sure to calibrate equipment. Uncalibrated equipment can cause over-delivery as well. Equipment should be calibrated at the beginning of the season, periodically during the remainder of the season, and any time changes or adjustments are made to the equipment.
8. Apply materials only when needed. The use of pesticides, when not needed, can increase the threat of contamination. Check irrigation practices as well. Do not irrigate immediately after a pesticide application, unless required by a pesticide's label. The increased water content in the soil might speed up the downward movement of a pesticide.

REMEMBER, GROUNDWATER MUST BE PROTECTED.

TOXICITY OF CHEMICALS USED IN PEST CONTROL

The danger in handling pesticides does not depend exclusively on toxicity values. Hazard is a function of both toxicity and the amount and type of exposure. Some chemicals are very hazardous from dermal (skin) exposure as well as oral (ingestion). Although inhalation values are not given, this type of exposure is similar to ingestion. A compound may be highly toxic but present little hazard to the applicator if the precautions are followed carefully.

Toxicity values are expressed as acute oral LD_{50} in terms of milligrams of the substance per kilogram (mg/kg) of test animal body weight required to kill 50 percent of the population. The acute dermal LD_{50} is also expressed in mg/kg. These acute values are for a single exposure and not for repeated exposures such as may occur in the field. Rats are used to obtain the oral LD_{50} and the test animals used to obtain the dermal values are usually rabbits.

CATEGORIES OF TOXICITY[1]

Categories	Signal Word	LD_{50} Value (mg/kg)	
		Oral	Dermal
I	Danger-Poison	0 – 50	0 – 200
II	Warning	50-500	200-2,000
III	Caution	500-5,000	2,000-20,000
IV	None[2]	5,000	5,000 20,000

[1] EPA accepted categories.

[2] No signal word required based on acute toxicity; however, products in this category usually display "Caution."

Read all labels and become familiar with the symptoms of pesticide poisoning. For help in a pesticide emergency, seek immediate medical attention and call the appropriate poison information number on the back cover of this book.

TOXICITY AND LD_{50} CALCULATIONS WEIGHT CONVERSIONS

1 ounce (oz) = 28 grams (gr)
1 pound (lb) = 454 grams (gr)
1 gram (gr) = 1,000 milligrams (mg)
1,000 mg = 0.035 oz
1 mg = 0.000035 oz

CONVERSIONS: BODY WEIGHT IN POUNDS (LB) TO BODY WEIGHT IN KILOGRAMS (KG)

(lb)		(kg)
25	=	11.25
50	=	22.5
75	=	33.75
100	=	45

To determine an exact weight, multiply known body weight in pounds by 0.45. *Example*: 100 lb x 0.45 = 45 kg

Note: All the following calculations use a body weight of 100 pounds. To determine the LD_{50}, first convert body weight to kilograms; to do this multiply weight in lb by 0.45.
Example: 100 x 0.45 = 45 kg

Next, multiply given LD_{50} by body weight in kg. **Note**: LD_{50} numbers are given by the manufacturer.
Example: LD_{50} of 11 x 45 kg = 495 mg

Next, to convert milligrams (mg) to ounces (oz), multiply mg by 0.000035. *Example*: 495 mg x 0.000035 = 0.017 oz.

The following is a chart of LD_{50} figures converted to ounces for three commonly used products in the agricultural industry.

	Body Weight in Pounds					
	LD_{50}	30	60	100	150	200
	Ounces					
Insecticide Furadan	11	0.005	0.010	0.017	0.026	0.035
Herbicide Micro-Tech/Partner	1,800	0.9	1.7	2.8	4.3	5.7
Fungicide Chlorothalonil	10,000	4.9	9.5	15.7	23.8	31.5

CONVERSION INFORMATION FOR USE OF PESTICIDES ON SMALL AREAS

LIQUID MATERIALS

Recommended Rate per acre	Approximate Rate per 1,000 sq. ft.	Approximate Rate per 100 sq. ft.
1 pint	¾ tablespoons	¼ teaspoon
1 quart	1½ tablespoons	½ teaspoon
2 quarts	3 tablespoons	1 teaspoon
1 gallon	6 tablespoons	2 teaspoons
25 gallons	4½ pints	1 cup
50 gallons	8 pints	1 pint
75 gallons	7 quarts	1½ pints
100 gallons	9 quarts	1 quart

For dry materials, such universal conversions are not possible because these materials vary widely in density. You can use volume measurements such as teaspoons, tablespoons, and cups, but you must first weigh a tablespoon of each product so that you will know what volume measurement to use to obtain the desired weight. Remember that there are 43,560 square feet in an acre. To convert a per-acre rate to 1,000 square feet, divide the per-acre rate by 43.56. To convert a per-acre rate to 100 square feet, divide the per-acre rate by 435.6.

Example: A rate of 2 pounds of Dithane DF per acre is desired for a planting of 1,000 square feet. Divide the per-acre rate of 907 grams (453.6 grams per pound) by 43.56 to get 20.8 grams. Since Dithane DF weighs about 10 grams per tablespoon, you would need two tablespoons. Knowing the weight per tablespoon for each product you work with, you can use a tablespoon for measuring, rather than weighing.

PESTICIDE DILUTION TABLES

The following tables provide quantity of either liquid or wettable powder concentrates to use per acre to give desired dosage of an active ingredient per acre.

HOW TO USE THESE TABLES

Example: Reading the product label, you determine that you need to apply 0.50 lbs of actual Guthion per acre to treat a specific problem. You have Guthion 2L liquid that contains 2 lb. of Active Ingredient per gallon of product. Referring to the "Liquid Concentrate" table find "2 lb" in the first column. Next locate the "0.50" column in the heading across the top of the table. These two columns intersect at "2.0 pints". Thus, you need to add 2 pints of Guthion 2L in enough water to treat one acre. The other two tables work the same way.

TABLE OF MEASURES

3 teaspoons (tsp) = 1 tablespoon	2 cups (c) = 1 pint
2 tablespoons (tbl) = 1 fluid once	2 pints (pt) = 1 quart
16 tablespoons (tbl) = 1 cup	4 quarts (qt) = 1 gallon
8 fluid ounces (fl oz) = 1 cup	

LIQUID CONCENTRATE – AMOUNT TO USE IN PINTS PER ACRE

Pounds A.I. /gallon	Pounds per acre of A.I. (Active Ingredient) Recommended							
	0.125	0.25	0.50	0.75	1.0	2.0	3.0	4.0
1 lb.	1.0	2.0	4.0	6.0	8.0	16.0	24.0	32.0
1½ lb.	6.7	1.3	2.6	4.0	5.3	10.6	16.0	21.3
2 lb.	0.5	1.0	2.0	3.0	4.0	8.0	12.0	16.3
3 lb.	0.34	0.67	1.3	2.0	2.7	5.3	8.0	10.7
4 lb.	0.25	0.50	1.0	1.5	2.0	4.0	6.0	8.0
5 lb.	0.20	0.40	0.80	1.2	1.6	3.2	4.8	6.4
6 lb.	0.17	0.34	0.67	1.0	1.3	2.6	4.0	5.3
7 lb.	0.14	0.30	0.60	0.90	1.1	2.3	3.4	4.6
8 lb.	0.125	0.25	0.50	0.75	1.0	2.0	3.0	4.0
9 lb.	0.11	0.22	0.45	0.67	0.90	1.8	2.7	3.6
10 lb.	0.10	0.20	0.40	0.60	0.80	1.6	2.4	3.2

WETTABLE POWDER – AMOUNT TO USE IN POUNDS PER ACRE

%A.I.	Pounds per acre of A.I. (Active Ingredient) Recommended							
	0.125	0.25	0.50	0.75	1.0	2.0	3.0	4.0
15%	13/16	1¾	3⅓	5	6½	13	20	26½
25%	½	1	2	3	4	8	12	16
40%	5/16	⅝	1¼	1¾	2½	5	7½	10
50%	¼	½	1	1½	2	4	6	8
75%	3/16	⅜	11/16	1	1⅓	2⅔	4	5½

DUST OR GRANULES– AMOUNT TO USE IN POUNDS PER ACRE

%A.I.	Pounds per acre of A.I. (Active Ingredient) Recommended							
	0.125	0.25	0.50	0.75	1.0	2.0	3.0	4.0
2½%	5	10	20	30	40	80	120	160
5%	2½	5	10	15	20	40	60	100
10%	1¼	2½	5	7½	10	20	30	40
20%	5/8	1¼	2½	3¾	5	10	15	20
25%	½	1	2	3	4	8	12	16

Insect Control for Commercial Vegetables

Read the pesticide label before application. High pressure (200 psi) and high volume (50 gallons per acre) aid in vegetable insect control. Ground sprays with airblast sprayers or sprayers with hollow cone drop nozzles are suggested. Incorporate several methods of control for best results. In recent years, the number of generic products has increased significantly. For brevity, these generic products typically are not listed within each section. The trade names listed are intended to aid in identification of products and are neither intended to promote use of specific trade names nor to discourage use of generic products. A list of active ingredients and generic brand names appears in a separate table at the end of this section.

Insecticides are placed into IRAC MOA classes based on their mode of action (insecticides in the same MOA class have the same mode of action). Effective insecticide resistance management involves the use of alternations, rotations, or sequences of different insecticide MOA classes. To prevent the development of resistance, it is important not to apply insecticides with the same MOA to successive generations of the same insect.

The following online databases provide current product labels and other relevant information:	
Database[1]	**Web Address**
Agrian Label Database	https://home.agrian.com/
Crop Data Management Systems	http://www.cdms.net/Label-Database
EPA Pesticide Product and Label System	https://iaspub.epa.gov/apex/pesticides/f?p=PPLS:1
Greenbook Data Solutions	https://www.greenbook.net/
Kelly Registration Systems[2]	http://www.kellysolutions.com

[1] Additional databases not included in this list may also be available. Please read the database terms of use when obtaining information from a particular website.

[2] Available for AK, AL, AZ, CA, CO, CT, DE, FL, GA, IA, ID, IN, KS, MA, MD, MN, MO, MS, NC, ND, NE, NJ, NV, NY, OK, OH, OR, PA, SC, SD, VA, VT, WA, and WI. Kelly Registration Systems works with State Departments of Agriculture to provide registration and license information.

TABLE 2-1. INSECT CONTROL FOR ASPARAGUS

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	dimethoate 400, MOA 1B	1 pt	48 hrs	180	Do not exceed 5 pints per acre per year.
	malathion, MOA 1B (various) 57 EC	2 pt	12 hrs	1	Aphid colonies appear by early September.
	pymetrozine, MOA 9B (Fulfill) 50WDG	2.75 oz	12 hrs	—	For aphid control on ferns after harvest.
	acetamiprid (Assail) 30 SG	2.5 oz	12	1	
Asparagus beetle, Japanese beetle, Grasshopper	carbaryl, MOA 1A (Sevin) 50 WP (Sevin) 80 S (Sevin) XLR Plus	 2 to 4 lb 1.25 to 2.5 lb 1 to 2 qt	12 hrs	1	Low rate to be used on seedlings or spears. Do not apply more often than once every 3 days. With established beetle populations, three consecutive weekly sprays are required. beetles and grasshoppers in the fall.
	acetamiprid (Assail) 30 SG	2.5 oz	12	1	
	dimethoate 400, MOA 1B	1 pt	48 hrs	180	Do not exceed 5 pints per acre per year.
	malathion, MOA 1B (various) 57 EC	2 pt	12 hrs	1	
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 pt	48 hrs	1	Let a row on edge of field near overwintering sites of asparagus beetles fern out. This will attract and hold beetles for that directed insecticide spray (trap and destroy).
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	spinetoram, MOA 5 (Radiant) 1 SC	4 to 8 fl oz	4 hrs	60	For asparagus beetle only. This use is only for asparagus ferns; do not apply within 60 days of spear harvest.

TABLE 2-1. INSECT CONTROL FOR ASPARAGUS (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Beet armyworm, Cutworm, Yellow-striped armyworm	*Bacillus thuringiensis,* MOA 11A (Dipel) DF	0.5 to1 lb	4 hrs	0	
	chlorantraniliprole, MOA 28 (Coragen) 1.67SC	3.5 to 5 fl oz	4 hrs	1	
	cyantraniliprole, MOA 28 (Exirel) 0.83EC	7 to 13.5 fl oz	12 hr	1	Do not make applications within 25 ft of water sources.
	methomyl, MOA 1A (Lannate) 2.4 LV (Lannate) 90 SP	 1.5 to 3 pt 0.5 to 1 lb	48 hrs	1	
	spinetoram, MOA 5 (Radiant) 1 SC	 4 to 8 fl oz	4 hrs	60	This use is only for asparagus ferns; do not apply within 60 days of spear harvest.
	spinosad MOA 5 (Entrust 2SC)	 4 to 6 fl oz	4 hrs	60	This use is only for asparagus ferns; do not apply within 60 days of spear harvest. **OMRI approved.**

TABLE 2-2. INSECT CONTROL FOR BEANS

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	acetamiprid MOA 4A (Assail) 30SG	2.5 to 5.3 oz	12 hrs	7	
	dimethoate 4 EC, MOA 1B	0.5 to 1 pt	48 hrs	0	On foliage as needed. Re-entry interval of 48 hours
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2F	 7 to 10.5 fl oz 16 to 24 fl oz	12 hrs	 21	See label for soil application instructions. Also controls leaf hoppers and thrips.
	Foliar treatment (Admire Pro) 4.6 F (various) 1.6 F	 1.2 fl oz 3.5 fl oz	12 hrs	 7	
	sulfoxaflor (Transform) 50WG	0.75 to 1.0 oz	24 hrs	7	
	flupyradifurone (Sivanto Prime)	 7 to 14 fl	4 hrs	7	
	spirotetramat, MOA 23 (Movento) 2 SC	 4 to 5 fl oz	24 hrs	1 (succulent); 7 (dried)	
Thrips	acephate, MOA 1B (Orthene) 97 PE	 0.5 to 1 lb	24 hrs	14	Lima beans may be treated and harvested the same day. Do not apply more than 2 pounds a.i. per acre per season.
	acetamiprid MOA 4A (Assail) 30SG	2.5 to 5.3 oz	12 hrs	7	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	methomyl, MOA 1A		48 hrs	1	
	(Lannate) 90 SP (Lannate) 2.4 LV	0.5 lb 1.5 pt			
	novaluron MOA 15 (Rimon) 0.83 EC	12 fl oz	12 hrs	1	Effective against immature thrips only.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 6 fl oz	4 hrs	3 (succulent); 28 (dried)	Do not apply more than 28 fluid ounces per acre per season on succulent beans or more than 12 fluid ounces on dried beans.
	spinosad, MOA 5 (Blackhawk)	2.5 to 3.3 oz	4 hrs	3 (succulent); 28 (dried)	Do not apply more than 20 ounces per acre per season on succulent beans or more than 8.3 ounces on dried beans.

TABLE 2-2. INSECT CONTROL FOR BEANS (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Corn earworm, European corn borer, Lesser cornstalk borer, Looper, Armyworm	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	
	spinetoram, MOA 5 (Radiant) 1 SC	4.5 to 6 fl oz	4 hrs	3 (succulent); 28 (dried)	Do not apply more than 28 fluid ounces per acre per season on succulent beans or more than 12 fluid ounces on dried beans.
	spinosad, MOA 5 (Blackhawk)	1.7 to 3.3 oz	4 hrs	3 (succulent); 28 (dried)	Do not apply more than 20 ounces per acre per season on succulent beans or more than 8.3 ounces on dried beans.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals. Not effective against armyworm.
Cowpea curculio	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals. Control may be poor in areas where resistant populations occur, primarily in the Gulf Coast areas. Addition of piperonyl butoxide synergist (Exponent) may improve control of pyrethroids.
Cucumber beetle, Bean leaf beetle, Japanese beetle, Cutworm	carbaryl, MOA 1A (Sevin) 50 WP 80 S XLR Plus	 4 lb 2.5 lb 1 qt	12 hrs	3 (succulent); 21 (dried)	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Grasshopper	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Leafminer	cyromazine, MOA 17 (Trigard) 75 WP	2.66 oz	12 hrs	7	
	naled, MOA 1B (Dibrom) 8 EC	1 pt	48 hrs	1	Re-entry interval is 48 hours
	spinetoram, MOA 5 (Radiant) 1 SC	4 to 8 fl oz	4 hrs	3 (succulent); 28 (dried)	Do not apply more than 28 fluid ounces per acre per season on succulent beans or more than 12 fluid ounces on dried beans.
	spinosad, MOA 5 (Blackhawk)	2.5 to 3.3 oz	4 hrs	3 (succulent); 28 (dried)	Do not apply more than 20 ounces per acre per season on succulent beans or more than 8.3 ounces on dried beans.
Lygus bug	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	carbaryl, MOA 1A (Sevin) 50 WP 80 S XLR Plus	 3 lb 1.875 lb 1.5 qt	12 hrs	 3 (succulent); 21 (dried)	On foliage when pods begin to form.
	dimethoate, MOA 1B (Dimethoate) 4 EC	1 pt	48 hrs	7	Do not apply if bees are visiting area to be treated when crops or weeds are in bloom.
Mexican bean beetle	acetamiprid MOA 4A (Assail) 30SG	2.5 to 5.3 oz	12 hrs	7	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	carbaryl, MOA 1A (Sevin) 50 WP (Sevin) 80 S (Sevin) XLR Plus	 1 to 2 lb 0.625 to 1.25lb 1 qt	12 hrs	3 (succulent); 21 (dry)	On foliage as needed. Use low rate on young plants.
	novaluron MOA 15 (Rimon) 0.83 EC	9 to 12 oz	12 hrs	1	Controls immature stages only.
Potato leafhopper	acetamiprid MOA 4A (Assail) 30SG	2.5 to 5.3 oz	12 hrs	7	
	carbaryl, MOA 1A (Sevin) 50 WP (Sevin) 80 S (Sevin) XLR Plus	 4 lb 2.5 lb 1 qt	12 hrs	3 (succulent); 21 (dry)	On foliage as needed.
	dimethoate 4 EC, MOA 1B	0.5 to 1 pt	48 hrs	7	
	methomyl, MOA 1A (Lannate) 90 SP (Lannate) 2.4 L	 0.5 lb 1.5 to 3 pt	48 hrs	 1 1 to 3	Do not graze before 3 days or use for hay before 7 days.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and their reentry and pre-harvest intervals.

TABLE 2-2. INSECT CONTROL FOR BEANS (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Seedcorn maggot, Wireworm	**Use seed pretreated with insecticide for seedcorn maggot control.**				Seed can be purchased pretreated. Pretreated seed will not control wireworms.
	bifenthrin MOA 3 (Empower) 1.15G	3.5 to 8.7 lb	9 days	9	Apply preplant broadcast incorporated in the top 1 to 3 inches of soil.
	chlorpyrifos MOA 1B (Lorsban) 4E	2 pts	24 hrs		Can be applied preplant broadcast incorporated in the top1 to 3 inches of soil, or at planting as a T-band application. For at planting application, apply 1.8 fluid ounces per 1,000 feet of row at 30-inch row spacing. Apply the spray in a 3 to 5 inch wide band over the row behind the planting shoe and in front of the press wheel to achieve shallow incorporation. Do not make more than one application per year or apply more than 1 pound a.i per acre.
	phorate, MOA 1B (Thimet) 20 G	4.9 to 9.4 oz/ 1,000 ft row	12 hrs	60	Drill granules to the side of seed at planting. Avoid contact with seed.
Spider mite	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	bifenazate MOA 20D (Acramite) 4 SC	16 to 24 fl oz	12 hrs	3	
	acequinocyl (Kanemite) 15 SC	31 fl oz	12 hrs	7	
	fenpyroximate (Portal) 0.4 EC	2 pt	12 hrs	1	For use on snap bean only.
Stink bug, Kudzu bug	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	naled, MOA 1B (Dibrom) 8 EC	1.5 pt/100 gal water	48 hrs	1	
Whiteflies	acetamiprid MOA 4A (Assail) 30 SG	4.0 to 5.3 oz	12 hrs	7	
	buprofezin, MOA 16 (Courier) 40 SC	9 to 13.6 fl oz	12 hrs	14	For use on snap beans only.
	flupyradifurone (Sivanto Prime)	10.5 to 14 fl	4 hrs	7	
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	 7 to 10.5 fl oz 16 to 24 fl oz	12 hrs	 21	See label for soil application instructions.
	Foliar treatment (Admire Pro) 4.6 F (various) 1.6 F	 1.2 fl oz 3.5 fl oz	12 hrs	 7	
	spirotetramat, MOA 23 (Movento)	4 to 5 fl oz	24 hrs	1 (succulent); 7 (dry)	PHI is 1 day for succulent beans and 7 days for dry beans.

TABLE 2-3. INSECT CONTROL FOR BEET

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	flonicamid, MOA 9A (Beleaf) 50SG	2 to 2.8 oz	12 hrs	7	
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	 4.4 to 10.5 fl oz 10 to 24 fl oz	12 hrs	 21	See label for soil application instructions. Will also control flea beetle.
	Foliar treatment (Admire Pro) 4.6 F (various) 1.6 F	 1.2 fl oz 3.5 fl oz	12 hrs	 7	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 10.5 fl oz	4 hrs	1	

TABLE 2-3. INSECT CONTROL FOR BEET (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid (cont'd)	thiamethoxam, MOA 4A (Platinum) 75 SG	1.7 to 2.17 oz	12 hrs		Platinum may be applied to direct-seeded crops in-furrow at seed or transplant depth, post seeding or transplant as a drench, or through drip irrigation. Do not exceed 12 ounces per acre per season of Platinum. Check label for plant-back restrictions for a number of crops.
	(Actara) 25 WDG	1.5 to 3 oz	12 hrs	7	
Armyworms, Beet webworm	chlorantraniliprole MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	
	methoxyfenozide MOA 18 (Intrepid) 2F	6 to 16 fl oz	4 hrs	7	
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	7	Do not apply more than 32 fluid ounces per acre per season.
	spinosad, MOA 5 (Blackhawk)	1.7 to 3.3 oz	4 hrs	3	
Blister beetle, Flea beetle	carbaryl, MOA 1A (Sevin) 50 WP (Sevin) 80 S (Sevin) XLR	3 lb 1.875 lb 1 qt	12 hrs	7	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Leafminer	spinetoram, MOA 5 (Radiant) 1 SC	6 to 10 fl oz	4 hrs	7	Control will be improved with addition of a spray adjuvant.

TABLE 2-4. INSECT CONTROL FOR BROCCOLI, BRUSSELLS SPROUT, CABBAGE, AND CAULIFLOWER

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	**Where whitefly resistance is an issue (or any other insect with a high potential for resistance to Group 4A MOA insecticides), a foliar-applied Group4A insecticide program and a soil-applied Group 4A program should not be used in the same season. Also, if using a foliar-applied program, avoid using a block of more than three consecutive applications of any products belonging to Group 4A insecticides.**				
	acetamiprid, MOA 4A (Assail) 30 SG	2 to 3 oz	12 hrs	7	
	clothianidin, MOA 4A (Belay) 50WD	4.8 to 6.4 oz (soil) 1.6 to 2.1 oz (foliar)	12 hrs	21 (soil) 7 (foliar)	Soil application at planting only.
	dimethoate 4 EC, MOA 1B	0.5 to 1 pt	48 hrs	7	
	flonicamid, MOA 20D (Beleaf) 50SG	2 to 2.8 oz	12 hrs	0	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 12.0 fl oz	4 hrs	1	
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	4.4 to 10.5 fl 10 to 24 fl oz	12 hrs	21	Do not follow soil applications of Admire with foliar applications of any neonicotinoid insecticide. Use only one application method. See label for soil application instructions. Imidacloprid also controls whiteflies.
	Foliar treatment (Admire Pro) 4.6 F (various) 1.6 F	1.3 fl oz 3.75 fl oz	12 hrs	7	Imidacloprid also controls whiteflies. Not effective against flea beetle.
	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 oz	12 hrs	7	
	spirotetramat, MOA 23 (Movento) 2 SC	4 to 5 fl oz	24 hrs	1	Do not exceed 10 fluid ounces per season. Requires surfactant.
	thiamethoxam, MOA 4A **Soil treatment** (Platinum) 75SG	1.66 to 3.67 oz	12 hrs	21	Platinum may be applied to direct-seeded crops in-furrow at seed or transplant depth, post seeding or transplant as a drench, or through drip irrigation. Do not exceed 3.67 oz per acre per season.
	Foliar treatment (Actara) 25WDG	1.5 to 3.0 oz	12 hrs	30	Thiamethoxam also controls whiteflies and certain thrips species.

TABLE 2-4. INSECT CONTROL FOR BROCCOLI, BRUSSELLS SPROUT, CABBAGE, AND CAULIFLOWER (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Diamondback moth, Cabbage looper, Imported cabbageworm, Corn earworm, Cross-stripped cabbageworm, Cabbage webworm, Armyworms	**Insecticide-resistant populations, widespread in Southeastern U.S., may not be controlled with some registered insecticides. To manage resistance, avoid transplants from Georgia and Florida and avoid repeated use of the same materials for extended periods of time. Repeated use of pyrethroid insecticides destroys natural enemies and often aggravates diamondback moth problems. Do not allow populations to increase to large densities before initiating treatments.**				
	Bacillus thuringiensis, MOA 11A (Dipel) 2X (Dipel) 4L (Javelin) WG (Xentari) WDG	 8 oz 1 to 2 qt 0.5 to 1 lb 0.5 to 1 lb	4 hrs	0	On foliage every 7 days. On summer or fall plantings, during periods when eggs and larvae are present. This usually occurs when true leaves appear; on other plantings, it may occur later. A spreader/sticker will be helpful. Not effective against Cabbage webworm.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	3	Foliar or soil application. See label for soil application instructions.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	5 to 10 fl oz	12 hrs	NA	Verimark is for soil application only. Apply at planting only. See label for application options.
	(Exirel) 0.83SE	7 to 17 fl oz	12 hrs	1	Exirel is for foliar application only. Use higher rates for cabbage looper.
	emamectin benzoate, MOA 6 (Proclaim) 5 WDG	3.2 to 4.8 oz	12 hrs	7	
	indoxacarb, MOA 22 (Avaunt) 30 WDG	2.5 to 3.5 oz	12 hrs	3	Add a wetting agent to improve spray. Do not apply more than 14 ounces (0.26 pound a.i.) per acre per crop. The minimum interval between sprays is 3 days.
	novaluron, MOA 15 (Rimon) 0.83 EC	6 to 12 fl oz	12 hrs	7	Use lower rates when targeting eggs or small larvae, and use higher rates when larvae are large. Make no more than three applications, or 24 fluid ounces per acre per season.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	
Flea beetle	acetamiprid, MOA 4A (Assail) 30 SG	2 to 3 oz	12 hrs	7	
	clothianidin, MOA 4A (Belay) 50WDG	4.8 to 6.4 oz (soil) 1.6 to 2.1 oz (foliar)	12 hrs	 7 (foliar)	Soil applications may only be made at planting.
	cyantraniliprole, MOA 28 (Verimark) 1.67SC (Exirel) 0.83SE	 6.75 to 13.5 fl oz 13.5 to 20.5 fl oz	 4 hrs 12 hrs	 1 1	Verimark is for at planting soil application only. See label for application options. Exirel is for foliar application only.
	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL **Soil treatment** (Venom) 70 SG (Scorpion) 35SL	 1 to 4 oz 2 to 7 fl oz 5 to 6 oz 9 to 10.5 fl oz	12 hrs	 1 21	See label for soil application options.
	dimethoate 4 EC, MOA 1B	0.5 to 1 pt	48 hrs	7	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Harlequin bug, Stink bug	clothianidin, MOA 4A (Belay) 50WDG	4.8 to 6.4 oz (soil) 1.6 to 2.1 oz (foliar)	12 hrs	NA 7 (foliar)	Soil application at planting only.
	dinotefuran, MOA 4A (Venom) 70 SG (Scorpion) 35 SL	 3 to 4 oz 2 to 7 fl oz	12 hrs	1	Do not exceed 6 oz of Venom per season.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.

TABLE 2-4. INSECT CONTROL FOR BROCCOLI, BRUSSELLS SPROUT, CABBAGE, AND CAULIFLOWER (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Yellowmargined leaf beetle	pyrethroid, MOA 3		12 hrs		Applications need to be made at the first sign of infestation. Problems are most common in spring and fall months along the gulf coast areas.
	chlorpyrifos, MOA 1B (Lorsban) 4 EC (Lorsban) Advanced (Lorsban) 75 WG	 4 to 4.5 pts 4 to 4.5 pts 3 lb	24 hrs	—	Preplant incorporate: Apply as a broadcast spray to the soil surface in a minimum spray volume of 10 gal or more, and incorporate into the top 2 to 4 inches of soil on the day of application.
	chlorpyrifos, MOA 1B (Lorsban) 4 EC	 1.6 to 2.75 oz/ 1,000 ft row	24 hrs	—	Direct seeded: apply in a 4-in. wide band behind planter shoe and in front of press wheel for shallow incorporation.
	(Lorsban) 15 G	4.6 to 9.2 oz/ 1,000 ft row	24 hrs	—	Direct seeded: place across seed row in 4-in. band behind planter shoe and in front of press wheel.
	diazinon, MOA 1B (Diazinon) 50 W or 50 WP	0.25 to 0.5 lb/ 50 gal	4 days	—	Transplant water: Apply in transplant water or drench water at 4 to 6 oz per plant at transplanting.
	cyantraniliprole (Verimark) 1.67 SC	10 to 13.5 fl oz	4	—	Apply to soil at planting as an in-furrow spray, transplant tray drench, transplant water, hill drench, surface band, or soil shank.
Thrips	dimethoate 4 EC, MOA 1B	0.5 to 1 pt	48 hrs	7	
	acetamiprid (Assail) 30SG	4.0 oz	12 hrs	7	Efficacy will vary depending on thrips species.
	imidacloprid, MOA 4A (Admire Pro) 4.6F (various) 2F	 1.3 fl oz 3.0 fl oz	12 hrs	7	Check label for rates for other formulations. Foliar applications only. Efficacy will vary depending on thrips species.
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 fl oz	48 hrs	1	
	novaluron, MOA 15 (Rimon) 0.83 EC	6 to 12 fl oz	12 hrs	7	Make no more than three applications, or 24 fl oz, per acre per season.
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 10 fl oz	4 hrs	1	
Whitefly	**Where whitefly resistance is an issue (or any other insect with a high potential for resistance to Group 4A MOA insecticides), a foliar-applied Group 4A insecticide program and a soil-applied Group 4A program should not be used in the same season. Also, if using a foliar-applied program, avoid using a block of more than 3 consecutive applications of any product belonging to Group 4A insecticides.**				
	acetamiprid, MOA 4A (Assail) 30 SG	2.5 to 4.0 oz	12 hrs	7	Use spreader stick to improve control.
	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL	 1 to 4 oz 2 to 7 oz	12 hrs	1	Do not follow soil applications with foliar applications of any neonicotinoid insecticide. Use only one application method. Do not apply more than 6 oz per acre per season using foliar applications, or 12 oz per acre per season using soil applications. Soil applications may be applied by: a narrow band below or above the seed line at planting; a post-seeding or transplant drench with sufficient water to ensure incorporation to the root zone; or through drip irrigation.
	Soil treatment (Venom) 70 SG (Scorpion) 35SL	 5 to 6 oz 9 to 10.5 fl oz		21	
	flupyradifurone (Sivanto Prime)	10.5 to 14 fl oz	4 hrs	7	
	spiromesifen, MOA 23 (Oberon) 2 SC	7 to 8.5 fl oz	12 hrs	7	Do not exceed 25.5 fl oz per acre per season.
	spirotetramat, MOA 23 (Movento) 2 SC	4 to 5 fl oz	24 hrs	1	Do not exceed 10 fl oz per season. Requires surfactant. Use a spreader-penetrator adjuvant.
	pyriproxyfen, MOA 7 (Knack) 0.86EC	8 to 10 fl oz	12 hrs	7	Only treat whole fields, and do not apply to any crop other than those for which Knack is registered within 30 days after the last application.

TABLE 2-5. INSECT CONTROL FOR CARROT

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid, leafhopper	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 1.6 F	 4.4 to 10.5 fl oz 10 to 24 fl oz	12 hrs	21	Must be applied to the soil. May be applied via chemigation into the root zone through low-pressure drip, trickle, micro-sprinkler, or equivalent equipment; in-furrow spray or shanked-in 1 to 2 inches below seed depth during planting; or in a narrow band (2 inches or less) 1 to 2 inches directly below the eventual seed row in a bedding operation 14 or fewer days before planting. Higher rates provide longer lasting control. See label for information on approved application methods and rate per 100 row feet for different row spacings.
	thiamethoxam, MOA 4A (Platinum) 75 SG	1.66 to 3.67 oz	12 hrs	30	Platinum may be applied to direct-seeded crops in-furrow at seeding, immediately after seeding with sufficient water to ensure incorporation into the root zone, or through trickle irrigation.
	(Actara) 25 WDG	1.5 to 3 oz	12 hrs	7	Actara is applied to foliage. Do not exceed 4 ounces Actara per acre per season.
	flonicamid, MOA 29 (Beleaf) 50 SG	2 to 2.8 fl oz	12 hrs	3	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 10.5 fl oz	4 hrs	7	
Armyworms, Parsleyworm	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	carbaryl, MOA 1A (Sevin) 80 S (Sevin) XLR Plus	 1.25 lb 1 qt	12 hrs	7	On foliage as needed.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	Coragen may be used for foliar or drip chemigation.
	methomyl, MOA 1A (Lannate) 2.4 LV (Lannate) 90 SP	 0.75 to 1.5 pt 0.25 to 0.5 lb	48 hrs	1	
	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 10 fl oz	4 hrs	1	Use higher rates against large larvae.
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	3	Radiant will not control leafhoppers. Do not make more than 4 applications per year.
Leafminer	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	3	
Wireworm	diazinon, MOA 1B (Diazinon) (AG 500)	4 qt	3 days	—	Broadcast and incorporate preplant.

TABLE 2-6. INSECT CONTROL FOR CELERY

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid, Leafhopper, Flea beetle	imidacloprid, MOA 4A (Admire Pro) 4.6 F (various) 2 F	 7 to 10.5 fl oz 16 to 24 fl oz	12 hrs	21	Apply via chemigation into the root zone, as an in-furrow spray at planting on/or below the seed, or as a post-seeding or transplant drench.
	flonicamid, MOA 29 (Beleaf) 50 SG	2 to 2.8 oz	12 hrs	0	Will not control flea beetle.
	flupyradifurone, MOA 4D (Sivanto) 200 SL	10.5 to 12.0 fl oz	4 hrs	1	Will not control flea beetle
	spirotetramat, MOA 23 (Movento) 2SC	4 to 5 fl oz	24 hrs	3	Do not exceed 10 fluid ounces per season. Not for flea beetle. Requires surfactant. Will not control flea beetle
	tolfenpyrad, MOA 21A (Torac) 1.29 EC	17 to 21 fl oz	12 hrs	1	
Armyworms, Corn earworm, Looper	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	emamectin benzoate, MOA 6 (Proclaim) 5 WDG	2.4 to 4.8 oz	12 hrs	7	Do not make more than two sequential applications without rotating to another product with a different mode of action.
	methomyl, MOA 1A (Lannate) 2.4 LV	3 pt	48 hrs	7	Methomyl may induce leafminer infestations.

TABLE 2-6. INSECT CONTROL FOR CELERY (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Armyworms, Corn earworm, Looper (cont'd)	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 10 fl oz	4 hrs	7	For early season applications only to young crop and small plants. For mid- to late-season applications and heavier infestations and under conditions in which thorough coverage is more difficult. Do not apply more than 16 fl oz per application and do not exceed 64 fl oz per season. See Rotational Crop Restrictions on label.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for registered pyrethroids and pre-harvest intervals.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	Use higher rates for armyworms.
Leafminer	abamectin, MOA 6 (Agri-Mek) 0.15EC	1.75 to 3.5 fl oz	12 hrs	7	
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	5 to 7.5 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	cyromazine, MOA 17 (Trigard 75WP)	2.66 oz	12 hrs	7	
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 10 fl oz	4 hrs	1	

TABLE 2-7. INSECT CONTROL FOR COLLARD AND MUSTARD GREENS

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	acetamiprid, MOA 4A (Assail) 30 SG	2 to 3 oz	12 hrs	7	
	clothianidin, MOA 4A (Belay) 50 WDG	4.8 to 6.4 oz (soil) 1.6 to 2.1 oz (foliar)	12 hrs	7 (foliar)	Soil application at planting only.
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 2.8 fl oz	12 hrs	0	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	10.5 to 12.0 fl oz	4 hrs	1	
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	4.4 to 10.5 fl oz 10 to 24 fl oz	12 hrs	21	See label for soil application instructions. Admire Pro will also control flea beetle.
	Foliar treatment (Admire Pro) 4.6 F (various) 2 F	1.3 fl oz 3.8 fl oz	12 hrs	7	
	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 oz	12 hrs	7	
	spirotetramat, MOA 23 (Movento) 2SC	4 to 5 fl oz	24 hrs	1	Do not exceed 10 fluid ounces per season. Requires surfactant.
Diamondback moth, Caterpillars, including Cabbage looper, Imported cabbageworm, Cross-stripped cabbageworm, Cabbage webworm, Armyworms	**Insecticide-resistant populations may not be controlled with some registered insecticides. To manage resistance, avoid transplants from Georgia and Florida, and avoid the repeated use of the same materials for extended periods of time. Use of pyrethroid insecticides destroys natural enemies and aggravates diamondback moth problems. Do not allow populations to increase to large densities before treatments are initiated. Also,** do not apply insecticides with the same mode of action (i.e., MOA group) more than twice to any generation of diamondback moth. After two applications, rotate to an insecticide with a different mode of action.				
	Bacillus thuringiensis, MOA 11A (Crymax) WDG (Dipel) 2X, DF (Dipel) (Xentari) WDG	0.5 to1.5 lb 8 oz 1 pt 0.5 to 1 lb	4 hrs	0	Use a spreader/sticker.

TABLE 2-7. INSECT CONTROL FOR COLLARD AND MUSTARD GREENS (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Diamondback moth, Caterpillars, including Cabbage looper, Imported cabbageworm, Cross-stripped cabbageworm, Cabbage webworm, Armyworms (cont'd)	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 4 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	emamectin benzoate, MOA 6 (Proclaim) 5 WDG	2.4 to 4.8 oz	12 hrs	14	
	indoxacarb, MOA 22 (Avaunt) 30 WDG	3.5 oz	12 hrs	3	Do not apply Avaunt more than twice to any generation of diamondback moth. After two applications, rotate to an insecticide with a different mode of action. Do not make more than 6 applications (4 in GA), or exceed 14 ounces per season per crop.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	
Flea beetle	carbaryl, MOA 1A (Sevin) 50 WP (Sevin) 80 S (Sevin) XLR	 3 lb 1.875 lb 1 qt	12 hrs	14	
	acetamiprid, MOA 4A (Assail) 30SG	2 to 4 oz	12 hrs	7	
	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL **Soil treatment** (Venom) 70 SG (Scorpion) 35SL	 1 to 4 oz 2 to 7 fl oz 5 to 6 oz 9 to 10.5 fl oz	12 hrs	 7 21	Do not follow soil applications with foliar applications. Use only one application method. Do not apply more than 6 ounces per acre per season using foliar applications, or 12 ounces per acre per season using soil applications. Soil applications may be applied by: a narrow band below or above the seed line at planting; a post-seeding or transplant drench with sufficient water to ensure incorporation to the root zone; or through drip irrigation.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals. May flare diamond back moth populations.
Grasshopper	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals. May flare diamond back moth populations.
Harlequin bug, Stink bug	acetamiprid, MOA 4A (Assail) 30 SG	3 to 4 oz	12 hrs	7	
	clothianidin, MOA 4A (Belay) 50 WDG	4.8 to 6.4 oz (soil) 1.6 to 2.1 oz (foliar)	12 hrs	7 (foliar)	Soil application at planting only.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals. May flare diamond back moth populations.
	thiamethoxam, MOA 4A (Actara) 25WDG	3 to 5.5 oz	12 hrs	7	
Root maggot	chlorpyrifos, MOA 1B (Lorsban) 4 EC (Lorsban) 75WDG	1.6 to 2.75 fl oz 1.1 to 1.8/ 1,000 ft row	24 hrs	—	For directed-seeded crops, apply as a 4-inch band over the row after planting. For transplanted crops, apply as a directed spray immediately after transplanting.
Whitefly	acetamiprid, MOA 4A (Assail) 30 SG	2.5 to 4.0 oz	12 hrs	7	Apply against adults, before nymphs are present. Use a spreader/sticker to improve control.
	flupyradifurone, MOA 4D (Sivanto) 200 L	10.5 to 14.0 fl oz	4 hrs	1	Do not make more than 3 applications or apply more than 28 fluid oz per season.
	pyriproxyfen, MOA 7C (Knack) 0.86 EC	8 to 10 fl oz	12 hrs	7	Do not apply Knack more than twice per season or exceed 0.134 pound per acre per season.
	spiromesifen, MOA 23 (Oberon) 2 SC	7 to 8.5 fl oz	12 hrs	7	Do not make more than 3 applications or apply more than 25.5 fl oz per season.
	spirotetramat, MOA 23 (Movento) 2 SC	4 to 5 fl oz	24 hrs	1	Do not exceed 10 fluid ounces per season. Requires surfactant.

TABLE 2-8. INSECT CONTROL FOR CORN, SWEET

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Corn earworm, Fall Armyworms, European corn borer	transgenic sweet corn varieties expressing *Bt* protein				Highly effective against European corn borer. Effectiveness against corn earworm will vary among BT traits; additional insecticide applications may be required to prevent damage to the ear tips of some varieties.
	pyrethroid, MOA 3		12 hrs		Check label for variety limitations and grazing restrictions. Also, instances of corn earworm resistance to pyrethroids are becoming more prevalent in recent years. To protect ears, begin sprays when tassel shoots first appear. The frequency of sprays will vary depending on location and intensity of earworm populations, ranging from daily to twice weekly in higher elevations. Corn earworms and fall armyworms present in the late whorl stage must be controlled before tassel emergence to prevent migration to ears.
	chlorantraniliprole MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	
	methomyl, MOA 1A (Lannate) 90 SP (Lannate) 2.4 LV	 4 to 6 oz 0.75 to 1.5 pt	48 hrs	0	Do not use methomyl for European corn borer control.
	indoxacarb, MOA 22 (Avaunt) 30 WDG	2.5 to 3.5 oz	12 hrs	3	For control of fall armyworm and European corn borer in whorl stage only. Do not apply more than 14 ounces Avaunt (0.26 lb a.i.) per acre per crop. Minimum interval between sprays is 3 days. Make no more than 4 applications per season.
	spinetoram, MOA 5 (Radiant) 1 SC	3 to 6 fl oz	4 hrs	1	Do not apply more than 36 ounces per acre per year.
	spinosad, MOA 5 (Blackhawk)	1.7 to 3.3 oz	4 hrs		
Cutworm	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Flea beetle, Grasshopper, Japanese beetle, Rootworm beetle	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Sap beetle	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	carbaryl, MOA 1A (Sevin) 50 WP (Sevin) 80 S (Sevin) XLR Plus	 2 lb 1.25 lb 1 qt	12 hrs	2	Infestations usually associated with prior ear damage. Populations build on over mature and damaged fruit and vegetables. Sanitation is important.
Southern corn billbug, Rootworm, Wireworm, Chinch bugs	***Seed treatments:*** clothianidin, MOA 4A (Poncho 600) imidacloprid, MOA 4A (Gaucho 600)	 1.13 fl oz per 80,000 seeds 4 to 8 oz per cwt seed		—	Seed treatments are applied by commercial seed treaters only. Not for use in hopper bins, slurry mixes, or any other type of on-farm treatment.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	chlorpyrifos, MOA 1B (Lorsban) 4 E	4 pt	24 hrs	0	Preplant incorporation treatment. For post emergence treatment use 2 to 3 pints.
	terbufos, MOA 1B (Counter) 15 G	Banded: 6.5 to 13 lb (40 in. row spacing) OR 8 to 16 oz/ 1,000 ft row OR In-Furrow: 6.5 lb (40 in. row) 8 oz/10 ft row			Place granules in a 7-inch band over the row directly behind the planter shoe in front of press wheel. Place granules directly in the seed furrow behind the planter shoe. Rotation is advised.
Stink bug	pyrethroids, MOA 3				See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	methomyl, MOA 1A (Lannate) 90SP	0.5 lb	48 hrs	0	Re-entry interval is 48 hours.

TABLE 2-9. INSECT CONTROL FOR CUCURBITS (CUCUMBER, CANTALOUPE, PUMPKIN, SQUASH, WATERMELON)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Insecticide applications in cucurbits should be made in late evening to protect pollinating insects. Refer to the pollination section of the general production recommendations in this publication for more information about protecting pollinators.					
Aphid	**Where whitefly resistance is an issue (or any other insect with a high potential for resistance to Group 4A MOA insecticides), a foliar applied Group 4A insecticide program and a soil-applied Group 4A program should not be used in the same season. Also, if using a foliar-applied program, avoid using a block of more than three consecutive applications of any products belonging to Group 4A insecticides.**				
	acetamiprid MOA 4A (Assail) 30SG	2.5 to 4.0 oz	12 hrs	0	Do not exceed 0.5 pound per acre per season.
	cyantraniliprole MOA 28 (Verimark) 1.67 SC	10 to 13.5 fl oz	4 hrs	1	Applied to the soil at planting or later via drip irrigation system. See label for application options.
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 2.8 oz	12 hrs	0	
	flupyradifurone, MOA 4D (Sivanto Prime) 200 SL **Soil Application**	21 to 28 fl oz	4 hrs	21	Soil applications through drip irrigation, injected below the seed level at planting, or drench at transplanting.
	Foliar Application	7 to 14 fl oz		1	DO NOT make foliar applications of Sivanto to muskmelon, cantaloupe, or honeydew melon.
	imidacloprid, MOA 4A (Admire Pro) 4.6 F	7 to 10.5 fl oz	12 hrs	21	Must be applied to the soil. May be applied preplant; at planting as a post-seeding drench, transplant water drench, or hill drench; subsurface sidedress or by chemigation using low-pressure drip irrigation methods. Will also control cucumber beetles and whiteflies.
	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 oz	12 hrs	0	Apply before aphids reach damaging levels. Do not exceed 5.5 ounces per acre per season.
	thiamethoxam, MOA 4A (Platinum) 75 SG	1.66 to 3.67 oz	12 hrs	30	Platinum is for soil application and may be applied to direct-seeded crops in-furrow at seed or transplant depth, post seeding or plant-back restrictions for a number of crops. Actara is for foliar application only.
Armyworms, Cabbage looper	*Bacillus thuringiensis*, MOA 11A (Crymax) WDG (Dipel) 2X (Xentari) WDG	0.5 to 1.5 lb 8 oz 0.5 to 1 lb	4 hrs	0	On foliage as needed.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	Coragen may be used for foliar or drip chemigation.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC (Exirel) 0.83SE	5 to 13.5 fl oz 7 to 17 fl oz	4 hrs 12 hrs	1 1	Verimark is for soil application only. It may be applied to the soil at planting at 6.75 to 13.5 ounces, or via drip chemigation at 5 to 10 fluid ounces. Do not make more than two soil or chemigation. See label for application options.
	indoxacarb, MOA 22 (Avaunt) 30WDG		12 hrs		
	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 10 fl oz	4 hrs	3	Use higher rates against large larvae.
	novaluron, MOA 15 (Rimon) 0.83EC	9 to 12 fl oz	12 hrs	1	
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	3	
Cucumber beetle	acetamiprid MOA 4A (Assail) 30SG	2.5 to 5.3 oz	12 hrs	0	Do not exceed 0.5 pound per acre per season.
	carbaryl MOA 1A (Sevin) 50 WP (Sevin) 80 S (Sevin) XLR Plus	2 lb 1.25 lb 1 qt	12 hrs	3	
	clothianidin, MOA 4A (Belay) 50 WDG	4.8 to 6.4 oz (soil)			Soil application at planting only.
		1.6 to 2.1 oz (foliar)	12 hrs	21 (foliar)	Do not use an adjuvant with foliar applications. Do not spray after the 4th true leaf.
	imidacloprid, MOA 4A (Admire Pro) 4.6 F	7 to 10.5 fl oz	12 hrs	21	Must be applied to the soil. See label for information on approved application methods. Will also control aphids and whiteflies.
Leafminer	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.

TABLE 2-9. INSECT CONTROL FOR CUCURBITS (CUCUMBER, CANTALOUPE, PUMPKIN, SQUASH, WATERMELON) (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Leafminer (cont'd)	abamectin, MOA 6 (Agri-Mek) 0.7 SC	1.75 to 3.5 fl oz	12 hrs	7	Do not use more than six applications per season.
	cyromazine, MOA 17 (Trigard) 75 WS	2.7 oz	12 hrs	0	
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	2 to 3.5 fl oz	4 hrs	1	For foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	3	
Pickleworm, Melonworm, cutworm	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	carbaryl MOA 1A (Sevin) 50 WP (Sevin) 80 S (Sevin) XLR Plus	2 lb 1.25 lb 1 qt	12 hrs	3	On foliage when worms appear in blossoms. Repeat as needed. Protect pollinators. Rarely a problem before July.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	2 to 3.5 fl oz	4 hrs	1	For foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	5 to 13.5 fl oz	4 hrs	1	Verimark is for soil application only. It may be applied to the soil at planting at 6.75 to 13.5 ounces, or via drip chemigation at 5 to 10 fluid ounces. Do not make more than two soil or chemigation. See label for application options.
	(Exirel) 0.83SE	7 to 17 fl oz	12 hrs	1	
	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 10 fl oz	4 hrs	3	
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	3	
Spider mites	**Spider mites are primarily a problem on cucumber and watermelon, and less of an issue on squash and pumpkin.**				
	abamectin, MOA 6 (Agri-Mek) 0.7 SC	1.75 to 3.4 fl oz	12 hrs	7	
	bifenazate, MOA 20D (Acramite) 50 WS	0.75 to 1.0 lb	12 hrs	3	Do not make more than one application per season.
	etoxazole, MOA 10B (Zeal) 72 WSP	2 to 3 oz	12 hrs	7	Does not kill adults.
	spiromesifen, MOA 23 (Oberon) 2 SC	7 to 8.5 fl oz	12 hrs	7	
Squash bugs	**Squash bug is a common pest of cantaloupe, pumpkin and squash. Although cucumber and watermelon are occasionally reported as hosts of squash bug, rarely do infestations occur.**				
	acetamiprid MOA 4A (Assail) 30SG	5.3 oz	12 hrs	0	Assail is most effective against newly laid eggs and nymphs.
	clothianidin, MOA 4A (Belay) 50SDG	4.8 to 6.4 oz (soil)		At planting 7	See application instructions and precautionary bee statement above under aphid.
		1.6 to 2.1 oz (foliar)	12 hrs	21 (foliar)	Do not use an adjuvant with foliar applications. Do not spray after the 4th true leaf.
	dinotefuran, MOA 4A (Venom) 70 SG (Scorpion) 35 SL	3 to 4 oz 2 to 7 fl oz	12 hrs	1	Do not exceed 6 ounces Venom per acre per season.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Squash vine borer	**Squash vine borer only attacks squash and pumpkin, and is more common in home gardens opposed to commercial plantings.**				
	acetamiprid MOA 4A (Assail) 30SG	5.3 oz	12 hrs	0	
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Thrips	methomyl, MOA 1A (Lannate) 2.4 LV (Lannate) 90 SP	0.75 to 1.5 pt 0.25 to 0.5 lb	48 hrs	0	
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 10 fl oz	4 hrs	3	
	acetamiprid MOA 4A (Assail) 30SG	1.1 to 2.3 oz	12 hrs	0	

TABLE 2-9. INSECT CONTROL FOR CUCURBITS (CUCUMBER, CANTALOUPE, PUMPKIN, SQUASH, WATERMELON) (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Whiteflies	acetamiprid MOA 4A (Assail) 30SG	1.1 to 2.3 oz	12 hrs	0	
	buprofezin, MOA 16 (Courier) 40 WP	9 to 13.6 oz	12 hrs	7	Use sufficient water to ensure good coverage. Do not apply more twice per crop cycle.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	5 to 7.5 fl oz	4 hrs	1	May be applied foliar or through drip irrigation. Drip chemigation must be applied uniformly to the root zone.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	10 fl oz	4 hrs	1	Verimark is for soil application only. It may be applied to the soil at planting at 6.75 to 13.5 ounces, or via drip chemigation at 5 to 10 fluid ounces. See label for application options.
	(Exirel) 0.83SE	13.5 to 20.5 fl oz	12 hrs	1	Exirel is for foliar application only. Use an adjuvant for best results.
	flupyradifurone, MOA 4D (Sivanto Prime) 200 SL **Soil Application**	21 to 28 fl oz			
	Foliar Application	10.5 to 14 fl oz			DO NOT make foliar applications of Sivanto to muskmelon or cantaloupe.
	imidacloprid, MOA 4A (Admire Pro) 4.6 F	7 to 10.5 oz	12 hrs	21	Must be applied to the soil. May be applied preplant; at planting; as a post-seeding drench or hill drench; subsurface sidedress; or by chemigation using low pressure drip or trickle irrigation. See label aphids and cucumber beetles.
	pyriproxyfen, MOA 7C (Knack) 0.86 EC	8 to 10 oz	12 hrs	7	Do not make more than two applications per season, and do not make applications closer than 14 days apart.
	spiromesifen, MOA 23 (Oberon) 2 SG	7 to 8.5 fl oz	12 hrs	7	Apply against adults, before nymphs are present. Do not exceed 3 applications per season.
	thiamethoxam, MOA 4A (Platinum) 75 SG	1.66 to 3.67 fl oz	12 hrs	30	Platinum is for soil application and may be applied to direct-seeded crops in-furrow at seed or transplant depth, post seeding or transplant as a drench, or through drip irrigation. Do not exceed 11 ounces per acre per season of Platinum. Check label for plant-back restrictions for a number of crops.
	(Actara) 25WDG	3 to 5.5 oz		0	Actara is for foliar application.
Wireworm	diazinon MOA 1B (Diazinon) AG 500	3 to 4 qt	3 days	—	Broacast on soil before planting and thoroughly work into upper 6 inches.

TABLE 2-10. INSECT CONTROL FOR EGGPLANT

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	**Where whitefly resistance is an issue (or any other insect with a high potential for resistance to Group 4A MOA insecticides), avoid making foliar applications of Group 4A insecticides when a soil-applied Group 4A program is used – i.e., do not make both foliar and soil applications of Group 4A insecticides. Also, if using a foliar-applied program, avoid using a block of more than three consecutive applications of any products belonging to Group 4A insecticides.**				
	acetamiprid, MOA 4A (Assail) 30 SG	2 to 4 oz	12 hrs	7	Thoroughly cover foliage to effectively control aphids. Do not apply more than once every 7 days, and do not exceed a total of 7 oz per season.
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 4.8 oz	12 hrs	0	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 12.0 fl oz	4 hrs	1	
	sulfoxaflor (Closer) 2 SC	1.5 to 2.0 fl oz	12 hrs	1	
	imidacloprid, MOA 4A **Soil Treatment** (Admire Pro) 4.6 F (various) 1.6 F	7 to 10.5 oz 16 to 24 fl oz	12 hrs	21	See label for soil application instructions. For short-term protection of transplants at planting, apply Admire Pro (0.44 ounces per 10,000 plants) not more than 7 days before transplanting by (1) uniformly spraying transplants, followed immediately by sufficient overhead irrigation to wash product into potting media, or (2) injection into overhead irrigation system with adequate volume to thoroughly saturate soil media.
	Foliar Treatment (Admire Pro) 4.6 F (various) 1.6 F	1.3 to 2.2 fl oz 3.75 fl oz	12 hrs	0	

TABLE 2-10. INSECT CONTROL FOR EGGPLANT (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid (cont'd)	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 oz	12 hrs	14	Apply before aphids reach damaging levels. Do not exceed 5.5 ounces per acre per season.
	spirotetramat, MOA 23 (Movento) 2 SC	4 to 5 fl oz	24 hrs	1	Do not exceed 10 fluid ounces per season. Requires surfactant.
	thiamethoxam, MOA 4A **Soil treatment** (Platinum) 75 SG	1.66 to 3.67 oz	12 hrs	30	Platinum may be applied to direct-seeded crops in-furrow at seed or transplant depth, post seeding or transplant as a drench, or through drip irrigation. Do not exceed 8 oz per acre per season. Check label for plant-back restrictions.
	Foliar treatment (Actara) 25 WDG	2 to 3 oz	12 hrs	0	Actara is for foliar application.
Blister beetle	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Colorado potato beetle	**Resistance to many insecticides is widespread in Colorado potato beetle. To reduce risk of resistance, scout fields and apply insecticides only when needed to prevent damage to the crop. Crop rotation will help prevent damaging Colorado potato beetle infestations. If control failures or reduced levels of control occur with a particular insecticide, do NOT make a second application of the same insecticide at the same or higher rate. If an additional insecticide application is necessary, a different insecticide representing a different MOA class should be used. Do NOT use insecticides belonging to the same class 2 years in a row for Colorado potato beetle control.**				
	abamectin, MOA 6 (Agri-Mek) 0.7 SC	1.75 to 3.5 fl oz	12 hrs	7	Apply when adults and small larvae are present but before large larvae appear. For resistance management, use the higher rate.
	acetamiprid, MOA 4A (Assail) 30 SG	2 to 4 oz	12 hrs	7	Do not apply more than once every 7 days, and do not exceed 7 ounces of formulation per season.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL	1 to 4 oz 2 to 7 fl oz	12 hrs	1	Do not follow soil applications with foliar applications on any neonicotinoid insecticide. Use only one application method. Do not apply more than 6 ounces per acre per season using foliar applications, or 12 ounces per acre per season using soil applications.
	Soil treatment (Venom) 70 SG (Scorpion) 35SL	5 to 6 fl oz 9 to 10.5 fl oz		21	Soil applications may be applied by (1) a narrow band below or above the seed line at planting, (2) a post-seeding or transplanting drench with sufficient water to ensure movement to the root zone, or (3) drip irrigation.
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	. 7 to 10.5 fl oz 16 to 24 fl oz	12 hrs	21	See application methods under Aphids, Thrips.
	Foliar treatment (Admire Pro) 4.6 F (various) 1.6 F	1.3 fl oz 3.75 fl oz	12 hrs	0	
	novaluron, MOA 15 (Rimon) 0.83 EC	9 to 12 fl oz	12 hrs	1	
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	
	thiamethoxam, MOA 4A (Platinum) 75 SG	1.66 to 3.67 oz	12 hrs	30	See application methods under Aphids.
	(Actara) 25 WDG	2 to 3 oz	12 hrs	0	
Eggplant lace bug	imidacloprid, MOA 4A **Foliar treatment** (Admire Pro) 4.6 F (various) 1.6 F	1.3 to 2.2 fl oz 3.8 to 6.2 fl oz	12 hrs	0	
	malathion, MOA 1B (various brands) 57 EC	3 pt	12 hrs	3	
Flea beetle	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	carbaryl, MOA 1A (Sevin) 50 WP (Sevin) 80 S (Sevin) XLR Plus	 2 lb 1.25 lb 1 lb	12 hrs	3	
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	6.75 to 13.5 fl oz	4 hrs	1	Verimark for soil application only. Apply at planting or via drip chemigation. See label for application options.

TABLE 2-10. INSECT CONTROL FOR EGGPLANT (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Flea beetle (cont'd)	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL	 1 to 4 oz 2 to 7 fl oz	12 hrs	1	Do not follow soil applications with foliar applications on any neonicotinoid insecticide. Use only one application method. Do not apply more than 6 ounces per acre per season using foliar applications, or 12 ounces per acre per season using soil applications.
	Soil treatment (Venom) 70 SG (Scorpion) 35SL	 5 to 6 fl oz 9 to 10.5 fl oz		21	Soil applications may be applied by (1) a narrow band below or above the seed line at planting, (2) a post-seeding or transplanting drench with sufficient water to ensure movement to the root zone, or (3) drip irrigation.
	thiamethoxam, MOA 4A (Platinum) 75 SG (Actara) 25 WDG	 1.66 to 3.67 oz 2 to 3 oz	12 hrs 12 hrs	30 0	See application methods under Aphids.
Hornworm, European corn borer, Beet Army worm, Corn earworm	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 4 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	5 to 10 fl oz	4 hrs	1	Verimark is for soil application only. Drip chemigation must be applied uniformly to the root zone. See label for application options.
	(Exirel) 0.83SE	7 to 13.5 fl oz	12 hrs	1	Exirel is for foliar application only.
	indoxacarb, MOA 22 (Avaunt) 30 WDG	2.5 to 3.5 oz	12 hrs	3	Do not apply more than 14 ounces per acre per season.
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 to 3 pt	48 hrs	5	
	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 16 fl oz	4 hrs	1	Apply at rates of 4 to 8 fluid ounces early in season when plants are small. Apply at rates of 8 to 16 ounces to large plants or when infestations are heavy. During periods of continuous moth flights, retreatments at 7 to 14 days may be required. Do not apply more than 16 fluid ounces per application or 64 fluid ounces of Intrepid 2F per acre per season.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Leafminer	abamectin, MOA 6 (Agri-Mek) 0.15 EC	8 to 16 fl oz	12 hrs	7	Use low rates for low to moderate infestations, and high rates for severe infestations
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	5 to 7.5 fl oz	4 hrs	1	Foliar, soil, or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for application instructions.
	oxamyl, MOA 1A (Vydate) 2 L	1 to 2 qt	48 hrs	7	
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	
Stink bug, leaffooted bug	pyrethroid MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL	 1 to 4 oz 2 to 7 fl oz	12 hrs	1	
	Soil treatment (Venom) 70 SG (Scorpion) 35SL	 5 to 6 fl oz 9 to 10.5 fl oz		21	
	thiamethoxam, MOA 4A (Actara) 25 WDG	3 to 5.5 oz	12 hrs	0	Do not exceed 11 ounces Actara per acre per season.
Spider mite	abamectin, MOA 6 (Agri-Mek) 0.7 SC	1.75 to 3.5 fl oz	12 hrs	7	Use low rates for low to moderate infestations, and high rates for severe infestations.
	acequinocyl, MOA 20B (Kanemite) 15SC	31 fl oz	12 hrs	1	
	bifenazate, MOA 20D (Acramite) 50 WS	0.75 to 1.0 lb	12 hrs	3	Do not make more than one application per season.
	etoxazole, MOA 10B (Zeal)	2 to 3 oz	12 hrs	7	Do not make more than one Zeal application per season.
	fenpyroximate MOA 21 (Portal) 0.4EC	2 pts	12 hrs	3	Do not make more than two applications per season.
	hexakis, MOA 12B (Vendex) 50 WP	2 to 3 lb	48 hrs	3	
	spiromesifen, MOA 23 (Oberon) 2 SG	7 to 8.5 fl oz	12 hrs	7	

TABLE 2-10. INSECT CONTROL FOR EGGPLANT (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Thrips	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL	 1 to 4 oz 2 to 7 fl oz	12 hrs	 1	See Whitefly for application instructions. Soil applications are more effective against thrips than foliar applications are.
	Soil treatment (Venom) 70 SG (Scorpion) 35SL	 5 to 6 oz 9 to 10.5 fl oz		21	
	imidacloprid, MOA 4A Admire Pro 4.6 F (various) 2 F	 7 to 10.5 fl oz 16 to 24 fl oz	12 hrs	21	See Aphids for application instructions.
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 to 3 pt	48 hrs	3	
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 10 fl oz	4 hrs	1	
Whitefly	acetamiprid, MOA 4A (Assail) 30 SG	2.5 to 4 oz	12 hrs	7	Begin applications when significant populations of adults appear. Do not wait until heavy populations have become established. Do not apply more than once every 7 days, and do not exceed 4 applications per season. Do not apply more than 7 ounces per season.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	5 to 7.5 fl oz	12 hrs	1	For foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	cyantraniliprole, MOA 28 (Verimark) 1.67SC	6.75 to 13.5 fl oz	4 hrs	1	Verimark for soil application only. Apply at planting or via drip chemigation. See label for application options.
	(Exirel) 0.83SE	13.5 to 20.5 fl oz	12 hrs	1	Exirel for foliar application only.
	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL	 1 to 4 oz 2 to 7 fl oz	12 hrs	1	
	Soil treatment (Venom) 70 SG (Scorpion) 35SL	 5 to 6 fl oz 9 to 10.5 fl oz		21	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	10.5 to 14.0 fl oz	4 hrs	1	
	imidacloprid, MOA 4A (Admire Pro) 4.6 F (various) 2 F	 7 to 10.5 fl oz 16 to 24 fl oz	12 hrs	21	Do not follow soil applications with applications of other neonico- tinoid insecticides (Assail or Venom). See Aphids for application methods and restrictions.
	pyriproxyfen, MOA 7C (Knack) 0.86 EC	8 to 10 fl oz	12 hrs	14	Knack prevents eggs from hatching. It does not kill whitefly adults. Applications should begin when 3 to 5 adults per leaf are present. Do not make more than 2 applications per season, and do not apply a second application within 14 days of the first application. Do not exceed 20 fluid ounces of Knack per acre per season. Check label for plant-back restrictions.
	spirotetramat, MOA 23 (Movento) 2SC	4 to 5 fl oz	24 hrs	1	Do not exceed 10 fl oz per season. Requires surfactant.
	spiromesifen, MOA 23 (Oberon) 2 SC	7 to 8.5 fl oz	12 hrs	7	Do not exceed 3 applications or 25.5 fluid ounces per season.
	thiamethoxam, MOA 4A (Platinum) 75 SG	1.66 to 3.67 oz	12 hrs	30	Platinum is for soil applications and may be applied to direct-seeded crops in furrow at seed or transplant depth, at post seeding or transplant as a drench, or through drip irrigation. Do not exceed 11 ounces per acre per season. Check label for plant-back restrictions for a number of plants.
	(Actara) 25WDG	3 to 5.5		0	Actara is for foliar application.

TABLE 2-11. INSECT CONTROL FOR HOPS

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphids and leafhoppers	imidacloprid, MOA 4A				
	(Admire) 4.6 F	2.8 fl oz	12 hrs		
	(generics) 2	6.4 fl oz	12 hrs	28	
	pymetrozine, MOA 9B (Fulfill) 50 WDG	4 to 6 oz	12 hrs	14	For aphids only. Will not control leafhoppers.
	spirotetramat, MOA 23 (Movento) 2 F	5 to 6 fl oz	24 hrs	7	Do not exceed 12.5 fl oz per acre per season. Will also control twospotted spider mite.
	malathion, MOA 1B				May suppress twospotted spider mite.
	5 EC	1 pt	12 hrs	10	
	8 EC	0.63 pt	12 hrs	10	
	pyrethrins, MOA 3 Pyganic EC 1.4 II Pyganic EC 5 II	16 to 64 fl oz 4.5 to 17 fl oz	12 hrs 12 hrs	0 0	**OMRI approved.** Pyrethrins degrade very quickly in sunlight. Do not expect residual control.
Japanese beetle	bifenthrin, MOA 3				See Table of Generic Insecticides for other bifenthrin products.
	(Brigade) 2 EC	3.8 to 6.4 fl oz	12 hrs	14	
	(Brigade) WD	9.6 to 16 of oz	12 hrs	14	
	imidacloprid, MOA 4A				
	(Admire) 4.6 F	2.8 fl oz	12 hrs		
	(generics) 2	6.4 fl oz	12 hrs	28	
Armyworms, cutworms, loopers, leafroller	*Bacillus thuringiensis,* MOA 11A		4 hrs	0	
	(Dipel) DF, MOA	0.5 to 1 lb			
	(Crymax) WDG	0.5 to 1.5 lb			
	bifenthrin, MOA 3				See Table of Generic Insecticides for other bifenthrin products.
	(Brigade) 2 EC	3.8 to 6.4 fl oz	12 hrs	14	
	(Brigade) WD	9.6 to 16 of oz	12 hrs	14	
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	0	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	spinosad, MOA 5 (Entrust) SC	4 to 6 fl oz	4 hrs	1	**OMRI approved.**
	spinetoram, MOA 5 (Delegate) 25WG	2.5 to 4 oz	4 hrs	1	
Spider mites	abamectin, MOA 6 (Agri-Mek) 0.7 SC	1.75 to 3.5 fl oz	12 hrs	7	Do not exceed 48 fluid ounces per acre per season, or more than two sequential applications.
	acequinocyl, MOA 20B (Kanemite) 15 SC	31 fl oz	12 hrs	1	The use of a surfactant/adjuvant with Kanemite on tomatoes is prohibited.
	Bifenazate, MOA 20D (Acramite) 50 WS	0.75 to 1.0 lb	12 hrs	3	Do not make more than one application per season.
	etoxazole, MOA 10B (Zeal) 72 WSP	3 to 4 oz	12 hrs	7	Apply when mites are low, because Zeal is primarily a ovicide/ larvicide.
	fenpyroximate MOA 21 (Portal) 0.4EC	2 pts	12 hrs	3	Do not make more than two applications per season.
	hexythiazox, MOA 10A (Savey) 50 DF	4 to 6 oz	12 hrs	—	May be applied up to burr formation in hop vines. Apply when mites are low, because Savey is primarily an ovicide, and also sterilizes females.
	Mineral oil (TriTek) Various brands	1 to 2% soln.	4hrs	0	**OMRI approved.** TriTek is the only emulsified formulation of oil. All others do not contain an emulsifier.

TABLE 2-12. INSECT CONTROL FOR LETTUCE

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	acetamiprid, MOA 4A (Assail) 30 SG	2 to 4 oz	12 hrs	7	Do not apply more than once every 7 days, and do not exceed 4 applications per season.
	clothianidin, MOA 4A (Belay) 2.13 SC	4.8 to 6.8 oz (soil); 1.6 to 2.1 oz (foliar)	12 hrs	7 (foliar)	Soil application at planting only.
	dimethoate 4 EC, MOA 1B	0.5 pt	48 hrs	14	
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 2.8 oz	12 hrs	0	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	10.5 to 12.0 fl oz	4 hrs	1	
	imidacloprid, MOA 4A **Soil Treatment** (Admire Pro) 4.6 F (various) 1.6 F	4.4 to 10.5 fl oz 10 to 24 fl oz	12 hrs	21	Do not follow soil applications with foliar applications of any neonicotinoid insecticide. See label for soil application instructions.
	Foliar Treatment (Admire Pro) 4.6 F (various) 1.6 F	1.3 fl oz 3.8 fl oz	12 hrs	7	
	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 oz	12 hrs	7	Apply before aphids reach damaging levels. Do not exceed 5.5 oz per acre per season
	spirotetramat, MOA 23 (Movento) 2SC	4 to 5 fl oz	24 hrs	3	Do not exceed 10 fluid ounces per season. Requires surfactant.
	thiamethoxam, MOA 4A **Soil treatment** (Platinum) 75 SG	1.66 to 3.67 oz	12 hrs	30	Do not follow applications of Platinum with foliar applications of any neonicotinoid insecticide. Platinum may be applied to direct-seeded crops in-furrow at the seeding or transplant depth, or as a narrow surface band above the seedling and followed by irrigation. Post seeding it may be applied as a transplant drench or through the drip irrigation.
	Foliar treatment (Actara) 25 WDG	1.5 to 3 oz	12 hrs	7	Actara is for foliar application.
	tolfenpyrad, MOA 21A (Torac) 1.29 EC	17 to 21 fl oz	12 hrs	1	Do not apply until at least 14 days after plant emergence or after transplanting to allow time for root establishment.
Cabbage looper, Corn Earworm, armyworms	*Bacillus thuringiensis,* MOA 11A (Crymax) WDG (Dipel) DF	0.5 to 1.5 lb 8 oz	4 hrs	0	Only target small armyworms with Bts.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	Foliar or drip chemigation.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	5 to 13.5 fl oz	4 hrs	1	Verimark is for soil application only. Applications made at planting and/or via drip chemigation. Use higher rates (>10 fluid ounces) where cabbage looper is a concern. See label for application options.
	(Exirel) 0.83SE	7 to 17 fl oz	12 hrs	1	Exirel is for foliar application only. Use higher rates (>13.5 fluid ounces) for Cabbage.
	emamectin benzoate, MOA 6 (Proclaim) 5 WDG	3.2 to 4.8 oz	12 hrs	7	Do not make more than two sequential applications without rotating to another product with a different mode of action.
	indoxacarb, MOA 22 (Avaunt) 30 WDG	2.5 to 3.5 lb	12 hrs	3	Do not apply more than 14 ounces of Avaunt (0.26 lb a.i.) per acre per crop. The minimum interval between sprays is 3 days.
	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 10 fl oz	4 hrs	1	Low rates for early-season applications to young or small plants. For mid- and late-season applications, use 6 to 10 ounces.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for registered pyrethroids and pre-harvest intervals. Not recommended for armyworms.
Leafhopper	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG	1 to 3 oz	12 hrs	7	Do not follow soil applications with foliar applications of any neonicotinoid insecticide. Use only one application method. Do not apply more than 6 ounces per acre (foliar) or 12 ounces per acre (soil).
	Soil treatment (Venom) 70 SG	5 to 6 fl oz		21	Soil applications may be applied by: (1) narrow band below or above the seed line at planting, (2) post seeding or transplant drench with sufficient water to ensure incorporation, or (3) drip irrigation.

TABLE 2-12. INSECT CONTROL FOR LETTUCE (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Leafhopper (cont'd)	dimethoate 4 EC, MOA 1B	0.5 pt	48 hrs	14	14-day interval for leaf lettuce.
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 10.5 fl oz	4 hrs	1	
	imidacloprid, MOA 4A (various) 1.6 F	3.75 fl oz	12 hrs	7	There is a 12-month plant-back restriction for a number of crops. Check label for restrictions.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for registered pyrethroids and pre-harvest intervals.
	thiamethoxam, MOA 4A (Actara) 25 WDG	1.5 to 3 oz	12 hrs	7	
	tolfenpyrad, MOA 21A (Torac) 1.29 EC	14 to 21 fl oz	12 hrs	1	Do not apply until at least 14 days after plant emergence or after transplanting to allow time for root establishment.

TABLE 2-13. INSECT CONTROL FOR OKRA

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	imidacloprid, MOA 4A		12 hrs		See label for soil treatment instructions.
	Soil treatment				
	(Admire Pro) 4.6 F	7 to 10.5 fl oz		21	
	(various) 2 F	16 to 24 fl oz			
	Foliar treatment		12 hrs	0	
	(Admire Pro) 4.6 F	1.3 to 2.2 fl oz			
	(various) 1.6 F	3.8 fl oz			
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 2.8 oz	12 hrs	0	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 12 fl oz	4 hrs	1	
	spirotetramat, MOA 23 (Movento) 2SC	4 to 5 fl oz	24 hrs	3	Do not exceed 10 fluid ounces per season. Not for flea beetle. Requires surfactant.
	sulfoxaflor (Closer) 2 SC	1.5 to 2.0 fl oz	12 hrs	7	
	malathion, MOA 1B		12 hrs	1	
	(various brands) 8 F	1.5 pt			
	(various brands) 25 WP	6 lb			
Blister beetle, Flea beetle, Japanese beetle	carbaryl, MOA 1A		12 hrs		On foliage as needed.
	(Sevin) 50 WP	4 lb		3	
	(Sevin) 80 S	2.5 lb			
	(Sevin) XLR Plus	2 qt			
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Corn earworm, Tobacco budworm, European corn borer	carbaryl, MOA 1A		12 hrs	3	On foliage as needed.
	(Sevin) 50 WP	4 lb			
	(Sevin) 80 S	2.5 lb			
	(Sevin) XLR Plus	2 qt			
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	2 to 3.5 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	cyantraniliprole, MOA 28				Verimark is for soil application only. Applications made at planting and/or via drip chemigation. See label for application options.
	(Verimark) 1.67 SC	5 to 10 fl oz	4 hrs	1	
	(Exirel) 0.83SE	7 to 17 fl oz	12 hrs	1	Exirel is for foliar application only. Rates >13.5 for loopers only.
	methoxyfenozide, MOA 18 (Intrepid) 2 F	8 to 16 fl oz	4 hrs	1	
	novaluron, MOA 15 (Rimon) 0.83 EC	9 to 12 fl oz	12 hrs	1	
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	For corn earworm only.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.

TABLE 2-13. INSECT CONTROL FOR OKRA (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Spider mites	bifenazate, MOA 20D (Acramite) 50 WP	0.75 to 1 lb	12 hrs	3	Do not make more than one application per season.
	fenpyroximate MOA 21 (Portal) 0.4EC	2 pt	12 hrs	3	Do not make more than two applications per season.
Stink bug, leaffooted bug	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Whitefly	buprofezin, MOA 16 (Courier) 40 SC	9 to 13.6 fl oz	12 hrs	1	
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	2 to 3.5 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.-
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	6.75 to 13.5 fl oz	4 hrs	1	Apply Verimark to at planting and/or later via drip irrigation or soil injection. See label for application options.
	(Exirel) 0.83SE	13.5 to 20.5 fl oz	12 hrs	1	Exirel is for foliar application.
	flupyradifurone, MOA 4D (Sivanto) 200 SL	10.5 to 14.0 fl oz	4 hrs	1	
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	 7 to 14 fl oz 16 to 32 fl oz	12 hrs	 21	See label for soil application instructions.
	Foliar treatment (Admire Pro) 4.6 F (various) 1.6 F	 1.3 to 2.2 fl oz 3.8 oz	12 hrs	 0	
	pyriproxyfen, MOA 7C (Knack) 0.86 EC	8 to 10 fl oz	12 hrs	1	Do not make more than two applications per season.
	spirotetramat, MOA 23 (Movento) 2SC	4 to 5 fl oz	24 hrs	3	Do not exceed 10 fluid ounces per season. Not for flea beetle. Requires surfactant.

TABLE 2-14. INSECT CONTROL FOR ONION

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Armyworms, Cutworm	chlorantraniliprole MOA 28 (Coragen)	3.5 to 7.5 fl oz	4 hrs	1	
	methoxyfenozide MOA 18 (Intrepid) 2F	4 to 8 fl oz 8 to 12 fl oz	4 hrs		Green onion only. Use lower rates in early season on small plants; use higher rates in late season and heavy infestations
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre- harvest intervals.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	
Leafminer	cyromazine, MOA 17 (Trigard) 75 WS	2.66 oz	12 hrs	7	
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	1	
Onion maggot, Seed corn maggot	**Onion seed pre-treated with cyromazine (Trigard) can be used to control onion and seed corn maggot.**				
	chlorpyrifos, MOA 1B (Lorsban) 4 E	32 fl oz	24 hrs		Apply as in-furrow drench at planting. Use a minimum of 40 gal per acre and incorporate to a depth of 1 to 2 inches. Do not make more than one application per year.
	diazinon, MOA 1B (Diazinon) (AG 500)	2 to 4 qt	3 days		Furrow application; drench the seed furrow at planting time. Apply as a furrow treatment at time of planting. Use separate hoppers for seed and chemical.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Thrips	acetamiprid MOA 4A (Assail) 70 WP	2.1 to 3.4 oz	12 hrs	7	
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 pt	48 hrs	7	
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	1	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre- harvest intervals.

TABLE 2-15. INSECT CONTROL FOR PEA, ENGLISH and SNOW PEA (SUCCULENT AND DRIED)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	acetamiprid MOA 4A (Assail) 70 WP	1 to 2.3 oz	12 hrs	7	Also controls leafhoppers. Succulent peas only.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre- harvest intervals.
	dimethoate, MOA 1B (Dimethoate) 400 (4E)	0.33 pt	48 hrs	0	Do not make more than one application per season, and do not feed or graze if a mobile viner is used, or for 21 days if a stationary viner is used. Re-entry interval is 48 hours.
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 10.5 fl oz	4 hrs	7	Will also control leafhopper
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	 7 to 10.5 fl oz 16 to 24 fl oz	12 hrs	 21	See label for soil application instructions.
	Foliar treatment (Admire Pro) 4.6 F (various) 1.6 F	 1.2 fl oz 3.5 fl oz	12 hrs	 7	
Armyworms, Cloverworm, Cutworm, Looper	chlorantraniliprole MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	
	spinetoram, MOA 5 (Radiant) 1 SC	4 to 8 fl oz	4 hrs	3 (succulent); 28 (dried)	Not for cutworm.
	spinosad, MOA 5 (Blackhawk)	2.2 to 3.3 oz	4 hrs	3 (succulent); 28 (dried)	
Leafhopper, Lygus bug, Stink bug	dimethoate, MOA 1B (Dimethoate) 400	0.33 to 1 pt	48 hrs	See label	Do not make more than one application per season. Do not feed or graze if a mobile viner is used, or for 21 days, if a stationary viner is used.
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 to 3 pt	48 hrs	3	Apply to foliage as needed.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for registered pyrethroids and pre-harvest intervals.
Seedcorn maggot	See **Beans** for control				

TABLE 2-16. INSECT CONTROL FOR PEA, SOUTHERN (COWPEAS)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid, Thrips	acetamiprid MOA 4A (Assail) 70 WP	1 to 2.3 oz	12 hrs	7	Succulent peas only.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for registered pyrethroids and pre-harvest intervals.
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 10.5 fl oz	4 hrs	7	Will not control thrips.
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	 7 to 10.5 fl oz 16 to 24 fl oz	12 hrs	21	See label for soil application instructions.
	Foliar treatment (Admire Pro) 4.6 F (various) 1.6 F	 1.3 fl oz 3.5 fl oz	12 hrs	 7	
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 8 fl oz	4 hrs	3 (succulent); 28 (dried)	Radiant is not effective against aphids.
	spinosad, MOA 5 (Blackhawk)	2.2 to 3.3 oz	4 hrs	3 (succulent); 28 (dried)	Blackhawk is not effective against aphids.
	sulfoxaflor (Transform) 50 WG	0.75 to 1.0 oz	12 hrs	7	
Bean leaf beetle	carbaryl, MOA 1A (Sevin) 4 L (Sevin) 80 S	 0.5 to 1 qt 0.625 to 1.25 lb	12 hrs	3	Do not feed treated foliage to livestock.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.

TABLE 2-16. INSECT CONTROL FOR PEA, SOUTHERN (COWPEAS) (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Corn earworm, Loopers, European corn borer,	chlorantraniliprole MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	
	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 16 fl oz	4 hrs	7	Use lower rates on smaller plants and higher rates in mid- to late season applications, against corn earworm. Do not apply more than 16 fluid ounces (0.25 pound a.i.) per acre per season.
	spinetoram, MOA 5 (Radiant) 1 SC	3 to 6 fl oz	4 hrs	3 (succulent); 28 (dried)	Do not apply more than 12 fluid ounces (0.188 a.i.) per acre per season.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	methomyl, MOA 1A (Lannate) 90SP	0.5 to 1 lb	48 hrs	1	Re-entry interval is 48 hr.
Cowpea curculio	pyrethroids, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals. Control may be poor in areas where resistant populations occur, primarily in parts of Alabama and Georgia. In areas where resistance is a problem, pyrethroid insecticides should be used at the highest labeled rate and synergized by tank-mixing with 1 pint piperonyl butoxide synergist per acre. In fields where resistance is a problem, applications every 3 to 5 days may be necessary to maintain control of the cowpea curculio population.
	methomyl, MOA 1A (Lannate) 90 SP	0.5 to 1 lb	48 hrs	1	Re-entry interval is 48 hours. Not effective against resistant cowpea curculio populations.
Stink bug	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals. Control may be poor in areas where resistant populations occur, primarily in the Gulf Coast areas.
	methomyl, MOA1A (Lannate) 90SP	0.5 to 1 lb	48 hrs	1	Re-entry interval is 48 hours.
Leafminer	spinetoram, MOA 5 (Radiant) 1 SC	5 to 8 fl oz	4 hrs	3 (succulent); 28 (dried)	
	spinosad, MOA 5 (Blackhawk)	2.5 to 3.3 oz	4 hrs	3 (succulent); 28 (dried)	

TABLE 2-17. INSECT CONTROL FOR PEPPER

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid, Flea beetle	acetamiprid, MOA 4A (Assail) 70 WP	0.8 to 1.2 oz	12 hrs	7	Do not apply more than once every 7 days, and do not exceed 4 applications per season.
	cyantraniliprole, MOA 28 (Coragen) SC	6.75 to 13.5 fl oz	4 hr	1	Apply to soil at planting, as a transplant tray drench, in transplant water or hill drench. After planting may be applied via drip irrigation.
	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL	1 to 4 oz 2 to 7 fl oz	12 hrs	1	Do not follow soil applications with foliar applications. Use only one application method. Do not apply more than 6 ounces per acre per season using foliar applications, or 12 ounces per acre per season using soil applications.
	Soil treatment (Venom) 70 SG (Scorpion) 35SL	5 to 6 oz 9 to 10.5 fl oz		21	Soil applications may be applied by 1) a narrow band below or above the seed line at planting; 2) a post-seeding or transplant drench with sufficient water to ensure incorporation to the root zone; or 3) drip irrigation. For flea beetle control only.
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 4.8 oz	12 hrs	0	Will not control flea beetle.
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 12.0 fl oz	4 hrs	1	
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	7 to 14 fl oz 16 to 32 fl oz	12 hrs	21	Where whitefly resistance is a concern, do not follow soil applications with foliar applications of any neonicotinoid. See label for soil application instructions. For short-term protection of transplants at planting, apply Admire Pro (0.44 oz/10,000 plants) not more than 7 days before transplanting by 1) uniformly spraying on transplants, followed immediately by sufficient overhead irrigation to wash product into potting media; or 2) injection into overhead irrigation system using adequate volume to thoroughly saturate soil media.
	Foliar treatment (Admire Pro) 4.6 F (various) 2 F	1.3 fl oz 3.8 fl oz	12 hrs	0	

TABLE 2-17. INSECT CONTROL FOR PEPPER (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid, Flea beetle (cont'd)	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 oz	12 hrs	0	Apply before aphids reach damaging levels. Do not exceed 5.5 ounces per acre per season. Not for flea beetle.
	spirotetramat, MOA 23 (Movento) 2SC	4 to 5 fl oz	24 hrs	1	Do not exceed 10 fluid ounces per season. Requires surfactant. Will not control flea beetle.
	sulfoxaflor (Closer) 2 SC	1.5 to 2.0 fl oz	12 hrs	1	
	thiamethoxam, MOA 4A **Soil treatment** (Platinum) 75 SG	1.66 to 3.67 oz	12 hrs	30	Platinum may be applied to direct-seeded crops in-furrow seeding or transplant depth, post seeding or transplant as a drench, or through drip irrigation. Actara is applied as a foliar spray. Do not exceed 11 ounces per acre per season of Platinum or Actara. Check label for plant-back restrictions for a number of crops. Actara is for foliar application.
	Foliar treatment (Actara) 25 WDG	1.5 to 3 oz	12 hrs	7	Actara is for foliar application.
Armyworms, Corn earworm, Looper, European corn borer, Hornworm	*Bacillus thuringiensis,* MOA 11A (Dipel) DF (Xentari) WDG	0.5 to 1.5 lb 2 to 4 oz	4 hrs	0	
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	2 to 3.5 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	5 to 10 fl oz	4 hrs	1	Verimark is for soil application only. Applications made at planting and/or via drip chemigation. See label for application options.
	(Exirel) 0.83SE	7 to 13.5 fl oz	12 hrs	1	Exirel is for foliar application only.
	emamectin benzoate, MOA 6 (Proclaim) 5 WDG	2.4 to 4.8 oz	12 hrs	7	Apply when larvae are first observed. Additional applications may be necessary to maintain control.
	indoxacarb, MOA 22 (Avaunt) 30 WDG	2.5 to 3.5 oz	12 hrs	3	Use only higher rate for control of armyworm and corn earworm. Do not apply more than 14 ounces of Avaunt (0.26 pound a.i. per acre per crop). Minimum interval between sprays is 5 days.
	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 16 fl oz	4 hrs	1	Apply at rates of 4 to 8 fluid ounces early in season when plants are small. Apply at rates of 8 to 16 ounces to large plants or when infestations are heavy. During periods of continuous moth flights re-treatments at 7 to 14 days may be required. Do not apply more than 16 fluid ounces per application or 64 fluid ounces of Intrepid per acre per season.
	novaluron, MOA 15 (Rimon) 0.83 EC	9 to 12 fl oz	12 hrs	1	The use of a surfactant/adjuvant with Rimon is prohibited on pepper.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Blister beetle, Stink bug, Leaffooted bug	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL	1 to 4 oz 2 to 7 fl oz	12 hrs	1	Do not combine foliar applications with soil applications, or vice versa. Use only one application method.
	Soil treatment (Venom) 70 SG (Scorpion) 35SL	5 to 6 oz 9 to 10.5 fl oz		21	
	thiamethoxam, MOA 4A (Actara) 25WDG	3 to 5.5 oz	12 hrs	0	
Leafminer	abamectin, MOA 6 (Agri-Mek) 0.7 SC	1.75 to 3.5 fl oz	12 hrs	7	
	cyromazine, MOA 17 (Trigard) 75 WP	2.66 oz	12 hrs	0	
	dimethoate 4 EC, MOA 1B	0.5 pt	48 hrs	0	Re-entry interval is 48 hr.
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 10 fl oz	4 hrs	1	
Pepper maggot	acephate, MOA 1B (Orthene) 97 PE	0.75 to 1 lb	24 hrs	7	
	dimethoate 4 EC, MOA 1B	0.5 to 0.67 pt	48 hrs	0	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for registered pyrethroids and pre-harvest intervals

TABLE 2-17. INSECT CONTROL FOR PEPPER (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Pepper weevil	acetamiprid, MOA 4A (Assail) 30 SG	4 oz	12 hrs	7	
	oxamyl, MOA 1A (Vydate) 2 L	2 to 4 pt	48 hrs	7	
	thiamethoxam, MOA 4A (Actara) 25 WP	3 to 4 oz	12 hrs	0	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for registered pyrethroids and pre-harvest intervals
Broad mite	abamectin, MOA 6 (Agri-Mek) 0.7 SC	1.75 to 3.5 fl oz	12 hrs	7	On foliage as needed.
	fenpyroximate MOA 21 (Portal) 0.4EC	2 pt	12 hrs	3	Do not make more than two applications per season.
	spiromesifen, MOA 23 (Oberon) 2 SG	7 to 8.5 fl oz	12 hrs	7	Do not exceed 3 applications per season
	spirotetramat MOA 23 (Movento) 2SC	4 to 5 fl oz	12 hrs	1	
Thrips	dinotefuran, MOA 4A (Venom) 70 SG (Scorpion) 35SL	5 to 6 oz 9 to 10.5 fl oz	12 hrs	21	
	imidacloprid, MOA 4A (Admire Pro) 4.6 F	7 to 14 fl oz	12 hrs	21	See Aphids for application instructions. Treating transplants before setting in the field, followed by drip irrigation may suppress incidence of tomato spotted virus. Imidacloprid is ineffective against western flower thrips.
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 pt	48 hrs	3	
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 10 fl oz	4 hrs	1	Do not exceed 29 fluid ounces per acre per season. Control of thrips may be improved by adding a spray adjuvant. See label for instructions. This is an option for insecticide-resistant thrips.
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 4.8 oz	12 hrs	0	

TABLE 2-18. INSECT CONTROL FOR POTATO, IRISH

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	acetamiprid, MOA 4A (Assail) 30 SG	1.5 to 4 oz	12 hrs	7	Do not make more than 4 applications per season. Thorough cov- erage is important. Assail belongs to the same class of insecticides (neonicotinoid) as Admire Pro, Provado, Actara, and Platinum and Colorado potato beetle populations have the potential to become resistant to this class.
	clothianidin MOA 4A (Belay) 50 WDG	1.0 to 1.5 oz	12 hrs	7	Apply Belay 50 WDG as foliar spray when populations reach a threshold level. Do not apply more than 3 applications. Belay belongs to the same class of insecticides (neonicotinoid) as Admire Pro, Provado, Actara, and Platinum and Colorado potato beetle populations have the potential to become resistant to this class.
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 2.8 oz	12 hrs	7	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 12.0 fl oz	4 hrs	1	
	dimethoate 4 EC, MOA 1B	0.5 to 1 pt	48 hrs	0	Do not apply more than 2 pints total per year.
	imidacloprid, MOA 4A (Admire Pro) 4.6F	1.2 fl oz	12 hrs	7	To minimize selection for resistance in Colorado potato beetle, do not use acetamiprid, imidacloprid, or thiamethoxam for aphid control if either of these compounds was applied to the crop for control of Colorado potato beetle. See comments on insecticide rotation under Colorado potato beetle.
	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 oz	12 hrs	14	Allow at least 7 days between applications. Do not exceed a total of 5.5 ounces (0.17 lb a.i.) per acre per season.
	thiamethoxam, MOA 4A (Actara) 25 WDG	3 oz	12 hrs	14	To minimize selection for resistance in Colorado potato beetle, do not use imidacloprid or thiamethoxam for aphid control if either of these compounds was applied to the crop for control of Colorado potato beetle.

TABLE 2-18. INSECT CONTROL FOR POTATO, IRISH (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Colorado potato beetle	**Colorado potato beetle populations in most commercial potato-growing areas have developed resistance to many insecticides. As a result, insecticides that are effective in some areas, or were effective in the past, may no longer provide control in particular areas. Colorado potato beetle readily develops resistance to insecticides. The following practices help to reduce the risk of resistance developing:** **CROP ROTATION AND INSECTICIDE ROTATION** **(the use of insecticides representing different modes of action IRAC MoA class number in different years and against different generations of potato beetle within a year)) are essential if insecticide resistance is to be managed and the risks of control failures due to resistance minimized. If control failures or reduced levels of control are observed with a particular insecticide, do NOT make a second application of the same insecticide at the same or higher rate. If an additional insecticide application is necessary, a different insecticide representing a different IRAC MoA class number should be used. Because potato beetle adults will move between adjacent and nearby fields from one year to the next, It is important to maintain the same rotation schedule of insecticide MOA classes in adjacent fields are groups of nearby fields.** **SCOUT FIELDS: All insecticide applications to the potato crop, regardless of the target insect pest, have the potential to increase the resistance of the Colorado potato beetle to insecticides. Unnecessary insecticide applications should be avoided by scouting fields for insect pests and applying insecticides only when potentially damaging insect populations are present.** **SPOT TREATMENTS: Because overwintered potato beetles invade rotated fields from sources outside the field, potato beetle infestations in rotated fields occur first along field edges early in the season. Limiting insecticide applications to infested portions of the field will provide effective control and reduce costs. Growers are advised to keep accurate records on which insecticides have been applied to their potato crop for control of Colorado potato beetle and on how effective those insecticides were at controlling infestations. This will make choosing an insecticide and maintaining** insecticide rotations easier. Monitoring the insecticide resistance status of local populations will also make insecticide selection easier.				
	abamectin, MOA 6 (Agri-Mek) 0.7 SC	1.75 to 3.5 fl oz	12 hrs	14	Apply when adults and/or small larvae are present but before large larvae appear. Do not exceed two applications per season. Apply in at least 20 gallons water per acre.
	Acetamiprid, MOA 4A (Assail) 70 WP	0.6 to 1.7 oz	12 hrs	7	Apply when most of the egg masses have hatched and many small but few large larvae are present. An additional application should be used only if defoliation increases. Allow at least 7 days between foliar applications. To minimize selection for resistance, do not use foliar applications of any IRAC MOA class 4A insecticides if any IRAC MOA class 4A insecticides were applied to the crop as soil or seed piece treatments. See comments on insect rotation under Colorado potato beetle.
	chlorantraniliprole, MOA 28 (Coragen) 1.67	3.5 to 5 oz	4 hrs	14	Do not apply more than 15.4 ounces Coragen per acre per crop season. Coragen treated insects may take several days to die, but stop feeding almost immediately after treatment.
	clothianidin MOA 4A (Belay) 50 WDG	1.9 to 2.8 fl oz	12 hrs	7	Apply Belay 50 WDG as foliar spray Apply when adults and/or small larvae are present but before large larvae appear. Do not apply more than 3 applications. Belay belongs to the same class of insecticides (neonicotinoid) as Admire Pro, Provado, Actara, and Platinum and Colorado potato beetle populations have the potential to become resistant to this class.
	cyantraniliprole, MOA 28 (Verimark) 1.67SC	6.75 to 13.5 fl oz	4 hr	NA	Apply in-furrow at planting. Do not apply any other MOA Group 28 insecticide for Colorado potato beetle control following an at-plant application for cyantraniliprole. When applied at 10-13.5 fluid ounces per acre will provide control of European corn borer in most years, except possibly in very early planted potatoes.
	dinotefuran, MOA 4A (Venom) 70 SG	1 to 1.5 oz (foliar) 6.5 to 7.5 oz (soil)	12 hrs	7	Soil treatment for preplant, preemergence, or ground crack application only. To minimize selection for resistance, do not use foliar applications of any IRAC MOA class 4A insecticides if any IRAC MOA class 4A insecticides were applied to the crop as soil or seed piece treatments. See comments on insecticide rotation under Colorado potato beetle.
	imidacloprid **Seed Piece treatment**, MOA 4A (Genesis) 240 g/L	0.4 to 0.6 fl oz/ 100 lb of seed tubers			Resistance has been reported and may reduce efficacy or duration of control. To minimize selection for resistance, do not use foliar applications of any IRAC MoA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. See label for specific instructions. For early planted potatoes control may be marginal because of the prolonged time between application and Colorado potato beetle emergence. Limit use to locations where Colorado potato beetles were a problem in the same or adjacent fields during the previous year. Do not apply other IRAC MOA class 4A insecticides to a field if seed pieces were treated with Genesis. See product label for restrictions on rotational crops.
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6F (various) 2.0 F	0.74 fl oz/ 1,000 ft row	12 hrs	—	Resistance has been reported and may reduce efficacy or duration of control. See comments on insecticide rotation under Colorado potato beetle. Admire Pro applied in-furrow at planting time may provide sea-son-long control. However, for early planted potatoes control may be marginal due to the prolonged time between application and Colorado potato beetle emergence. Use only in potato fields that have a history of potato beetle infestations. If potatoes are rotated to a field adjacent to one planted in potato last year, a barrier treatment may be effective. Admire Pro may also be applied as a seed treatment. Check label for instructions regarding this use. Check label for restrictions on planting crops following Admire Pro treated potatoes. There have been reports of low levels of resistance to imidacloprid. To minimize selection for resistance, do not use foliar applications of any IRAC MoA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. See comments on insecticide rotation under Colorado potato beetle.

TABLE 2-18. INSECT CONTROL FOR POTATO, IRISH (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Colorado potato beetle (cont'd)	**Foliar treatment** (Admire Pro) 4.6 (various) 1.6 F	 1.3 fl oz 3.75 fl oz	12 hrs	7	Resistance has been reported and may reduce efficacy or duration of control. To minimize selection for resistance, do not use foliar applications of any IRAC MoA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. See comments on insecticide rotation under Colorado potato beetle. Apply when most of the egg masses have hatched and most larvae are small (1/8 to 3/16 in.). An additional application should be made only if defoliation increases. Allow at least 7 days between foliar applications. Do not exceed 5.6 fluid ounces of Admire Pro per field per acre per season. Regardless of formulation, do NOT apply more than a total of 0.31 pound imidacloprid per season. Foliar applications of imidacloprid should not be applied If soil application was used.
	imidacloprid + cyfluthrin premix, MOA 4A and 3 (Leverage) 2.7 SE	3 to 3.75 fl oz		7	There have been reports of low levels of resistance to imidacloprid. To minimize selection for resistance, do not use foliar applications of any IRAC MOA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. See comments on insecticide rotation under Colorado potato beetle. pply when most of the egg masses have hatched and most larvae are small (1/8 to 3/16 inch). An additional application should be made only if defoliation increases. Leverage will control European corn borer if application coincides with egg hatch and presence of small corn borer larvae. Leverage should not be used in fields treated with Admire Pro.
	novaluron, MOA 15 (Rimon) 0.83 EC	9 to 12 fl oz	12 hrs	14	
	spinosad, MOA 5 (Blackhawk) 36WG	1.7 to 3.3 oz		3	Apply when most egg masses have hatched and both small and large larvae are present. Thorough coverage is important. Do not apply more than a total of 0.33 pound a.i. (14.4 ounces of Blackhawk or 21 ounces of Radiant) per crop. Do not apply in consecutive generations of Colorado potato beetle and do not make more than two applications per single generation of Colorado potato beetle. Do not make successive applications less than 7 days apart. To minimize the potential for resistance, do NOT use spinosad or spinetoram if either product was applied to a potato crop in the field or an adjacent field within the last year.
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	7	See comments above under spinosad.
	thiamethoxam **seed piece treatment,** MOA 4A (Cruiser) 5 FS	0.11 to 0.16 fl oz/ 100 lb			See label for specific instructions. Resistance to neonicotinoid insecticides has been reported and may reduce efficacy or duration of control by thiamethoxam. To minimize selection for resistance, do not use foliar applications of any IRAC MoA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. See comments on insecticide rotation under Colorado potato beetle. For early planted potatoes control may be marginal because of the prolonged time between application and Colorado potato beetle emergence. Limit use to locations where Colorado potato beetles were a problem in the same or adjacent fields during the previous year.
	thiamethoxam, MOA 4A (Platinum) 75 SG	1.66 to 2.67 oz	12 hrs	7	Resistance to neonicotinoid insecticides has been reported and may reduce efficacy or duration of control by thiamethoxam. To minimize selection for resistance, do not use foliar applications of any IRAC MOA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. See comments on insecticide rotation under Colorado potato beetle. Platinum applied in-furrow at planting time may provide season-long control. For early planted potatoes control may be marginal because of the prolonged time between application and Colorado potato beetle emergence. Limit use to locations where Colorado potato beetles were a problem in the same or adjacent fields in the previous year. See product label for restrictions on rotational crops.
	(Actara) 25 WDG	3 oz	12 hrs	7	Resistance to neonicotinoid insecticides has been reported and may reduce efficacy or duration of control by thiamethoxam. To minimize selection for resistance, do not use foliar applications of any IRAC MOA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. See comments on insecticide rotation under Colorado potato beetle. Actara is applied as foliar spray. Apply when most of the eggs have hatched and most of the larvae are small (1/8 to 3/16 inch). An additional application should be made only if defoliation increases. Allow at least 7 days between applications. Do not make more than 2 applications of Actara per crop per season.

TABLE 2-18. INSECT CONTROL FOR POTATO, IRISH (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Colorado potato beetle (cont'd)	thiamethoxam, MOA 4A + chlorantraniliprole, MOA 28 Premix (Voliam Flex)	4 oz		14	Resistance to neonicotinoid insecticides has been reported and may reduce efficacy or duration of control by thiamethoxam. To minimize selection for resistance, do not use foliar applications of any IRAC MOA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. See comments on insecticide rotation under Colorado potato beetle. Voliam Flexi is applied as a foliar spray. Apply when most of the eggs have hatched and most of the larvae are small (1/8 to 3/16 inch.). An additional application should be made only if defoliation increases. Allow at least 7 days between applications. To minimize selection for resistance, do not use foliar applications of any IRAC MOA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. Do not exceed 8 ounces of Voliam Flexi. See label for rotational restrictions. Volam Flexi can be expected to provide control of European corn borer if application is timed correctly (see European corn borer for correct timing.
European corn borer	**The Atlantic variety of potato is very tolerant of injury by European corn borer larvae. Consequently, control is not recommended on Atlantic unless more than 30 percent of the stems are infested. Control on all other varieties is recommended when infestations reach 20 percent infested stems. Application timing is critical. Scout for eggs and treat when eggs hatch or at the first sign of larvae entering petioles. Several days of cool wet weather will kill larvae and may eliminate the need for insecticide applications. If this occurs, flag additional egg masses and apply insecticide at hatch.**				
	pyrethroid, MOA 3		12 hrs		Apply when threshold is reached (usually during the first half of May). A second application may be needed if the percentage of infested stems increases substantially 7 to 10 days after the first application. Ground applications are usually more effective than aerial applications. See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	chlorantraniliprole, MOA 28 (Coragen) 1.67	3.5 to 5 oz	4 hrs	14	Do not apply more than 15.4 ounces Coragen per acre per crop season.
	thiamethoxam, MOA 4A + chlorantraniliprole, MOA 28 premix (Voliam Flexi)	4 oz	12 hrs	14	Voliam Flexi is applied as a foliar spray. Apply when most of the eggs have hatched and most of the larvae are small (1/8 to 3/16 inch.). An additional application should be made only if defoliation increases. Allow at least 7 days between applications. To minimize selection for resistance, do not use foliar applications of any IRAC MOA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. Do not exceed 8 ounces of Voliam Flexi. See label for rotational restrictions Voliam Flexi can be expected to provide control of Colorado potato beetle if application is timed correctly (see Colorado potato beetle section for correct timing). If imidacloprid or thiamethoxam resistant Colorado potato beetles occur in the field, application of Volium Flexi should to control European corn borer has the potential to further increase resistance levels.
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	7	Do not apply more than a total of 0.25 pound a.i. (32 fl oz) per crop.
Flea beetle	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 (various) 1.6 F	0.74 fl oz/ 1,000 ft row	12 hrs	—	If imidacloprid or thiamethoxam resistant Colorado potato beetles occur in the field, application of imidacloprid to control flea beetles has the potential to further increase resistance levels. Iimidacloprid applied in-furrow at planting time may provide season-long control of flea beetles. However, for early planted potatoes control may be marginal due to the prolonged time between application and crop emergence. Check label for restrictions on planting crops following Admire Pro treated potatoes.
	Foliar treatment (Admire Pro) 4.6 (various) 1.6 F	1.3 fl oz 3.75 fl oz	12 hrs	7	See comments for imidacloprid resistance in Colorado potato beetle
	thiamethoxam **seed piece treatment**, MOA 4A (Cruiser) 5 FS	0.11 to 0.16 fl oz/100 lb	12 hrs		See label for specific instructions. For early planted potatoes control may be marginal because of the prolonged time between application and flea beetle emergence. Limit use to locations where Colorado potato beetles were a problem in the same or adjacent fields during the previous year. To minimize selection for resistance, do not use foliar applications of any IRAC MOA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. See comments on insecticide rotation under Colorado potato beetle.
	thiamethoxam, MOA 4A (Platinum) 2 SC	5 to 8 fl oz	12 hrs	7	Platinum applied in-furrow at planting time may provide season-long control. However, for early planted potatoes control may be marginal due to the prolonged time between application and crop emergence. Limit use to locations where Colorado potato beetles were not a problem in the same or adjacent fields during the previous year. See product label for restrictions on rotational crops. See comments for imidacloprid resistance in Colorado potato beetle.

TABLE 2-18. INSECT CONTROL FOR POTATO, IRISH (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Flea beetle (cont'd)	(Actara) 25 WDG	3 oz	12 hrs	7	Actara is applied as foliar spray. See comments for imidacloprid resistance in Colorado potato beetle. If imidacloprid or thiamethoxam resistant Colorado potato beetles occur in the field, application of Volium Flexi should to control flea beetle has the potential to further increase resistance levels. See comments for imidacloprid resistance in Colorado potato beetle.
	thiamethoxam, MOA 4A chlorantraniliprole MOA 28 (Voliam Flexi)	4 fl oz		14	Do not exceed a total of 8.0 fluid ounces per acre Voliam Flexi or 0.094 lb a.i/ acre of thiamethoxam-containing products or 0.2 pound a.i/acre of chlorantraniliprole-containing products per growing season.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Leafhopper	carbaryl, MOA 1A (Sevin) 50 WP (Sevin) 80 S (Sevin) XLR Plus	1 to 2 lb 0.625 to 1.25 lb 1 pt	12 hrs	7	On foliage when leafhoppers first appear. Repeat every 10 days as needed. Often a problem in the mountains.
	dimethoate, MOA 1B (various formulations)				Check label for rate, PHI and REI.
	imidacloprid + cyfluthrin premix, MOA 4A and 3 (Leverage) 2.7 SE (Leverage) 360	3 to 3.80 fl oz 2.8 fl oz	7	7	There have been reports of low levels of resistance to imidacloprid. To minimize selection for resistance, do not use foliar applications of any IRAC MOA class 4A insecticides if any of these compounds were applied to the crop as soil or seed piece treatments. See comments on insecticide rotation under Colorado potato beetle. Apply when most of the egg masses have hatched and most larvae are small (1/8 to 3/16 inch). An additional application should be made only if defoliation increases. Leverage should not be used in fields treated with Admire Pro.
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 pt	48 hrs	6	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Leafminer	dimethoate, MOA 1B (various formulations)				Check label for rate, PHI and REI.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	14	
Blister beetle, Leaffooted bug, Plant bug, Stink bug, Vegetable weevil	carbaryl, MOA 1A (Sevin) 50 WP	2 to 4 lb	12 hrs	7	On foliage as needed.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Potato tuberworm	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	14	Do not exceed 4 applications per acre per crop. Do not apply more than 15.4 ounces Coragen per acre per crop season. Minimum interval between applications is 5 days.
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 pt	48 hrs	6	Prevent late-season injury by keeping potatoes covered with soil. To prevent damage in storage, practice sanitation.
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Thrips	dimethoate 4 EC, MOA 1B	0.5 pt	48 hrs	0	
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	7	
	spinosad, MOA 5 (Blackhawk) 36WG	2.25 to 3.5 oz	4 hrs	3	Control may be improved by addition of an adjuvant to the spray mixture.
Wireworm	**Planting in fields previously in corn, soybean, or fallow may increase risk of wireworm.**				
	bifenthrin, MOA 3 (Capture LFR)	25.5 fl oz			In furrow at planting.
	Clothianidin (Belay) 50 WDG	6 oz	12 hrs		In-furrow at planting.
	ethoprop, MOA 1B (Mocap) 15 G	1.4 lb per 1,000 row ft	48 hrs	90	In-furrow at planting.
	fipronil, MOA 2B (Regent) 4 SC	3.2 fl oz	0 hrs	90	In-furrow at planting. Do NOT use T-banding over the top of a closed furrow.
	phorate, MOA 1B (Thimet) 20 G	Row Treatment: 10 to 20 oz (38 in. row spacing)	12 hrs	90	Can contribute to insecticide-resistance problems with Colorado potato beetle

TABLE 2-19. INSECT CONTROL FOR RADISH

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid, Flea beetle, leafminer	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 10.5 fl oz	4 hrs	7	Will not control flea beetles or leafminer.
	imidacloprid, MOA 4A **Foliar treatment:** (Admire Pro) 4.6 F (various) 1.6 F	 1.2 fl oz 3.5 fl oz	12 hrs	 7	Will not control leafminer.
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 2.8 oz	12 hrs	0	
	thiamethoxam, MOA 4A (Platinum) 75SG (Actara) 25WDG	 1.7 to 2.17 oz 1.5 to 3 oz	12 hrs	 30 7	See label for soil application instructions.
Root maggot	chlorpyrifos, MOA 1B (Lorsban) 4E	1 fl oz/1,000 linear ft	24 hrs	—	Water-based drench in-furrow planting. Use a minimum of 40 gal of water per acre.
Wireworm	diazinon, MOA 1B (AG 500) 50 WP	 2 to 4 qt 4 to 8 lb	3 days		Broadcast just before planting and immediately incorporate into the upper 4 to 8 inches of soil.

TABLE 2-20. INSECT CONTROL FOR SPINACH (cont d)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid	acetamiprid, MOA 4A (Assail) 30SG	2 to 4 oz	12 hrs	7	Do not apply more than once every 7 days, and do not exceed 5 applications per season.
	clothianidin, MOA 4A (Belay) 50 WDG	4.8 to 6.0 oz (soil) 1.6 to 2.1 fl oz (foliar)	12 hrs	7	Soil application at planting only.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	6.75 to 10 fl oz	4 hrs	1	Soil applications made at planting only. See label for application options.
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 2.8	12 hrs	0	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	10.5 to 12.0 fl oz	4 hrs	1	
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	 4.4 to 10.5 fl oz 10 to 24 fl oz	12 hrs	 21	Do not follow soil applications with foliar applications of any neonicotinoid insecticides. See label for soil application instructions.
	Foliar treatment (Admire Pro) 4.6 F (various) 1.6 F	 1.2 fl oz 3.8 fl oz	12 hrs	 7	
	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 oz	12 hrs	7	Apply before aphids reach damaging levels. Use sufficient water to ensure good coverage.
	spirotetramat, MOA 23 (Movento) 2SC	4 to 5 fl oz	24 hrs	3	Do not exceed 10 fluid ounces per season. Requires surfactant.
	thiamethoxam, MOA 4A **Soil treatment** (Platinum) 75SG	 1.7 to 2.17 oz	 12 hrs	 30	See label for soil application instructions.
	Foliar treatment (Actara) 25WDG	 1.5 to 3 oz	 12 hr	 7	
	tolfenpyrad, MOA 21A (Torac) 1.29 EC	17 to 21 fl oz	12 hrs	1	
Leafminer	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	5 to 7.5 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	cyromazine, MOA 17 (Trigard) 75 WP	2.66 oz	12 hrs	7	
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 10 fl oz	4 hrs	1	Spray adjuvants may enhance efficacy against leafminers. See label for information on adjuvants.

TABLE 2-20. INSECT CONTROL FOR SPINACH (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Armyworms, Beet webworm, Corn earworm, Cutworm, Looper	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	3	
	indoxacarb, MOA 22 (Avaunt) 30 SG	2.5 to 3.5 oz	12 hrs	3	
	methomyl, MOA 1A (Lannate) 90 SP (Lannate) 2.4 LV	 0.5 lb 1.5 pt	48 hrs	7	Air temperature should be well above 32 degrees F. Do not apply to seedlings less than 3 in. in diameter.
	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 10 fl oz	4 hrs	1	Use low rates for early-season applications to young or small plants and 6 to 10 oz for mid- to late-season applications.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.

TABLE 2-21. INSECT CONTROL FOR SWEETPOTATO

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphids, Leafhopper, Whitefly	**Aphids, leafhoppers, and whiteflies are rarely a problem.**				
	clothianidin, MOA 4A (Belay) 2.13 SC	9 to 12 oz (soil)	12 hrs	21	Soil application as an in-furrow or sidedress application. For sidedress applications, immediately cover with soil.
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 2.8 oz	12 hrs	7	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 14.0 fl oz	4 hrs	1	For aphids and leafhopper use 7.0 to 10.5 fluid ounces, for whitefly use 10.5 to 14.0 fluid ounces.
	imidacloprid, MOA 4A (Admire Pro) 4.6 F (various) 1.6 F	 1.2 fl oz 3.5 fl oz	12 hrs	7	Two applications may be needed to control heavy populations. Allow 5 to 7 days between applications.
	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 to 5.5 oz	12 hrs	14	
	thiamethoxam, MOA 4A (Actara) 25 WDG	 3 oz		14	Two applications of Actara may be needed to control heavy populations. Allow 7 to 10 days between applications. Do not exceed a total of 6 ounces of Actara per crop per season
Armyworms, Looper, Corn earworm, Hornworm	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	Foliar application only on sweetpotato.
	novaluron, MOA 15 (Rimon) 0.83 EC	9 to 12 fl oz	12 hrs	14	Do not make more than 2 applications per crop per season.
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	7	
	spinosad MOA 5 (Blackhawk)	1.7 to 3.5 oz	4 hrs	3	
Cucumber beetle (adults), Japanese beetle (adults), Tortoise beetle	**Cucumber beetle larvae (diabrotica) are a serious pest of sweetpotato in LA and MS. Controlling adult cucumber beetles in areas with a history of diabrotica damage can reduce damage to roots. Foliage feeding by beetles rarely causes economic loss, and control is not warranted unless defoliation is severe.**				
	carbaryl, MOA 1A (Sevin) 50 WP (Sevin) 80 S, WSB (Sevin) XLR Plus	 4 lb 2.5 lb 2 qt	12 hrs	7	Treat for tortoise beetles only if significant defoliation is observed. Tortoise beetles are frequently present but rarely reach levels requiring treatment.
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	7	
	bifenthrin, MOA 3 (various) 2 EC	9.6 to 19.2 fl oz	12 hrs	21	
	chlorpyrifos, MOA 1B (Lorsban) 15 G (Lorsban) 4 E (Lorsban Advanced)	 13.5 lb 4 pt 4 pt	24 hrs	125 (60 in NC for Lorsban Advanced only)	
	clothianidin MOA 4A (Belay) 2.13 SL	 12 fl oz	12 hrs		
	imidacloprid (Admire Pro) 4.6SC	10.5 fl oz or 0.75 fl oz per 1,000 ft	3 days	60 days (NC Only) 125 days elsewhere	

TABLE 2-21. INSECT CONTROL FOR SWEETPOTATO (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Flea beetle, Wireworm, White grub	bifenthrin, MOA 3 (various) 2 EC	9.6 to 19.2 fl oz	12 hrs	21	Apply as broadcast, preplant application to the soil and incorporate 4 to 6 inches prior to bed formation. This use has been demonstrated to control overwintered wireworm populations and reduce damage to roots at harvest. Chlorpyrifos will not control whitefringed beetle or other grubs that attack sweetpotato.
	chlorpyrifos, MOA 1B (Lorsban) 15 G (Lorsban) 4 E (Lorsban Advanced)	 13.5 lb 4 pt 4 pt	24 hrs	125 (60 in NC for Lorsban Advanced only)	Research has shown that best control is achieved when chlorpyrifos is applied as a preplant application incorporated 4 to 6 inches deep prior to bed formation, followed by 1 or more soil-directed, incorporations of bifenthrin during routine cultivation.
	chlothianidin MOA 4A (Belay) 2.13 SL	12 fl oz	12 hrs		Bifenthrin should be directed onto each side of the bed from the drill to the middle of the furrow and incorporated with cultivating equipment set to throw soil toward the drill. The objective is to provide a barrier of treated soil that covers the bed and furrows.
	imidacloprid (Admire Pro) 4.6SC	10.5 fl oz or 0.75 fl oz per 1,000 ft	3 days	60 days (NC Only) 125 days elsewhere	Foliar sprays of various insecticides that target adults to prevent egg laying have not been shown to provide any reduction in damage to roots by wireworm larvae at harvest.
Fruit fly (vinegar fly)	pyrethroid, MOA 3 (Pyrenone)	1 gal.100,00 cu ft	12 hrs	—	Postharvest application in storage. Apply as a space fog with a mechanical or thermal generator. Do not make more than 10 applications.
Sweetpotato weevil	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Thrips	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	7	
Whitefringed beetle	phosmet, MOA 1B (Imidan) 70 W	1.33 lb	5 days	7	Do not make more than five applications per season. Whitefringed beetle adults are active in July and August. Do not plant in fields with a recent history of whitefringed beetles.

TABLE 2-22. INSECT CONTROL FOR TOMATO

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid, Flea beetle	acetamiprid, MOA 4A (Assail) 30 SG	2 to 4 oz	12 hrs	7	Do not apply more than once every 7 days, and do not exceed 5 applications per season.
	clothianidin, MOA 4A (Belay) 50 WDG	4.8 to 6.4 oz (soil) 1.6 to 2.1 oz (foliar)	12 hrs	7	Soil applications at planting only
	cyantraniliprole, MOA 28 (Verimark) 1.67SC	6.75 to 13.5 fl oz	4	1	Soil applications at planting will control aphids and flea beetles. See label for application options.
	dimethoate 4 EC, MOA 1B	0.5 to 1 pt	48 hrs	7	Do not exceed rate with dimethoate as leaf injury may result.
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 4.8 oz	12 hrs	0	Will not control flea beetle.
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 10.5 fl oz	4 hrs	1	Will not control flea beetle.
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6F (various) 2F	 7 to 10.5 fl oz 16 to 24 fl oz	12 hrs	21	For short-term protection at planting, apply Admire Pro transplants in the planthouse not more than 7 days before planting at the rate of 0.44 (4.6 F formulation) or 1 ounce (2 F formulation) per 10,000 plants. See label for instructions of greenhouse transplant and field soil applications.
	Foliar treatment (Admire Pro) 4.6F (various) 2F	 1.2 fl oz 3.75 fl oz	12 hrs	0	
	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 oz	12 hrs	0	For aphids only.
	sulfoxaflur MOA 4C (Closer) 2 SC	1.5 to 2 fl oz	12 hrs	1	
	thiamethoxam, MOA 4A (Platinum) 75 SG (Actara) 25 WDG	 1.66 to 3.67 oz 2 to 3 oz	 12 hrs 12 hrs	30 0	Platinum may be applied to direct-seeded crops in-furrow seeding or transplant depth, post seeding or transplant as a drench, or through drip irrigation. Do not exceed 11 ounces per acre per season of Platinum. Check label for plant-back restrictions for a number of crops.

TABLE 2-22. INSECT CONTROL FOR TOMATO (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Armyworms	*Bacillus thuringiensis,* MOA 11A		4 hrs	0	Start applications when larvae are small, and continue at 5- to 7-day intervals during periods of infestation.
	(Crymax) WDG	0.5 to 1.5 lb			
	(Dipel) 2X	0.5 to 1 lb			
	(Xentari)	0.5 to 1 lb			
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 4 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	emamectin benzoate, MOA 6 (Proclaim) 5 WDG	2.4 to 4.8 oz	12 hrs	7	Apply when larvae are first observed.
	indoxacarb, MOA 22 (Avaunt) 30 DG	3.5 oz	12 hrs	3	Do not apply more than 14 ounces of Avaunt (0.26 a.i.) per acre per crop. The minimum interval between sprays is 5 days.
	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 10 fl oz	4 hrs	1	Use low rates for early-season applications to young or small plants and 6 to 10 ounces for mid- and late-season applications.
	novaluron, MOA 15 (Rimon) 0.83 EC	9 to 12 fl oz	12 hrs	1	Do not make more than 3 applications per season.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	
Colorado potato beetle	acetamiprid, MOA 4A (Assail) 30 SG	1.5 to 2.5 oz	12 hrs	7	
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uniformly to the root zone. See label for instructions.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	5 to 10 fl oz	4 hrs	1	Apply Verimark to soil via drip irrigation or soil injection.
	(Exirel) 0.83SE	7 to 13.5 fl oz	12 hrs	1	Exirel is for foliar application.
	imidacloprid, MOA 4A		12 hrs		See application instructions above under aphid/flea beetle.
	Soil treatment				
	(Admire Pro) 4.6 F	7 fl oz		21	
	(various) 2 F	16 fl oz			
	Foliar treatment		12 hrs		
	(Admire Pro) 4.6 F	1.3 to 2.2 fl oz		0	
	(various) 2 F	3.75 fl oz			
	spinetoram, MOA 5 (Radiant)1SC	5 to 10 fl oz	4 hrs	1	
	thiamethoxam, MOA 4A (Platinum) 75 SG	1.66 to 3.67 oz	12 hrs	30	Platinum may be applied to direct-seeded crops in-furrow seeding or transplant depth, post seeding or transplant as a drench, or through drip irrigation. Do not exceed 11 oz per acre per season of Platinum. Check label for plant-back restrictions for a number of crops.
	(Actara) 25 WDG	2 to 3 oz	12 hrs	0	Actara is for foliar applications.
Cabbage looper, Hornworm, Tomato fruitworm, Pinworm	*Bacillus thuringiensis,* MOA 11A		4 hrs	0	
	(Dipel) DF, MOA	0.5 to 1 lb			
	(Crymax) WDG	0.5 to 1.5 lb			
	pyrethroid, MOA 3				See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	3.5 to 5 fl oz	4 hrs	1	Foliar or drip chemigation. Drip chemigation must be applied uni- formly to the root zone. See label for instructions.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	5 to 10 fl oz	4 hrs	1	Verimark is for soil application only. Applications made at planting and/or via drip chemigation after planting. See label for applica-tion options.
	(Exirel) 0.83SE	7 to 13.5 fl oz	12 hrs	1	Exirel is for foliar application only.
	emamectin benzoate, MOA 6 (Proclaim) 5 WDG	2.4 to 4.8 oz	12 hrs	7	
	indoxacarb, MOA 22 (Avaunt) 30 WDG	2.5 to 3.5 oz	12 hrs	3	Do not apply more than 14 ounces of Avaunt (0.26 pound a.i.) per acre per crop. The minimum interval between sprays is 5 days.
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 to 3 pt	48 hrs	1	Methomyl may induce leafminer infestation.
	methoxyfenozide, MOA 18 (Intrepid) 2 F	4 to 10 fl oz	4 hrs	1	Use low rates for early-season applications to young or small plants and 6 to 10 ounces for mid- and late-season applications. Intrepid provides suppression of pinworm only.
	novaluron, MOA 15 (Rimon) 0.83 EC	9 to12 fl oz	12 hrs	1	Do not make more than 3 applications per season.
	spinetoram, MOA 5 (Radiant) 1 SC	5 to 10 fl oz	4 hrs	1	

TABLE 2-22. INSECT CONTROL FOR TOMATO (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Cutworm	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Leafminer	abamectin, MOA 6 (Agri-Mek) 0.7 SC	1.75 to 3.5 fl oz	12 hrs	7	Do not exceed 48 fluid ounces per acre per season, or more than two sequential applications.
	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	5 to 7.5 fl oz	4 hrs	1	Foliar or soil chemigation. Drip chemigation must be applied uniformly to the root zone. See label for soil application instructions.
	cyromazine, MOA 17 (Trigard) 75 WP	2.66 oz	12 hrs	0	See label for plant-back restrictions.
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 8 fl oz	4 hrs	1	Do not exceed 29 fl oz per acre per season.
Spider mite	abamectin, MOA 6 (Agri-Mek) 0.7 SC	1.75 to 3.5 fl oz	12 hrs	7	Do not exceed 48 fluid ounces per acre per season, or more than two sequential applications.
	acequinocyl, MOA 20B (Kanemite) 15SC	31 fl oz	12 hrs	1	The use of a surfactant/adjuvant with Kanemite on tomatoes is prohibited.
	bifenazate, MOA 20D (Acramite) 50 WS	0.75 to 1.0 lb	12 hrs	3	Do not make more than one application per season.
	cyflumetofen, MOA 25 (Nealta) 1.67 SC	13.7 fl oz	12 hrs	3	Do not make more than one application before using an effective miticide with a different mode of action.
	fenpyroximate MOA 21 (Portal) 0.4EC	2 pts	12 hrs	3	Do not make more than two applications per season.
	spiromesifen, MOA 23 (Oberon) 2 SG	7 to 8.5 fl oz	12 hrs	7	Do not exceed 3 applications per season.
Stink bug	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
	dinotefuran, MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL	1 to 4 oz 2 to 7 oz	12 hrs	1	Soil applications of Venom or Scorpion may be made in a narrow band under the plant row as a post-transplant drench, as a soil incorporated sidedress after plants are established, or in drip irrigation water. See label for instructions.
	Soil treatment (Venom) 70 SG (Scorpion) 35SL	5 to 6 fl oz 9 to 10.5 fl oz		21	
	thiamethoxam, MOA 4A (Actara) 25 WDG	3 to 5.5 oz	12 hrs	0	Do not exceed 11 ounces Actara per acre per season.
Thrips	dimethoate 4 EC, MOA 1B	0.5 to 1 pt	48 hrs	7	
	dinotefuran MOA 4A **Foliar treatment** (Venom) 70 SG (Scorpion) 35SL	1 to 4 oz 2 to 7 fl oz	12 hrs	1	Dinotefuran will not control western flower thrips, nor will soil applications control flower infestations of thrips.
	Soil treatment (Venom) 70 SG (Scorpion) 35SL	5 to 6 oz 9 to 10.5 fl oz		21	
	flonicamid MOA 9C (Beleaf) 50SG	2.4 to 4.8 fl oz	12	0	Beleaf has shown good activity against insecticide resistant western flower thrips.
	imidacloprid (Admire Pro) 4.6 SC Planthouse treatment of transplants	0.44 fl oz per 10,000 plants	12 hrs	—	For suppression of TSWV, treatment transplants in the planthouse not more than 7 days before planting in the field. Transplants should be treated with overhead irrigation immediately after planting to ensure movement of imidacloprid into the soil media. See label for instructions.
	methomyl, MOA 1A (Lannate) 2.4 LV	1.5 to 3 pt	48 hrs	1	On foliage as needed.
	novaluron, MOA 15 (Rimon) 0.83 EC	9 to12 fl oz	12 hrs	1	Do not make more than 3 applications per season.
	spinetoram, MOA 5 (Radiant) 1 SC	6 to 10 fl oz	4 hrs	1	Will control thrips on foliage, not in flowers.
Whitefly	**For resistance management of whiteflies, do not follow a soil application of a neonicotinoid (MOA group 4A) with a foliar application of any neonicotinoid.**				
	acetamiprid, MOA 4A (Assail) 30 SG	2.5 to 4 oz	12 hrs	7	Do not apply more than once every 7 days, and do not exceed 5 applications per season.
	buprofezin, MOA 16 (Courier) 40 SC	9 to 13.6 fl oz	12 hrs	1	Use sufficient water to ensure good coverage. Do not apply more than twice per crop cycle, and allow 28 days between applications.

TABLE 2-22. INSECT CONTROL FOR TOMATO (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Whitefly (cont'd)	chlorantraniliprole, MOA 28 (Coragen) 1.67 SC	5 to 7.5 fl oz	4 hrs	1	Foliar or soil application. Drip chemigation must be applied uniform- ly to the root zone. See label for soil application instructions.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	6.75 to 13.5 fl oz	4 hrs	1	Apply Verimark to at planting and/or later via drip irrigation or soil injection. See label for application options.
	(Exirel) 0.83SE	13.5 to 20.5 fl oz	12 hrs	1	Exirel is for foliar application.
	dinotefuran MOA 4A **Soil treatment** (Venom) 70 SG (Scorpion) 35 SL	 5 to 6 oz 9 to 10.5 fl oz	12 hrs	 21	See soil application instructions above under stink bug.
	Foliar treatment (Venom) 70 SG (Scorpion) 35 SL	 1 to 4 oz 2 to 7 fl oz		1	
	imidacloprid, MOA 4A (Admire Pro) 4.6 F (various) 2 F	 16 to 24 fl oz 7 to 10.5 fl oz	12 hrs	21	Apply through a drip irrigation system or as a transplant drench with sufficient water to reach root zone. As a sidedress, apply 2 to 4inches to the side of the row and incorporate 1 inch or more. Residual activity will increase with increased rates. Use higher rate for late-season or continuous infestations. Trickle irrigation applications will also control aphids and suppress stinkbugs.
	pyriproxyfen, MOA 7C (Knack) 0.86EC	8 to 10 fl oz	12 hrs	1	Do not apply more than two applications per growing season, and do not make applications closer than 14 days.
	spiromesifen, MOA 23 (Oberon) 2 SC	7 to 8.5 fl oz	12 hrs	7	Do not make more than 3 applications per season.
	spirotetramat, MOA 23 (Movento) 2SC	4 to 5 fl oz	24 hrs	1	Do not exceed 10 fluid ounces per season. Requires surfactant.
	thiamethoxam, MOA 4A (Platinum) 75 SG	 1.66 to 3.67 oz	12 hrs	30	Platinum may be applied to direct-seeded crops in-furrow at seeding or transplanting, post seeding or transplant as a drench, or through drip irrigation. Do not exceed 11 oz per acre per season of Platinum. Check label for plant-back restrictions for a number of crops.
	(Actara) 25 WDG	3 to 5.5 oz	12 hrs	0	Actara is for foliar applications.
Wireworm	diazinon, MOA 1B (Diazinon) AG 500 or 50 WP	2 to 4 qt	48 hrs	—	Broadcast before planting and incorporate. Wireworms may be a problem in fields previously in pasture, corn, or soybean.

TABLE 2-23. INSECT CONTROL FOR TURNIP

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Aphid, Flea beetle	clothianidin, MOA 4A (Belay) 50 WDG	4.8 to 6.4 oz (soil) 1.6 to 2.1 oz (foliar)	12 hrs	7 (foliar)	Soil application as in in-furrow, side dress application, seed or transplant drench, or chemigation. See label for application instructions.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	6.75 to 13.5 fl oz	4 hrs	4	Soil applications made at planting only. See label for application options.
	dimethoate 4 EC, MOA 1B	0.5 pt	48 hrs	14	
	flonicamid, MOA 20D (Beleaf) 50 SG	2 to 2.8 oz	12 hrs	0	
	flupyradifurone, MOA 4D (Sivanto) 200 SL	7.0 to 10.5 fl oz	4 hrs	7	Will not control flea beetle
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6 F (various) 2 F	 4.4 to 10.5 fl oz 10 to 24 fl oz	12 hrs	 21	See label for soil application instructions.
	Foliar treatment (Admire Pro) 4.6 F (various) 2 F	 1.2 fl oz 3.8 fl oz	12 hrs	7	
	pymetrozine, MOA 9B (Fulfill) 50 WDG	2.75 oz	12 hrs	7	Will not control flea beetle.
	thiamethoxam, MOA 4A (Platinum) 75 SG	 1.7 to 4.01 oz	12 hrs	Apply at planting	Platinum is for soil application and Actara for foliar application.
	(Actara) 25 WDG	1.5 to 3 oz	12 hrs	7	

TABLE 2-23. INSECT CONTROL FOR TURNIP (cont'd)

Insect	Insecticide, Mode of Action Code, and Formulation	Amount of Formulation Per Acre	Restricted Entry Interval (REI)	Pre harvest Interval (PHI) (Days)	Precautions and Remarks
Harlequin bug, Vegetable weevil, Yellow margined leaf beetle	clothianidin, MOA 4A (Belay) 50 WDG	4.8 to 6.4 oz (soil) 1.6 to 2.1 oz (foliar)	12 hrs	7 (foliar)	Soil application as in in-furrow, side dress application, seed or trans plant drench, or chemigation. See label for application instructions.
	dinotefuran MOA 4A (Venom) 70 SG	2 to 3 oz	12 hrs	1	For use on turnip greens only, not turnips roots.
	imidacloprid, MOA 4A **Soil treatment** (Admire Pro) 4.6F (Various) 2F	4.4 to 10.5 fl oz 10 to 24 fl oz	12 hrs	21	Soil applications of imidacloprid will not control harlequin bug past 20 days after application.
	Foliar treatment (Admire Pro) 4.6F (Various) 2F	1.2 fl oz 2.4 fl oz		7	
	thiamethoxam, MOA 4A (Platinum) 75 SG	1.7 to 4.01 oz	12 hrs	Apply at plant	Platinum is for soil application and Actara for foliar application.
	(Actara) 25 WDG	1.5 to 3 oz		7	
	pyrethroid, MOA 3		12 hrs		See **Table 2-25** for a list of registered pyrethroids and pre-harvest intervals.
Cabbage looper, Diamondback moth	**Insecticide-resistant populations, widespread in the Southeast, may not be controlled with some registered insecticides. To manage resistance, avoid transplants from Georgia and Florida, and avoid the repeated use of the same materials for extended periods of time. Repeated use of pyrethroid insecticides often aggravates diamondback moth problems. Do not allow populations to increase to large densities before treatments are initiated.**				
	Bacillus thuringiensis, MOA 11A (Crymax) WDG (Dipel) 2 X (Dipel) 4 L (Xentari) WDG	0.5 to 1.5 lb 8 oz 1 to 2 pt 0.5 to 1 lb	4 hrs	0	On foliage every 7 days as needed.
	chlorantraniliprole, MOA 28 (Coragen)	3.5 to 5.0 fl oz	4 hrs	1	For turnip greens or root turnips.
	cyantraniliprole, MOA 28 (Verimark) 1.67 SC	5 to 10 fl oz	4 hrs	1	Verimark and Exirel are for greens only, not root turnips Verimark is for soil application only. Applications made at planting and/or later via drip chemigation. See label for application options. Exirel is for foliar application only.
	(Exirel) 0.83SE	7 to 13.5 fl oz	12 hrs	1	
	emamectin benzoate, MOA 6 (Proclaim) 5 WDG	2.4 to 4.8 oz	12 hrs	14	For turnip greens only.
	indoxacarb, MOA 22 (Avaunt) 30 WDG	2.5 to 3.5 oz	12 hrs	3	Avaunt may be applied only to turnip greens, not root turnips.
	spinetoram, MOA 5 (Radiant) 1 SC	3 to 6 fl oz	4 hrs	1	
Root maggot	chlorpyrifos, MOA 1B (Lorsban) 4 E (Lorsban) 75 WDG	1 to 2 pt 1.1 to 1.8 oz/ 1,000 ft row	24 hrs	21	Irrigation or rainfall after application will enhance activity.

TABLE 2-24. RELATIVE EFFECTIVENESS OF INSECTICIDES AND MITICIDES FOR INSECT AND MITE CONTROL ON FIELD-GROWN VEGETABLES.

Not all insecticides listed below are registered on all vegetable crops. Refer to the label before applying to a specific crop. Ratings are based on a consensus of vegetable entomologists in the southeastern United States.

Key: "E" very effective; "G" effective; "F" somewhat effective; "-" ineffective or insufficient data

Chemical class (IRAC)	Common name	Example Product	Flea Beetle	Colorado potato beetle*	Cucumber beetles	Corn earworm*	European corn borer	Fall armyworm	Cabbage looper	Imported cabbageworm	Diamondback moth*	Squash vine borer	Beet armyworm*	Stinkbugs/Harlequin bug	Squash bug	Aphids*	Thrips	Western Flower Thrips*	Leafminer	Maggots	Whiteflies*	Cutworms	Wireworms	White grubs	Spider mites*
1A	carbaryl	Sevin	E	F	G	F	G	F	F	G	F	F	–	–	–	–	F	–	–	–	–	F	–	–	–
	methomyl	Lannate	F	–	–	G	G	G	G	G	G	–	F	G	G	F	E	G	F	–	F	–	–	–	–
	oxamyl	Vydate	F	F	F	–	–	–	–	–	–	–	–	F	F	G	G	–	–	–	F	–	–	–	–
1B	malathion	Malathion	G	F	G	F	F	F	F	G	F	F	-	F	F	F	F	–	-	F	–	F	–	–	–
	chlorpyrifos	Lorsban	–	–	-	F	F	F	F	G	F	–	–	–	-	-	F	–	-	E	–	G	G	G	-
	acephate	Orthene	–	–	-	F	E	G	F	G	–	–	–	–	-	G	G	–	F	-	F	G	–	–	-
	diazinon	Diazinon	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	-	G	–	F	G	F	-
	dimethoate	Dimethoate	G	–	F	–	–	–	–	–	–	-	-	G	F	E	E	F	G	–	–	-	–	–	–
3	permethrin	Pounce	G	F	G	G	G	F	G	E	F	E	–	F	G	F	F	–	F	–	-	G	–	–	–
	alpha cypermethrin	Fastac	E	F	E	G	E	G	G	E	F	E	–	G	E	F	F	–	F	–	-	G	–	–	–
	zeta cypermethrin	Mustang Max	E	F	E	G	E	G	G	E	F	E	–	G	E	F	F	–	F	–	-	E	–	–	–
	cyfluthrin	Baythroid/Renounce	G	F	G	G	G	F	G	E	F	E	–	G	E	F	F	–	F	–	-	E	–	–	–
	lambda cyhalothrin	Karate	E	F	E	G	E	G	G	E	F	E	–	G	E	F	F	–	F	–	-	E	–	–	F
	esfenvalerate	Asana XL	G	G	G	G	G	F	G	E	F	G	–	F	G	F	F	–	F	–	-	G	–	–	–
	gamma cyhalothrin	Proaxis	E	F	E	G	E	G	G	E	F	E	–	E	E	F	F	–	F	–	-	E	–	–	–
	fenpropathrin	Danitol	G	–	G	G	G	F	F	E	F	G	–	E	E	F	F	–	F	–	F	G	–	–	F
	bifenthrin	Brigade	E	F	E	G	G	F	F	E	F	E	–	E	E	F	F	–	F	F	F	E	G	F	F
4A	imidacloprid	Admire	F	G	E	–	–	–	–	–	–	-	-	F	G	E	G	–	-	G	G	–	F	G	–
	acetamiprid	Assail	G	E	G	–	–	–	–	–	-	F	–	F	G	E	G	–	–	-	G	–	–	–	–
	clothianidin	Belay	E	E	G	–	–	–	–	–	–	–	–	G	G	G	-	-	F	G	-	–	F	G	–
	thiamethoxam	Platinum/Actara	E	G	G	–	–	–	–	–	–	-	-	G	G	E	F	–	F	G	G	–	F	F	–
	dinotefuran	Venom/Scorpion	E	E	G	–	–	–	–	–	–	-	-	E	E	F	G	–	F	–	G	-	-	-	-
4C	sulfoxaflor	Closer, Transform	–	–	–	–	–	–	–	–	–	–	–	F	–	E	–	–	–	–	E	–	–	–	–
4D	flupyradifurone	Sivanto	–	–	–	–	–	–	–	–	–	–	–	–	–	E	–	–	–	–	E	–	–	–	–
	spinosad	Blackhawk/Entrust	–	E	–	G	G	G	G	E	G	G	G	–	-	-	G	G	E	–	-	F	–	–	–
	spinetoram	Radiant	–	E	–	E	E	G	G	E	G	G	G	–	-	-	E	G	E	–	-	F	–	–	–
	emamectin benzoate	Proclaim	–	–	-	G	G	G	E	E	E	G	E	–	–	-	-	-	F	–	-	F	–	–	–
	abamectin	Agri-Mek	–	E	–	–	–	–	–	–	–	–	–	–	–	-	G	F	E	–	–	-	–	–	E
7C	pyriproxyfen	Knack/Distance	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	G	–	–	–	–
9B	pymetrozine	Fulfill	–	–	–	–	–	–	–	–	–	–	–	–	–	E	–	–	–	–	F	–	–	–	–
9C	flonicamid	Beleaf	–	–	–	–	–	–	–	–	–	–	–	–	–	E	E	E	–	–	–	–	–	–	–
10	etoxazole	Zeal	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	G
11	Bt	Dipel, various	–	–	-	F	F	F	G	E	G	F	F	–	–	–	–	–	–	–	–	–	–	–	–
15	novaluron	Rimon	–	E	–	E	E	E	G	E	F	G	E	F	F	–	G	G	G	–	G	–	–	–	–
16	buprofezin	Courier	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	G	–	–	–	–
17	cyromazine	Trigard	–	G	–	–	–	–	–	–	–	–	–	–	–	-	-	-	E	–	-	–	–	–	–
18	methoxyfenozide	Intrepid	–	–	-	G	G	E	E	E	F	G	E	–	–	–	–	–	–	–	–	–	–	–	–
20B	acequinocyl	Kanemite	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	E
20D	bifenazate	Acramite/Floramite	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	E
	fenpyroximate	Portal	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	G
	tolfenpyrad	Torac	G	–	–	F	F	F	F	G	–	-	F	–	–	G	G	F	–	–	F	–	–	–	–
22A	indoxacarb	Avaunt	F	G	F	E	G	G	E	E	G	G	E	–	–	-	-	-	F	–	-	F	–	–	–
	spiromesifen	Oberon	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	G	–	–	–	G
	spirotetramat	Movento	–	–	–	–	–	–	–	–	–	–	–	–	-	E	–	–	–	–	G	-	–	–	–
25	cyflumetofen	Nealta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	G
	chlorantraniliprole	Coragen	–	E	–	E	E	E	E	E	E	G	E	–	–	-	F	–	E	–	G	–	–	–	–
	cyantraniliprole	Verimark/Exirel	G	E	–	E	E	E	E	E	E	G	E	–	–	G	F	F	E	G	G	–	–	–	–

* Denotes that insecticide-resistant populations may occur in some areas and can affect the performance of insecticides.

TABLE 2-25. PREHARVEST INTERVALS *(IN DAYS)* FOR PYRETHROID INSECTICIDES IN VEGETABLE CROPS.

Table 2-24 to compare relative efficacy of these products against specific insect pests. Read the pesticide label for specific rates and application instructions.

		Common Name/Example Product (Restricted Entry Interval – REI)										
		alpha cypermethrin Fastac (12 hrs)	beta cyfluthrin Baythroid XL (12 hrs)	bifenthrin Brigade (12 hrs)	cypermethrin Various names (12 hrs)	cyfluthrin Tombstone (12 hrs)	esfenvalerate Asana XL(12 hrs)	fenpropathrin Danitol (24 hrs)	gamma cyhalothrin Proaxis (24 hrs)	lambda cyhalothrin Karate/Warrior (24 hrs)	permethrin Pounce (12 hrs)	zeta cypermethrin Mustang Max (12 hrs)
	Asparagus	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	1
Bulb Vegetables	Onions, Green	NR	NR	NR	7	NR	NR	NR	NR	NR	NR	7
	Onions, Dry Bulb	NR	NR	NR	7	NR	NR	NR	14	14	1	7
Brassica Leafy Vegetables	Broccoli, Brussels Sprout, Cabbage, Cauliflower, Kohlrabi	1	0	0	7	1	0	3	7	1	7	1
	Collard, Mustard Green	NR	NR	NR	7	NR	NR	NR	14	14	1	7
Cereal Corn	Sweet Corn	3	0	1	NR	0	1	NR	1	1	1	3
Cucurbits	Cantaloupe, Watermelon	1	0	3	NR	0	3	7	NR	1	0	1
	Cucumber, Pumpkin, Summer Squash, Winter Squash	1	0	3	NR	0	3	7	NR	1	0	1
Fruiting Vegetables	Eggplant, Pepper	1	7	7	NR	0	7	3	5	5	3	1
	Tomato	1	0	1	NR	7	1	3	5	5	0	1
	Okra	1	NR	7	NR	NR	NR	NR	NR	NR	NR	1
Legumes	Edible-podded	1	NR	3	NR	NR	3	NR	7	7	NR	1
	Succulent Shelled Pea and Bean	1	3	3	NR	3	3	7	7	7	NR	1
	Dried Shelled Pea and Bean	21	7	14	NR	7	21	NR	21	21	NR	21
Leafy Vegetables, Except Brassica	Head and Leaf Lettuce	1	0	7	5A	0	7A	NR	1	1	1	1
	Spinach	1	0	40	NR	0	NR	NR	NR	NR	1	1
	Celery	1	0	NR	NR	0	NR	NR	NR	NR	3	1
Root and Tuber Vegetables	Beet, Carrot, Radish, Turnip	1	0	21	NR	0	7	NR	NR	NR	1	1
	Potato	1	0	21	NR	0	NR	NR	NR	7	14	1
	Sweetpotato	1	0	21	NR	0	NR	NR	NR	7	NR	1

NR - Not registered.
[A] Head lettuce only.

TABLE 2-26. LIST OF GENERIC INSECTICIDES BY ACTIVE INGREDIENT.

Active Ingredient	Original Product and Formulation (Manufacturer)	Generics and Formulation (Manufacturer)	
Abamectin	Agri-Mek 0.15EC	Abacus 0.15 EC (Rotam)	Reaper 0.15 EC (Loveland)
		Abba 0.15 EC (Makhteshim)	Temprano 0.15 EC (Chemtura)
		Abba Ultra 0.3 EC (Makhteshim)	Timectin 0.15 EC (Tide Intl.)
		Agri-Mek 0.7 EC (Syngenta)	Reaper Advance 0.15 EC (Loveland)
		Epi-Mek 0.15 EC (Syngenta)	Zoro 0.15 EC (Cheminova)
		Nufarm Abamectin 0.15 EC (Nufarm)	
Acephate	Orthene 90SP (Valent)	Acephate 90 Prill (Makhteshim)	Acephate 97 UP (United Phosphorous)
		Acephate 90 WDG (Loveland)	Bracket 90 WDG (Winfield)
		Acephate 90 WSP (Loveland)	Orthene 97 (Amvac)
Bifenthrin	Brigade 2 EC, Capture 2 EC (FMC)	Bifen 2AG Gold (Direct AG Source)	Ruckos LFR (Helena)
		Bifenture 2 EC (United Phosphorous)	Slugbug 2 EC (Real Farm)
		Bifenthrin 2 EC (Aceto)	Sniper 2 EC (Loveland)
		Discipline 2 EC (Amvac)	Tailgunner 2 EC (Makhteshim)
		Fanfare 2 EC (Makhteshim)	Tundra 2 EC Winfield)
		Frenzy Veloz (Real Farm)	Xpedient (Amvac)
		Revere (Adama	
Carbaryl	Sevin 50 WP 4 L, 80 S, SL , XLR (Bayer)	Carbaryl 4 L (Drexel, Loveland)	Prokoz Sevin SL (Prokoz)
Chlorpyrifos	Lorsban 4 E, 15 G, 75 WDG, Advanced 3.76 E (DowAgro Sciences)	Chlorpyrifos 4 E (Makhteshim, Drexel)	Vulcan 3.76 E (Makhteshim)
		Govern 4 E (Tenkos)	Warhawk 4 E (Loveland)
		Hatchet 4 E (Dow AgroSciences)	Whirlwind 4 E (Helena)
		Nufos 4E (Tenkos)	Yuma 4 E (Winfield)
		Saurus 15 G (Helena)	

TABLE 2-26. LIST OF GENERIC INSECTICIDES BY ACTIVE INGREDIENT. (cont'd)

Active Ingredient	Original Product and Formulation (Manufacturer)	Generics and Formulation (Manufacturer)	
Cyfluthrin	Brigade XL, 1 EC, Renounce 20 WP (Bayer)	Tombstone 2 E (Loveland) Battery 2.5 EC (Winfield)	Tombstone Helios 2 E (Loveland) Holster (Loveland)
Esfenvalerate	Asana XL 0.66EC (DuPont)	S-FenvaloStar 0.66 EC (LG Life Sciences)	Zyrate (Rotam)
Gamma-cyhalothrin	Proaxis 0.5 EC (Loveland)	Declare Insecticide 0.5 EC (Cheminova)	Proaxis Insecticide 0.5 EC (Cheminova)
Hexithiazox	Savey, Onager	Hexy 2E (Sharda)	
Imidacloprid	Admire 2 F, Pro 4.6 F, Provado 1.6 F (Bayer)	Advise 2 FL (Winfield) Mana Alias 2 F, 4 F (Makhteshim) Amtide Imidacloprid 2 F (AmTide) Couraze 2 F, 4 F (Cheminova) Imida E-AG, 1.6F, 2F (Cheminova) Imidacloprid 4 SC (Willowood) Lada 2 F (Rotam) Macho 2 FL, 4 F (Albaugh) Malice 75 WSP (Loveland)	Midash 2 SC (Sharda USA) Montana 2 F, 4 F (Rotam NA) NuPrid 2 F, 2 SC, 4 F Max, 4.6 F, (Nufarm) Pasada 1.6 F (Makhteshim) Prey 1.6 F (Loveland) Sherpa 1.6 F (Loveland) Widow 2 F (Loveland) Wrangler 4 F (Loveland)
Lambda-cyhalothrin	Karate 2 ME, Warrior 2 ME (Syngenta)	Grizzly Z 1 CS (Winfield) Kendo 1 EC (Helm) Kiaso 24 WG (Nufarm) Lambda T 1 CS (Helena) Lambda CY 1 EC (United Phosphorous) Lambda-Cyhalothrin 1 EC (Nufarm) LambdaStar 1 EC, 1 CS (LG Life Sciences)	Lamcap 1 CS (Syngenta) Lambda-CY AG (Direct AG Source) Paradigm 1 EC (Makhteshim) Province 1 SC (TENKoz) Silencer 1 EC (Makhteshim) Willowood Lambda-Cy 1 EC (Willowood)
Permethrin	Pounce 3.2 EC (FMC)	Arctic 3.2 EC (Winfield) Perm-Up 3.2 EC (United Phosphorous) Perm Star 3.2 EC (LG Life Sciences)	Permethrin 3.2 EC (Loveland, TENKoz, Helena) Stiletto (Wilbur Ellis)
Zeta-cypermethrin	Mustang Max 1.5 EW (FMC)	Respect 0.8 EC (BASF)	

TABLE 2-27. COMPONENTS OF INSECTICIDE MIXTURES.

Premix Trade Name	Components (Legacy trade name)
Athena	abamectin (Agri-Mek) + bifenthrin (Brigade)
Agri-Flex	abamectin (Agri-Mek) + thiamethoxam (Actara)
Cormoran	acetamiprid (Assail) + novaluron
Gladiator	avermectin B1 (Agri-Mek) + zeta-cypermethrin (Mustang Max)
Hero, Steed	bifenthrin (Brigade) + zeta-cypermethrin (Mustang Max)
Voliam Xpress, Besiege	chlorantraniliprole (Coragen) + lambda-cyhalothrin (Warrior, Karate)
Cobalt, Bolton	chlorpyrifos (Lorsban) + gamma-cyhalothrin (Proaxis)
Kilter	imidacloprid (Admire) + lambda-cyhalothrin (Warrior, Karate)
Endigo ZC	lambda-cyhalothrin (Warrior, Karate) + thiamethoxam (Actara)
Leverage 360	imidacloprid (Admire) + beta-cyfluthrin (Baythroid XL)
Leverage 2.7	imidacloprid (Admire) + cyfluthrin (Baythroid)
Brigadier, Swagger, Skyraider, Tempest	bifenthrin (Brigade) + imidacloprid (Admire)
Durivo, Voliam Flexi	chlorantraniliprole (Coragen) + thiamethoxam (Actara, Platinum)
Triple Crown	zeta-cypermethrin (Mustang Max), bifenthrin (Brigade), imidacloprid (Admire)

INSECT CONTROL FOR GREENHOUSE VEGETABLES

Sound cultural practices, such as sanitation and insect-free transplants, help prevent insect establishment and subsequent damage. Separate plant production houses, use of yellow sticky traps, and timely sprays will help prevent whitefly buildup. Use of Encarsia parasites for whitefly and other biological control agents in conjunction with use of pesticides is encouraged. Unless a pesticide label specifically states that a product cannot be used in a greenhouse vegetable crop, the product can be used on those crops for which it is registered. However, pesticides behave differently in the field and the greenhouse, and for many products, information is not available on greenhouse crop phytotoxicity and residue retention. If unsure of the safety of a product to a crop, apply to a small area before treating the entire crop.

TABLE 2-28. INSECT CONTROL FOR GREENHOUSE VEGETABLES

CROP Insect	Insecticide and Formulation	Amount of Formulation	Re Entry Interval	Pre Harvest Interval (PHI) (Days)	Precautions and Remarks
INSECT CONTROL FOR CUCUMBER					
Aphid	flonicamid, MOA 29 (Beleaf) 50SG	0.065 to 0.1 oz per 1000 sq ft	12 hrs	0	May be applied either to the soil as a drench or drip irrigation for preventive control, or sprayed onto plans as a rescue treatment.
	imidacloprid, MOA 4A (Admire Pro) 4.6 F	0.6 fl oz/1,000 plants	12 hrs	0	Apply in a minimum of 21 gallons water using soil drenches, microirrigation, or drip irrigation. Do not apply to immature plants as phytotoxicity may occur. Make only one application per crop per season.
	insecticidal soap (M-Pede) 49 EC	2 tbsp/gal water	12 hrs	0	
Cabbage looper	*Bacillus thuringiensis,* MOA 11 (various)	0.5 to 1 lb OR 3 pt/100 gal water	4 hrs	—	Most are **OMRI approved**
	spinosad, MOA 5		4 hrs	1	Do not make more than two consecutive applications.
	(Entrust) SC	3 fl oz/100 gal			**OMRI approved.**
Spider mite	insecticidal soap (M-Pede) 49 EC	2 tbsp/gal water	12 hrs		Use predatory mites. **OMRI Approved.**
	mineral oil (TriTek)	1 to 2 gal/100 gal	4 hrs	0	Begin applications when mite populations are low, and repeat at weekly intervals.
	Fenpyroximate, MOA 21A (Akari) 5SC	1 to 2 pts per 100 gal	12 hrs	7	
Whitefly, Leafminer	acetamiprid, MOA 4A (Assail) 30 SG	0.1 oz per 1000 sq ft	12	0	
	flonicamid, MOA 20 (Beleaf) 30SG	0.065 to 0.1 oz per 1000 sq ft	12 hrs	0	
	imidacloprid, MOA 4A (Admire Pro) 4.6 F	0.6 fl oz/1,000 plants	12 hrs	0	Apply in a minimum of 21 gallons water using soil drenches, micro-ir-ri- gation, or drip irrigation. Do not apply to immature plants as phytotoxicity may occur. Make only one application per crop per season.
	insecticidal soap (M-Pede) 49 EC	2 tbsp/gal water	12 hrs	0	May be used alone or in combination. Acts as an exciter. **OMRI Approved**.
	Beauveria bassiana (Mycotrol WP)	0.25 lb/20 gal water		0	Apply when whiteflies observed. Repeat in 4- to 5-day intervals. **OMRI Approved.**
INSECT CONTROL FOR LETTUCE					
Aphid, Leafminer, Whitefly	fulymetrozine, MOA 9B (Fulfill) 50 WG	0.063 oz per 1000 sq ft	12 hrs	0	Will not control leafminer.
	pyrethrins, MOA 3 (Pyganic) 5 EC	0.25 to 0.5 fl oz per gal water	12 hrs	0	May be used alone or tank mixed with a companion insecticide (see label for details). **OMRI approved.**
	malathion, MOA 1B (various) 57 EC 25 WP	 1 qt/100 gal water 4 lb/100 gal water	24 hrs	 14 14	
	insecticidal soap (M-Pede) 49 EC	2 tbsp/gal water	12 hrs	0	May be used alone or in combination. Acts as an exciter. Insecticidal soaps can cause phytotoxicity under high temperatures or slow drying conditions. If unsure, apply to a small area before treating the entire crop. **OMRI approved**.
	Beauveria bassiana (Mycotrol WP)	0.25 lb/20 gal water	4 hrs	0	Under high aphid or whitely pressure, apply at 2 to 5 day intervals. **OMRI approved.**
Cabbage looper	*Bacillus thuringiensis,* MOA 11 (Javelin) WG	0.5 to 1.25/100 gal water	4 hrs	0	
	spinosad, MOA 5 Entrust SC	3 fl oz/100 gal	4 hrs	1	Do not make more than two consecutive applications.

TABLE 2-28. INSECT CONTROL FOR GREENHOUSE VEGETABLES (cont'd)

CROP Insect	Insecticide and Formulation	Amount of Formulation	Re Entry Interval	Pre Harvest Interval (PHI) (Days)	Precautions and Remarks
INSECT CONTROL FOR LETTUCE (cont'd)					
Slugs	iron phosphate (Sluggo)	0.5 to 1 lb/1,000 sq ft	4 hrs	1	Scatter the bait around the perimeter of the greenhouse to provide a protective barrier. If slugs are within the crop, then scatter the bait on the ground around the plants. Do not make more than 3 applications within 21 days. Sluggo will control slugs and snails, while Bug-N-Sluggo will also control earwigs, cutworms, sowbugs and pillbugs. Sluggo is **OMRI approved.**
	iron phosphate + spinosad (Bug-N-Sluggo)	0.5 to 1 lb/1,000 sq ft	4 hrs	1	
Spider mite	insecticidal soap (M-Pede) 49 EC	2 tbsp/gal water	12 hrs	0	Begin applications when mite populations are low, and repeat at weekly intervals.
	mineral oil (TriTek)	1 to 2 gal/100 gal	4 hrs	0	
INSECT CONTROL FOR TOMATO AND PEPPER					
Aphid	flonicamid, MOA 20 (Beleaf) 50SG	0.1 oz per 1000 sq ft	12 hrs	0	May be applied to the soil as a drench or drip irrigation for preventive control, or as a spray for rescue treatments. Will also control whiteflies.
	imidacloprid, MOA 4A (Admire Pro) 4.6	0.6 fl oz/1,000 plants	12 hrs	0	Apply in a minimum of 21 gallons water using soil drenches, microirrigation, or drip irrigation. Do not apply to immature plants as phytotoxicity may occur. Make only one application per crop per season. Also controls whiteflies.
	malathion, MOA 1B (various) 10 A 57 EC 25 WP	 1 lb/50,000 cu ft 1 qt/100 gal water 4 lb/100 gal water	12 hrs	 15 hrs 1 1	
	insecticidal soap (M-Pede) 49 EC	2 tbsp/gal water	12 hrs	0	May be used alone or in combination. Acts as an exciter.
	Beauveria bassiana (Mycotrol WP)	0.25 lb/20 gal water		0	Apply when whiteflies are observed. Repeat in 4-to 5-day intervals.
Armyworm, Fruitworm, Cabbage looper, Pinworm	*Bacillus thuringiensis*, MOA 11 (Javelin) WG (Agree) WP (Dipel) DF (Xentari) DF	 0.5 lb to 1.25 lb/100 gal water 1 to 2 lb 0.5 to 1.25 lb 0.5 to 1.5 lb	4 hrs	0	
	chlorfenapyr, MOA 13 (Pylon) 2SC	6.5 to 13 fl oz/100 gal water, or per acre area	12 hrs	0	For use on tomatoes more than 1 inch in diameter at maturity. Do not make more than two applications at 5 to 10 day intervals before rotating to an insecticide with a different mode of action
	cyantraniliprole, MOA 28 (Exirel) SE	7 to 13.5 fl oz per acre, or per 100 gal	12 hrs	1	
	spinosad, MOA 5 (Entrust) SC	3 fl oz/100 gal	4 hrs	1	Do not make more than two consecutive applications. Do not apply to seedling tomatoes or peppers grown for transplants.
Leafminer	cyantraniliprole, MOA 28 (Exirel) SE	13.5 to 20.5 fl oz per acre, or per 100 gal	12 hrs	1	
	diazinon, MOA 1B (Diazinon, Spectracide)	4 to 8 oz/100 gal water	48 hrs	3	Keep ventilators closed for 2 hours or overnight. Plant injury may result if labeling directions are not followed. For use by members of N.C. Greenhouse Vegetable Growers Association only.
	spinosad, MOA 5 (Entrust) SC	10 fl oz/100 gal	4 hrs	1	Do not apply to seedlings grown for transplants
Slug	metaldehyde (various) bait	Follow label directions	12 hrs		Apply to soil surface around plants. Do not contaminate fruit.
	iron phosphate (Sluggo)	½ teaspoon per 9-inch pot		0	
Spider mite, Broad mite, Rust mite	acequinocyl, MOA 20B (Kanemite) 15SC	31 fl oz/100 gal	12 hrs	1	
	bifenazate (Floramite) SC	4 to 8 fl oz/100 gal water (1/4 to 1/2 tsp/gal)	12 hr	3	For use on tomatoes more than 1 inch in diameter at maturity. Not registered on pepper. Not for rust mite.
	mineral oil (TriTek)	1 to 2 gal/100 gal		0	Begin applications when mite populations are low, and repeat at weekly intervals.
	chlorfenapyr, MOA 13 (Pylon) 2SC	9.8 to 13 fl oz/100 gal water or per acre area		0	For use on tomatoes, more than1 inch in diameter at maturity. Do not make more than two applications at 5 to 10 day intervals before rotating to an insecticide with a different mode of action.
	fenpyroximate, MOA 21A (Akari) 5SC	1 to 2 pts per 100 gal	12 hrs	1	
	insecticidal soap (M-Pede) 49 EC	2 tbsp/gal water	12 hrs	0	

TABLE 2-28. INSECT CONTROL FOR GREENHOUSE VEGETABLES (cont'd)

CROP Insect	Insecticide and Formulation	Amount of Formulation	Re Entry Interval	Pre Harvest Interval (PHI) (Days)	Precautions and Remarks
INSECT CONTROL FOR TOMATO AND PEPPER (cont'd)					
Thrips, including western flower	*Beauveria bassiana* (Mycotrol WP)	0.25 lb/20 gal water		0	Use screens on intake vents. Apply when whiteflies observed. Repeat in 4- to 5-day intervals.
	cyantraniliprole, MOA 28 (Exirel) SE	13.5 to 20.5 fl oz per acre, or per 100 gal	12 hrs	1	For foliage-feeding thrips only, not those in flowers.
	spinosad, MOA 5 (Entrust) SC	5.5 fl oz/100 gal	4 hrs	1	Do not make more than two consecutive applications, and do not apply more than 6 times in a 12-month period against thrips. Do not apply to seedlings grown from transplants.
Whitefly	imidacloprid, MOA 4A (Admire Pro) 4.6 F	0.6 fl oz/1,000 plants	12 hrs	0	Apply in a minimum of 21 gallons water using soil drenches, micro-irrigation, or drip irrigation. Do not apply to immature plants as phytotoxicity may occur. Make only one application per crop per season. Also controls aphids.
	cyantraniliprole, MOA 28 (Exirel) SE	13.5 to 20.5 fl oz per acre, or per 100 gal	12 hrs	1	
	flonicamid, MOA 29 (Beleaf) 50SG	0.1 oz per 1000 sq ft	12 hrs	0	For use on tomato only.
	insecticidal soap (M-Pede) 49 EC	2 tbsp/gal water	12 hrs	0	
	pyrethrins and PBO, MOA 3 (Pyganic) 5EC	0.25 to 0.5 fl oz per gal	12 hrs	0	May be used alone or tank mixed with a companion insecticide. (See label for details).
	Beauveria bassiana (Mycotrol WP)	0.25 lb/20 gal water	4 hrs	0	Apply when whiteflies are observed. Repeat in 4- to 5-day intervals. **OMRI approved**.
	buprofezin, MOA 16 (Talus) 40SC	9 to 13.6 oz/100 gal water or per acre area	12 hrs	1	Insect growth regulator that affects immature stages of whiteflies. Will not kill adults. For use on tomatoes only.
	pyriproxyfen, MOA 7C (Distance) 0.86EC	6 fl oz/100 gal water	12 hrs	<1	Insect growth regulator that affects immature stages of whiteflies. Will not kill adults. Do not use on tomatoes more than 1 inch in diameter. Do not apply on non-bell peppers.

TABLE 2-29. ALTERNATIVE IPM & BIOINSECTICIDE RECOMMENDATIONS IN VEGETABLE CROPS.

NOTE: Many approved insecticides have not been tested thoroughly in the commercial vegetable systems. Use systems-based and exclusion practices to reduce the overall pest infestation level before resorting to insecticide applications in organic farming systems. Targeted insecticide applications at correct rate can protect natural enemies. Always read the insecticide label before application.

Target Pest	Cropping System	Systems-based Practices (for pest prevention)	Mechanical tactics(for pest prevention)	Biorational Insecticides#
Aphid	Multiple crops	Timely planting and harvest, reduce water stress, early planted okra can be used as a trap crop	Use of reflective mulches to protect transplants, Water jet can dislodge aphids, Insect netting for gardens or short rows*	Insecticidal soap & oil, Paraffinic oil, *Beauveria bassiana*
Armyworms	Multiple crops	Weed control, field sanitation, control soil organic residue (larvae hide under thick organic residue)	Insect netting for gardens or short rows*, High tunnel pest exclusion system for commercial producers^	*Bacillus thuringiensis* (single AI or premix), Insecticidal soap & oil, Spinosad, Neem**, *Chromobacterium*-based insecticide
Asparagus beetle	Asparagus	Use some portion of field as early planted trap crop	Manually remove beetles from trap crops	Pyrethrins, Spinosad
Bean leaf beetle	Snap, lima pole beans,	Sanitation (removal of crop debris), timely planting	Insect netting for gardens or short rows*	Pyrethrins, Spinosad
Blister beetle	Multiple crops	—	Insect netting for gardens or short rows*	Spinosad, Pyrethrin
Cabbage looper (small caterpillars)	Multiple crops	Remove alternate host plants (wild mustard, shepherd's purse)	Insect netting for gardens or short rows*, High tunnel pest exclusion system for commercial producers^	*Bacillus thuringiensis* (single AI or premix), Insecticidal soap, Pyrethrins (single AI or premix), Spinosad, Neem**
Colorado potato beetle	Multiple crops	Crop rotation, plant tolerant varieties	Insect netting for gardens or short rows*	Insecticidal soap, Neem**, Pyrethrins (use for larval control), Spinosad
Corn earworm/ Tomato fruitworm	Multiple crops	—	Insect netting for gardens or short rows*	*Bacillus thuringiensis* (single AI or premix), Insecticidal soap & oil, Spinosad, Neem**, *Chromobacterium* (Grandevo)
Cowpea curculio	Cowpeas, Snap, Lima, Pole beans	Crop rotation, sanitation, early harvest of crop,	Insect netting for gardens or short rows*	Pyrethrins, Spinosad (adults are difficult to kill due to insecticide resistance)
Cucumber beetle	Multiple crops	Perimeter trap cropping with Hubbard squash	Insect netting to block beetles*	Pyrethrins, Neem**, Parasitic nematodes (weekly soil drench for caterpillars)
Cutworm	Multiple crops	Need-based soil tillage and organic matter management	Plant collars, Insect netting (temporary exclusion methods)*	*Bacillus thuringiensis* (single AI or premix with directed spray at plant base; Spinosad foliar and stem spray; spinosad-based bait (Seduce)

TABLE 2-29. ALTERNATIVE IPM & BIOINSECTICIDE RECOMMENDATIONS IN VEGETABLE CROPS. (cont'd)

NOTE: Many approved insecticides have not been tested thoroughly in the commercial vegetable systems. Use systems-based and exclusion practices to reduce the overall pest infestation level before resorting to insecticide applications in organic farming systems. Targeted insecticide applications at correct rate can protect natural enemies. Always read the insecticide label before application.

Target Pest	Cropping System	Systems-based Practices (for pest prevention)	Mechanical tactics(for pest prevention)	Biorational Insecticides#
Diamondback moth & Imported cabbage worm	Collard & Mustard greens	—	Insect netting over short rows to block moths* (soon after transplanting)	*Bacillus thuringiensis* (single AI or premix), Insecticidal soap (for small caterpillars), Neem**, Pyrethrins
European corn borer	Multiple crops	Use tolerant cultivars when possible	—	*Bacillus thuringiensis* (single AI or premix), Insecticidal soap, Neem**, Pyrethrins
Flea beetle	Multiple crops	Timely planting of crops, Perimeter trap cropping with eggplants	Insect netting immediately after transplanting*	Insecticidal oil, Neem**, Spinosad, Parasitic nematodes (drench in soil), Pyrethrins,
Grasshopper	Multiple crops	Maintain a grassy patch (non-crop habitat) and use nematode insecticidal bait	Insect netting for gardens*, High tunnel pest exclusion system for commercial producers^	Pyrethrins (multiple applications), Nolo Bait (*Nosema locustae*) for use in grassy areas or near fences (undisturbed non-crop areas)
Hornworm	Tomato	Timely harvesting of fruits	Insect netting for gardens*, High tunnel pest exclusion system for commercial producers^	Spinosad, *Bacillus thuringiensis,* Pyrethrins, Neem,
Japanese beetle	Multiple crops	Sunflower and sorghum trap crops may deter feeding on main crop	Insect netting for gardens*, High tunnel pest exclusion system for commercial producers^	Pyrethrins, Neem (multiple sprays), Milky spore disease
Leaffooted bug	Fruiting vegetables(tomato, okra, eggplant)	Trap cropping with *Peredovik* sunflower & *NK300* sorghum provides significant reduction. Plant extra rows of trap crop in drought year.	High tunnel pest exclusion system for commercial producers^	Pyrethrins
Leafhopper	Multiple crops	—	—	Insecticidal soap, Pyrethrins, Neem**
Leafminer	Multiple crops	Select vigorous hybrid plant varieties	Pick and destroy mined leaves	Neem**, Spinosad
Mealy bugs	Multiple crops	—	Hand-picking	Insecticidal soap and oil
Onion maggot, seed corn maggot	Multiple crops	Use well-composted manure, soil tillage exposes maggots to natural enemies	—	—
Parsleyworm (black swallowtail)	Parsley, dill, carrot	—	Hand-pick and destroy caterpillars	*Bacillus thuringiensis* (DiPel)
Pepper weevil	Pepper	Crop rotation	Hand-pick insects, Insect netting for small areas	Insecticidal soap, Neem, Pyrethrins, Parasitic nematodes (drench in soil weekly)
Spider mite	Multiple crops	Plant and harvest timely; provide irrigation; problem could be severe in drought years	—	Paraffinic oil, Neem oil, Sulfur dust or spray (check label before use), *Chenopodium* Terpene Extract (Requiem), *Isaria fumosoroseus* (PFR97), Soluble silica (Sil-Matrix); *do not use pyrethrins*
Squash vine borer	Pumpkin, squash	Timely planting, trap cropping with Hubbard squash (Baby Blue and New England), sanitation or removing crop debris	Deworming vines in home garden, Insect netting at plant base early in the season to exclude moths	Pyrethrins, Spinosad (early season spray after detecting moths or eggs at plant base)
Squash bug	Pumpkin, squash	Trap cropping with Hubbard squash; plant tolerant varieties, sanitation (remove crop debris)	Insect netting for gardens*, High tunnel pest exclusion system for commercial producers can slow down pest migration^	Pyrethrins (weekly spray at low population levels)
Stink bug & Harlequin bug	Multiple crops	Trap crop of sorghum, okra for stink bugs	Insect netting for gardens*, High tunnel pest exclusion system for commercial producers^	Pyrethrins, Spinosad (target nymphs after scouting)
Thrips	Multiple crops	Timely planting, avoid planting ornamental close to vegetable crops	Dense insect netting material is available for commercial producers	Spinosad, Insecticidal soap, Paraffinic oil, *Chenopodium* Terpene Extract (Requiem)
Whitefly	Multiple crops	Crop rotation, avoid planting ornamental close to vegetable crops, problem intensifies in drought	—	*Metarhizium anisopliae,* Insecticidal soap, Neem oil, *Beauveria bassiana, Chenopodium* Terpene Extract
Yellowmargined leaf beetle	Brassica crops	Turnips and Napa Cabbage are defoliated rapidly. Trap cropping with turnips and insecticidal treatment can reduce build up.	Insect netting (temporary exclusion methods) for reducing adult insect infestation*	Spinosad, *Chromobacterium* (Grandevo), Pyrethrins (use in rotation with frequent foliar applications)

* Relatively low-cost temporary insect netting products include the Super-Light Insect Barrier (GardensAlive.com), Insect Netting (AgFabric), AgroFabric Pro 19 Row Cover or other lightweight exclusion material are suitable for early season pest prevention over single rows of crop.

** Check the Oregon Department of Agriculture and the Organic Materials Review Institute websites for updates regarding recall of neem-based insecticides.

^ High tunnel pest exclusion (permanent system) using 50 percent woven shade cloth on side- and end-walls can exclude large moths and reduce caterpillar pressure. Details at http://www.southernsare.org/News-and-Media/SSARE-Bulletins/High-Tunnel-Pest-Exclusion-System-HTPE.

Organic insecticides are currently available as single active ingredient (AI) or in the form of premixes, such as Azera (neem + pyrethrins), Leap (BT + methyl salicylate), BotaniGard Maxx (pyrethrins + Beauveria bassiana).

Disease Control for Commercial Vegetables

Caution: At the time these table was prepared, the entries were Caution: At the time these tables were prepared, the entries were believed to be useful and accurate. However, labels change rapidly and errors are possible, so the user must follow all directions on the product label. Federal tolerances for fungicides may be canceled or changed at any time. Information in the following table must be used in the context of an integrated disease management program. Many diseases are successfully managed by combined strategies—using resistant varieties, crop rotation, deep-turn plowing, sanitation, seed treatments, cultural practices, and fungicides. Always use top quality seed and plants obtained from reliable sources. Seeds are ordinarily treated by commercial producers for control of decay and damping-off diseases. Preplant fumigation of soils, nematode control chemicals, and greenhouse disease control products are provided in separate tables following the crop tables. The efficacy tables will help you select the appropriate disease control materials for some vegetable crops. These tables are located at the end of each crop table.

Rates: Some foliar rates are based on mixing a specified amount of product in 100 gal of water and applying the finished spray for complete coverage of foliage just to the point of run off with high-pressure (over 250 psi) drop nozzle sprayers. Actual amount of product and water applied per acre will vary depending on plant size and row spacing. Typically, 25 to 75 gallons (gal) per acre of finished spray are used. Concentrate spray (air blast, aircraft, etc.) rates are based on the amount of product per acre. Caution: With concentrate sprays, it is easy to apply too much product. Some fungicides are adversely affected by pH of water; adjust pH of water if specified on label. Some fungicides will cause damage to the plant if applied at temperatures above 90°F. Do not feed treated foliage to livestock unless allowed by the label. Do not reenter fields until sprays have dried; some fungicides may have a reentry requirement of one to several days. Read the label. Do not exceed maximum number of applications on the label. Do not exceed maximum limit of fungicide per acre per application or per year as stated on the label. See label for rotational crops. In all cases, follow directions on the label. The label is the law.

The following online databases provide current product labels and other relevant information:	
Database[1]	Web Address
Agrian Label Database	https://home.agrian.com/
Crop Data Management Systems	http://www.cdms.net/Label-Database
EPA Pesticide Product and Label System	https://iaspub.epa.gov/apex/pesticides/f?p=PPLS:1
Greenbook Data Solutions	https://www.greenbook.net/
Kelly Registration Systems[2]	http://www.kellysolutions.com

[1] Additional databases not included in this list may also be available. Please read the database terms of use when obtaining information from a particular website.

[2] Available for AK, AL, AZ, CA, CO, CT, DE, FL, GA, IA, ID, IN, KS, MA, MD, MN, MO, MS, NC, ND, NE, NJ, NV, NY, OK, OH, OR, PA, SC, SD, VA, VT, WA, and WI. Kelly Registration Systems works with State Departments of Agriculture to provide registration and license information.

TABLE 3-1. DISEASE CONTROL PRODUCTS FOR ASPARAGUS

E. Sikora, Plant Pathologist, Auburn University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Crown rot	mancozeb (various)	M	See label	See label	See label	Soak crowns 5 min in burlap bag with gentle agitation, drain, and plant.
Gray mold	fenhexamid (Elevate)	17	1.5 lb/A	180	_	Apply at fern stage only. Make up to four applications. Repeat at 7-to 14-day intervals if conditions favor disease development.
Phytophthora crown rot, spear rot	mefenoxam (Ridomil Gold SL)	4	1 pt/A	1	2	Apply over beds after seeding or covering crowns, 30 to 60 days before first cutting, and just before harvest.
	fosetyl-AL (Aliette)	33	5 lb/A	110	0.5	
Rust	myclobutanil (Rally 40W)	3	5 oz/A	180	1	Begin applications to developing ferns after harvest has taken place. Repeat on a schedule not to exceed 14 days. Do not apply to harvestable spears.
	sulfur (various)	M	See label	0	1	
	tebuconazole (various)	3	4 to 6 fl oz/A	180	0.5	Apply to developing ferns at first sign of rust and repeat on a 14 day interval; no more than 3 applications per season.
	copper oxychloride/ hydroxide (Badge SC)	M	1 to 2.5 pints/A	0	48 hr	Recommended for tank mixture with other registered products. For suppression. Addition of spread/sticker is recommended

TABLE 3-1. DISEASE CONTROL PRODUCTS FOR ASPARAGUS (cont'd)

E. Sikora, Plant Pathologist, Auburn University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Rust, Cercospora leaf spot	chlorothalonil (various)	M	2 to 4 lb/A	190	0.5	Repeat applications at 14 to 28 day intervals depending on disease pressure. Do not apply more than 12 pints/ acres during each growing season.
	mancozeb (various)	M	See label	See label	See label	Apply to ferns after harvest; spray at first appearance of disease at 7 to10 day intervals. Do not exceed 8 lb product per acre per crop.
Purple spot	azoxystrobin (various)	11	6 to 15.5 fl oz/A	100	4 hr	Do not apply more than 1 foliar application of Quadris (or other group 11 fungicide) before alternating with a fungicide with a different mode of action.
	chlorothalonil (various)	M	2 to 4 lb/A	190	0.5	Repeat applications at 14 to 28 day intervals depending on disease pressure. Do not apply more than 12 pints/ acre during each growing season.
	trifloxystrobin (Flint 50 WDG)	11	3 to 4 oz/A	180	12 hr	Make no more than one application before alternating with fungicides that have a different mode of action. Begin applications preventively when conditions are favorable for disease and continue as needed on a 7 to 14 day interval.

TABLE 3-2. IMPORTANCE OF ALTERNATIVE MANAGEMENT PRACTICES FOR DISEASE CONTROL IN ASPARAGUS

E. Sikora, Plant Pathologist, Auburn University; A. Keinath, Plant Pathologist, Clemson University

Scale: "E" excellent; "G" good; "F" fair; "P" poor; "NC" no control; "ND" no data.

Strategy	Rust	Cercospora blight	Stemphylium blight	Fusarium root rot	Phytophthora crown/spear rot
Avoid overhead irrigation	F	F	F	NC	NC
Crop rotation (5 years or more)	NC	NC	NC	F	P
Clip and bury infected ferns	G	G	G	NC	NC
Destroy infected ferns	E	E	E	NC	NC
Encourage air movement/wider row spacing	P	P	G	NC	NC
Plant in well-drained soil	NC	NC	NC	F	F
Destroy volunteer asparagus	F	NC	NC	NC	NC
Pathogen-free planting material	NC	NC	NC	E	E
Resistant/tolerant cultivars	G	G	NC	G	NC

TABLE 3-3. DISEASE CONTROL PRODUCTS FOR BASIL

L. Quesada-Ocampo, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Damping off (*Pythium* spp.)	mefenoxam (Ridomil Gold SL)	4	1.0 to 2.0 pt/acre	21	2	Limit of 2 soil applications per season.
Leaf spots, fungal (Botrytis, Alternaria, Fusarium), Powdery mildew	cyprodinil + fludioxonil (Switch 62.5WG)	9 + 12	11 to 14 oz/acre	7	0.5	Limit of 56 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	fluopyram (Luna Privilege)	7	4.0 to 6.84 fl oz/acre	3	0.5	Limit of 13.7 fl oz per acre per season. Apply as needed on a 7- to 10-day interval. When disease pressure is severe, use the higher rates and/or shorter intervals.
	fluopyram + trifloxystrobin (Luna Sensation)	7 + 11	5.0 to 7.6 fl oz/acre	7	0.5	Limit of 15.3 fl oz per acre per season. Apply as needed on a 7- to 10-day interval. When disease pressure is severe, use the higher rates and/or shorter intervals.
Downy mildew *(Peronospora belbahrii)*	cyazofamid (Ranman 400SC)	21	2.75 to 3 fl oz/acre	0	0.5	Limit of 27 fl oz per acre per season. Alternate with a fungicide with a different mode of action. May be applied through sprinkler irrigation system.
	mandipropamid (Revus)	40	8 fl oz/acre	1	4 hr	Limit of 32 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	phosphorous acid (Confine Extra, K-Phite)	33	1 to 3 qt/20 to 100 gal water/acre	0	4 hr	Do not apply at less than 3-day intervals.
	potassium phosphite (Fosphite, Fungiphite, Helena Prophyt)	33	1 to 3 qt/100 gal water/acre	0	4 hr	Do not apply at less than 3-day intervals.
Fusarium wilt and Pythium and Rhizoctonia root rots	phosphorous acid(Confine Extra, K-Phite)	33	1 to 3 qt/20 to100 gal water/acre	0	4 hr	Do not apply at less than 3-day intervals.
	potassium phosphite (Fosphite, Fungiphite, Helena Prophyt)	33	1 to 3 qt/100 gal water/acre	0	4 hr	Do not apply at less than 3-day intervals.

TABLE 3-4. DISEASE CONTROL PRODUCTS FOR BEAN

E. Sikora, Plant Pathologist, Auburn University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
BEAN, SNAP						
Anthracnose, Botrytis, Sclerotinia	azoxystrobin (various)	11	6.2 to 15.4 fl oz	0	4 hr	For anthracnose only. Do not apply more than three sequential applications.
	boscalid (Endura 70 WG)	7	8 to 11 oz	7	0.5	Many other dried and succulent beans on label.
	chlorothalonil (various)	M	2.7 lb/acre	7	2	Spray first appearance, 11 lb limit per acre per crop, 7-day intervals. **Not for Sclerotinia control.**
	thiophanate-methyl (various)	1	1 to 2 lb/acre	14	1	Spray at 25% bloom; repeat at full bloom. Do not exceed 4 lb product per season.
	fluazinam (Omega 500)	29	0.5 to 0.85 pts	14	3	Apply at 10 to 30% bloom.
	fluxapyroxad + pyraclostrobin (Priaxor)	7+11	4.0 to 8.0 fl oz	7	12 hr	Begin prior to disease development and continue on a 7 to 14 day spray schedule.
Ascochyta blight, Botrytis gray mold, white mold	boscalid (Endura 70 WG)	7	8 to 11 oz	7	0.5	
	penthiopyrad (Fontelis)	7	14 to 30 fl oz/acre	0	12 hr	Begin sprays prior to disease development.
Alternaria, Anthracnose, Ascochyta, rust, southern blight, web blight	azoxystrobin + propiconazole (Quilt Xcel; Aframe Plus)	11+3	10.5 to 14 oz/A	7	0.5	Apply when conditions are conducive for disease. Up to three applications may be made on 7-14 day intervals.
Botrytis gray mold, white mold (*Sclerotinia*)	fludioxonil (various)	12	7 oz	7	0.5	Begin before disease develops and continue on 7 day intervals until conditions no longer favor disease development. Do not apply more than 28 oz/A. Do not use on cowpeas.
Bacterial blights	fixed copper (various)	M	See labels	1	1	Spray first appearance, 10-day intervals.
Powdery mildew	sulfur (various)	M	See labels	0	1	Spray at first appearance, 10 to 14 day intervals. Avoid days over 90°F.
Cottony leak (*Pythium* spp.)	fenamidone (Reason 500 SC)		5.5 to 8.2 fl oz	3	0.5	Begin applications when conditions become favorable for disease development. Do not make more than one application before alternating to a product with a different mode of action.
Cottony leak, downy mildew, Phytophthora blight	cyazofamid (Ranman)	21	2.75 fl oz	0	0.5	Read label for specific directions for each disease as well as use restrictions.
Rhizoctonia root rot	azoxystrobin (various)	11	0.4 to 0.8 fl oz/1,000 row feet	—	4 hr	Apply in-furrow or banded applications shortly after plant emergence.
	myclobutanil (various)	3	4 to 5 oz/acre	0	1	For Rhizoctonia only.
	dichloropropene (Telone C-17) (Telone C-35)	—	 10.8 to 17.1 gal/acre 13 to 20.5 gal/acre	—	5	Rate is based on soil type; see label for in-row rates.
	metam-sodium (Vapam 42 HL)	—	37.5 to 75 gal/ trt acre	—	—	Rate is based on soil properties and depth of soil to be treated; apply 14 to 21 days before planting.
Rhizoctonia and Fusarium seed rot and damping off	prothioconazole (Redigo 480)	3	0.16 to 0.32 fl oz/100 lbs seed	—	—	For seed rot and damping off caused by Rhizoctonia and Fusarium.
	penflufen + trifloxystrobin (Evergol Xtend)	7+11	See label	—	—	For seed rot and damping off caused by Rhizoctonia, Fusarium, Phomopsis, or Botrytis. Seed treatment only.
Rust (Uromyces)	azoxystrobin (various)	11	6.2 to 15.4 fl oz/acre	0	4 hr	Make no more than three sequential applications.
	pyraclostrobin (various)	11	6.0 to 9.0 fl oz		12 hr	Make no more than two sequential applications.
	boscalid (Endura 70 WG)	7	8 to 11 oz/acre	7	0.5	Many other dried and succulent beans on label.
	chlorothalonil (various)	M	1.25 to 2.7 lb/acre	7	2	Spray first appearance, 11 lb limit per acre per crop, 7-day intervals.
	myclobutanil (various)	3	4 to 5 oz/acre	0	1	Spray at first appearance.
	sulfur (various)	M	See label	0	1	Spray at 7 to 10 day intervals.
	tebuconazole (various)	3	4 to 6 fl oz/acre	7	0.5	Apply before disease appears when conditions favor rust development and repeat at 14-day intervals: maximum 24 fl oz per season.
White mold *(Sclerotinia)*	dicloran (Botran 75 W)	14	2.5 to 4 lb/acre	2	0.5	Use low rate for bush varieties and high rate for pole varieties.

TABLE 3-4. DISEASE CONTROL PRODUCTS FOR BEAN (cont'd)

E. Sikora, Plant Pathologist, Auburn University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
BEAN, LIMA						
Alternaria, Anthracnose, Ascochyta, bean rust, southern blight, web blight (Rhizoctonia)	Azoxystrobin + propiconazole (Quilt Xcel, Aframe Plus)	11+3	10.5-14 fl oz	7	0.5	Apply when conditions are conducive for disease. Up to three applications may be made on a 7- to 14-day interval.
Botrytis, Sclerotinia, leaf spots	azoxystrobin (various)	11	6.2 to 15.4 fl oz/ acre	0	4 hr	Leaf spots only; do not make more than three sequential applications.
	thiophanate-methyl (various)	1	1.5 to 2 lb/acre	14	1	4 lb limit per acre per crop.
	iprodione (various)	2	1.5 to 2 lb/acre	0	1	DO NOT apply to cowpea. Snap or succulent bean hay must not be fed to livestock. Read label for all restrictions.
	fluazinam (Omega 500)	29	0.5 to 0.85 pts	30	3	Apply at 10 to 30% bloom.
	penthiopyrad (Fontelis)	7	14 to 30 fl oz/acre	0	12 hr	Begin sprays prior to disease development.
	pyraclostrobin (various)	11	6.0 to 9.0 fl oz	21	12 hr	Make no more than two sequential applications.
	fluxapyroxad + pyraclostrobin (Priaxor)	7+11	4.0 to 8.0 fl oz	21	12 hr	Begin prior to disease development and continue on a 7 to 14 day spray schedule.
Botrytis gray mold, white mold (Sclerotinia)	fludioxonil (various)	12	7 oz	7	0.5	Begin before disease develops and continue on 7 day intervals until conditions no longer favor disease development. Do not apply more than 28 oz/A. Do not use on cowpeas.
Cottony leak, downy mildew Phytophthora blight	Cyazofamid (Ranman)	21	2.75 fl oz	0	0.5	Read label for specific directions for each disease as well as use restrictions.
Damping off, Pythium, Rhizoctonia	azoxystrobin (various)	11	0.4 to 0.8 fl oz/1,000 row feet	—	4 hr	Rhizoctonia only. Make in-furrow or banded applications shortly after plant emergence.
	mefenoxam (various)	4	0.5 to 2 pt/trt acre	—	2	For Pythium only. Soil incorporate. See label for row rates. Use proportionally less for band rates.
	azoxystrobin + mefenoxam (Uniform)	11+4	0.34 fl oz/1,000 row ft	—	—	Limit of one application per season. In-furrow spray. See label directions.
Rhizoctonia, Fusarium, Phomopsis, Botrytis	penflufen + trifloxystrobin (Evergol Xtend)	7+11	See label	—	—	For seed rot and damping off caused by Rhizoctonia, Fusarium, Phomopsis, or Botrytis. Seed treatment only.

TABLE 3-5. EFFICACY OF PRODUCTS FOR FOLIAR DISEASE CONTROL IN BEANS

E. Sikora, Plant Pathologist, Auburn University

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Product[1]	Fungicide group [F]	Preharvest Interval (Days)	Aerial Rhizoctonia	Anthracnose	Brown Spot (*Pseudomonas*)	Cercospora	Common Bacterial Blight	Common Rust	Downy Mildew	Gray Mold (*Botrytis*)	Halo Blight	Powdery Mildew	Pythium Cottony Leak	Pythium Damping off	Rhizoctonia Sore Shin	Sclerotinia Blight	Southern Blight (*S. rolfsii*)
azoxystrobin (various)	11	14	G	G	NC	G	NC	E	ND	P	NC	P	F	NC	G	NC	E
azoxystrobin + mefenoxam (Uniform)	11+4	—	F	F	NC	G	NC	ND	ND	NC	NC	NC	P	G	G	NC	NC
boscalid (Endura)	7	7-21	ND	ND	NC	ND	NC	ND	NC	G	NC	ND	NC	NC	ND	E	P
penthiopyrad (Fontelis)	7	0	ND	ND	NC	ND	NC	ND	NC	G	NC	ND	NC	NC	ND	E	F
dicloran (Botran)	14	—	NC	NC	NC	NC	NC	NC	NC	F	NC	NC	NC	NC	NC	F	NC
fluazinam (Omega 500)	29	30	ND	ND	NC	NC	NC	NC	ND	G	NC	NC	NC	NC	ND	G	F
chlorothalonil (various)	M	7	P	F	NC	G	NC	G	F	NC	NC	P	NC	NC	NC	NC	NC
cyprodinil + fludioxonil (Switch)	9+12	7	ND	ND	NC	ND	NC	ND	NC	G	NC	ND	NC	NC	ND	E	P
fixed copper (various)	M	0	NC	P	F	P	F	P	F	P	F	P	NC	NC	NC	NC	NC
iprodione (Rovral)	2	—	P	NC	NC	NC	NC	NC	NC	G	NC	NC	NC	NC	F	G	NC
mefenoxam (Ridomil)	4	—	NC	NC	NC	NC	NC	NC	G	NC	NC	NC	[F]R	[G]R	NC	NC	NC
pyraclostrobin (various)	11	7-21	G	G	NC	G	NC	E	ND	P	NC	P	F	NC	F	NC	F
fluxapyroxad + pyraclostrobin (Priaxor)	7+11	7-21	G	G	NC	G	NC	E	ND	G	NC	P	F	NC	F	E	F
sulfur (various)	M	0	NC	F	NC	F	NC	F	P	P	NC	F	NC	NC	NC	NC	NC
tebuconazole (various)	3	7	NC	NC	NC	F	NC	G	NC	F	NC	NC[R]	NC	NC	P	NC	G
thiophanate-methyl (Topsin M)	1	14-28	P	F	NC	G	NC	ND	NC	NC	NC	ND	NC	NC	P	F	NC

[1] Efficacy ratings do not necessarily indicate a labeled use for every disease.

[F] To prevent resistance in pathogens, alternate fungicides within a group with fungicides in another group. Fungicides in the "M" group are generally considered "low risk" with no signs of resistance developing to the majority of fungicides.

[R] Resistance reported in the pathogen.

TABLE 3-6. IMPORTANCE OF ALTERNATIVE MANAGEMENT PRACTICES FOR DISEASE CONTROL IN BEANS

E. Sikora, Plant Pathologist, Auburn University

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Strategy	Anthracnose	Ashy stem blight	Botrytis gray mold	Cercospora	Common Bacterial blight and halo blight	Fusarium root rot	Mosaic viruses	Powdery mildew	Pythium damping-off	Rhizoctonia root rot	Root knot	Rust (more on pole beans)	Southern blight (*Sclerotium rolfsii*)	White mold (*Sclerotinia*)
Avoid field operations when leaves are wet	E	NC	E	F	E	NC	NC	NC	NC	NC	NC	E	NC	NC
Avoid overhead irrigation	E	NC	E	E	E	NC	NC	NC	P	NC	NC	E	NC	G
Change planting date	F	F	NC	P	F	G	F	P	E	E	P	G (early)	NC	NC
Cover cropping with antagonist	NC	ND	NC	NC	NC	NC	NC	NC	NC	NC	G	NC	NC	NC
Crop rotation	G	P	F	F	G	F	P	P	F	F	G	NC	F	E
Deep plowing	E	F	E	P	E	F	NC	NC	F	F	E	NC	E	E
Destroy crop residue	E	F	E	F	E	NC	NC	NC	P	P	F	F	G	E
Encourage air movement	E	NC	E	F	E	NC	NC	E	P	NC	NC	F	NC	G
Increase between-plant spacing	P	NC	P	F	P	P	P	P	F	F	NC	P	F	G
Increase soil organic matter	NC	F	NC	NC	NC	F	NC	NC	NC	NC	F	NC	NC	NC
Insecticidal oils	NC	NC	NC	NC	NC	NC	F	NC	NC	NC	NC	NC	NC	NC
pH management	NC	NC	NC	NC	NC	F	NC	NC	NC	NC	NC	NC	NC	NC
Plant in well-drained soil	F	F	F	NC	F	E	NC	NC	E	E	NC	NC	P	F
Plant on raised beds	F	P	F	NC	F	E	NC	NC	E	E	NC	NC	P	F
Plastic mulch bed covers	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	F
Postharvest temperature control	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	E
Reflective mulch	NC	NC	NC	NC	NC	NC	G	NC	NC	NC	NC	NC	NC	P
Reduce mechanical injury	NC	NC	NC	NC	NC	F	P	NC	NC	NC	NC	NC	P	NC
Rogue diseased plants	NC	NC	P	NC	NC	NC	F	NC	NC	NC	NC	NC	P	F
Row covers	NC	NC	NC	NC	NC	NC	F	NC	NC	NC	NC	NC	NC	NC
Soil solarization	NC	NC	P	NC	NC	F	NC	NC	F	G	F	NC	F	G
Pathogen-free planting material	E	G	NC	F	E	NC	G	NC	NC	NC	NC	NC	NC	NC
Resistant cultivars	E	G	NC	E	E	G	E	E	NC	NC	NC	E	NC	F
Weed control	F	NC	F	NC	F	F	E	F	NC	NC	F	F	P	F

TABLE 3-7. DISEASE CONTROL PRODUCTS FOR BROCCOLI, BRUSSEL SPROUT, CABBAGE, AND CAULIFLOWER

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Alternaria leaf spot	azoxystrobin + difenoconazole (Quadris Top 2.72 SC)	11+3	14 fl oz/acre	1	0.5	Apply prior to disease, but when conditions are favorable on 7 to 14 day schedule. Alternate to a non-QoI fungicide after 1 application. No more than 4 applications per season.
	boscalid (Endura 70 EG)	7	6 to 9 oz/acre	0	0.5	Begin applications prior to disease development, and continue on a 7 to 14 day interval. Make no more than 2 applications per season.
	cyprodinil + difenoconazole (Inspire Super 2.82 SC)	9+3	16 to 20 fl oz/acre	7	0.5	Begin applications prior to disease development, and continue on a 7 to 10 day interval. Make no more than 2 sequential applications before rotating to another effective fungicide with a different mode of action. Do not exceed 80 fl oz per season.
	cyprodinil +fludioxonil (Switch 62.5WG)	9+12	11 to 14 oz/acre	7	0.5	Apply when disease first appears, and continue on 7 to 10 day interval. Do not exceed 56 oz of product per acre per year.
	fluxapyroxad + pyraclostrobin (Priaxor 500 SC)	7+11	6.0 to 8.2 fl oz/ acre	3	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications. **Do not apply to turnip greens or roots.**
	triflumizole (Procure 480SC)	3	6 to 8 fl oz/acre	1	0.5	Apply when disease first appears and continue on 14 day interval. Do not exceed 18 fl oz per season.

TABLE 3-7. DISEASE CONTROL PRODUCTS FOR BROCCOLI, BRUSSEL SPROUT, CABBAGE, AND CAULIFLOWER (cont'd)

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Alternaria leaf spot, gray mold	penthiopyrad (Fontelis 1.67 SC)	7	14 to 30 fl oz/acre	0	0.5	Do not exceed 72 fl oz of product per year. Make no more than 2 sequential applications per season before rotating to another effective product with a different mode of action.
Black leg	iprodione (Rovral 4F)	2	2 lb/acre 2 pt/acre	0	—	Apply to base of plant at 2- to 4-leaf stage. A second application may be made up to the harvest date. Do not use as a soil drench. **For broccoli only.**
	fluxapyroxad + pyraclostrobin (Priaxor 500 SC)	7+11	6.0 to 8.2 fl oz/ acre	3	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications. **Do not apply to turnip greens or roots.**
Black rot, downy mildew	acibenzolar-*S*-methyl (Actigard 50WG)	P1	0.5 to 1 oz/acre	7	0.5	Begin applications 7 to 10 days after thinning, not to exceed 4 applications per a season.
	fixed copper (various)	M1	See labels	0	1 to 2	Apply on 7 to 10 day intervals after transplanting or shortly after seeds have emerged. Some reddening on older broccoli leaves and flecking of cabbage wrapper leaves may occur. Check label carefully for recommended rates for each disease on each crop.
Clubroot	cyazofamid (Ranman) 34.5 SC	21	*Transplant:* 12.9 to 25.75 fl oz/100 gal water *Banded:* 20 fl oz/acre	0.5	0	Either apply immediately after transplanting with 1.7 fl oz of solution per transplant, or as a banded application with soil incorporation of 6 to 8 inches prior to transplanting. Do not apply more than 39.5 fl oz/ acre/season; or 6 (1 soil + 5 foliar) applications per season. Do not make more than 3 consecutive applications without rotating to another fungicide with a different mode of action for 3 subsequent applications.
	fluazinam (Omega 500F)	29	*Transplant:* 6.45 fl oz/100gal water *Banded:* 2.6 pts/acre	50	50	Apply either directly as a drench to transplants or as a banded application with soil incorporation of 6 to 8 inches prior to transplanting. Use of product can delay harvest and cause some stunting without adverse effects on final yields.
Downy mildew	ametoctradin + dimethomorph (Zampro 525SC)	40+45	14 fl oz/acre	0	0.5	Do not make more than 2 sequential applications before alternating to a fungicide with a different mode of action. Addition of an adjuvant may improve performance (see label for specifics).
	cyazofamid (Ranman 400 SC)	21	2.75 fl oz/acre	0	0.5	Begin applications on a 7 to 10 day schedule when dis- ease first appears or weather is conducive. Do not apply more than 39.5 fl oz/acre/season; or 6 (1 soil+ 5 foliar) applications per season. Do not make more than 3 consecutive applications without rotating to another fungicide with a different mode of action for 3 subsequent applications.
	fluopicolide (Presidio 4 SC)	43	3 to 4 fl oz/acre	2	0.5	Must be tank mixed with another fungicide with a different mode of action. No more than 2 sequential applications before rotating to another effective product of a different mode of action. Limited to 4 applications, 12 fl oz/ acre per season.
	fosetyl-AL (Aliette 80WDG)	33	2 to 5 lb/acre	3	1	Apply when disease first appears; then repeat on 7 to 21 day intervals. Do not tank mix with copper fungicides. A maximum of 7 applications can be made per season.
	mandipropamid (Revus 2.08 SC)	40	8 fl oz/acre	1	0.5	Apply prior to disease development and continue throughout season at 7 to 10 day intervals; maximum 32 fl oz per season.
	oxathiapiprolin + mandipropamid (Orondis Ultra A + Orondis Ultra B)	U15 + 40	2.0 to 4.8 fl oz/acre + 8 fl oz/acre	0	4 hr	**Must tank mix Orondis Ultra and Ultra B before application.** Apply prior to disease development at 10-day intervals. Make no more than 2 sequential applications before alternating with fungicides that have a different mode of action. Maximum of 4 applications per crop per year of all Orondis products.
	potassium phosphite (various)	33	2 to 4 pt/acre	0	4 hr	Apply when weather is foggy as a preventative. Do not apply to plants under water or temperature stress. Spray solution should have a pH greater than 5.5. Apply in at least 30 gal water per acre.
Downy mildew, Alternaria leaf spot	azoxystrobin (Quadris 2.08 F)	11	6.0 to 15.5 fl oz/ acre	0	4 hr	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. Do not apply more than 92.3 fl oz per acre per season.
	chlorothalonil (various)	M5	See labels	7	2	Apply after transplanting, seedling emergence, or when conditions favor disease development. Repeat as needed on a 7 to 10 day interval.
	cyprodinil + difenoconazole (Inspire Super 2.82 SC)	9+3	16 to 20 fl oz/acre	7	0.5	Begin applications prior to disease development, and continue on a 7 to 10 day interval. Make no more than 2 sequential applications before rotating to another effective fungicide with a different mode of action. Do not exceed 80 fl oz per season.

TABLE 3-7. DISEASE CONTROL PRODUCTS FOR BROCCOLI, BRUSSEL SPROUT, CABBAGE, AND CAULIFLOWER (cont'd)

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Downy mildew, Alternaria leaf spot (cont'd)	fenamidone (Reason 500SC)	11	5.5 to 8.2 fl oz/acre	2	0.5	Begin applications on a 5 to 10 day schedule when disease first appears or weather is conducive. Do not apply more than 24.6 fl oz/acre/season. Do not make more than 1 application without rotating to another fungicide with a different mode of action.
	mancozeb various	M3	1.6 to 2.1 lb/acre	10	1	Spray at first appearance of disease and continue on a 7 to 10 day interval. No more than 12.8 lbs/acre per season.
	mefenoxam + chlorothalonil (Ridomil Gold/Bravo)	4+M5	1.5 lb/acre	7	2	Begin applications when conditions favor disease but prior to symptoms. Under severe disease pressure use additional fungicides between 14 day intervals. Do not make more than four applications per crop.
	oxathiapiprolin + mandipropamid (Orondis Opti A + Orondis Opti B)	U15 + M5	2.0 to 4.8 fl oz/acre + 1.5 pt/acre	7	0.5	**Must tank mix Orondis Opti A and Opti B before application.** Apply prior to disease development at 10-day intervals. Make no more than 2 sequential applications before alternating with fungicides that have a different mode of action. Maximum of 8 applications at the low rate or 4 applications at the high rate per crop per year of Orondis Opti; if Ultra and Opti are both used, then the maximum is 4 applications.
Powdery mildew	azoxystrobin + difenoconazole (Quadris Top 2.72 SC)	11+3	14 fl oz/acre	1	0.5	Apply prior to disease, but when conditions are favorable, on 7 to 14 day schedule. Alternate to a non-QoI fungicide after 1 application. No more than 4 applications per season.
	boscalid (Endura 70 EG)	7	6 to 9 oz/acre	0	0.5	Begin applications prior to disease development, and continue on a 7 to 14 day interval. Make no more than 2 applications per season; disease suppression only.
	cyprodinil + difenoconazole (Inspire Super 2.82 SC)	9+3	16 to 20 fl oz/acre	7	0.5	Begin applications prior to disease development, and continue on a 7 to 10 day interval. Make no more than 2 sequential applications before rotating to another effective fungicide with a different mode of action. Do not exceed 80 fl oz per season.
	cyprodinil + fludioxonil (Switch 62.5WG)	9+12	10 to 12 oz/acre	7	0.5	Apply when disease first appears, and continue on 7 to 10 day intervals. Do not exceed 56 oz of product per acre per year.
	fluxapyroxad + pyraclostrobin (Priaxor 500 SC)	7+11	6.0 to 8.2 fl oz/ acre	3	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications. Do not apply to turnip greens or roots.
	penthiopyrad (Fontelis 1.67 SC)	7	14 to 30 fl oz/acre	0	0.5	Do not exceed 72 fl oz of product per year. Make no more than 2 sequential applications per season before rotating to another effective product with a different mode of action.
	sulfur (various)	M2	See labels	0	1	Apply when disease first appears; then repeat as needed on a 14-day interval. Avoid applying on days over 90°F. Also for use on greens (collard, kale, and mustard), rutabaga, and turnip.
	triflumizole (Procure 480 SC)	3	6 to 8 fl oz/acre	1	0.5	Apply when disease first appears and continue on a 14 day interval. Do not exceed 18 fl oz per season.
Pythium damping off, Phytophthora basal stem rot	fluopicolide (Presidio 4 F)	43	3 to 4 fl oz/acre	2	0.5	Apply as a soil drench at transplant. As plants enlarge, use apply directly to soil by chemigation on a 10 day schedule as conditions favor disease, but prior to disease development. No more than 2 sequential applications before rotating to another effective product of a different mode of action. Limited to 4 applications, 12 fl oz/ acre per season.
	mefenoxam (Ridomil Gold 4 SL)	4	0.25 to 2 pt/acre	—	2	Apply 1 to 2 pt per acre as a broadcast, preplant application to soil and incorporate in top 2 in. of soil. For Pythium control, use only 0.25 to 0.5 pt per acre.
	metalaxyl (MetaStar 2 EAG)	4	4 to 8 pt/ trt acre	—	2	Preplant incorporated or surface application.
Rhizoctonia bottom rot	boscalid (Endura 70 WP)	7	6 to 9 oz/acre	0	0.5	Begin applications prior to disease development and continue on a 7 to 14 day interval. Make no more than 2 applications per season; disease suppression only.
Rhizoctonia stem (wirestem) and root rot	azoxystrobin (Quadris 2.08 SC)	11	5.8 to 8.7 fl oz/ acre on 36-in. rows	0	4 hr	Rate is equivalent to 0.4 to 0.6 fl oz per 1000 row feet. Apply at planting as a directed spray to the furrow in a band 7 inches wide. See label for other row spacings.
	boscalid (Endura 70 EG)	7	6 to 9 oz/acre	0	0.5	Begin applications prior to disease development and continue on a 7 to 14 day interval. Make no more than 2 applications per season.
	penthiopyrad (Fontelis 1.67 SC)	7	16 to 30 fl oz/acre	0	0.5	Do not exceed 72 fl oz of product per year. Make no more than 2 sequential applications per season before rotating to another effective product with a different mode of action.
	Coniothyrium minitans (Contans WG)	—	1 to 4 lb/acre	0	4 hr	**OMRI listed product.** Apply to soil surface and incorporate no deeper than 2 inches. Works best when applied prior to planting or transplanting. Do not apply other fungicides for 3 weeks after applying Contans.

TABLE 3-7. DISEASE CONTROL PRODUCTS FOR BROCCOLI, BRUSSEL SPROUT, CABBAGE, AND CAULIFLOWER (cont'd)

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Sclerotinia stem rot (white mold)	boscalid (Endura 70 EG)	7	6 to 9 oz/acre	0	0.5	Begin applications prior to disease development and continue on a 7 to 14 day interval. Make no more than 2 applications per season.
	penthiopyrad (Fontelis 1.67 SC)	7	16 to 30 fl oz/acre	0	0.5	Do not exceed 72 fl oz of product per year. Make no more than 2 sequential applications per season before rotating to another effective product with a different mode of action.
	Coniothyrium minitans (Contans WG)	—	1 to 4 lb/acre	0	4 hr	**OMRI listed product.** Apply to soil surface and incorporate no deeper than 2 inches. Works best when applied prior to planting or transplanting. Do not apply other fungicides for 3 weeks after applying Contans.

TABLE 3-8. EFFICACY OF PRODUCTS FOR DISEASE CONTROL IN BRASSICAS

Keinath, Plant Pathologist, Clemson University; E. Sikora, Plant Pathologist, Auburn University

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Product [1,2]	Crop Group [2]	Fungicide group [F]	Preharvest interval (Days)	Alternaria Leaf Spot	Bacterial Soft Rot	Black Rot	Black Leg	Bottom Rot (*Rhizoctonia*)	Cercospora & Cercosporella	Clubroot	Downy Mildew	Powdery Mildew	Pythium damping-off	Sclerotinia/Raisin Head	Wirestem (*Rhizoctonia*)
acibenzolar-S-methyl (Actigard)	H&S	21	7	NC	ND	F	NC	NC	NC	NC	G	P	ND	ND	NC
ametoctradin + dimethomorph (Zampro)	B	45+40	0	NC	NC	NC	NC	NC	NC	NC	E	NC	NC	NC	NC
azoxystrobin (Quadris and others)	B	11	0	E	NC	NC	F	ND	F	NC	G	F	NC	NC	F
azoxystrobin + difenoconazole (Quadris Top)	B	11+3	1	E	NC	NC	ND	ND	G	NC	G	F	NC	NC	F
boscalid (Endura) [3]	B	7	0 to 14	G	NC	NC	NC	NC	NC	NC	P	P	NC	F	F
chlorothalonil (Bravo, Echo, Equus, and others)	H&S	M	7	F	NC	NC	NC	P	F	NC	F	F	NC	NC	NC
fixed copper [4]	B	M	0	P	NC	P	NC	NC	P	NC	F	F	NC	NC	NC
cyazofamid (Ranman)	B	21	0	NC	NC	NC	NC	NC	NC	NC	G	NC	NC	NC	NC
cyprodinil + fludioxonil (Switch)	B	9+12	7	F	NC	NC	NC	NC	F	NC	NC	F	NC	NC	NC
difenoconazole + cyprodinil (Inspire Super)	B	3+9	7	G	NC	NC	ND	NC	G	NC	NC	F	NC	P	NC
dimethomorph (Forum)	B	40	0	NC	NC	NC	NC	NC	NC	NC	G	NC	NC	NC	NC
fenamidone (Reason)	B	11	2	F	NC	NC	NC	NC	F	NC	E	NC	NC	NC	NC
fluopicolide (Presidio)	B	43	2	NC	NC	NC	NC	NC	NC	NC	E	NC	NC	NC	NC
fluazinam (Omega 500) [6]	B	29	20 to 50	NC	NC	NC	NC	NC	NC	F	NC	NC	NC	NC	G
fluxapyroxad + pyraclostrobin (Priaxor)	B	7+11	3	G	NC	ND	G	ND	G	NC	F	F	NC	ND	NC
fosetyl-Al (Aliette)		33	3	NC	NC	NC	NC	NC	NC	NC	F	NC	NC	NC	NC
iprodione (Rovral) [5]	H&S	2	—	NC	NC	NC	F	NC	NC	NC	NC	NC	NC	P	P
mandipropamid (Revus)	B	40	1	NC	NC	NC	NC	NC	NC	NC	E	NC	NC	NC	NC
mancozeb (Manzate, Penncozeb, Dithane)	H&S	M	7	F	NC	NC	NC	NC	F	NC	F	P	NC	NC	NC
mefenoxam (Ridomil Gold EC) pre-plant	B	4	—	NC	NC	NC	NC	NC	NC	NC	F	NC	F^R	NC	NC
mefenoxam + chlorothalonil (Ridomil Gold Bravo)	H&S	4+M	7	F	NC	NC	NC	P	F	NC	F	F	NC^R	NC	NC
oxathiapiprolin (Orondis)	H&S	U15	7	NC	NC	NC	NC	NC	NC	NC	E	NC	ND	NC	NC
penthiopyrad (Fontelis)	B	7	0	E	NC	NC	ND	NC	ND	NC	NC	G	NC	G	NC
potassium phosphite (various)	B	33	0	NC	NC	NC	NC	NC	NC	NC	G	NC	NC	NC	NC
pyraclostrobin (Cabrio) [3]	B	11	0 to 3	E	NC	NC	ND	NC	E	NC	F	F	NC	NC	P
sulfur (various)	B	M	0	P	NC	NC	NC	NC	P	NC	P	F	NC	NC	NC
tebuconazole (Folicur, Tebuzol, Tegrol)	B	3	7	F	NC	NC	ND	NC	F	NC	NC	ND	NC	NC	NC
triflumizole (Procure)	B	3	1	NC	NC	NC	NC	NC	NC	NC	NC	G	NC	NC	NC

[1] Efficacy ratings do not necessarily indicate a labeled use for every disease.

[2] H&S = fungicides registered only on head and stem brassicas (broccoli, Brussel sprout, cabbage, and cauliflower). B = fungicides registered on all brassica crops except turnip greens and root turnips; see Tables 3-18 and 3-31 for products registered on turnips. Always refer to product labels prior to use.

[3] Shorter PHI is for head and stem brassicas (broccoli, Brussel sprout, cabbage, and cauliflower) and longer PHI is for leafy brassica greens.

[4] Phytotoxicity is seen when fosetyl-Al is tank-mixed with copper.

[5] Applications of iprodione made for black leg may suppress Alternaria, Sclerotinia, and wirestem on broccoli.

[6] Use a 20-day PHI for Omega 500 on leafy greens and a 50-day PHI for head and stem brassicas.

[F] To prevent resistance in pathogens, alternate fungicides within a group with fungicides in another group. Fungicides in the "M" group are generally considered "low risk" with no signs of resistance developing.

TABLE 3-9. IMPORTANCE OF ALTERNATIVE MANAGEMENT PRACTICES FOR DISEASE CONTROL IN BRASSICAS

E. Sikora, Plant Pathologist, Auburn University

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Strategy	Alternaria leaf spot	Bacterial soft rot	Black rot	Black leg	Bottom rot (*Rhizoctonia*)	Cercospora	Clubroot	Downy mildew	Powdery mildew	Pythium	Sclerotinia head	Wirestem (*Rhizoctonia*)
Avoid field operations when leaves are wet	P	F	G	F	F	P	NC	P	NC	NC	NC	NC
Avoid overhead irrigation	E	E	E	E	F	E	NC	G	P	NC	NC	NC
Change planting date	P	P	NC	NC	P	NC	NC	NC	NC	P	NC	F
Cover cropping with antagonist	NC	NC	NC	NC	NC	NC	P	NC	NC	P	NC	NC
Crop rotation	F	F	G	G	P	F	NC	F	NC	NC	P	P
Deep plowing	F	F	G	G	F	F	NC	F	NC	NC	F	F
Destroy crop residue	F	F	G	G	F	F	NC	F	NC	NC	P	P
Encourage air movement	F	P	P	P	F	F	NC	F	NC	P	F	NC
Increase between-plant spacing	F	P	P	P	F	F	NC	F	NC	P	F	NC
Increase soil organic matter	NC	NC	NC	NC	P	NC	P	NC	NC	NC	NC	P
Hot water seed treatment	P	NC	E	G	NC	NC	NC	NC	NC	NC	NC	NC
pH management	NC	NC	NC	NC	NC	NC	E	NC	NC	NC	NC	NC
Plant in well-drained soil	P	F	P	P	G	P	E	P	NC	F	F	G
Plant on raised beds	NC	F	P	NC	G	NC	E	P	NC	F	F	G
Plastic mulch bed covers	P	NC	NC	NC	F	NC	NC	NC	NC	NC	NC	NC
Postharvest temperature control	NC	E	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Reflective mulch	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Reduce mechanical injury	NC	E	G	NC	NC	NC	NC	NC	NC	NC	F	P
Rogue diseased plants	P	NC	NC	F	P	NC	NC	NC	NC	NC	NC	NC
Row covers	NC	P	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Soil solarization	NC	NC	NC	P	F	NC	NC	NC	NC	P	P	F
Pathogen-free planting material	F	NC	E	E	F	NC	G	NC	NC	NC	P	F
Resistant cultivars	NC	NC	E	NC	NC	NC	P	F	F	NC	NC	P
Weed control	F	NC	F	F	NC	F	F	F	F	NC	F	NC

DISEASE CONTROL

***CANTALOUPE* - SEE CUCURBITS**

TABLE 3-10. DISEASE CONTROL PRODUCTS FOR CORN, SWEET

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Seedling diseases caused by *Rhizoctonia* and *Penicillium*	pyraclostrobin (Stamina 1.67FC)	11	0.8 to 1.6 fl oz/ 100 lbs of seed	NA	NA	Seed treatment. Seed treated on-farm must be dyed.
Soilborne diseases, Rhizoctonia root and stalk rot	fluoxastrobin (Aftershock)	11	0.16 to 0.24 fl oz/ 1000 row feet	7	0.5	May be applied as a banded or in-furrow spray. Consult label for specifics.
	azoxystrobin (various)	11	0.4 to 0.8 fl oz/ 1000 row feet	7	4 hr	See label for banded or in-furrow sprays. Apply no more than 2.88 qt per crop per acre per season, including soil applications..
Anthracnose, Eyespot, Gray leaf spot (Cercospora leaf spot), Northern corn leaf blight (*Exserohilum* [*Helminthosporium*] *turcicum*) Northern corn leaf spot (*Bipolaris zeicola* [*Helminthosporium carbonum*[) Southern corn leaf blight (*Bipolaris* [*Helminthosporium*] *maydis*), Rust, Southern rust	azoxystrobin (various)	11	See labels	7	4 hr	Use lower rate for rust. Make no more than 2 sequential applications before alternating with fungicides that have a different mode of action. Apply no more than 123 fl oz per crop per acre per season. **Not registered for Southern rust.**
	azoxystrobin + propiconazole (Quilt, Quilt XCEL, Avaris)	11 + 3	7 or 10.5 to 14 fl oz/ acre	14	0.5	Use 7 fl oz of Quilt or Avaris for 3 Helminthosporium diseases. Must rotate every application with a non-Group 11 fungicide. Maximum 56 fl oz/acre (4 applications at the high rate) per crop.
	chlorothalonil (various)	M5	See labels	14	2	Spray at first appearance, 4 to 14 day intervals. **Not registered for anthracnose, eyespot, or gray leaf spot.**
	fluoxastrobin (Aftershock)	11	3.8 fl oz/acre	30	0.5	Soil and foliar treatments. Maximum 2 applications per season. Do not apply after early dough stage.
	fluxapyroxad + pyraclostrobin (Priaxor)	7 + 11	4 to 8 fl oz/acre	7	0.5	Do not make more than 2 sequential applications before switching to a fungicide with a different mode of action. Maximum 4 (high rate) or 2 applications (low rate) per crop. Crop damage may occur when an adjuvant is used; read label for specifics.
	mancozeb (various)	M3	See labels	7	1	Start applications when disease first appears and repeat at 4 to 7 day intervals. **Not registered for anthracnose, eyespot, gray leaf spot, or Southern rust.**
	penthiopyrad (Vertisan)	7	10 to 24 fl oz/acre	7	0.5	No more than 2 sequential applications of the fungicide before switching to a fungicide with another mode of action. **Not registered for eyespot.**
	propiconazole (various)	3	See labels	14	0.5	16 fl oz per acre per crop maximum. **Not registered for anthracnose.**
	pyraclostrobin (Headline SC & EC)	11	6 to 12 fl oz/acre	7	0.5	Do not make more than 2 sequential applications or 6 applications of this fungicide or other group 11 fungicides per crop. **Not registered for eyespot.**
	pyraclostrobin + metconazole (Headline AMP)	11 + 3	10 to 14.4 fl oz/ acre	7	0.5	No more than 2 sequential applications before alternating with a different mode of action. Maximum 4 (high rate) or 5 applications (low rate) per crop. **Not registered for eyespot.**
	trifloxystrobin + propiconazole (Stratego)	11 + 3	10 fl oz/acre	14	0.5	Apply Stratego when disease first appears and continue on a 7 to 14 day interval. Alternate applications of Strat- ego with another product with a different mode of action than Group 11 fungicides. Maximum 3 applications per crop. **Not registered for the 3 Helminthosporium diseases.**
	trifloxystrobin + propiconazole (Stratego YLD)	11 + 3	4 to 5 fl oz/acre	0	0.5	Alternate Stratego YLD sprays with another mode of action than a group 11 fungicide. Maximum 4 (high rate) or 5 applications (low rate) per crop. **Not registered for the 3 Helminthosporium diseases.**
Brown spot (*Physoderma maydis*)	fluxapyroxad + pyraclostrobin (Priaxor)	7 + 11	4 to 8 fl oz/acre	7	0.5	Do not make more than 2 sequential applications of Priaxor before switching to a fungicide with a different mode of action. Maximum 4 (high rate) or 2 applications (low rate) per crop. Crop damage may occur when an adjuvant is used; read label for specifics.
	penthiopyrad (Vertisan)	7	16 to 24 fl oz/acre	0	0.5	No more than 2 sequential applications of the fungicide before switching to a fungicide with another mode of action.
	pyraclostrobin (Headline SC & EC)	11	6 to 12 fl oz/acre	7	0.5	Do not exceed 2 sequential applications of this fungicide or with other group 11 fungicides.
	pyraclostrobin + metconazole (Headline AMP)	11 + 3	10 to 14.4 fl oz/ acre	7	0.5	No more than 2 sequential applications before alternating with a different mode of action.
Yellow leaf blight (*Peyronellaea zeamaydis* [*Phyllosticta maydis*])	fluxapyroxad + pyraclostrobin (Priaxor)	7 + 11	4 to 8 fl oz/acre	7	0.5	Do not make more than 2 sequential applications of Priaxor before switching to a fungicide with a different mode of action. Maximum 4 (high rate) or 2 applications (low rate) per crop. Crop damage may occur when an adjuvant is used; read label for specifics.

***CUCUMBERS* - SEE CUCURBITS**

TABLE 3-11. DISEASE CONTROL PRODUCTS FOR CUCURBITS

L. Quesada-Ocampo, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Angular leaf spot	fixed copper (various)	M	See labels	See label	See label	See label. Rates vary depending on the formulation. Repeated use may cause leaf yellowing.
Bacterial leaf spot	acibenzolar-*S*-methyl (Actigard) 50 WP	21	0.5 to 1 oz/acre	0	0.5	Apply to healthy, actively growing plants. Do not apply to stressed plants. Apply no more than 8 oz per acre per season.
Bacterial fruit blotch	fixed copper (various)	M	See labels	0	0	See label. Rates vary depending on the formulation. Start applications at first bloom; ineffective once fruit reaches full size. Repeated use may cause leaf yellowing.
	acibenzolar-*S*-methyl (Actigard) 50 WP	P1	0.5 to 1 oz/acre	0	0.5	Apply to healthy, actively growing plants. Do not apply to stressed plants. Apply no more than 8 oz per acre per season.
Bacterial wilt	NA	NA	NA	NA	NA	See Insect Control section for Cucumber Beetles.
Belly (fruit) rot, Rhizoctonia	azoxystrobin (various)	11	See labels	1	4 hr	Make banded application to soil surface or in-furrow application just before seed are covered.
	azoxystrobin + chlorothalonil (Quadris Opti)	11 + M	3.2 pints/acre	1	0.5	Do not apply more than one foliar application before alternating with a fungicide with a different mode of action. Do not make more than 4 applications of QoI group 11 fungicides per crop per acre per year.
	fluopyram + tebuconazole (Luna Experience 3.3 F)	7 + 3	17 fl oz/acre	7	0.5	**APPLY ONLY TO WATERMELON**. Make no more than 2 applications before alternating to a fungicide with different active ingredients. **Do not rotate with tebuconazole. Not labeled for use in Louisiana.**
	thiophanate-methyl (Topsin M 70 WP)	1	0.5 lb/acre	0	0.5	Apply in sufficient water to obtain runoff to soil surface.
Cottony leak (*Pythium* spp.)	metalaxyl (MetaStar 2 E)	4	4 to 8 pt/treated acre	0	2	Soil surface application in 7 in. band.
Damping off *(Pythium* spp.) and fruit rot	mefenoxam (Ridomil Gold 4 SL) (Ultra Flourish 2 EL)	4	1 to 2 pt/ acre 2 to 4 pt/ acre	0	2	Preplant incorporated (broadcast or band); soil spray (broadcast or band); or injection (drip irrigation).
	metalaxyl (MetaStar 2 E)	4	4 to 8 pt/ acre	0	2	Preplant incorporated or surface application.
	propamocarb (Previcur Flex 6 F)	28	12.8 fl oz/100 gal	2	0.5	Rates based on rock wool cube saturation in the greenhouse. See label for use in seedbeds, drip system, and soil drench.
Downy mildew	ametoctradin + dimethomorph (Zampro4.38 SC)	45 + 40	14 oz/A	0	0.5	Make no more than 2 applications before alternating to a fungicide with different active ingredients. Do not rotate with Forum. Maximum of 3 applications per crop per season.
	azoxystrobin (Quadris 2.08 F)	11	11 to 15.4 fl oz/ acre	1	4 hr	Make no more than one application before alternating with a fungicide with a different mode of action. Apply no more than 2.88 qt per crop per acre per season. Resistance reported.
	azoxystrobin + chlorothalonil (Quadris Opti)	11 + M	3.2 pints/acre	1	0.5	Do not apply more than one foliar application before alternating with a fungicide with a different mode of action. Do not make more than 4 applications of QoI group 11 fungicides per crop per acre per year.
	chlorothalonil (various)	M	See label	See label	See label	See labels. Rates vary depending on the formulation. Spray at first appearance and then at 7 to 14 day interval. Avoid late-season application after plants have reached full maturity.
	chlorothalonil + potassium phosphite (Catamaran 5.27 SC)	M + 33	6 pints/acre	0	0.5	Apply no more than 50 pints per crop per acre per season.
	chlorothalonil + zoxamide (Zing!)	M + 22	36 fl oz/acre	0	0.5	May cause sunburn in watermelon fruit, see label for details.
	cyazofamid (Ranman 400 SC)	21	2.1 to 2.75 fl oz/ acre	0	0.5	Do not apply more than 6 sprays per crop. Make no more than 3 consecutive applications followed by 3 applications of fungicides from a different resistance management group.
	cymoxanil (Curzate 60 DF)	27	3.2 oz/acre	3	0.5	Use only in combination with labeled rate of protectant fungicide (e.g., mancozeb or chlorothalonil).
	dimethomorph (Forum 4.17SC)	40	6 fl oz/acre	0	0.5	Must be applied as a tank mix with another fungicide with a different mode of action. Do not make more than two sequential applications.
	famoxadone + cymoxanil (Tanos 50WP)	11 + 27	8 oz/acre	3	0.5	Do not make more than one application before alternating with a fungicide that has a different mode of action. Must be tank-mixed with contact fungicide with a different mode of action.
	fenamidone (Reason 500 SC)	11	5.5 fl oz/acre	14	0.5	Begin applications when conditions favor disease development, and continue on 5 to 10 day interval. Do not apply more than 22 fl oz per growing season. Alternate with fungicide from different resistance management group, and make no more than 4 total applications of Group 11 fungicides per season.
	fixed copper (various)	M	See labels	See label	See label	See label. Rates vary depending on the formulation. Repeated use may cause leaf yellowing.
	fluazinam (Omega 500F)	29	0.75 to 1.5 pints/ acre	30	0.5	**APPLY ONLY TO MELONS**. Initiate applications when conditions are favorable for disease development or when disease symptoms first appear. Repeat applications on a 7 to 10 day schedule.

TABLE 3-11. DISEASE CONTROL PRODUCTS FOR CUCURBITS (cont'd)

L. Quesada-Ocampo, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Downy mildew (cont'd)	fluopicolide (Presidio 4F)	43	3 to 4 fl oz/acre	2	0.5	Tank mix with another downy mildew fungicide with a different mode of action.
	fosetyl-AL (Aliette 80 WDG)	33	2 to 5 lb/acre	0.5	0.5	Do not tank mix with copper-containing products. Mixing with surfactants or foliar fertilizers is not recommended.
	mandipropamid (Revus 2.08F)	40	8 fl oz/acre	1	0.5	For disease suppression only. Resistance reported.
	mancozeb (various)	M	See labels	See label	See label	See label. Rates vary depending on the formulation. Labeled on all cucurbits.
	mefenoxam + chlorothalonil (Ridomil Gold Bravo, Flouronil 76.5 WP)	4 + M	2 to 3 lb/acre	7	2	Spray at first appearance and repeat at 14-day intervals. Apply full rate of protectant fungicide between applications. Avoid late-season application when plants reach full maturity. Resistance reported.
	oxathiapiprolin + chlorothalonil (Orondis Opti SC)	49 + M	1.7 to 2.5 pt/acre	0	0.5	Limit to 10 pt per acre per year. Limit to six foliar applications per acre per year for the same crop. Do not follow soil applications of Orondis with foliar applications of Orondis. Begin foliar applications prior to disease development and continue on a 5- to 14-day interval. Use the higher rates when disease is present.
	oxathiapiprolin (Orondis Ultra A) + mandipropamid (Orondis Ultra B)	49 + 40	2.0 to 4.8 fl oz/acre 8 fl oz/acre	0	4 hr	Limit to 19.2 fl oz of Orondis Ultra A and 32 fl oz of Orondis Ultra B per acre per year. Limit to six foliar applications per acre per year for the same crop. Do not follow soil applications of Orondis with foliar applications of Orondis. Begin foliar applications prior to disease development and continue on a 5- to 14-day interval. Use the higher rates when disease is present.
	propamocarb (Previcur Flex 6 F)	28	1.2 pt/acre	2	0.5	Begin applications before infection; continue on a 7 to 14 day interval. Do not apply more than 6 pt per growing season. Always tank mix with another Downy mildew product.
	pyraclostrobin (Cabrio 20 WG)	11	8 to 12 oz/acre	0	0.5	Make no more than one application before alternating to a fungicide with a different mode of action. Resistance reported.
	pyraclostrobin + boscalid (Pristine 38 WG)	11 + 7	12.5 to 18.5 oz/acre	0	1	Make no more than 4 applications per season. Resistance reported.
	trifloxystrobin (Flint 50 WDG)	11	4 oz/acre	0	0.5	Begin applications preventatively and continue as needed alternating applications of Ridomil Gold Bravo on a 7 to 14 day interval. Resistance reported.
	zoxamide + mancozeb (Gavel 75 DF)	22 + M	1.5 to 2 lb	5	2	Begin applications when plants are in 2-leaf stage, and repeat at 7 to 10 day intervals. Now labeled on all cucurbits. Maximum 8 applications per season.
Fusarium wilt	prothioconazole (Proline 480 SC)	3	5.7 fl oz/acre	7	0.5	One soil and two foliar applications allowed by either ground or chemigation application equipment (including drip irrigation). Do not use in water used for hand transplanting. Not for use in greenhouse/transplant house.
Gummy stem blight, Black rot	prothioconazole (Proline 480 SC)	3	5.7 fl oz/acre	7	0.5	One soil and two foliar applications allowed by either ground or chemigation application equipment (including drip irrigation). Do not use in water used for hand transplanting. Not for use in greenhouse/transplant house.
	tebuconazole (Monsoon 3.6 F)	3	8 oz/acre	7	0.5	Maximum 3 applications per season. Apply as a protective spray at 10 to 14 day intervals. Add a surfactant.
Leaf spots: *Alternaria*, Anthracnose (*Colletotrichum*), *Cercospora*, Gummy stem blight (*Didymella*), Target spot (*Corynespora*)	azoxystrobin (Quadris 2.08 F)	11	11 to 15.4 fl oz/acre	1	4 hr	Make no more than one application before alternating with a fungicide with a different mode of action. Apply no more than2.88 qt per crop per acre per season. Do not use for Gummy stem blight where resistance to group 11(QoI) fungicides exists.
	azoxystrobin + chlorothalonil (Quadris Opti)	11 + M	3.2 pints/acre	1	0.5	Do not apply more than one foliar application before alternating with a fungicide with a different mode of action. Do not make more than 4 applications of QoI group 11 fungicides per crop per acre per year.
	azoxystrobin + difenoconazole (Quadris Top 1.67 SC)	11 + 3	12 to 14 fl oz/acre	1	0.5	Not for Target spot. Make no more than one application before alternating with fungicides that have a different mode of action. Apply no more than 56 fl oz per crop per acre per season.
	chlorothalonil (various)	M	See label	See label	See label	See labels. Rates vary depending on the formulation.
	chlorothalonil + potassium phosphite (Catamaran 5.27 SC)	M + 33	6 pints/acre	0	0.5	Apply no more than 50 pints per crop per acre per season. Do not apply to watermelon fruit when stress conditions conducive to sunburn occur.
	cyprodinil + fludioxonil (Switch 62.5 WG)	9 + 12	11 to 14 oz/acre	1	0.5	Only for Alternaria and Gummy stem blight. Make no more than 2 applications before alternating to a different fungicide. Maximum of 4 to 5 applications at high and low rates.
	difenoconazole + cyprodinil (Inspire Super 2.82 SC)	3 + 9	16 to 20 fl oz/acre	7	0.5	Not for Target spot. Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Apply no more than 80 fl oz per crop per acre per season.
	famoxadone + cymoxanil (Tanos 50WP)	11 + 27	8 oz/acre	3	0.5	Only for Alternaria and Anthracnose; do not make more than one application before alternating with a fungicide that has a different mode of action; must be tank-mixed with contact fungicide with a different mode of action.

TABLE 3-11. DISEASE CONTROL PRODUCTS FOR CUCURBITS (cont'd)

L. Quesada-Ocampo, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Leaf spots: *Alternaria*, Anthracnose (*Colletotrichum*), *Cercospora*, Gummy stem blight (*Didymella*), Target spot (*Corynespora*) (cont'd)	fenamidone (Reason) 500 SC	11	5.5 fl oz/acre	14	0.5	Begin applications when conditions favor disease development, and continue on 5 to 10 day interval. Do not apply more than 22 fl oz per growing season. Alternate with fungicide from different resistance management group, and make no more than 4 total applications of Group 11 fungicides per season.
	fixed copper (various)	M	See label	See label	See label	See labels. Rates vary depending on the formulation. Repeated use may cause leaf yellowing.
	mancozeb (various)	M	See label	See label	See label	See labels. Rates vary depending on the formulation. Labeled on all cucurbits.
	fluopyram + tebuconazole (Luna Experience) 3.3 F	7 + 3	8 to 17 fl oz/acre	7	0.5	**APPLY ONLY TO WATERMELON.** Not for *Cercospora* or target spot. Make no more than 2 applications before alternating to a fungicide with different active ingredients. Do not rotate with tebuconazole. **Not labeled for use in Louisiana.**
	fluopyram + trifloxystrobin (Luna Sensation) 1.67 F	7 + 11	7.6 fl oz/acre	0	0.5	**APPLY ONLY TO WATERMELON** and only to control Alternaria and Anthracnose. Make no more than 2 applications be- fore alternating to a fungicide with different active ingredients. Maximum 4 applications per season. **Not labeled for use in Louisiana.**
	fluxapyroxad + pyraclostrobin (Merivon 500 SC)	7 + 11	4 to 5.5 fl oz/ acre	0	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications per crop.
	potassium phosphite + tebuconazole (Viathon)	33 + 3	4 pints/acre	7	0.5	A**PPLY ONLY TO WATERMELON.** Maximum 3 applications per crop.
	pyraclostrobin (Cabrio) 20 WG	11	12 to 16 oz/acre	0	0.5	Do not use for Gummy stem blight where resistance to group11 (QoI) fungicides exists. Make no more than one application before alternating to a fungicide with a different mode of action.
	pyraclostrobin + boscalid (Pristine) 38 WG	11 + 7	12.5 to 18.5 oz/ acre	0	1	Not for target spot. Do not use for gummy stem blight where resistance to group 7 and group 11 fungicides exists. Use highest rate for anthracnose. Make no more than 4 applications per season.
	thiophanate-methyl (Topsin M) 70 WP	1	0.5 lb/acre	0	0.5	Spray at first appearance and then at 7 to 10 day intervals. Resistance reported in gummy stem blight fungus.
	zoxamide + mancozeb (Gavel) 75 DF	22 + M	1.5 to 2 lb	5	2	Cercospora and Alternaria only. Begin applications when plants are in 2-leaf stage and repeat at 7 to 10 day intervals. Now labeled on all cucurbits. Maximum 8 applications per season.
Phytophthora blight	ametoctradin + dimethomorph (Zampro) 4.38SC	45 + 40	14 oz/acre	0	0.5	Make no more than 2 applications before alternating to a fungicide with different active ingredients. Do not rotate with Forum. Maximum of 3 applications per crop per season. Apply at planting as a preventive drench treatment. Addition of a spreading or penetrating adjuvant is recommended.
	cyazofamid (Ranman) 400 SC	21	2.75 lf oz/acre	0	0.5	Do not apply more than 6 sprays per crop. Make no more than 3 consecutive applications followed by 3 applications of fungicides from a different resistance man- agreement group. Resistant isolates have been found.
	dimethomorph (Forum) 4.17SC	40	6 fl oz/acre	0	0.5	Must be applied as a tank mix with another fungicide with a different mode of action. Do not make more than two sequential applications.
	fluopicolide (Presidio) 4F	43	3 to 4 fl oz/acre	2	0.5	Tank mix with another Phytophthora fungicide with a different mode of action. May be applied through drip irrigation to target crown rot phase.
	mandipropamid (Revus) 2.08F	40	8 fl oz/acre	0	0.5	For disease suppression only, apply as foliar spray with copper-based fungicide.
	oxathiapiprolin (Orondis Gold 200) + mefenoxam (Orondis Gold B)	49+4	2.4 to 19.2 fl oz/ acre 1.0 to 2.0 pt/acre	0	4 hr	Limit to 38.6 fl oz of Orondis Gold 200 per acre per year. Limit to four applications per acre per year for the same crop. Do not follow soil applications of Orondis with foliar applications of Orondis. Apply at planting in furrow, by drip, or in transplant water. Use the higher rates for heavier soils, for longer application intervals, or for susceptible varieties.
	oxathiapiprolin (Orondis Ultra A) + mandipropamid (Orondis Ultra B)	49+40	2.0 to 4.8 fl oz/acre 8 fl oz/acre	0	4 hr	Limit to 19.2 fl oz of Orondis Ultra A and 32 fl oz of Orondis Ultra B per acre per year. Limit to six foliar applications per acre per year for the same crop. Do not follow soil applications of Orondis with foliar applications of Orondis. Begin foliar applications prior to disease development and continue on a 5- to14-day interval. Use the higher rates when disease is present.
Plectosporium blight	azoxystrobin (Quadris) 2.08 F	11	11 to 15.4 fl oz/ acre	1	4 hr	Make no more than one application before alternating with a fungicide with a different mode of action. Apply no more than 2.88 quarts per crop per acre per season, and do not make more than four applications of Group 11 products.
	azoxystrobin + difenoconazole (Quadris Top) 1.67 SC	11 + 3	12 to 14 fl oz/acre	1	0.5	Make no more than one application before alternating with fungicides that have a different mode of action. Apply no more than 56 fl oz per crop per acre per season.

TABLE 3-11. DISEASE CONTROL PRODUCTS FOR CUCURBITS (cont'd)

L. Quesada-Ocampo, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Plectosporium blight (cont'd)	fluxapyroxad + pyraclostrobin (Merivon 500 SC)	7 + 11	4 to 5.5 fl oz/ acre	0	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications per crop.
	trifloxystrobin (Flint) 50 WDG	11	1.5 to 2 oz/acre	0	0.5	Make no more than one application before alternating with fungicides that have a different mode of action. Begin applications preventively when conditions are favorable for disease and continue as needed on a 7 to 14 day interval.
	pyraclostrobin (Cabrio) 20WG	11	12 to 16 oz/acre	0	0.5	Make no more than 1 application before alternating to a fungicide with a different mode of action.
Powdery mildew	acibenzolar-S-methyl (Actigard) 50 WP	P1	0.5 to 1 oz/acre	0	0.5	Apply to healthy, actively growing plants. Do not apply to stressed plants. Apply no more than 8 oz per acre per season.
	azoxystrobin + chlorothalonil (Quadris Opti)	11 + M	3.2 pints/acre	1	0.5	Do not apply more than one foliar application before alternating with a fungicide with a different mode of action. Do not make more than 4 applications of QoI group 11 fungicides per crop per acre per year.
	azoxystrobin + difenoconazole (Quadris Top) 1.67 SC	11 + 3	12 to 14 fl oz/acre	1	0.5	Make no more than one application before alternating with fungicides that have a different mode of action. Apply no more than 56 fl oz per crop per acre per season.
	chlorothalonil (various)	M	See label	See label	See label	Spray at first appearance and then at 7 to 14 day intervals. Avoid late-season application after plants have reached full maturity. Does not control PM on leaf undersides.
	chlorothalonil + potassium phosphite (Catamaran) 5.27 SC	M + 33	6 pints/acre	0	0.5	Apply no more than 50 pints per crop per acre per season. Do not apply to watermelon fruit when stress conditions conducive to sunburn occur.
	difenoconazole + cyprodinil (Inspire Super) 2.82 SC	3 + 9	16 to 20 fl oz/acre	7	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Apply no more than 80 fl oz per crop per acre per season.
	cyprodinil + fludioxonil (Switch) 62.5 WG	9 + 12	11 to 14 oz/acre	1	0.5	Make no more than 2 applications before alternating to a different fungicide. Maximum of 4 to 5 applications at high and low rates. Not for target spot, anthracnose, or Cercospora.
	fixed copper (various)	M	See label	See label	See label	See label. Rates vary depending on the formulation. Repeated use may cause leaf yellowing.
	cyflufenamid (Torino) 0.85 SC	U6	3.4 oz/acre	0	4 hr	Do not make more than 2 applications per crop.
	fluopyram + tebuconazole (Luna Experience) 3.3 F	7 + 3	8 to 17 fl oz/acre	7	0.5	**APPLY ONLY TO WATERMELON.** Make no more than 2 applications before alternating to a fungicide with different active ingredients. Do not rotate with tebuconazole. **Not labeled for use in Louisiana.**
	fluxapyroxad + pyraclostrobin (Merivon 500 SC)	7 + 11	4 to 5.5 fl oz/ acre	0	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications per crop.
	metrafenone (Vivando)	U8	15.4 fl oz/acre	0	0.5	Supplemental label expires December 31, 2017. Begin applications prior to disease and continue in a 7- to 10-day interval.
	myclobutanil (Rally) 40 WP	3	2.5 to 5 oz/acre	0	1	Apply no more than 1.5 lb per acre per crop. Observe a 30- day plant-back interval.
	penthiopyrad (Fontelis) 1.67 SC	7	12 to 16 fl oz/acre	1	0.5	Make no more than 2 sequential applications before switching to another fungicide. Do not rotate with Pristine or Luna Experience.
	pyraclostrobin + boscalid (Pristine) 38 WG	11 + 7	12.5 to 18.5 oz/ acre	0	1	Make no more than 4 applications per season.
	quinoxyfen (Quintec) 2.08 SC	13	4 to 6 fl oz/acre	3	0.5	Make no more than 2 applications before alternating to a different fungicide. Maximum of 24 fl oz/acre per year. **DO NOT USE ON SUMMER SQUASH or CUCUMBER**; labeled on winter squashes, pumpkins, gourds, melon and watermelon.
	sulfur (various)	M	See label	See label	See label	See labels. Rates vary depending on the formulation. Do not use when temperature is over 90 degrees F or on sulfur-sensitive varieties.
	tebuconazole (Monsoon) 3.6F	3	4 to 6 fl oz/acre	7	0.5	Apply before disease appears when conditions favor development and repeat at 10 to 14 day intervals; max 24 fl oz per season.
	triflumizole (Procure) 50 WS	3	4 to 8 oz/acre	0	0.5	Begin applications at vining or first sign of disease, and repeat at 7 to 10 day intervals.
Scab	acibenzolar-S-methyl (Actigard) 50 WP	P1	0.5 to 1 oz/acre	0	0.5	Apply to healthy, actively growing plants. Do not apply to stressed plants. Apply no more than 8 oz per acre per season.
	chlorothalonil (various)	M	See label	See label	See label	See labels. Rates vary depending on the formulation.
	chlorothalonil + potassium phosphite (Catamaran) 5.27 SC	M + 33	6 pints/acre	0	0.5	Apply no more than 50 pints per crop per acre per season. Do not apply to watermelon fruit when stress conditions conducive to sunburn occur.
Vine decline	fludioxonil (Cannonball)	12	4 to 8 oz/acre	14	0.5	APPLY ONLY TO MELONS.

TABLE 3-12. EFFICACY OF PRODUCTS FOR DISEASE CONTROL IN CUCURBITS

L. Quesada-Ocampo, Plant Pathologist, NCSU; A. Keinath, Plant Pathologist, Clemson University; S. Bost, Plant Pathologist, UT; M. Paret, Plant Pathologist, UF

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Product[1]	Fungicide group [F]	Preharvest interval (Days)	Alternaria Leaf Blight	Angular Leafspot	Anthracnose	Bacterial Fruit Blotch	Belly Rot	Cercospora Leaf Spot	Cottony Leak	Damping off (Pythium)	Downy Mildew	Gummy Stem Blight	Phytophthora Blight (foliage and fruit)	Phytophthora Blight (crown and root)	Plectosporium Blight	Powdery Mildew	Target Spot
acibenzolar-S-methyl (Actigard)	21	0	NC	ND	NC	F	NC	NC	ND	ND	ND	NC	ND	ND	NC	ND	NC
ametoctradin + dimethomorph (Zampro)	45+40	0	ND	NC	NC	NC	NC	NC	ND	ND	F	NC	G	G	NC	NC	NC
azoxystrobin[2] (Quadris)	11	1	G	NC	G	NC	F	G	NC	NC	NC[R]	NC[R]	NC	NC	F	NC[R]	G
azoxystrobin + chlorothalonil (Quadris Opti)	11 + M05	0	G	NC	G	NC	F	G	NC	NC	NC[R]	F	NC	NC	F	F	F
azoxystrobin + difenoconazole (Quadris Top)	11 + 3	1	ND	NC	G	NC	ND	ND	ND	ND	ND	F	ND	ND	F	F	ND
boscalid (Endura)	7	0	ND	NC	NC	NC	NC	ND	NC	NC	NC	NC[R]	NC	NC	ND	F[R]	ND
chlorothalonil[5] (various)	M05	0	F	NC	G	NC	NC	G	NC	NC	F	F	NC	NC	F	F	G
cyazofamid (Ranman)	21	0	NC	NC	NC	NC	NC	NC	ND	NC	G	NC	F	NC	NC	NC	NC
cyflufenamid (Torino)	U06	0	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	G	NC
cymoxanil (Curzate)	27	3	NC	NC	NC	NC	NC	NC	ND	ND	F	NC	F	NC	NC	NC	NC
cyprodinil + fludioxonil (Switch)	9 + 12	1	ND	NC	F	NC	ND	ND	NC	NC	NC	F	NC	NC	F	F	NC
difenoconazole + benzovindiflupyr (Aprovia Top)	3 + 7	0	ND	NC	F	NC	ND	ND	NC	NC	NC	G	NC	NC	ND	ND	ND
difenoconazole + cyprodinil (Inspire Super)	3 + 9	7	F	NC	P	NC	NC	F	NC	NC	NC	F	NC	NC	F	F	ND
dimethomorph (Forum)	40	0	NC	NC	NC	NC	NC	NC	NC	NC	P	NC	P	NC	NC	NC	NC
famoxadone[2] + cymoxanil (Tanos)	11 + 27	3	ND	NC	P	NC	NC	ND	NC	NC	F	NC	ND	NC	NC	NC	NC
fenamidone (Reason)	11	14	F	NC	ND	NC	NC	NC	ND	NC	F[R]	NC	F	NC	NC	NC	NC
fixed copper (various)[P, 5]	M01	1	P	F	P	F	NC	P	NC	NC	P	P	ND	NC	P	P	P
fluopicolide (Presidio)	43	2	NC	NC	NC	NC	NC	NC	NC	NC	P[R]	NC	F	F	NC	NC	NC
fluopyram + tebuconazole (Luna Experience)	7 + 3	7	ND	NC	NC	NC	ND	NC	NC	NC	NC	G	NC	NC	NC	G	NC
fluopyram + trifloxystrobin (Luna Sensation)	7 + 11	0	ND	NC	F	NC	NC	NC	NC	NC	NC	F	NC	NC	NC	F	NC
fluoxastrobin (Evito)	11	1	G	NC	G	NC	F	G	NC	NC	NC[R]	NC[R]	NC	NC	F	NC[R]	F
flutriafol (Rhyme, Topguard)[P]	3	0	ND	NC	NC	NC	NC	ND	NC	NC	NC	F	NC	NC	NC	P	NC
fluxapyroxad + pyraclostrobin (Merivon)	7 + 11	0	G	NC	F	NC	ND	ND	NC	NC	NC	F	NC	NC	F	ND	ND
kresoxim-methyl (Sovran)	11	0	ND	NC	ND	NC	ND	ND	NC	NC	ND	NC[R]	ND	NC	ND	NC[R]	ND
mancozeb (Dithane, Manzate, Penncozeb)[5]	M03	5	F	NC	G	NC	NC	G	NC	NC	F	F	P	NC	F	P	G
mancozeb + fixed copper [4] (ManKocide)	M03 + M05	5	P	F	F	F	NC	P	NC	NC	F	NC	P	NC	P	P	F
mandipropamid (Revus)	40	0	NC	NC	NC	NC	NC	NC	NC	NC	NC[R]	NC	F	P	NC	NC	NC
mefenoxam[33] (Ridomil Gold EC, Ultra Flourish)	4	0	NC	NC	NC	NC	NC	NC	F[R]	G[R]	NC	NC	F[R]	F[R]	NC	NC	NC
mefenoxam[2] + chlorothalonil[5] (Ridomil Gold/Bravo, Flouronil)	4 + M05	0	F	NC	F	NC	NC	F	F[R]	F[R]	F[R]	F	F[R]	NC	F	F	F
mefenoxam[2] + copper[5] (Ridomil Gold/Copper)	4 + M01	5	P	P	NC	P	NC	P	F[R]	F[R]	F[R]	NC	F[R]	NC	P	NC	P
mefenoxam[2] + mancozeb[5] (Ridomil Gold MZ)	4 + M03	5	F	NC	F	NC	NC	F	F[R]	F[R]	F[R]	F	F[R]	NC	F	NC	F
metrafenone (Vivando)	U08	0	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	G	NC
myclobutanil[2] (Rally)	3	0	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	F	NC
oxathiapiprolin (Orondis Opti, Orondis Ultra, Orondis Gold)	U15	0	ND	NC	ND	NC	ND	ND	NC	NC	G	ND	G	G	ND	ND	ND
penthiopyrad (Fontelis)	7	1	ND	NC	F	NC	ND	F	NC	NC	NC	NC[R]	NC	NC	NC	F	NC
phosphonate[6] (Aliette, Agri-Fos, Phostrol, ProPhyte)	33	0.5	NC	NC	NC	NC	NC	NC	NC	NC	P	NC	NC	F	NC	NC	NC
potassium phosphite + tebuconazole (Viathon)	33 + 3	7	ND	NC	ND	NC	ND	ND	ND	ND	P	F	ND	ND	NC	F	NC
propamocarb (Previcur Flex)	28	2	NC	NC	NC	NC	NC	NC	NC	ND	F	NC	G	NC	NC	NC	NC
prothioconazole (Proline)	3	7	ND	NC	NC	NC	ND	F	NC	NC	NC	G	NC	NC	ND	ND	ND
pyraclostrobin[2] (Cabrio)	11	0	G	NC	G	NC	NC	ND	NC	NC	NC[R]	NC[R]	P	NC	G	NC[R]	E
pyraclostrobin[2] + boscalid[2] (Pristine)	11 + 7	0	G	NC	F	NC	ND	G	NC	NC	NC[R]	NC[R]	P	NC	F	F	E
quinoxyfen (Quintec)	13	3	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	G	NC
sulfur (various)[P,5]	M	0	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	F	NC
tebuconazole (various)	3	7	ND	NC	NC	NC	NC	F	NC	NC	NC	F	NC	NC	NC	F	NC
tetraconazole (Mettle)	3	0	ND	NC	NC	NC	NC	ND	NC	NC	NC	NC	NC	NC	NC	F	NC
thiophanate-methyl[3] (Topsin M)	1	1	F	NC	F	NC	F	F	NC	NC	NC	NC[R]	NC	NC	F	NC[R]	P
trifloxystrobin[2] (Flint)	11	0	G	NC	G	NC	ND	ND	NC	NC	NC[R]	NC[R]	NC	NC	G	NC[R]	G
triflumizole (Procure)	3	0	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	F	NC
zoxamide + mancozeb (Gavel)	22 + M03	5	F	NC	F	NC	NC	F	NC	NC	F	F	P	NC	F	P	F

[1] Efficacy ratings do not necessarily indicate a labeled use for every disease.

[2] Curative activity; locally systemic.

[3] Systemic.

[4] When used in combination with chlorothalonil or mancozeb, gives increased control.

[5] Contact control only; no systemic control.

[6] Check manufacturers label for compatibility with other products.

[P] Can be phytotoxic at temperatures above 90°F; read the label carefully.

[F] To prevent resistance in pathogens, alternate fungicides within a group with fungicides in another group. Fungicides in the "M" group are generally considered "low risk" with no signs of resistance developing to the majority of fungicides.

[R] Resistance reported in the pathogen.

TABLE 3-13. IMPORTANCE OF ALTERNATIVE MANAGEMENT PRACTICES FOR DISEASE CONTROL IN CUCURBITS

L. Quesada-Ocampo, Plant Pathologist, NCSU; A. Keinath, Plant Pathologist, Clemson University; S. Bost, Plant Pathologist, UT; M. Paret, Plant Pathologist, UF

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Strategy	Alternaria leaf blight	Angular leaf spot	Anthracnose	Bacterial fruit blotch	Bacterial wilt	Belly rot	Cercospora leaf spot	Choanephora fruit rot	Cottony leak	Downy mildew	Gummy stem blight	Mosaic virus	Phytophthora blight	Plectosporium blight	Powdery mildew	Pythium damping off	Root knot	Target spot
Avoid field operations when leaves are wet	P	F	P	F	F	NC	NC	P	NC	P	P	NC	NC	ND	NC	NC	NC	NC
Avoid overhead irrigation	F	F	F	F	P	NC	P	NC	NC	F	F	NC	F	P	P	NC	NC	P
Change planting date from Fall to Spring[1]	G	P	G	P	P	F	G	F	F	G	G	F	F	F	F	G	G	G
Cover cropping with antagonist	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	F	NC
Crop rotation with non-host (2 to 3 years)	F	F	F	F	NC	P	F	NC	NC	NC	F	NC	F	F	NC	P	F	F
Deep plowing	P	NC	P	NC	NC	F	P	NC	NC	NC	F	NC	P	P	NC	P	F	P
Destroy crop residue immediately	F	P	F	P	P	P	P	NC	P	F	F	F	P	P	F	NC	F	P
Encourage air movement[2]	F	P	F	P	NC	NC	F	F	F	F	F	NC	NC	P	NC	NC	NC	F
Soil organic amendments[3]	ND	NC	ND	NC	NC	P	ND	NC	F	NC	ND	NC	P	ND	NC	F	F	ND
Insecticidal/horticultural oils[4]	NC	NC	NC	NC	F	NC	NC	NC	NC	NC	NC	F	NC	NC	F	NC	NC	NC
pH management (soil)	NC	NC	NC	NC	NC	NC	NC	NC	ND	NC	NC	NC	ND	NC	NC	ND	ND	NC
Plant in well-drained soil	NC	NC	NC	NC	NC	F	NC	P	F	NC	NC	NC	F	NC	NC	F	P	NC
Plant on raised beds	NC	NC	NC	NC	NC	P	NC	P	F	NC	F	NC	F	NC	NC	F	P	NC
Plastic mulch bed covers	NC	NC	NC	NC	NC	F	NC	P	F	NC	F	NC	F	P	NC	NC	NC	NC
Postharvest temperature control (fruit)	NC	NC	F	F	NC	F	NC	F	F	NC	F	NC	F	F	NC	NC	NC	NC
Reflective mulch (additional effect over plastic mulch)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	F	NC	NC	NC	NC	NC	NC
Reduce mechanical injury	P	P	P	P	F	P	P	P	P	NC	P	P	P	P	NC	NC	NC	P
Rogue diseased plants/fruit (home garden)	F	P	P	P	P	NC	P	P	P	P	P	F	F	NC	NC	P	F	P
Row covers (insect exclusion)	NC	NC	NC	NC	G	NC	NC	NC	NC	NC	NC	G	NC	NC	NC	NC	NC	NC
Soil solarization (reduce soil inoculum)	P	NC	P	NC	NC	F	P	NC	P	NC	P	NC	P	P	NC	F	P	P
Pathogen-free planting material	P	E	F	E	NC	NC	NC	NC	NC	NC	E	NC	NC	NC	NC	F	NC	NC
Resistant cultivars[5]			E			E				E		E			E			
Destroy volunteer plants	F	F	F	F	F	NC	F	NC	NC	F	F	F	F	NC	F	NC	P	F

[1] Early planting reduces risk.

[2] Air movement can be encouraged by increasing plant spacing, orienting beds with prevailing wind direction and increasing exposure of field to prevailing wind.

[3] Soil organic amendments = cover crops; composted organic wastes.

[4] Insecticidal/Horticultural oil = Sunspray Ultra-Fine Spray Oil (Sun Company, Inc.), JMS Stylet oil; Safe-T-Side (Brandt Consolidated, Inc.); PCC 1223 (United Ag Products).

[5] Resistance available in some cucurbits.

TABLE 3-14. EXAMPLE SPRAY PROGRAM FOR FOLIAR DISEASE CONTROL IN WATERLEMON PRODUCTION

A. Keinath, Plant Pathologist, Clemson University

This spray program is based on research conducted at the Clemson Coastal Research and Education Center, Charleston, SC, and on a survey of watermelon fields in South Carolina in 2015 and 2016. The most common diseases in both survey years were gummy stem blight and powdery mildew. The spring program is designed to manage bacterial fruit blotch, bacterial leaf spots, gummy stem blight, powdery mildew, anthracnose, and downy mildew. The fall program is designed to manage gummy stem blight, downy mildew, and anthracnose.

- Protectants (chlorothalonil and mancozeb) are effective against anthracnose all season, but other disease-specific fungicides must be used against gummy stem blight, downy mildew, and powdery mildew. See Tables 3-11 and 3-12.
- Start spraying when vines start to run or no later than when the first blooms (the male ones) open.
- In the spring season, check http://cdm.ipmpipe.org to see where and when downy mildew has been reported on watermelon. In the fall, spray preventatively for downy mildew. Substitute Orondis Opti for Ranman if downy mildew is present in your field.
- From vine run until mid-May, spray every 10 days. After mid-May or when powdery and downy mildew typically show up in your area, spray every week through harvest regardless of the weather. Weekly sprays are needed to protect watermelon from powdery and downy mildew. Dry weather limits gummy stem blight but promotes powdery mildew; dry weather does not limit downy mildew or anthracnose if they are already present in a field.
- Do not stop spraying until you stop harvesting. Downy and powdery mildew can attack a crop any time it goes more than one week without a fungicide spray. Fungicides with a 7-day PHI are not recommended during the harvest period (usually after week 5); note that mancozeb and Gavel have a 5-day PHI.
- If this spray schedule is used to select fungicides for other cucurbits (vine crops), note that not all fungicides in this spray schedule are labeled on other cucurbits. Luna Experience is registered only on watermelon. Luna Experience is not registered for use in Louisiana. Quintec is not registered on cucumber. To control powdery mildew on other cucurbits or in Louisiana, use Procure in place of Luna fungicides or Quintec.

Spray	Fungicide Program for Spring Watermelon*	Comments on Spring Program	Fungicide Program for Fall Watermelon*
1 (vine run)	mancozeb + fixed copper	For prevention of bacterial leaf spots.	chlorothalonil or Catamaran
2	chlorothalonil or Catamaran	Do not tank mix copper with chlorothalonil.	chlorothalonil
3a**	tebuconazole	If fruit blotch is a concern, add fixed copper.	tebuconazole + **Ranman**
3b**	tebuconazole + Flint	Add Flint if anthracnose fruit rot was found the previous year.	(same as 3a)
4	chlorothalonil (or mancozeb)	If fruit blotch is a concern, substitute mancozeb + fixed copper.	Quadris Top
5a**	mancozeb + Quintec	The protectant switches here from chlorothalonil to mancozeb to avoid injury to fruit on hot, sunny days.	Gavel
5b**	Luna Experience	Use Luna Experience if gummy stem blight is present.	(same as 5a)
6	Gavel	Note 5-day PHI.	mancozeb
7a**	mancozeb + Torino	Note 5-day PHI on mancozeb.	mancozeb + **Ranman**
7b**	Switch	Use Switch if gummy stem blight is present.	Switch
8	mancozeb + **Ranman**	If downy mildew is seen earlier in the season, apply Ranman as soon as possible.	chlorothalonil
9-12	If more sprays are needed after spray 8 until the last harvest, apply sprays 5 to 8 again.		

*Fungicides that control downy mildew are in bold. Fungicides that control powdery mildew are underlined.

**Option "a" is a lower cost treatment that may be less effective. Option "b" is a more expensive fungicide that also is more effective

TABLE 3-15. DISEASE CONTROL PRODUCTS FOR EGGPLANT

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC Code	Rate of Material Formulation	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Anthracnose fruit rot, Early blight, Gray mold	azoxystrobin (various)	11	See labels	0	4 hr	Apply at flowering to manage green fruit rot. Limit of 61.5 fl oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action. Labeled for anthracnose ONLY.
	boscalid (Endura 70 WG)	7	2.5 to 3.5 oz/acre	0	0.5	Limit of 21 oz per acre per season. Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Labeled for early blight and gray mold ONLY.
	chlorothalonil (various)	M5	1.5 pt/acre	3	1	Limit of 12 pt per acre per season. Labeled for anthracnose and gray mold ONLY.
	difenoconazole + benzovindiflupyr (Aprovia Top 1.62EC)	3 + 7	10.5 to 13.5 fl oz/acre	14	0.5	Make no more than 2 consecutive applications before switching to a non-Group 7 fungicide. Make no more than 5 applications at the low rate or 4 applications at the high rate per year. Labeled for anthracnose ONLY.
	fenamidone (Reason500 SC)	11	5.5 to 8.2 fl oz/acre	14	0.5	Limit of 24.6 fl oz per growing season. Make no more than **one** application before rotating to another effective fungicide with a different mode of action. Labeled for early blight only.
	fluoxastrobin (Aftershock, Evito 280 SC)	11	2 to 5.7 fl oz/acre	3	0.5	Limit of 22.8 fl oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action. **NOTE: Do not overhead irrigate for 24 hours following a spray application.** Labeled for early blight only.
	penthiopyrad (Fontelis1.67 SC)	7	16 to 24 fl oz/acre	0	0.5	Limit of 72 fl oz per acre per year. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.

TABLE 3-15. DISEASE CONTROL PRODUCTS FOR EGGPLANT (cont'd)

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC Code	Rate of Material Formulation	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Anthracnose fruit rot, Early blight, Gray mold (cont'd)	pyraclostrobin various	11	8 to 12 oz/acre	0	4 hr	Apply at flowering to manage green fruit rot. Limit of 96 oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action.
	pyraclostrobin + fluxapyroxad (Priaxor500 SC)	11 + 7	4.0 to 8.0 fl oz/acre	0	0.5	Limit of 24 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action. Labeled for anthracnose and early blight ONLY.
Phomopsis fruit rot	copper (various)	M1	See labels	See labels	2	Make first application at flowering. If disease is present, make additional applications at 7 to 10-day intervals. Do not spray copper when temperatures are above 90 °F.
Phytophthora blight	ametoctradin + dimethomorph (Zampro525 SC)	45 + 40	14 fl oz/acre	4	0.5	Limit of 3 applications per acre per season. Make no more than two sequential applications before rotating to another effective fungicide with a different mode of action.
	cyazofamid (Ranman400 SC)	21	2.75 fl oz/acre	0	0.5	Limit of 16.5 fl oz per acre per season. Apply to the base of the plant at transplanting or in the transplant water. Make no more than three consecutive applications followed by three consecutive applications of another effective fungicide with a different mode of action.
	copper (various)	M1	See labels	0	2	Begin applications when conditions first favor disease development and repeat at 3 to 10 day intervals if needed depending on disease severity. Use the higher rates when conditions favor disease. Do not spray copper when temperatures are above 90 °F.
	dimethomorph (Acrobat, Forum)	40	6 fl oz/acre	0	0.5	**SUPPRESSION ONLY**. Limit of 30 fl oz per acre per season. Make no more than two sequential before alternating with fungicides that have a different mode of action. **NOTE: Must tank mix with another fungicide with a different mode of action.**
	famoxadone + cymoxanil (Tanos 50 DF)	11 + 27	8 to 10 oz/acre	3	0.5	**SUPPRESSION ONLY**. Make no more than **one** application before alternating with a fungicide with a different mode of action. **NOTE: Must tank mix with another fungicide with a different mode of action (i.e. copper).**
	fluazinam (Omega500 F)	29	1 to 1.5 pt/acre	30	0.5	Apply as a soil drench at 1.5 pt per acre. For foliar applications, use 1 pt per acre. Limit of 9 pt per acre per season.
	fluopicolide (Presidio4 SC)	43	3 to 4 fl oz/acre	2	0.5	Limit of 4 applications at the low rate or 3 applications at the high rate per season. Make no more than two times sequentially before alternating with fungicides that have a different mode of action. **NOTE: Must be tank-mixed with another mode of action product.**
	mefenoxam + copper hydroxide (Ridomil Gold +Copper)	4 + M1	2 lb/acre	7	2	See label for an optimal spray program. Limit of four applications per crop per year. Do not exceed 0.4 lb a.i. per acre per season of mefenoxam + metalaxyl (MetaStar).
	oxathiapiprolin + mefenoxam (Orondis Gold 200 + Orondis Gold B)	U15 + 4	2.4 to 19.2 fl oz/acre + 1 pt/acre	7	4 hr	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications per crop per year. **Must tank mix both products before application.**
	mandipropamid (Revus2.08 F, Micora)	40	8 fl oz/acre	1	0.5	**SUPPRESSION ONLY**. Limit of 4 applications per acre per season. **NOTE: Must tank mix with another fungicide with a different mode of action (i.e. copper).**
Southern blight	fluoxastrobin (Aftershock, Evito 280SC)	11	2 to 5.7 fl oz/acre	3	0.5	Limit of 22.8 fl oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action. **NOTE: Do not overhead irrigate for 24 hours following a spray application.**
	penthiopyrad (Fontelis1.67 SC)	7	16 to 24 fl oz/acre	0	0.5	Apply 5 to 10 days after transplanting and again 14 days later. Limit of two applications per crop. Follow with a FRAC Group 11 fungicide if additional protection is needed.
	pyraclostrobin various	11	12 to 16 oz/acre	0	4 hr	**SUPPRESSION ONLY**. Apply at flowering to manage green fruit rot. Limit of 4 applications per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action.
	pyraclostrobin + fluxapyroxad (Priaxor500 SC)	11 + 7	4.0 to 8.0 fl oz/acre	0	0.5	Limit of 2 applications per season. Best option based on tests on tomato in SC.
Pythium root rot	mefenoxam (various)	4	See labels	—	2	**MAY ONLY BE APPLIED AT PLANTING**. Apply in a 12 to 16 in. band or in 20 to 50 gal water per acre in transplant water. Mechanical incorporation or 0.5 to 1 in. irrigation water is needed for movement into root zone if rain is not expected. After initial application, two supplemental applications (1 pt per treated acre) can be applied.

TABLE 3-15. DISEASE CONTROL PRODUCTS FOR EGGPLANT (cont'd)

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC Code	Rate of Material Formulation	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Pythium root rot (cont'd)	metalaxyl (MetaStar2 E)	4	4 to 8 pt/treated acre	7	2	Limit of 12 pt per acre per season. Preplant (soil incorporated), at planting (in water or liquid fertilizer), or as a basil-directed spray after planting. See label for the guidelines for supplemental applications.
Rhizoctonia seedling and root rot	azoxystrobin (various)	11	0.4 to 0.8 fl oz/ 1,000 row feet	—	4 hr	Make in-furrow or banded applications shortly after plant emergence. Under cool, wet conditions, crop injury from soil directed applications may occur.
	difenoconazole + benzovindiflupyr (Aprovia Top 1.62 EC)	3 + 7	10.5 to 13.5 fl oz/acre	14	0.5	Make no more than 2 consecutive applications before switching to a non-Group 7 fungicide. Make no more than 5 applications at the low rate or 4 applications at the high rate per year.
Verticillium wilt	Polyoxin D (OSO 5%)	19	6.5 to 13 fl oz/acre	0	4 hr	**SUPPRESSION ONLY.** Can be applied using banded or irrigation water applications. Limit of 6 applications at maximum rate per acre per season.

TABLE 3-16. DISEASE CONTROL PRODUCTS FOR GARLIC

E. Pfeufer, Plant Pathologist, University of Kentucky

Disease	Material	FRAC Code	Rate of Material Formulation	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Botrytis blight (*Botrytis* spp.), purple blotch (*Alternaria porri*), downy mildew (*Peronospora destructor*)	azoxystrobin (various)	11	6.2 to 15.4 fl oz/acre	0	4 hr	Use higher rate for downy mildew and Botrytis. Do not make more than two sequential applications.
	azoxystrobin + difenoconazole (Quadris Top)	11+3	14 fl oz/acre	7	0.5	Begin sprays prior to disease onset and spray on a 7 to 14 day schedule. Do not rotate with Group 11 fungicides.
	azoxystrobin + chlorothalonil (Quadris Opti)	11+M	1.6 to 3.2 pt/acre	14	0.5	Make no more than one application before alternating with a fungicide with a different mode of action. Use higher rates for downy mildew.
	boscalid (Endura) 70 WG	7	6.8 oz/acre	7	0.5	Not for downy mildew. Do not make more than 2 sequential applications or more than 6 applications per season.
	chlorothalonil (various)	M	See label	7	2	Spray at first appearance; 7-14 day intervals.
	chlorothalonil + cymoxanil (Ariston)	M+27	1.6 to 2.4 pt/acre	7	0.5	Not for Botrytis blight. Apply prior to favorable infection periods; continue on 7 to 9 day interval; alternate with a different mode of action.
	chlorothalonil + zoxamide (Zing!)	M+22	30 fl oz/acre	7	0.5	Follow protective spray schedule when diseases are in the area; continue on 7-day interval.
	difenoconazole + cyprodinil (Inspire Super)	3+9	16 to 20 fl oz/acre	14	0.5	Make no more than two applications before alternating with a fungicide with a different mode of action.
	famoxadone + cymoxanil (Tanos)	11+27	8 oz/acre	3	0.5	Not for Botrytis.
	fenamidone (Reason)	11	5.5 oz/acre	7	0.5	**Not for Botrytis.**
	fluazinam (Omega 500)	29	1.0 pt/acre	7	1	Initiate sprays when conditions are favorable for disease at disease onset. Spray on a 7 to 10 day or schedule.
	fluxapyroxad + pyraclostrobin (Merivon)	7+11	4 to 11 fl oz/acre	7	0.5	Use higher rates for downy mildew suppression. Apply at disease onset; continue on 7 to 14 day schedule. No more than 3 applications/season.
	mefenoxam + chlorothalonil (Ridomil Gold/Bravo)	4+M	2.5 pt/acre	7	2	Spray at first appearance; 7 to 14 day intervals.
	pyraclostrobin (Cabrio)	11	8 to 12 oz/acre	7	0.5	Not for *Botrytis*. Use highest rate for downy mildew. Make no more than 2 sequential applications and no more than 6 applications per season.
	pyraclostrobin + boscalid (Pristine 38 WG)	11+7	10.5 to 18.5 oz/acre	7	1	Use highest rate for suppression only on downy mildew. Make no more than 6 applications per season.
	pyrimethanil (Scala 5F)	9	9 or 18 fl oz/acre	7	0.5	Not for downy mildew. Use lower rate in a tank mix with broad-spectrum fungicide and higher rate when applied alone. Do not apply more than 54 fl oz per crop.
Downy mildew (*Peronospora destructor*)	dimethomorph (Forum 50 WP)	40	6.4 oz/acre	0	0.5	Must be applied as a tank mix with another fungicide active against downy mildew; apply every 7 to10 days. Do not make more than two sequential applications.
	mandipropamid (Revus)	40	8.0 fl oz/acre	7	0.5	Apply as a tank mix with another fungicide active against downy mildew. Apply with a silicone-based adjuvant. 7 to 10 day schedule.
	mefenoxam + mancozeb (Ridomil Gold MZ)	4+M	2.5 lb/acre	7	2	Use with a suitable adjuvant.
	ametoctradin + dimethomorph (Zampro)	45+40	14.0 fl oz/acre	0	12 hr	Tank-mix with a broad-spectrum fungicide like chlorothalonil or mancozeb.

TABLE 3-16. DISEASE CONTROL PRODUCTS FOR GARLIC (cont'd)

E. Pfeufer, Plant Pathologist, University of Kentucky

Disease	Material	FRAC Code	Rate of Material Formulation	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
White rot *(Sclerotium cupartum)*	azoxystrobin (various)	11	See labels	0	4 hr	Do not make more than two sequential applications.
	azoxystrobin + chlorothalonil (Quadris Opti)	11+M	1.6 to 3.2 pt/acre	7	0.5	Make no more than one application before alternating with a fungicide with a different mode of action.
	boscalid (Endura)	7	6.8 oz/acre	7	0.5	Apply at planting in a 4- to 6-inch banded spray. Under high disease pressure, apply as a foliar spray.
	iprodione (Rovral 50 WP)	2	4 lb/acre	—	1	Spray cloves as they are being covered by soil (38 to 40 in. bed spacing). One application per year.
	metam-sodium (various)	—	37.5 to 75 gal/acre	—	2	Rate is based on soil properties and depth of soil to be treated.

TABLE 3-17. DISEASE CONTROL PRODUCTS FOR HOP

L. Quesada-Ocampo, Plant Pathologist, NCSU

Disease	Material	FRAC Code	Rate of Material For-mulation	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Downy mildew (*Pseudoperonospora humuli*)	fosetyl-Al (Aliette WDG)	33	2.5/acre	24	0.5	Apply as a directed foliar spray. When conditions are warm and humid applications should be made as follows: (1) when shoots are 6-12 inches high; (2) after training when vines are 5-6 feet tall; (3) approximately three weeks after the second application; and (4) during bloom. Use sufficient volume of water to insure complete coverage of foliage.
	fixed copper (various)	M	See label	See label	See label	See labels. Rates vary depending on the formulation. Repeated use may cause leaf yellowing.
	dimethomorph (Forum)	40	6 fl oz/acre	7	0.5	Begin sprays prior to disease. Minimum interval is 10 days. Maximum 3 applications per season.
	cymoxanil (Curzate 60DF)	27	3.2 oz/acre	7	0.5	Tank mix with a protectant fungicide. Begin applications prior to disease and continue at 10- to 14-day intervals.
	potassium phosphite (various)	33	See label	See label	See label	See labels. Rates vary depending on the formulation.
	metalaxyl (MetaStar 2E)	4	1 qt/acre	45	2	Apply as a soil drench (1qt/acre in 20 gals) and follow with foliar fixed copper applications. Apply as foliar spray (1 qt/acre in 50 gals) in combination with fixed copper. Do not make more than 3 applications per season.
	ametoctradin + dimethomorph (Zampro)	45 + 40	11 to 14 fl oz/acre	7	0.5	Begin applications prior to disease and continue at 10- day intervals. Do not make more than 3 applications per season.
	famoxadone + cymoxanil (Tanos)	27 + 11	8 oz/acre	7	0.5	Begin applications prior to disease and continue at 6- to 8-day intervals. Do not make more than 6 applications per season.
	mefenoxam (Ridomil Gold SL)	4	0.50 pt/acre	45	2	Can apply as soil drench or foliar spray, see label for details. Tank mix with fixed copper.
	mandipropamid (Revus)	40	8 fl oz/acre	7	4 hr	Begin applications prior to disease and continue at 7- to 10-day intervals. Do not make more than 3 applications per season.
	cyazofamid (Ranman 400 SC)	21	2.5 to 2.75 fl oz/ acre	3	0.5	Begin applications prior to disease and continue at 7- to 10-day intervals. Do not apply more than 32 fl oz per season.
Powdery mildew (*Sphaerotheca humuli, S. macularis*)	tebuconazole (Folicur 3.6F)	3	4 to 8 fl oz/acre	14	0.5	Begin applications prior to disease and continue at 10- to 14- day intervals. Do not apply more than 16.5 fl oz per acre per season.
	trifloxystrobin (Flint)	11	See label	14	0.5	Several rates available. Begin applications prior to disease and continue at 10- to 14-day intervals.
	metrafenone (Vivando)	U8	15.4 fl oz/acre	3	0.5	Begin applications prior to disease and continue at 7- to 14-day intervals. Do not make more than 2 applications per season.
	quinoxyfen (Quintec)	13	8.2 fl oz/acre	21	0.5	Do not make more than 4 applications per season.
	triflumizole (Procure 400 SC)	3	12 fl oz/acre	7	0.5	Begin applications prior to disease and continue at 14-day intervals. Do not apply more than 36 fl oz per acre per season.
	pyraclostrobin + boscalid (Pristine)	11 + 7	See label	14	0.5	Ground and aerial applications allowed, see label for details. Begin ground applications prior to disease and continue at10- to 21-day intervals. Do not make more than 3 applications per season.

TABLE 3-18. DISEASE CONTROL PRODUCTS FOR GREENS, LEAFY BRASSICA

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC Code	Rate of Material	Minimum Days Harv.	Minimum Days Reentry	Method, Schedule, and Remarks
Leafy Brassica Greens (Collard, Kale, Mustard, Rape Salad Greens, Turnip Greens). For turnips harvested for roots, see Remarks and Table 3-31 Root Vegetables.						
Alternaria leaf spot, Cercospora leaf spot, Anthracnose, White spot, and various foliar diseases (see specific labels)	boscalid (Endura 70 WG)	7	6 to 9 oz/acre	14	0.5	Begin applications prior to disease development, and continue on a 7 to 14 day interval. Make no more than 2 applications per season. **Do not apply to turnip greens or roots.**
	azoxystrobin + difenoconazole (Quadris Top 2.72 SC)	11 + 3	12 to 14 fl oz/acre	1	0.5	Make no more than one application before alternating to another fungicide with a different mode of action (NOT Quadris or Cabrio).
	azoxystrobin (various)	11	see labels	0	4 hr	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. **May be applied to turnip grown for roots.**
	fluxapyroxad + pyraclostrobin (Priaxor 500 SC)	7 + 11	6.0 to 8.2 fl oz/ acre	3	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications. **Do not apply to turnip greens or roots.**
	pyraclostrobin (Cabrio 20 EG, Pyrac 2 EC)	11	12 to 16 oz/acre 8 to 12 oz/acre (turnip greens)	3	0.5	Begin applications prior to disease development and continue on a 7 to 10 day interval. Make no more than 2 sequential applications before alternating to a fungicide with a different mode of action.
	tebuconazole (various)	3	3 to 4 oz/acre	7	0.5	For optimum results use as a preventative treatment. Folicur 3.6 F must have 2 to 4 hours of drying time on foliage for the active ingredient to move systemically into plant tissue before rain or irrigation occurs
	cyprodonil + fludioxonil (Switch 62.5WG)	9 + 12	11 to 14 oz/acre	7	0.5	Apply when disease first appears, and continue on 7 to 10 day intervals. See label for complete list of greens.
	penthiopyrad (Fontelis 1.67 SC)	7	14 to 30 fl oz/acre	0	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. **May be applied to turnips grown for roots.**
	difenoconazole + cyprodinil (Inspire Super 2.82SC)	3 + 9	16 to 20 fl oz/acre	7	0.5	Make no more than 2 sequential applications before alternating to a fungicide with a different mode of action.
Bacterial blight (*Pseudomonas*), Xanthomonas leaf blight	none					Based on field trials in SC, no fungicides, bactericides, or biopesticides are effective against these diseases. Use a 1-yr crop rotation away from all brassicas and early or once-over harvesting if disease appears.
Botrytis gray mold	penthiopyrad (Fontelis 1.67 SC)	7	14 to 30 fl oz/acre	0	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. **May be applied to turnips grown for roots.**
	difenoconazole + cyprodinil (Inspire Super 2.82SC)	3 + 9	16 to 20 fl oz/acre	7	0.5	Make no more than 2 sequential applications before alternating to a fungicide with a different mode of action.
Downy Mildew	pyraclostrobin (Cabrio 20 EG)	7	12 to 16 oz/acre	3	0.5	Begin applications prior to disease development and continue on a 7 to 10 day interval. Make no more than 2 sequential applications before alternating to a fungicide with a different mode of action.
	fluopicolide (Presidio 4 SC)	43	3 to 4 fl. oz/acre	2	0.5	Make applications on a 7 to 10 day schedule. Presidio must be tank mixed with another fungicide with a different mode of action. Make no more than 2 sequential applications before rotating to a fungicide with a different mode of action. Apply no more than 12 oz per acre and make no more than 4 applications per season.
	cyazofamid (Ranman 400 SC)	21	2.75 fl. oz/acre	0	0.5	Make applications on a 7 to 10 day schedule. Do not apply more than 39.5 fl. oz/acre per crop growing season.
	mandipropamid (Revus 2.08 SC)	40	8.0 fl oz/acre	1	0.5	Begin applications prior to disease development and continue on a 7 to 10 day interval. Make no more than 2 consecutive applications before switching to another effective non-group 40 fungicide. **Do not apply to turnip greens or roots.**
	fenamidone (Reason 500SC)	11	5.5 to 8.2 oz/acre	2	0.5	Begin applications as soon as conditions become favorable for disease development. Applications should be made on a 5 to 10 day interval. Do not make more than one application of Reason 500 SC before alternating with a fungicide from a different resistance management group.
	ametoctradin + dimethomorph (Zampro 525 SC)	45 + 40	14 fl oz/acre	0	0.5	Do not make more than 2 sequential applications before alternating to a fungicide with a different mode of action. Addition of an adjuvant may improve performance (see label for specifics).
	dimethomorph (Forum4.16 SC)	40	6.4 oz/acre	0	0.5	Must be tank-mixed with another fungicide active against Phytophthora blight. Do not make more than 2 sequential applications before alternating to another effective fungicide with a different mode of action. Do not make more than 5 applications per season. **Do not apply to turnip greens or roots.**

TABLE 3-18. DISEASE CONTROL PRODUCTS FOR GREENS, LEAFY BRASSICA (cont'd)

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC Code	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Downy Mildew (cont'd)	fosetyl-Al (Aliette 80W DG)	33	2 to 5 lb/acre	3	1	Apply when disease first appears; then repeat on 7 to 21 day intervals. Do not tank mix with copper fungicides. A maxi- mum of 7 applications can be made per season. **Do not apply to turnip greens or roots.**
	potassium phosphite (various)	33	2 to 4 pt/acre	0	4 hr	Apply when weather is foggy as a preventative. Do not apply to plants under water or temperature stress. Spray solution should have a pH greater than 5.5. Apply in at least 30 gal water per acre.
Powdery mildew	boscalid (Endura 70 WG)	7	6 to 9 oz/acre	14	0.5	Begin applications prior to disease development, and continue on a 7 to 14 day interval. Make no more than 2 applications per season; disease suppression only. **Do not apply to turnip greens or roots.**
	pyraclostrobin (Cabrio 20 EG, Pyrac 2 EC)	11	12 to 16 oz/acre	3	0.5	Begin applications prior to disease development and continue on a 7 to 10 day interval. Make no more than 2 sequential applications before alternating to a fungicide with a different mode of action.
	triflumizole (Procure 480SC)	3	6 to 8 oz/acre	1	0.5	Make no more than two sequential applications before rotating with a fungicide with a different mode of action. Do not rotate with Rally or Nova.
	cyprodonil + fludioxonil (Switch 62.5WG)	9 + 12	11 to 14 oz/acre	7	0.5	Apply when disease first appears, and continue on 7 to 10 day intervals. See label for complete list of greens. May be used on turnip where leaves only will be harvested. **Do not apply to turnip grown for roots.**
	penthiopyrad (Fontelis 1.67 SC)	7	14 to 30 fl oz/acre	0	0.5	Make no more than 2 sequential applications before alternating with fungicides that have a different mode of action. **May be applied to turnips grown for roots.**
	difenoconazole + cyprodinil (Inspire Super)	3 + 9	16 to 20 fl oz/acre	7	0.5	Make no more than 2 sequential applications before alternating to a fungicide with a different mode of action.
	fluxapyroxad + pyraclostrobin (Priaxor 500 SC)	7+11	6.0 to 8.2 fl oz/ acre	3	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications. **Do not apply to turnip greens or roots.**
	tebuconazole (various)	3	3 to 4 oz/acre	7	0.5	For optimum results use as a preventative treatment. Folicur 3.6 F must have 2 to 4 hours of drying time on foliage for the active ingredient to move systemically into plant tissue before rain or irrigation occurs. **May be applied to turnip grown for roots.**
Rhizoctonia bottom rot	boscalid (Endura 70 WG)	7	6 to 9 oz/acre	14	0.5	Begin applications prior to disease development, and continue on a 7 to 14 day interval. Make no more than 2 applications per season; disease suppression only. **Do not apply to turnip greens or roots.**
Sclerotinia stem rot (White mold)	boscalid (Endura 70 WG)	7	6 to 9 oz/acre	14	0.5	Begin applications prior to disease development, and continue on a 7 to 14 day interval. Make no more than 2 applications per season. **Do not apply to turnip greens or roots.**
	penthiopyrad (Fontelis 1.67 SC)	7	16 to 30 fl oz/acre	0	0.5	Do not exceed 72 fl oz of product per year. Make no more than 2 sequential applications per season before rotating to another effective product with a different mode of action.
	Coniothyrium minitans (Contans WG)	—	1 to 4 lb/acre	0	4 hr	**OMRI listed product.** Apply to soil surface and incorporate no deeper than 2 inches. Works best when applied prior to planting or transplanting. Do not apply other fungicides for 3 weeks after applying Contans.
Seedling root rot, basal stem rot (Rhizoctonia)	azoxystrobin (Quadris 2.08 SC)	11	0.4 to 0.8 fl oz per 1000 row feet	0	4 hr	Apply at planting as a directed spray to the furrow in a band 7 inches wide.
White rust	azoxystrobin (Quadris 2.08 SC)	11	6.2 to 15.4 fl oz/ acre	0	4 hr	Make no more than 2 sequential applications.
	fenamidone (Reason 500SC)	11	8.2 oz/acre	2	0.5	Begin applications as soon as conditions become favorable for disease development. Applications should be made on a 5 to 10 day interval. Do not make more than 1 application of Reason 500 SC before alternating with a fungicide from a different resistance management group.
	fluxapyroxad + pyraclostrobin (Priaxor 500 SC)	7 + 11	6.0 to 8.2 fl oz/ acre	3	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications. **Do not apply to turnip greens or roots.**

TABLE 3-19. DISEASE CONTROL PRODUCTS FOR JERUSALEM ARTICHOKE (SUNCHOKE)

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC Code	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Pythium damping off	mefenoxam (Ridomil Gold 4 SL) (Ultra Flourish 2 SL)	4	1 to 2 pt/treated acre 2 to 4 pt/treated acre	1	2	Soil incorporation. See label for row rates.
	fluopicolide (Presidio 4 SC)	43	3 to 4 fl oz/acre	7	0.5	Apply every 10 days if needed. Do not apply more than 2 times sequentially and not more than 4 times at the low rate or 3 times at the high rate per acre per season.
Cercospora leaf spot, Powdery mildew, Rust	azoxystrobin (various)	11	see labels	14	4 hr	Must rotate every other application with a non-Group 11 fungicide. Maximum of 8 applications per crop per year.
	azoxystrobin + difenoconazole (Quadris Top 2.72 SC)	11 + 3	8 to 14 fl oz/acre	1	0.5	Make no more than 2 applications before alternating to another fungicide with a different mode of action (NOT Quadris).
	difenoconazole + benzovindiflupyr (Aprovia Top 1.62EC)	3 + 7	10.5 to 13.5 fl oz/acre	14	0.5	Make no more than 2 consecutive applications before switching to a non-Group 7 fungicide. Make no more than 3 applications at the low rate or 2 applications at the high rate per year.
Southern blight	azoxystrobin (Quadris 2.08 SC)	11	6.0 to 15.5 fl oz/acre	14	4 hr	Make one application at the high rate before symptoms typically are seen, based on prior year observations.
White mold (Sclerotinia basal stalk rot)	boscalid (Endura 70 EG)	7	10 oz/acre	30	0.5	2 applications per crop per season.
	Coniothyrium minitans (Contans WG)	NA	1 to 4 lb/acre	0	4 hr	**OMRI listed product.** Apply to soil surface and incorporate no deeper than 2 inches. Works best when applied prior to planting or transplanting. Do not apply other fungicides for 3 weeks after applying Contans.

TABLE 3-20. DISEASE CONTROL PRODUCTS FOR LETTUCE AND ENDIVE

E. Sikora, Plant Pathologist, Auburn University; L. Quesada-Ocampo, Plant Pathologist, North Carolina State University; A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC Code	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Bottom rot, (Rhizoctonia)	azoxystrobin (various)	11	0.4 to 0.8 fl oz/ 1,000 row feet	—	4 hr	Rhizoctonia only. Make in-furrow or banded applications shortly after plant emergence.
Seed decay, Seedling blight, damping-off	fludioxonil (Spirato 480FS) (Maxim 4FS)	12	0.08 to 0.16 fl oz/ 100 lb of seed	—	12	Used to control diseases of seed such as Aspergillus, Fusarium, and Rhizoctonia among others. Does NOT control Pythium or Phytophthora.
Downy mildew	ametoctradin + dimethomorph (Zampro 525 SC)	45+40	14 fl oz/acre	0	12 hr	Do not make more than 2 sequential applications before alternating to a fungicide with a different mode of action. Addition of an adjuvant may improve performance (see label for specifics). Do not apply more than 42 fl oz per acre per season.
	azoxystrobin (various)	11	6.2 to 15.4 fl oz/ acre	0	4 hr	Make no more than two sequential applications before alternating with a fungicide with a different mode of action.
	cyazofamid (Ranman 400 SC)	21	2.75 fl oz/acre	0	0.5	Apply on a 7 to 10 day interval when disease first appears or when conditions favorable for disease development. Do not make subsequent applications, and limit applications to six per year.
	cymoxanil (Curzate)	27	3.2 to 5.0 oz/acre	3	0.5	Curzate is only labeled for lettuce and spinach. Use only in combination with a protectant fungicide. Apply on a 5 to 7 day schedule.
	cymoxanil + famoxadone (Tanos)	27+11	8.0 oz	1	0.5	See label for directions.
	dimethomorph (various)	40	6.4 oz/acre	0	0.5	Must be applied as a tank mix with another fungicide active against downy mildew. Do not make more than two sequential applications.
	fenamidone (Reason 500 SC)	11	5.5 to 8.2 fl oz	2	0.5	Alternate with fungicides with a different mode of action.
	mandipropamid (various)	40	See label	See label	See label	Begin applications as soon as crop and/or environmental conditions become favorable for disease development. Apply on a 7 - 10 day interval depending upon disease conditions.
	acibenzolar-S-methyl (Actigard 50WG)	P1	0.75 to 1 oz/acre	7	0.5	Do not apply prior to thinning or within 5 days after transplanting. Apply preventatively every 7 to 10 days, not to exceed 4 applications (4 oz) per a season.
	fluopicolide (Presidio)	43	3 to 4 fl oz/acre	2	0.5	Tank mix with another downy mildew fungicide with a different mode of action.
	oxathiapiprolin + mefenoxam (Orondis Gold 200 + Orondis Gold B)	U15 + 4	4.8 to 19.2 fl oz/acre + 1 to 2 pt/acre	0	4 hr	Must tank mix Orondis Gold 200 and Gold B before application. Apply at planting, in furrow, by drip, or in transplant water. Make no more than 2 sequential applications before alternating with fungicides that have a different mode of action. Maximum of 4 applications at the low rate or 2 applications at high rate per crop per year. Use either soil (Orondis Gold) or foliar (Orondis Ultra) applications but not both on the same crop.

TABLE 3-20. DISEASE CONTROL PRODUCTS FOR LETTUCE AND ENDIVE (cont'd)

E. Sikora, Plant Pathologist, Auburn University; L. Quesada-Ocampo, Plant Pathologist, North Carolina State University; A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC Code	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Downy mildew (cont'd)	oxathiapiprolin + mandipropamid (Orondis Ultra + Orondis Ultra B)	U15 + 40	2.0 to 4.8 fl oz/acre + 8 fl oz/acre	0	4 hr	Must tank mix Orondis Ultra and Ultra B before application. Apply prior to disease development at 3 to 14-day intervals. Make no more than 2 sequential applications before alternating with fungicides that have a different mode of action. Maximum of 6 applications at the low rate or 4 applications at the high rate per crop per year. Use either soil (Orondis Gold) or foliar (Orondis Ultra) applications but not both on the same crop.
	mono- and di-potassium salts of phosphorous acid (Alude, K-Phite)	33	1 to 4 quarts in a minimum of 10 gal/ acre	0	4 hr	Do not apply at a less than 3-day interval.
	propamocarb (Previcur Flex)	28	2 pt/acre	2	0.5	Previcur Plus is only labeled for head and leaf lettuce. Do not apply more than 8 pt per growing season; begin applications before infection, and continue on a 7 to 10 day interval.
Downy mildew, leaf spots	azoxystrobin (various)	11	6.2 to 15.4 fl oz/ acre	7	4 hr	Use highest rate for downy mildew. Make no more than 2 sequential applications before alternating with fungicides that have a different mode of action. Apply no more than 2.88 qt per crop per acre per season.
	fixed copper (various)	M1	See label	See label	See label	See label. Rates vary depending on the formulation.
	pyraclostrobin (various)	11	12 to 16 oz/acre	0	0.5	Begin applications prior to disease development and continue on 7-to14 day intervals.
	fluxapyroxad + pyraclostrobin (Merivon 500 SC)	7 + 11	4 to 11 fl oz/ acre	1	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Suppression only of downy mildew.
	mancozeb (various)	M3	See labels	See label	See label	Rates vary depending on the formulation. Spray at first appearance of disease and continue on a 7 to 10 day intervals.
Leaf spots	penthiopyrad (Fontelis)	7	14 to 24 fl oz/acre	3	0.5	Begin applications before disease development. DO NOT make more than two consecutive applications before switching to a fungicide with a different mode of action.
	flutriafol (Rhyme)	3	5-7 oz/acre	7	0.5	Apply preventatively or when conditions are favorable for disease development.
	cyprodinil + fludioxonil (Switch 62.5 WDG)	9+12	11 to 14 oz/acre	0	0.5	Switch also has activity against basal rot, Sclerotinia, and Gray mold. Alternate with a fungicide with a different mode of action after 2 applications.
Gray mold	dicloran (Botran 5F)	14	See label	14	0.5	Application instructions vary by crop; see label. Two applications may be applied per season. Do not apply more than 3.2 quarts per season.
	penthiopyrad (Fontelis)	7	14 to 24 fl oz/acre	3	0.5	Begin applications before disease development. **DO NOT** make more than two consecutive applications before switching to a fungicide with a different mode of action.
	boscalid (Endura)		7-9 oz/acre	14	0.5	Begin applications prior to the onset of disease and continue on a 7-day interval.
Seed decay, Seedling blight, damping-off	fludioxonil (Spirato 480FS) (Maxim 4FS)	12	0.08 to 0.16 fl oz/100 lb of seed	—	12	Used to control diseases of seed such as Aspergillus, Fusarium, and Rhizoctonia among others. Does NOT control Pythium or Phytophthora.
Powdery mildew	penthiopyrad (Fontelis)	7	14 to 24 fl oz/acre	0	0.5	Begin applications before disease development. DO NOT make more than two sequential applications before switching to a fungicide with a different mode of action.
	quinoxyfen (Quintec)	13	6 fl oz	1	1	Alternate with a fungicide with a different mode of action
	sulfur (various)	M2	See label	See label	See label	Apply at early leaf stage and repeat every 10 to 14 days or as needed. Do not apply if temperatures are expected to exceed 90°F within 3 days of application due to the risk of crop injury.
	triflumizole (various)	3	6 to 8 fl oz/acre	0	0.5	Applications should begin prior to disease development. Repeat on a14-day schedule. Do not apply more than 18 fl oz per acre per season.
	azoxystrobin (various)	11	6.2 to 15.4 fl oz/ acre	0	4 hr	Make no more than two sequential applications before alternating with a fungicide with a different mode of action.
	fluxapyroxad + pyraclostrobin (Merivon 500 SC)	7 + 11	4 to 11 fl oz/ acre	1	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action.
	myclobutanil (Rally) 40 WSP	3	5 oz/acre	3	1	For use on lettuce only. Apply when disease first appears and continue on a 14-day intervals.
Pythium damping-off	mefenoxam (various)	4	See label	-	2	Apply preplant incorporated or surface application at planting.
	metalaxyl (various)	4	See label	-	2	Banded over the row, preplant incorporated, or injected with liquid fertilizer
	propamocarb (Previcur Flex)	28	2 pt/acre	2	0.5	Previcur Plus is only labeled for head and leaf lettuce. Various application methods; see label.

TABLE 3-20. DISEASE CONTROL PRODUCTS FOR LETTUCE AND ENDIVE (cont'd)

E. Sikora, Plant Pathologist, Auburn University; L. Quesada-Ocampo, Plant Pathologist, North Carolina State University; A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC Code	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Rust	penthiopyrad (Fontelis)	7	14 to 24 fl oz/acre	3	0.5	Begin applications before disease development. DO NOT make more than two sequential applications before switching to a fungicide with a different mode of action.
	sulfur (various)	M2	See labels	14	1	Apply at early leaf stage and repeat every 10 to 14 days or as needed. Do not apply if temperatures are expected to exceed 90°F within 3 days of application due to the risk of crop injury.
Sclerotinia	boscalid (Endura)	7	See label	14	0.5	Begin applications prior to onset of disease. Use higher rate when disease pressure is high.
	Coniothyrium minitans (Contans WG)	NA	1 to 4 lb/acre	0	4 hr	OMRI listed product. Apply to soil surface and incorporate no deeper than 2 inches. Works best when applied prior to planting or transplanting. Do not apply other fungicides for 3 weeks after applying Contans.
	dicloran (Botran)	14	See label	14	0.5	Rate depends specific crop and timing of application. See label.
	iprodione (Rovral)	2	1.5 to 2 lb/acre	14	1	Only for use on lettuce. Also effective for bottom rot and Botrytis. Use higher rate when disease pressure is high.
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	3	0.5	Begin applications before disease development. Continue on 7-14 day intervals. Do not make more than2 consecutive applications before switching to a fungicide with a different mode of action.

MUSKMELON (CANTALOUPE) - SEE CUCURBITS

TABLE 3-21. DISEASE CONTROL PRODUCTS FOR OKRA

E. Sikora, Plant Pathologist, Auburn University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Alternaria, gray mold, powdery mildew	cyprodinil + fludioxonil (Switch 62.5WG)	9 + 12	11 to 14 oz/acre	0	0.5	Begin applications before disease development and continue on 7 to 10 day interval. Make no more than 2 consecutive applications before alternating to a fungicide with a different. Do not apply more than 56 oz per acre per season.
Alternaria, gray mold, powdery mildew, Septoria leaf spot, target spot	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	0	0.5	Begin applications before disease development and continue on 7 to 14 day interval. Do not exceed more than 72 oz per acre per year.
Anthracnose, bacterial leaf spot, leaf spots, pod spots, powdery mildew	fixed copper (various)	M	See label	0	See label	
Anthracnose, Botrytis leaf mold, powdery mildew, Cercospora leaf spot	chlorothalonil; cymoxanil (Ariston)	M + 27	2 to 4.4 pints/acre	3	0.5	Begin applications before disease development and continue on 7-day interval.
Anthracnose, gray leaf spot, powdery mildew, Cercospora leaf spot	difenoconazole; azoxystrobin (Quadris Top)	3 + 11	8 to 14 fl oz/acre	0	0.5	Begin applications before disease development and continue on 7 to 10 day interval. Make no more than 2 consecutive applications before alternating to a fungicide with a different. Do not apply more than 55 fl oz per acre per season
	difenoconazole + cyprodinil (Inspire Super)	3 + 9	16 to 20 fl oz/acre	0	0.5	Begin applications before disease development and continue on 7 to 10 day interval. Make no more than 2 consecutive applications before alternating to a fungicide with a different mode of action. Do not apply more than 80 fl oz per acre per season.
	fludioxonil (various)	12	5 to 7 fl oz/acre	0	0.5	Begin applications before disease development and continue on 7-day interval.
Anthracnose, gray leaf spot, powdery mildew, Cercospora leaf spot, Rhizoctonia stem rot	difenoconazole; benzovindiflupyr (Aprovia Top)	3 + 7	10.5 to 13.5 oz/A	0	0.5	Begin applications before disease development and continue on 7 to 10 day interval. Make no more than 2 consecutive applications before alternating to a fungicide with a different mode of action. Refer to label for information on addition of an adjuvant.
Cercospora leaf spot	chlorothalonil (various)	M	1.5 pt/A	3	0.5	Begin applications when disease is expected. Repeat every 7 to 10 days.
	tebuconazole (various)	3	4 to 6 fl oz/A	3	0.5	**DO NOT** apply more than 24 fl oz per acre per season.
Powdery mildew, anthracnose, Cercospora leaf spot	flutriafol (Topguard)	3	14 fl oz/acre	0	0.5	Apply preventatively or when conditions are favorable for disease development.
Downy mildew	mandipropamid (Micora)	40	5.5 to 8 fl oz/A	—	4 hr	Tank mix Micora with a non-Group 40 fungicide and begin applications prior to disease development. **DO NOT** apply more than two applications per crop, or in consecutive applications.

TABLE 3-21. DISEASE CONTROL PRODUCTS FOR OKRA (cont'd)

E. Sikora, Plant Pathologist, Auburn University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Anthracnose, Powdery mildew	azoxystrobin (various)	11	6.0 to 15.5 fl oz/ acre	0	4	Do not apply more than two sequential applications before alternating with a fungicide with a different mode of action. Do not make more than 4 applications strobilurin fungicides per acre per season.
	chlorothalonil (various)	M	1.5 pt/acre	3	0.5	Begin applications when disease is expected. Repeat every 7 to 10 days.
	myclobutanil (Rally 40WSP)	3	2.5 to 5 oz/acre	0	1	Do not make more than 4 applications per season. Minimum re-treatment interval: 10 to 14 days.
Phytophthora blight	oxathiapiprolin + mandipropamid (Orondis Ultra A+ Orondis Ultra B)	U15 + 40	2.4 to 4.8 fl oz/ acre + 8 fl oz/acre	0	4	Apply at planting, in furrow, by drip, or in transplant water. Disease suppression only. Do not make more than 2 applications before switching to a different mode of action.
Rhizoctonia seedling rot	azoxystrobin (various)	11	0.4 to 0.8 fl oz/1,000 row feet	—	4 hr	Make in-furrow or banded applications shortly after plant emergence.

TABLE 3-22. DISEASE CONTROL PRODUCTS FOR ONION

E. Pfeufer, Plant Pathologist, University of Kentucky

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
ONION (green)						
Damping off (*Pythium* spp.)	mefenoxam (Ridomil Gold 4 SL)	4	0.5 to 1 pt/trt acre	—	2	See label for low rates. Also for dry onion.
	metalaxyl (various)	4	2 to 4 pt/trt acre	—	2	Preplant incorporated or soil surface spray.
Downy mildew (*Peronospora destructor*)	azoxystrobin (various)	11	9.2 to 15.4 fl oz/ acre	0	4 hr	Make no more than one application before alternating with a fungicide with a different mode of action. Apply no more than 2.88 qt per crop per acre per season.
	azoxystrobin + chlorothalonil (Quadris Opti)	11+M	2.4 to 3.6 pt/acre	14	0.5	Make no more than one application before alternating with a fungicide with a different mode of action.
	chlorothalonil (various)	M	See labels	14	2	Suppression only. Maximum of three sprays.
	chlorothalonil + cymoxanil (Ariston)	M+27	2.0 to 2.4 pt/acre	14	0.5	Apply prior to favorable infection periods; continue on 7 to 9 day interval; alternate with a different mode of action.
	dimethomorph (Forum 50 WP)	40	6.4 oz/acre	0	0.5	Must be applied as a tank mix with another fungicide active against downy mildew. Do not make more than two sequential applications.
	fenamidone (Reason 500 SC)	11	5.5 fl oz/acre	7	0.5	Begin applications when conditions favor disease development, and continue on 5 to 10 day interval. Do not apply more than 22 fl oz per growing season. Alternate with fungicide from different resistance group.
	fluxapyroxad + pyraclostrobin (Merivon)	7+11	8 to 11 fl oz/ acre	7	0.5	Suppression only. Apply at disease onset; continue on 7 to 14 day schedule. No more than 3 applications/season.
	mandipropamid (Revus 2.08F)	40	8 fl oz/acre	7	0.5	Apply prior to disease development and continue throughout season at 7 to10 day intervals; maximum 24 fl oz per season.
	ametoctradin + dimethomorph (Zampro)	45+40	14.0 fl oz/acre	0	12 hr	Begin applications prior to disease development and continue on a 5 to 7 day spray interval.
	mefenoxam + chlorothalonil (Ridomil Gold/Bravo)	4+M	2.5 lb/acre	14	2	
	pyraclostrobin (Cabrio)	11	8 to 12 oz/acre	7	0.5	Make no more than 2 sequential applications and no more than 6 applications per season.
	pyraclostrobin + boscalid (Pristine)	11+7	18.5 oz/acre	7	1	For suppression only. Make a maximum of 6 applications per season.
Leaf blight (*Botrytis* spp.)	azoxystrobin (various)	11	6.2 to 15.4 fl oz/ acre	7	4 hr	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Apply no more than 2.88 qt per crop per acre per season.
	azoxystrobin + difenoconazole (Quadris Top)	11+3	12 to 14 oz/acre	7	0.5	Make no more than one application before alternating with a fungicide with a different mode of action.
	azoxystrobin + chlorothalonil (Quadris Opti)	11+M	1.6 to 3.6 pts/acre	14	2	Applications should begin prior to disease onset and subsequent applications should be made on a 7 to 14 day interval.
	azoxystrobin + propiconazole (various)	11+3	14 to 26 fl oz	0	0.5	Make only one application before rotating to a non-group 11 fungicide.
	azoxystrobin + tebuconazole (Custodia)	11+3	8.6 to 12.9 fl oz	7	0.5	Use higher rate and shorter interval when disease conditions are severe.
	boscalid (Endura 70 WG)	7	6.8 oz/acre	7	0.5	Do not make more than 2 sequential applications or more than 6 applications per season.
	chlorothalonil (various)	M	See labels	14	0.5	Spray at first appearance. Maximum of three sprays.
	cyprodinil + fludioxonil (Switch)	9+12	11 to 14 oz/acre	7	0.5	Do not plant rotational crops other than onions or strawberries for 12 months following the last application.

TABLE 3-22. DISEASE CONTROL PRODUCTS FOR ONION (cont'd)

E. Pfeufer, Plant Pathologist, University of Kentucky

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
ONION (green) (cont'd)						
Leaf blight (*Botrytis* spp.) (cont'd)	dicloran (Botran)	14	1.5 to 2.7 lb/acre	14	0.5	
	difenoconazole + cyprodinil (Inspire Super)	3+9	16 to 20 fl oz/acre	14	0.5	Make no more than two applications before alternating with a fungicide with a different mode of action.
	fluopyram + tebuconazole (Luna Experience)	7+3	8.0 to 12.8 fl. oz/acre	7	0.5	Observe seasonal application limits for both group 7 and group 3 fungicides.
	fluxapyroxad + pyraclostrobin (Merivon)	7+11	4 to 11 fl oz/ acre	7	0.5	Apply at disease onset; continue on 7 to 14 day schedule. No more than 3 applications/season.
	mefenoxam + chlorothalonil (Ridomil Gold/Bravo)	4+M	2.5 lb/acre	14	2	
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	3	0.5	Begin sprays prior to disease development and continue on a 7 to 14 day schedule.
	propiconazole (various)	3	4 to 8 oz/acre	0	0.5	Alternate with a different mode of action.
	pyraclostrobin (Cabrio)	11	8 to 12 oz/acre	7	0.5	Make no more than 2 sequential applications and no more than 6 applications per season.
	pyraclostrobin + boscalid (Pristine)	11+7	14.5 to 18.5 oz/acre	7	1	Make a maximum of 6 applications per season.
	pyrimethanil (Scala)	9	9 or 18 fl oz/acre	7	0.5	Use lower rate in a tank mix with broad-spectrum fungicide and higher rate when applied alone. Do not apply more than 54 fl oz per crop.
Purple blotch (*Alternaria porri*)	azoxystrobin (various)	11	6.2 to 12.3 fl oz/ acre	7	4 hr	Make no more than two sequential applications before alternating with a fungicide with a different mode of action. Apply no more than 2.88 qt per crop per acre per season.
	azoxystrobin + difenoconazole (Quadris Top)	11+3	12 to 14 oz/acre	7	0.5	Make no more than one application before alternating with a fungicide with a different mode of action.
	azoxystrobin + chlorothalonil (Quadris Opti)	11+M	1.6 to 3.2 pt/acre	14	0.5	Make no more than one application before alternating with a fungicide with a different mode of action.
	azoxystrobin + propiconazole (various)	11+3	14 to 26 fl oz	0	0.5	Make only one application before rotating to a non-group 11 fungicide.
	azoxystrobin + tebuconazole (Custodia)	11+3	8.6 to 12.9 fl oz	7	0.5	Use higher rate and shorter interval when disease conditions are severe.
	boscalid (Endura) 70WG	7	6.8 oz/acre	7	0.5	Do not make more than 2 sequential applications or more than 6 applications per season.
	chlorothalonil (various)	M	See labels	14	2	Spray at first appearance. Maximum of three sprays.
	chlorothalonil + cymoxanil (Ariston)	M+27	2.0 to 2.4 pt/acre	14	0.5	Apply prior to favorable infection periods; continue on 7 to 9 day interval; alternate with a different mode of action.
	cyprodinil + fludioxonil (Switch)	9+12	11 to 14 oz/acre	7	0.5	Do not plant rotational crops other than onions or strawberries for 12 months following the last application.
	difenoconazole + cyprodinil (Inspire Super)	3+9	16 to 20 fl oz/acre	14	0.5	Make no more than two applications before alternating with a fungicide with a different mode of action.
	fenamidone (Reason)	11	5.5 to 8.2 fl oz	7	0.5	Begin applications when conditions favor disease development, and continue on 5 to 10 day interval. Do not apply more than 22 fl oz per growing season. Alternate with fungicide from different resistance management group.
	fluopyram + tebuconazole (Luna Experience)	7+3	8.0 to 12.8 fl. oz/acre	7	0.5	Observe seasonal application limits for both group 7 and group 3 fungicides.
	fluxapyroxad + pyraclostrobin (Merivon)	7+11	4 to 11 fl oz/ acre	7	0.5	Apply at disease onset; continue on 7 to 14 day schedule. No more than 3 applications/season.
	mefenoxam + chlorothalonil (Ridomil Gold/Bravo)	4+M	2.5 lb/acre	14	2	
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	3	0.5	Begin sprays prior to disease development and continue on a 7-14 day schedule.
	propiconazole (various)	3	4 to 8 fl oz	0	0.5	Alternate with a different mode of action.
	pyraclostrobin (Cabrio)	11	8 to 12 oz/acre	7	0.5	Make no more than 2 sequential applications and no more than 6 applications per season.
	pyraclostrobin + boscalid (Pristine)	11+7	10.5 to 18.5 oz/acre	7	1	Make a maximum of 6 applications per season.
	pyrimethanil (Scala)	9	9 or 18 fl oz/acre	7	0.5	Use lower rate in a tank mix with broad-spectrum fungicide and higher rate when applied alone. Do not apply more than 54 fl oz per crop.
Stemphylium leaf blight (*Stemphylium vesicarium*)	azoxystrobin + difenoconazole (Quadris Top)	11+3	12 to 14 oz/acre	7	0.5	Make no more than one application before alternating with a fungicide with a different mode of action.
	azoxystrobin + propiconazole (Avaris 2XS)	11+3	14 to 26 fl oz	0	0.5	Make only one application before rotating to a non-group 11 fungicide.
	difenoconazole + cyprodinil (Inspire Super)	3+9	16 to 20 fl oz/acre	14	0.5	Make no more than two applications before alternating with a fungicide with a different mode of action.
	fluxapyroxad + pyraclostrobin (Merivon)	7+11	4 to 11 fl oz/ acre	7	0.5	Apply at disease onset; continue on 7 to 14 day schedule. No more than 3 applications/season.
	pyraclostrobin + boscalid (Pristine)	11+7	10.5 to 18.5 oz/acre	7	1	Make no more than 6 applications per season.

TABLE 3-22. DISEASE CONTROL PRODUCTS FOR ONION (cont'd)

E. Pfeufer, Plant Pathologist, University of Kentucky

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
ONION (dry)						
Damping off (*Pythium* spp.)	mefenoxam (Ridomil Gold)	4	0.5 to 1 pt/trt acre	—	2	See label for row rates. Also for green onion.
	metalaxyl (various)	4	2 to 4 pt/trt acre	—	2	Preplant incorporated or soil surface spray.
	azoxystrobin + mefenoxam (Uniform)	11 + 4	0.34 fl oz / 1000ft	-	0	In furrow treatment.
Downy mildew (*Peronospora destructor*)	azoxystrobin (various)	11	9.2 to 15.4 fl oz/ acre	0	4 hr	Make no more than one application before alternating with a fungicide with a different mode of action. Apply no more than 2.88 qt per crop per acre per season.
	azoxystrobin + chlorothalonil (Quadris Opti)	11+M	2.4 to 3.2 pt/acre	14	0.5	Make no more than one application before alternating with a fungicide with a different mode of action.
	ametoctradin + dimethomorph (Zampro)	45+40	14.0 fl oz/acre	0	12 hr	Begin applications prior to disease development and continue on a 5 to 7 day spray interval.
	chlorothalonil + cymoxanil (Ariston)	M+27	1.6 to 2.4 pt/acre	7	0.5	Apply prior to favorable infection periods; continue on 7 to 9 day interval; alternate with a different mode of action.
	dimethomorph (Forum)	40	6.4 oz/acre	0	0.5	Must be applied as a tank mix with another fungicide active against downy mildew. Do not make more than two sequential applications.
	cyazofamid (Ranman)		2.75 to 3.0 oz/acre	0	0.5	Use a surfactant for best results.
	famoxadone + cymoxanil(Tanos)	11+27	8.0 oz/acre	3	0.5	Apply preventively on a 5 to 7 day schedule and do not rotate with group 11 fungicides.
	fenamidone (Reason)	11	5.5 fl oz/acre	7	0.5	Use as soon as environmental conditions become favorable.
	fluazinam (Omega 500)	29	1.0 pt/acre	7	1	Initiate sprays when conditions are favorable for disease or at disease onset. Spray on a 7 to 10 day schedule.
	mandipropamid (Revus)	40	8 fl oz/acre	1	0.5	Apply prior to disease development and continue throughout season at 7 to10 day intervals; maximum 32 fl oz per season.
	mefenoxam + mancozeb (Ridomil Gold MZ)	4+M	2.5 lb/acre	7	2	Use with a suitable adjuvant.
	pyraclostrobin + boscalid (Pristine)	11+7	18.5 oz/acre	7	1	Suppression only. Make no more than 6 applications per season.
Leaf blight (*Botrytis* spp.)	azoxystrobin (various)	11	6.2 to 15.4 fl oz/ acre	7	4 hr	Make no more than two sequential applications before alternating with fungicides with a different mode of action. Apply no more than 2.88 qt per crop per acre per season.
	azoxystrobin + chlorothalonil (Quadris Opti)	11+M	1.6 to 3.2 pt/acre	14	0.5	Make no more than one application before alternating with a fungicide with a different mode of action.
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	3	12 hr	Begin sprays prior to disease development and con- tine on a 7 to 14 day schedule.
	cyprodinil + fludioxonil (Switch)	9+12	11 to 14 oz/acre	7	0.5	Do not plant rotational crops other than onions or strawberries for 12 months following the last application.
	dicloran (Botran)	14	1.5 to 2.7 lb/acre	14	0.5	Use lower rate in a tank mix with broad-spectrum fungicide and higher rate when applied alone. Do not apply more than 54 fl oz per crop.
	difenoconazole + cyprodinil (Inspire Super)	3+9	16 to 20 fl oz/acre	7	0.5	Make no more than two applications before alternating with a fungicide with a different mode of action.
	fixed copper (various)	M	See labels			Spray at first appearance, 7 to 10 day intervals. Do not apply to exposed bulbs.
	pyraclostrobin (Cabrio)	11	12 oz/acre	7	0.5	Make no more than 2 sequential applications and no more than 6 applications per season.
	pyrimethanil (Scala)	9	9 or 18 fl oz/acre	7	0.5	Use lower rate in a tank mix with broad-spectrum fungicide and higher rate when applied alone. Do not apply more than 54 fl oz per crop.
Neck rot (*Botrytis* spp.), purple blotch *(Alternaria porri),* downy mildew (*Peronospora destructor*)	azoxystrobin + chlorothalonil (Quadris Opti)	11+M	1.6 to 3.2 pt/acre	14	0.5	Make no more than one application before alternating with a fungicide with a different mode of action.
	azoxystrobin + propiconazole (various)	11+3	14 to 26 oz / acre	14	0.5	
	azoxystrobin + tebuconazole (various)	11+3	See labels	7	0.5	See labels for specific rates and application instructions.
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	3	12 hr	Begin sprays prior to disease development and con- tine on a 7 to 14 day schedule.
	chlorothalonil (various)	M	0.9 to 1 lb/acre	7	0.5	Will only suppress neck rot and downy mildew.
	chlorothalonil + zoxamide (Zing)	M+22	30 fl oz/acre	7	0.5	Follow protective spray schedule when diseases are in the area.
	cyprodinil (Vanguard)	12	10 oz/acre	7	0.5	Suppressive only on neck rot.
	boscalid (Endura)	7	6.8 oz/acre	7	0.5	Not for downy mildew. Do not make more than 2 sequential applications or more than 6 applications per season.

TABLE 3-22. DISEASE CONTROL PRODUCTS FOR ONION (cont'd)

E. Pfeufer, Plant Pathologist, University of Kentucky

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
ONION (dry) (cont'd)						
Neck rot (*Botrytis* spp.), purple blotch *(Alternaria porri),* downy mildew (*Peronospora destructor*) (cont'd)	fixed copper (various)	M	See labels	1	1	May reduce bacterial rots.
	fluazinam (Omega 500)	29	1.0 pt/acre	7	1	Initiate sprays when conditions are favorable for disease or at disease onset. Spray on a 7 to 10 day schedule.
	fluopyram + tebuconazole (Luna Experience)	7 + 3	8 to 12.8 oz/acre	7	0.5	Not for downy mildew. Suppresses *Sclerotium* spp.
	fluopyram + pyrimethanil (Luna Tranquility)	7 + 9	16 to 27 oz / acre	7	0.5	Not for downy mildew. Suppresses *Sclerotium* spp.
	fluxapyroxad + pyraclostrobin (Merivon)	7+11	4 to 11 fl oz/ acre	7	0.5	Use higher rates for downy mildew suppression. Apply at disease onset; continue on 7 to 14 day schedule. No more than 3 applications/season.
	iprodione (various)	2	1.5 lb/acre	7	0.5	Not for downy mildew. Apply when conditions are favorable; 14-day intervals.
	mancozeb (various)	M	2 to 3 lb/acre	7	1	Do not exceed 30 lb per acre per crop.
	mefenoxam + chlorothalonil (Ridomil Gold/Bravo)	4+M	2.5 pt/acre	7	2	
	oxathiapiprolin + chlorothalonil	49 + M	1.75 to 2 pt/acre	14	0.5	Observe chlorothalonil season limits.
	propiconazole	3	4 to 8 oz/acre	14	0.5	Not for downy mildew. Alternate with a different mode of action.
	pyraclostrobin + boscalid (Pristine)	11+7	14.5 to 18.5 oz/acre	7	1	Make no more than 6 applications per season.
	tebuconazole (various)	3	4 to 6 fl oz/ acre	7	0.5	Not for downy mildew or Botrytis. Suppresses *Sclerotium* spp.
	tebuconazole + chlorothalonil (Muscle)	3 + M	1.1 to 1.6 pt / acre	7 to 14	0.5	Not for downy mildew or Botrytis.
	tebuconazole + potassium phosphate (Viathon)	3 + 33	2 to 3 pts/acre	7	0.5	
	zoxamide + mancozeb (Zing!)	22 + M	1.5 to 2 lb/acre	7	0.5	Use preventatively.
Pink root (*Phoma* spp.)	metam-sodium (Vapam)	—	37.5 to 75 gal/	—	2	Rate is based on soil properties and depth of soil to be treated.
	dichloropropene (Telone) C-17 C-35	—	 10.8 to 17.1 gal/acre 13 to 20.5 gal/acre	—	5	Rate is based on soil type; see label for in-row rates.
Smut (*Urocystis* spp.)	mancozeb (various)	M	3 lb/29,000 ft row	—	—	
Stemphylium leaf blight (*Stemphylium vesicarium*)	azoxystrobin + difenoconazole (Quadris Top)	11+3	14 fl oz/acre	7	0.5	Begin sprays prior to disease onset and spray on a 7 to 14 day schedule. Do not rotate with Group 11 fungicides.
	difenoconazole + cyprodinil (Inspire Super)	3+9	16 to 20 fl oz/acre	7	0.5	Make no more than two applications before alternating with a fungicide with a different mode of action.
	fluxapyroxad + pyraclostrobin (Merivon)	7+11	4 to 11 fl oz/ acre	7	0.5	Apply at disease onset; continue on 7 to 14 day schedule. No more than 3 applications/season.
	iprodione (various)	2	1.5 lb/acre 50 to 100 gal/acre	7	0	Start 7-day foliar sprays at first appearance of favorable conditions.
	pyraclostrobin + boscalid (Pristine)	11+7	10.5 to 18.5oz/acre	7	1	Make no more than 6 applications per season.
	fluazinam (Omega 500)	29	1.0 pt/acre	7	2	Initiate sprays when conditions are favorable for disease or at disease onset. Spray on a 7 to 10 day schedule.
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	3	0.5	Begin sprays prior to disease development and continue on a 7 to 14 day schedule.
White rot (*Sclerotium cepivorum*)	azoxystrobin + chlorothalonil (Quadris Opti)	11+M	1.6 to 3.2 pt/acre	14	0.5	Make no more than one application before alternating with a fungicide with a different mode of action.
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	3	0.5	Begin sprays prior to disease development and continue on a 7 to 14 day schedule.
	fludioxonil (various)	12	7 oz / acre	7	0.5	In furrow treatment only.
	dicloran (Botran)	14	5.3 lb/acre	14	0.5	Apply 5-in. band over seed row and incorporate in top 1.5 to 3 in. of soil, 1 to 2 weeks before seeding.
	dichloropropene (Telone) C-17 C-35	—	 10.8 to 17.1 gal/acre 13 to 20.5 gal/acre	—	5	Rate is based on soil type; see label for in-row rates.
	thiophanate-methyl (various)	1	See label			Spray into open furrow at time of seeding or planting in a row.

TABLE 3-23. EFFICACY OF PRODUCTS FOR DISEASE CONTROL IN ONION

E. Pfeufer, Plant Pathologist, University of Kentucky

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Product[1]	Fungicide group [F]	Preharvest interval (Days)	Bacterial Streak (*Pseudomonas viridiflava*)	Black Mold (*Aspergillus niger*)	Botrytis Leaf Blight (*B. squamosa*)	Botrytis Neck Rot (*B. allii*)	Damping off (*Pythium* spp.)	Downy Mildew (*P. destructor*)	Fusarium Basal Rot (*F. oxysporum*)	Onion Smut (*Urocystis colchici*)	Center Rot (*Pantoea ananatis*)	Pink Root (*Phoma terrestris*)	Purple Blotch (*Alternaria porri*)	Stemphylium Leaf Blight and Stalk Rot	White Rot (*Sclerotium cepivorum*)
ametoctradin + dimethomorph (Zampro)	40 + 45	0	NC	NC	NC	NC	NC	G	NC	NC	NC	NC	NC	NC	NC
azoxystrobin (various)	11	7	NC	G	F	NC	NC	ND	NC	ND	NC	NC	G	G	ND
azoxystrobin + difenoconazole (Quadris Top)	11 + 3	1	NC	NC	F	NC	NC	ND	NC	NC	NC	NC	G	F	NC
boscalid (Endura)	7	7			G							G		G	
chlorothalonil (various)	M	14	NC	NC	F	NC	NC	P	NC	NC	NC	NC	F	F	NC
chlorothalonil + zoxamide (Zing!)	M + 22	7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
chlorothalonil + cymoxanil (Ariston)	M + 27	7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cyprodinil + fludioxonil (Switch)	9 + 12	7	NC	NC	F	ND	NC	NC	NC	NC	NC	NC	F	F	NC
cyprodinil + difenoconazole (Inspire Super)	9 + 3	7	ND	ND	F	ND	ND	ND	ND	ND	ND	ND	ND	G	ND
dichloropropene + chloropicrin, fumigant (Telone C-17)	—	—	NC	NC	NC	NC	P	NC	F	NC	NC	F	NC	NC	F
dimethomorph (Forum)	40	0	NC	NC	NC	NC	NC	F	NC	NC	NC	NC	NC	NC	NC
fenamidone (Reason)	11	7	NC	NC	P	NC	NC	G	NC	NC	NC	NC	P	P	NC
famoxadone + cymoxanil (Tanos)	11 + 27	3	NC	NC	F	NC	NC	P	NC	NC	NC	NC	F	F	NC
fixed copper (various)	M	1	F	NC	F	NC	NC	F	NC	NC	F	NC	F	NC	NC
fluazinam (Omega 500)	29	2	NC	NC	G	NC	NC	G	NC	NC	NC	NC	E	E	NC
fluopyram + pyrimethanil (Luna Tranquility)	7 + 9	7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	E	ND
fluxapyroxad + pyraclostrobin (Merivon)	7 + 11	7	ND	ND	G	ND	ND	ND	ND	ND	ND	ND	G	G	ND
iprodione (various)	2	7	NC	NC	F	P	NC	NC	NC	NC	NC	NC	G	F	F
mancozeb (various)	M	7	NC	NC	F	NC	NC	F	NC	E	NC	NC	F	F	NC
mancozeb + copper (ManKocide)	M + M	7	F	NC	F	NC	NC	F	NC	F	F	NC	F	F	NC
mandipropamid (Revus)	40	7	NC	NC	NC	ND	F	F	NC	NC	NC	NC	NC	NC	NC
mefenoxam (Ridomil Gold EC)	4	7	NC	NC	NC	NC	F	ND	NC	NC	NC	NC	NC	NC	NC
mefenoxam + chlorothalonil (Ridomil Gold Bravo)	4 + M	14	NC	NC	F	NC	P	F	NC	NC	NC	NC	F	F	NC
mefenoxam + copper (Ridomil Gold/ Copper)	4 + M	7	F	NC	NC	NC	P	F	NC	NC	F	NC	NC	NC	NC
mefenoxam + mancozeb (Ridomil Gold MZ)	4 + M	7	NC	NC	F	NC	P	F	NC	F	NC	NC	F	F	NC
metam sodium, fumigant (Vapam)	—	—	NC	NC	NC	NC	F	NC	F	NC	NC	E	NC	NC	F
penthiopyrad (Fontelis)	7		ND	ND	G	ND	ND	ND	ND	ND	ND	ND	G	ND	ND
potassium phosphite + tebuconazole (Viathon)	33 + 3	7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	G	ND	ND
pyraclostrobin (Cabrio)	11	7	NC	ND	F	NC	NC	F	NC	ND	NC	NC	G	G	ND
pyraclostrobin + boscalid (Pristine)	11 + 7	7	NC	ND	G	F	NC	F	NC	ND	NC	NC	E	E	ND
pyrimethanil (Scala)	9	7	NC	ND	F	NC	NC	NC	NC	ND	NC	NC	F	F	NC
tebuconazole (various)	3	7	ND	ND	G	ND	ND	ND	ND	ND	ND	ND	G	ND	ND

[1] Efficacy ratings do not necessarily indicate a labeled use for every disease.

[F] To prevent resistance in pathogens, alternate fungicides within a group with fungicides in another group. Fungicides in the "M" group are generally considered "low risk" with no signs of resistance developing to the majority of fungicides.

[R] Resistance reported in the pathogen.

TABLE 3-24. DISEASE CONTROL PRODUCTS FOR PARSLEY

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Damping off and root rot (Pythium, Phytophthora)	mefenoxam (Ridomil Gold 4 SL) (Ultra Flourish 2 EC)	4	1 to 2 pt/treated acre 1 to 4 pt/treated acre	0	0.5	Apply preplant incorporated or surface application at planting.
	metalaxyl (MetaStar 2 E)	4	2 to 8 pt/treated acre	0	2	Banded over the row, preplant incorporated, or injected with liquid fertilizer.

TABLE 3-24. DISEASE CONTROL PRODUCTS FOR PARSLEY (cont'd)

A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Alternaria leaf spot Cercospora leaf spot (Early blight) Powdery mildew, Septoria leaf spot (late blight)	azoxystrobin (various)	11	see labels	0	4 hr	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Apply no more than 1.88 lb per crop per acre per season.
	cyprodinil + fludioxonil (Switch62.5 WG)	9 + 12	11 to 14 oz/acre	0	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action for two applications. Apply no more than 56 oz per crop per acre per season.
	fixed copper (generic)	M1	See label	0	0	Spray at first disease appearance, 7 to 10 day intervals.
	fluxapyroxad + pyraclostrobin (Merivon 500 SC)	7 + 11	4 to 11 fl oz/ acre	3	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Maximum of 3 applications per crop.
	penthiopyrad (Fontelis 1.67 F)	7	14 to 24 fl oz	3	0.5	Do not make more than two sequential applications. Maximum of 72 fl oz/acre per year.
	propiconazole (various)	3	3-4 fl oz/A	14	0.5	Begin at first sign of disease and repeat at 14-day intervals. Make no more than two consecutive applications before rotating to another fungicide with a different mode of action.
	pyraclostrobin (Cabrio 20 EG, Pyrac 2 EC	11	12 to 16 oz/acre	0	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Apply no more than 64 oz per crop per acre per season.
Web blight and root rot (Rhizoctonia)	azoxystrobin (Quadris 2.08 F)	11	0.125 to 0.25 oz/ 1000 row ft soil application or 6.0 to 15.5 fl oz/acre foliar	0	4 hr	Apply as banded spray to the lower stems and soil surface. Make no more than two sequential applications. Soil applications are included in this maximum.
White mold (Sclerotinia)	cyprodinil + fludioxonil (Switch62.5 WG)	9 + 12	11 to 14 oz/acre	0	0.5	Make no more than two sequential applications before alternating with fungicides that have a different mode of action for two applications. Apply no more than 56 oz per crop per acre per season. First application at thinning and second application 2 weeks later.
	penthiopyrad (Fontelis1.67 F)	7	16 to 30 fl oz	3	0.5	Do not make more than two sequential applications. Maximum of 72 fl oz/acre per year.
	Coniothyrium minitans (Contans WG)	NA	1 to 4 lb/acre	0	4 hr	**OMRI listed product.** Apply to soil surface and incorporate no deeper than 2 inches. Works best when applied prior to planting or transplanting. Do not apply other fungicides for 3 weeks after applying Contans.

TABLE 3-25. IMPORTANCE OF ALTERNATIVE MANAGEMENT PRACTICES FOR DISEASE CONTROL IN PARSLEY

A. Keinath, Plant Pathologist, Clemson University

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Strategy	Alternaria leaf spot	Cercospora leaf spot	Powdery mildew	Pythium damping off and root rot	Rhizoctonia damping off and root rot	Root knot nematode	Sclerotinia white mold	Septoria blight
Avoid field operations when leaves are wet	G	G	NC	NC	NC	NC	P	G
Avoid overhead irrigation	G	G	NC	NC	NC	NC	G	G
Biofungicide	ND	ND	F	ND	ND	ND	F	ND
Change planting date	NC	NC	NC	NC	E (early)	E (early)	G (late)	NC
Suppressive cover crops	NC	NC	NC	NC	NC	F	NC	NC
Crop rotation with non-host	E	E	NC	P	P	P	F	E
Deep plowing	G	G	P	NC	F	P	F	G
Destroy crop residue	G	G	P	NC	F	P	P	G
Encourage air movement	G	G	P	P	NC	NC	E	G
Flooding (where feasible)	NC	NC	NC	NC	F	G	G	NC
Increase soil organic matter	NC	NC	F	P	P	F	NC	NC
Hot water seed treatment	ND	ND	NC	NC	NC	NC	NC	E
Plant in well-drained soil	P	P	NC	E	G	NC	F	P
Plant on raised beds	NC	NC	NC	E	G	NC	F	NC
Plastic mulch bed covers	NC	NC	F	F	F	NC	P	NC
Postharvest temperature control	NC	NC	NC	NC	NC	NC	E	NC
Reduce mechanical injury	NC	NC	NC	NC	P	NC	G	NC
Soil solarization	F	F	NC	P	F	F	P	F
Pathogen-free seed	E	E	P	NC	NC	NC	P	E
Resistant/tolerant cultivars	NC	NC	NC	NC	P	NC	NC	F
Weed control	P	P	F	NC	NC	F	F	P

TABLE 3-26. DISEASE CONTROL PRODUCTS FOR PEA

E. Sikora, Plant Pathologist, Auburn University; A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
PEA (English)						
Anthracnose	azoxystrobin (Quadris) 2.08 F	11	6.2 to 15.4 fl oz/ acre	0	4 hr	Do not make more than two sequential applications.
	penthiopyrad (Fontelis) 1.67 F	7	14 to 30 fl oz	0	0.5	Do not make more than two sequential applications. Maximum of 72 fl oz/acre per crop.
	pyraclostrobin + fluxapyroxad (Priaxor) 500 SC	11+7	4.0 to 8.0 fl oz/acre	7	12 hr	Do not make more than two sequential applications. Maximum of 16 fl oz/acre per crop.
Ascochyta leaf spot and blight	azoxystrobin (Quadris) 2.08 F	11	6.2 to 15.4 fl oz/ acre	0	4 hr	Do not make more than two sequential applications.
	boscalid (Endura) 70 WG	7	8 to 11 oz/ acre	7	0.5	Maximum of 2 applications per crop.
	penthiopyrad (Fontelis) 1.67 F	7	14 to 30 fl oz	0	0.5	Do not make more than two sequential applications. Maximum of 72 fl oz/acre per crop.
	pyraclostrobin + fluxapyroxad (Priaxor) 500 SC	11+7	4.0 to 8.0 fl oz/acre	7	12 hr	Do not make more than two sequential applications. Maximum of 16 fl oz/acre per crop.
Gray mold (Botrytis), White mold (Sclerotinia)	boscalid (Endura) 70 WG	7	8 to 11 oz/ acre	7	0.5	Maximum of 2 applications per crop.
	penthiopyrad (Fontelis) 1.67 F	7	14 to 30 fl oz	0	0.5	Do not make more than two sequential applications. Maximum of 72 fl oz/acre per year.
	pyraclostrobin + fluxapyroxad (Priaxor) 500 SC	11+7	4.0 to 8.0 fl oz/acre	7	12 hr	Do not make more than two sequential applications. Maximum of 16 fl oz/acre per crop.
White mold (Sclerotinia)	*Coniothyrium minitans* (Contans WG)	—	1 to 4 lb/acre	0	4 hr	**OMRI listed product.** Apply to soil surface and incorporate no deeper than 2 inches. Works best when applied prior to planting or transplanting. Do not apply other fungicides for 3 weeks after applying Contans.
Powdery mildew	boscalid (Endura) 70 WG	7	8 to 11 oz/acre	7	0.5	Maximum of 2 applications per crop.
	fixed copper (various)	M	See label	0	1 to 2	See label
	penthiopyrad (Fontelis) 1.67 F	7	14 to 30 fl oz	0	0.5	Do not make more than two sequential applications. Maximum of 72 fl oz/acre per year.
	pyraclostrobin + fluxapyroxad (Priaxor) 500 SC	11+7	4.0 to 8.0 fl oz/acre	7	12 hr	Do not make more than two sequential applications. Maximum of 16 fl oz/acre per crop.
	sulfur (various)	M	See labels	0	1	Spray at first appearance, 10 to 14 day intervals. Do not use sulfur on wet plants or on hot days (in excess of 90°F).
Pythium damping off	mefenoxam (Ridomil Gold) 4 EC	4	0.5 to 1 pt/trt acre	—	2	Incorporate in soil. See label for row rates.
Rhizoctonia root rot	pyraclostrobin + fluxapyroxad (Priaxor) 500 SC	11+7	4.0 to 8.0 fl oz/acre	7	12 hr	Do not make more than two sequential applications. Maximum of 16 fl oz/acre per crop.
Rust *(Uromyces)*	azoxystrobin (Quadris) 2.08 F	11	6.2 fl oz/acre	0	4 hr	Do not make more than two sequential applications.
	penthiopyrad (Fontelis) 1.67 F	7	14 to 30 fl oz	0	0.5	Do not make more than two sequential applications. Maximum of 72 fl oz/acre per year.
	pyraclostrobin + fluxapyroxad (Priaxor) 500 SC	11+7	4.0 to 8.0 fl oz/acre	7	12 hr	Do not make more than two sequential applications. Maximum of 16 fl oz/acre per crop.
PEA (Southern)						
Anthracnose	thiophanate-methyl (various)	1	1 to 1.5 lb/acre	28	0.5	Use no more than 4 lb (2.8 lb a.i.) per acre per year.
Anthracnose, Rust	azoxystrobin (various)	11	2 to 5 oz/acre	14 (dry) 0 (succulent)	4 hr	Make no more than 2 sequential applications before alternating with a fungicide with a different mode of actions. Use no more than 1.5 lb a.i. per acre per season.
Ascochyta blight, Gray mold, White mold	boscalid (Endura 70 WG)	7	8 to 11 oz/acre	21 (dry) 7 (succulent)	0.5	Maximum of 2 applications per season.
Ascochyta blight, Rust, White mold	prothioconazole (various)	3	5.7 fl oz /acre	7	0.5	Maximum of 3 applications per year. Use no more than17.1 fl oz per acre per year.
Downy mildew, Bacterial blights	fixed copper (various)	M	See label	See label	See label	See label
Downy mildew, *Cercospora*, Anthracnose, Rust	chlorothalonil (various)	M	1.4 to 2 pt/acre	14	2	Spray early bloom; repeat at 7 to 10 day intervals; for dry beans only.
Alternaria, Anthracnose, Ascochyta, powdery mildew, rust, Cercospora	difenconazole + benzovindiflupyr (Aprovia Top)	3+7	10.5-11 fl oz	14	0.5	Begin prior to disease development and continue on 14-day schedule.
Alternaria, Anthracnose, Ascochyta, rust, southern blight, web blight	azoxystrobin + propiconazole (various)	3+11	10.5 to 14 oz/acre	7 (succulent) 14 (dry)	0.5	Apply when conditions are conducive for disease. Up to three applications may be made on 7-14 day intervals
Alternaria, Anthracnose, Ascochyta, downy mildew, powdery mildew, rust, Cercospora, white mold	picoxystrobin (Approach)	11	6 to 12 fl oz	14	0.5	Do not apply more than three sequential applications. For white mold, use higher rates.
	penthiopyrad (Fontelis) 1.67 F	7	14 to 30 fl oz	0	0.5	Do not make more than two sequential applications. Maximum of 72 fl oz/acre per year.

TABLE 3-26. DISEASE CONTROL PRODUCTS FOR PEA (cont'd)

E. Sikora, Plant Pathologist, Auburn University; A. Keinath, Plant Pathologist, Clemson University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Downy mildew, Cercospora, Anthracnose, Rust, Powdery mildew	pyraclostrobin (various)	7	6-9 fl oz	21	0.5	Make no more than 2 sequential applications before alternating with a fungicide with a different mode of action. Use no more than 18 fl oz per acre per season.
	sulfur (various)	M	See label	0	1	Spray at first appearance; 7 to 10 day interval.
Pythium damping off	mefenoxam (various)	4	0.5 to 1 pt/ treated acre	—	0.5	Broadcast or banded over the row as a soil spray at planting or preplant incorporation into the top 2 inches of soil.
	metalaxyl (various)	4	2 to 4 pt/treated acre	—	2	Broadcast or banded over the row as a soil spray at planting or preplant incorporation into the top 2 inches of soil.
Rhizoctonia root rot	azoxystrobin (various)	11	0.4 to 0.8 fl oz/1,000 row feet	—	4 hr	Make in-furrow or banded application shortly after plant emergence.
	penflufen (Evergol Prime)	7	0.05 to 0.1 fl oz of the product per 100,000 seeds.	--	0.5	Apply using commercial slurry or mist-type seed treatment equipment.
Rhizoctonia and Fusarium seed and seedling decay	fluxapyroxad (various)	7	0.24 to 0.47 fl oz/100 lbs seed	--	---	Seed treatment
Rhizoctonia, and Fusarium seed rot, damping-off, Botrytis seedling blight, Phomopsis seed decay	penflufen + trifloxystrobin (various)	11	Apply 0.25 – 0.5 fl oz/100 lbs seed	---	---	Apply using commercial slurry or mist-type seed treatment equipment.
White mild (Sclerotinia)	*Coniothyrium minitans* (Contans WG)	—	1 to 4 lb/acre	0	4 hr	**OMRI listed product.** Apply to soil surface and incorporate no deeper than 2 inches. Works best when applied prior to planting or transplanting. Do not apply other fungicides for 3 weeks after applying Contans.
	fludioxonil (various)	12	7 oz/acre	7	0.5	Make no more than 2 sequential applications before alternating with a fungicide with a different mode of action for 2 applications. Use no more than 28 oz/acre per year.
Cottony leak (*Pythium* spp.)	fenamidone (Reason 500 C)	11	5.5 - 8.2 fl oz/acre	3	0.5	Begin applications as soon as crop and/or environmental conditions become favorable for disease development. DO NOT use on COWPEA.
Cottony leak, downy mildew, Phytophthora capsici	cyazofamid (Ranman)	21	2.75 fl oz/acre	0	0.5	Application instructions vary by disease; please follow label directions. DO NOT apply to cowpeas used for livestock feed.
Sclerotinia white mold and Botrytis gray mold	fluazinam (Omega 500F)	29	0.5 to 0.85 pt/acre	30	0.5	DO NOT use more than 1.75 pints of per acre. PHI varies by crop; see label restrictions.

TABLE 3-27. DISEASE CONTROL PRODUCTS FOR PEPPER

B. Dutta, Extension Vegetable Pathologist, University of Georgia

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Aphid-transmitted viruses: PVY, TEV, WMV, CMV	JMS Stylet-Oil		3 qt/100 gal water	0	Dry	Use in 50 to 200 gal per acre depending on plant size. Spray weekly when winged aphids first appear.
Anthracnose fruit rot	azoxystrobin (various)	11	See label	0	4 hr	Apply at flowering to manage green fruit rot. Limit of 61.5 fl oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action.
	azoxystrobin + difenoconazole (Quadris Top)	11+3	8 to 14 fl oz/acre	0	0.5	Limit of 55.3 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	chlorothalonil (various)	M	See labels	7	1	See labels. Rates vary depending on the formulation.
	chlorothalonil + cymoxanil (Ariston)	M+27	2 to 2.44 pt/acre	3	0.5	Limit of 18.1 pt per acre per year.
	difenoconazole + benzovindiflupyr (Aprovia Top)	11+3	10.5 to 13.5 fl oz/ acre	0	0.5	Limit of 53.6 fl oz per acre per year. Not labeled for greenhouse use. No more than two applications of Aprovia top may be applied on a 7-day interval.
	famoxadone + cymoxanil (Tanos)	11+27	8 to 10 oz/acre	3	0.5	Make no more than **one** application before alternating with a fungicide with a different mode of action. **NOTE: Must tank mix with another fungicide with a different mode of action (i.e. maneb or copper).**
	fenamidone (Reason)	11	5.5 to 8.2 fl oz/acre	14	0.5	Limit of 24.6 fl oz per growing season. Make no more than **one** applications before rotating to another effective fungicide with a different mode of action.

TABLE 3-27. DISEASE CONTROL PRODUCTS FOR PEPPER (cont'd)

B. Dutta, Extension Vegetable Pathologist, University of Georgia

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Anthracnose fruit rot (cont'd)	mancozeb (various)	M	See labels	7	1	See labels. Rates vary depending on the formulation.
	mancozeb + copper (ManKocide)	M+M	2 to 3 lb/acre	7	2	Limit of 39 lb per acre per season.
	pyraclostrobin (Cabrio EG)	11	8 to 12 oz/acre	0	4 hr	Apply at flowering to manage green fruit rot. Limit of 96 oz per acre per season. Make no more than **one** sequential application before alternating with fungicides that have a different mode of action.
	pyraclostrobin + fluxapyroxad (Priaxor)	11+7	4.0 to 8.0 fl oz/acre	0	0.5	**RIPE ROT ONLY.** Limit of 24 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	penthiopyrad (Fontelis)	7	24 fl oz/acre	0	0.5	**SUPPRESSION ONLY**. Limit of 72 fl oz per acre per year. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	trifloxystrobin (Flint)	11	3 to 4 oz/acre	3	0.5	**SUPPRESSION ONLY**. Limit of 16 oz per acre per year. Make no more than **one** application before alternating with fungicides that have a different mode of action.
Bacterial soft rot	famoxadone + cymoxanil (Tanos)	11+27	8 to 10 oz/acre	3	0.5	**SUPPRESSION ONLY**. Make no more than **one** application before alternating with a fungicide with a different mode of action. **NOTE: Must tank mix with another fungicide with a different mode of action (i.e. maneb or copper).**
Bacterial spot (field)	acibenzolar-S-methyl (Actigard 50 WG)	21	0.33 oz to 0.75 oz/acre	14	0.5	**FOR CHILI PEPPERS ONLY EXCEPT IN THE STATE OF GEORGIA[1].** Begin applications within one week of transplanting or emergence. Make up to six weekly, consecutive applications.
	fixed copper (various)	M	See labels	0	2	See label. Rates vary depending on the formulation. Make first application 7 to 10 days after transplanting. Carefully examine field for disease to deter mine need for additional applications. If disease is present, make additional applications at 5-day intervals. Applying mancozeb with copper significantly enhances bacterial spot control. Do not spray copper when temperatures are above 90 °F.
	famoxadone + cymoxanil(Tanos)	11+27	8 to 10 oz/acre	3	0.5	**SUPPRESSION ONLY**. Make no more than **one** application before alternating with a fungicide with a different mode of action. **NOTE: Must tank mix with another fungicide with a different mode of action (i.e. maneb or copper).**
	mancozeb (various)	M	See labels	7	1	See label. Rates vary depending on the formulation.
	mancozeb + copper (ManKocide)	M+M	2 to 3 lb/acre	7	2	Limit of 39 lb per acre per season.
	quinoxyfen (Quintec)	13	6.0 fl oz/acre	3	0.5	Use 6 oz of product per acre in no less than 30 gallons of water per acre. **NOTE: May only be used to manage bacterial spot in Georgia, Florida, North Carolina, and South Carolina (Section 2(ee)).**
	methyl salicylate + *Bacillus thuringiensis* subsp. *kurstaki* (Leap)	NA	16 to 64 fl oz/acre	See label	0.5	Apply preventatively on a 5-10 day schedule. For best disease control, LEAP should be used in tank mix or rotation with other registered pathogen control products, especially if disease is already observed in the crop.
Bacterial spot (transplants)	streptomycin sulfate (Agri-Mycin 17, Firewall, Streptrol)	25	1 lb/100 gal	—	1	**MAY ONLY BE APPLIED TO TRANSPLANTS.** Spray when seedlings are in the 2-leaf stage and continue at 5-day intervals until transplanted into field. **NOTE: Some pathogen strains are resistant to streptomycin sulfate.**
	fixed copper (various)	M	See labels	0	2	See labels. Rates vary depending on the formulation. Begin applications when conditions first favor disease development and repeat at 3 to 10 day intervals if needed depending on disease severity. Use the higher rates when conditions favor disease. Do not spray copper when temperatures are above 90 °F.
Bacterial spot (seed)	sodium hypochlorite (Clorox 5.25%, regular formulation)	—	1 pt + 4 pt water	—	—	Add 1 TSP of surfactant (Tween-20 or 80, Silwet) to improve coverage on the seed.
Cercospora leaf spot	azoxystrobin + difenoconazole (Quadris Top) 29.6 SC	11+3	8 to 14 fl oz/acre	0	0.5	Limit of 55.3 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action. The addition of non-ionic based surfactant or oil concentrate is recommended.
	pyraclostrobin (Cabrio)	11	8 to12 fl oz/acre	0	0.5	Limit of 96 fl oz per acre per season. Do not make more than one application of product before alternating to a labeled fungicide with different mode of action.
	difenoconazole + benzovindiflupyr (Aprovia Top)	7+3	10.5 to 13.5 fl oz/acre	0	0.5	Limit of 53.6 fl oz per acre per year. Make more than two applications before alternating to another fungicide with a non-group 7 mode of action.
	fixed copper (various)	M	See labels	0	2	See labels. Rates vary depending on the formulation. Begin applications when conditions first favor disease development and repeat at 3 to 10 day intervals if needed depending on disease severity. Use the higher rates when conditions favor disease. Do not spray copper when temperatures are above 90 °F.
	mancozeb (various)	M	See labels	7	1	See labels. Rates vary depending on the formulation.
	mancozeb + copper (ManKocide)	M+M	2 to 3 lb/acre	7	2	Limit of 39 lb per acre per season.

TABLE 3-27. DISEASE CONTROL PRODUCTS FOR PEPPER (cont'd)

B. Dutta, Extension Vegetable Pathologist, University of Georgia

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Phytophthora foliar blight and fruit rot (*Phytophthora capsici*)	cyazofamid (Ranman Fungicide)	21	2.75 fl oz/acre	0	0.5	Limit of 16.5 fl oz per acre per season. Apply to the base of the plant at transplanting or in the transplant water. Make no more than three consecutive applications followed by three consecutive applications of another effective fungicide with a different mode of action.
	oxathiapiprolin + mefenoxam (Orondis Gold 200 + Orondis Gold B)	U15+4	2 to 4.8 fl oz/acre 2.4 to 19.2 fl oz/acre	0	0.5	Limit of 19.2 fl oz per acre per season. Do not follow soil applications of Orondis Gold 200 with foliar applications of Orondis Opti A or Orondis Ultra A.
	oxathiapiprolin + chlorothalonil (Orondis Opti A + Orondis Opti B)	U15 +M	2.0 to 4.8 fl oz/acre 1.5 pt/acre	14	0.5	See labels. For resistance management, do not follow soil applications of Orondis with foliar applications of Orondis Opti A.
	oxathiapiprolin + mandipropamid (Orondis Ultra; premix)	U15 +40	5.5 to 8.0 fl oz/acre	See label	4hr	Use higher rate if disease is present. For best results, begin the disease resistance program with an initial treatment at planting or transplanting with a fungicide registered for its use. Apply Orondis Ultra as a foliar spray in a mixture with copper-based fungicide beginning at first appearance of symptoms.
	fixed copper (various)	M	See labels	0	2	See labels. Rates vary depending on the formulation. Begin applications when conditions first favor disease development and repeat at 3 to 10 day intervals if needed depending on disease severity. Use the higher rates when conditions favor disease. Do not spray copper when temperatures are above90 °F.
	dimethomorph (Acrobat, Forum)	40	6 fl oz/acre	0	0.5	**SUPPRESSION ONLY**. Limit of 30 fl oz per acre per season. Make no more than two sequential before alternating with fungicides that have a different mode of action. **NOTE: Must tank mix with another fungicide with a different mode of action.**
	mancozeb (various)	M	See labels	7	1	See labels. Rates vary depending on the formulation.
	mancozeb + copper (ManKocide)	M+M	2 to 3 lb/acre	7	2	**SUPPRESSION ONLY**. Limit of 39 lb per acre per season.
	mefenoxam + copper hydroxide (Ridomil Gold/ Copper)	4+M	2 lb/acre	7	2	See label for an optimal spray program. Limit of four applications per crop per year. Do not exceed 0.4 lb a.i. per acre per season of mefenoxam + metalaxyl (MetaStar).
	famoxadone + cymoxanil (Tanos)	11+27	8 to 10 oz/acre	3	0.5	**SUPPRESSION ONLY**. Make no more than **one** application before alternating with a fungicide with a different mode of action. **NOTE: Must tank mix with another fungicide with a different mode of action (i.e. maneb or copper).**
	fenamidone (Reason) 500SC	11	8.2 fl oz/acre	14	0.5	**SUPRESSION ONLY.** Limit of 24.6 fl oz per growing season. Make no more than one applications before rotating to another effective fungicide with a different mode of action.
	fluazinam (Omega) 500F	29	1 to 1.5 pt/acre	30	0.5	Apply as a soil drench at 1.5 pt per acre. For foliar applications, use 1 pt per acre. Limit of 9 pt per acre per season.
	fluopicolide (Presidio)	43	3 to 4 fl oz/acre	2	0.5	Limit of 12 fl oz per acre per season. Make no more than two times sequentially before alternating with fungicides that have a different mode of action. . **NOTE: Must be tank-mixed with another mode of action product.**
	mandipropamid (Revus, Micora)	40	8 fl oz/acre	1	0.5	**SUPPRESSION ONLY**. Limit of 32 fl oz per acre per season. **NOTE: Must tank mix with another fungicide with a different mode of action (i.e. copper).**
	ametoctradin + dimethomorph (Zampro)	45+40	14 fl oz/acre	4	0.5	Limit of 42 fl oz per acre per season. Make no more than two sequential applications before rotating to another effective fungicide with a different mode of action.
Phytophthora or Pythium root rot (field)	mefenoxam (Ridomil Gold, Ultra Flourish)	4	See label	—	2	**MAY ONLY BE APPLIED AT PLANTING**. Apply in a 12 to 16 in. band or in 20 to 50 gal water per acre in transplant water. Mechanical incorporation or 0.5 to 1 in. irrigation water is needed for movement into root zone if rain is not expected. After initial application, two supplemental applications (1 pt per treated acre) can be applied. **NOTE: Strains of *Phytophthora capsici* insensitive to Ridomil Gold have been detected in some North Carolina and Louisiana pepper fields.**
	metalaxyl (MetaStar) 2E	4	4 to 8 pt/treated acre	7	2	Limit of 12 pt per acre per season. Preplant (soil incorporated), at planting (in water or liquid fertilizer), or as a basal-directed spray after planting. See label for the guidelines for supplemental applications.
	oxathiapiprolin + mefenoxam (Orondis Gold 200 + Orondis Gold B)	U15 + 4	2.4 to 19.2 fl oz/acre 1 pt/acre	7	2	See labels

TABLE 3-27. DISEASE CONTROL PRODUCTS FOR PEPPER (cont'd)

B. Dutta, Extension Vegetable Pathologist, University of Georgia

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Powdery mildew	azoxystrobin (various)	11	6 to 15.5 fl oz/ acre	0	4 hr	Limit of 61.5 fl oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action.
	azoxystrobin + difenoconazole (Quadris Top) 29.6 SC	11+3	8 to 14 fl oz/acre	0	0.5	Limit of 55.3 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	chlorothalonil + cymoxanil (Ariston)	M+27	2 to 2.44 pt/acre	3	0.5	Limit of 18.1 pt per acre per year.
	difenoconazole + benzovindiflupyr (Aprovia Top)	7+3	10.5 to 13.5 fl oz/ acre	0	0.5	Limit of 53.6 fl oz per acre per year. Make more than two applications before alternating to another fungicide with a non-group 7 mode of action.
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	0	0.5	Limit of 72 fl oz per acre per year. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	pyraclostrobin + fluxapyroxad (Priaxor)	11+7	6.0 to 8.0 fl oz/acre	0	0.5	Limit of 24 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	quinoxyfen (Quintec)	13	4.0 to 6.0 fl oz/acre	3	0.5	Limit of 24 fl oz per acre per year. Make no more than two consecutive applications before alternating with fungicides that have a different mode of action. **NOTE: Under certain environmental conditions leaf spotting or chlorosis may occur after application; discontinue use if symptoms occur.**
	sulfur (various)	M	See label	See label	See label	See labels. Rates vary depending on the formulation. Apply at first appearance and repeat at 14-day intervals as needed.
	trifloxystrobin (Flint)	11	1.5 to 2 oz/acre	3	0.5	Limit of 16 oz per acre per year. Make no more than **one** application before alternating with fungicides that have a different mode of action.
Southern blight (*Sclerotium rolfsii*)	fluoxastrobin (Aftershock, Evito 280SC)	11	2 to 5.7 fl oz/acre	3	0.5	Limit of 22.8 fl oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action. **NOTE: Do not overhead irrigate for 24 hours following a spray application.**
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	0	0.5	Limit of 19.2 fl oz per acre per season. Make no more than2 sequential applications of Fontelis before switching to a fungicide with different mode of action. **For non-bell peppers only**
	PCNB (Blocker 4F) (transplanting)	14	4.5 to 7.5 pt/100 gal; use 0.5 pt of solution per plant.	NA	0.5	Transplanting: Apply at the time of transplanting for Southern blight suppression. The solution should be agitated often to maintain a uniform mixture to assure proper dosage. Limit of7.5 lb a.i. per acre per season.
	PCNB (Blocker 4F) (in furrow)	14	1.2 to 1.9 gal; apply 10.6 to 16.7 fl oz product per 1000 ft of row	NA	0.5	In furrow: Apply in 8 to 10 gals of water per acre based on36-inch row spacing. Apply as in-furrow sprays to the open "V" trench just prior to planting. When cultivating, set plows as flat as possible to avoid getting non-treated soil against stems or plants. Limit of 7.5 lb a.i. per acre per season.
	pyraclostrobin (Cabrio) 20EG	11	12 to 16 oz/acre	0	4 hr	**SUPPRESSION ONLY**. Apply at flowering to manage green fruit rot. Limit of 96 oz per acre per season. Make no more than **one** sequential application before alternating with fungicides that have a different mode of action.
	pyraclostrobin + fluxapyroxad (Priaxor)	11+7	4.0 to 8.0 fl oz/acre	0	0.5	**SUPPRESSION ONLY.** Limit of 24 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
Target spot (*Corynespora cassiicola*)	boscalid (Endura)	7	3.5 oz/acre	0	0.5	Limit of 21 oz per acre per season. Make no more than two sequential applications before alternating with fungicides that have a different mode of action.
	cyprodinil + difenoconazole (Inspire Super)	9+3	16 to 20 fl oz/acre	0	0.5	Limit of 80 fl oz per acre per season.
	fluoxastrobin (Aftershock, Evito 480SC)	11	2 to 5.7 fl oz/acre	3	0.5	Limit of 22.8 fl oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action. **NOTE: Do not overhead irrigate for 24 hours following a spray application.**
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	0	0.5	**SUPPRESSION ONLY**. Limit of 72 fl oz per acre per year. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	pyraclostrobin (Cabrio) 20EG	11	8 to 12 oz/acre	0	4 hr	Apply at flowering to manage green fruit rot. Limit of 96 oz per acre per season. Make no more than **one** sequential application before alternating with fungicides that have a different mode of action.
	pyraclostrobin + fluxapyroxad (Priaxor)	11+7	4.0 to 8.0 fl oz/acre	0	0.5	Limit of 24 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.

[1] A Special Local Need Label (24(c)) is available in the state of Georgia (EPA SLN No. GA-120006, Expires December 31, 2017) for use on sweet peppers (bell peppers, pimento, lamuyo, cubanelle, and banana peppers).

TABLE 3-28. EFFICACY OF PRODUCTS FOR DISEASE CONTROL IN PEPPER

B. Dutta, Extension Vegetable Pathologist, University of Georgia

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Product[1]	Fungicide group	Preharvest interval (Days)	Anthracnose (immature fruit rot)	Bacterial Spot	Phytophthora Blight (root and crown)	Phytophthora Blight (fruit and foliage)	Pythium Damping-off	Southern Blight
azoxystrobin (Quadris)	11	0	F	NC	NC	NC	NC	ND
chlorothalonil (various)	M	3	P	NC	NC	P	NC	NC
difenoconazole + benzovindiflupyr (Aprovia Top)	7+3	0	F	NC	NC	NC	NC	NC
cyazofamid (Ranman)	21	0	NC	NC	F	G	NC	NC
oxathiapiprolin (Orondis Gold 200)	U15	0	NC	NC	G	F	NC	NC
oxathiapiprolin (Orondis Opti A)	U15	0	NC	NC	F	G	NC	NC
dimethomorph (Acrobat, Forum)	40	4	NC	NC	NC	P	NC	NC
dimethomorph + amectoctradin (Zampro)	40 + 45	4	NC	NC	F	G	ND	NC
famoxadone + cymoxanil (Tanos)	11 + 27	3	P	NC	NC	P	NC	ND
fixed copper (various)	M	Check label	P	F	NC	F	NC	NC
fluopicolide (Presidio)	43	2	NC	NC	F	G	NC	NC
fluoxastrobin (Evito)	11	3	NC	NC	NC	NC	NC	ND
fluxapyroxad + pyraclostrobin (Priaxor)	11 + 7	7	F	NC	NC	NC	NC	ND
mancozeb[2] (Dithane, Manzate)	M	5	F	P	P	P	NC	NC
mandipropamid (Revus)	40	1	NC	NC	F	G	NC	NC
mefenoxam[R] (Ridomil Gold EC, Ultra Flourish)	4	0	NC	NC	E	NA	G	NC
mefenoxam[R] + copper (Ridomil Gold + copper)	4 + M	14	P	F	NA	G	NC	NC
methyl salicylate + *Bacillus thuringiensis* subsp. *kurstak*i (Leap)		Check label	NC	F-G	NC	NC	NC	NC
penthiopyrad (Fontelis)	7	0	ND	NC	NC	NC	NC	ND
propamocarb (Previcur Flex)	28	5	NC	NC	NC	NC	F	NC
pyraclostrobin (Cabrio)	11	0	G	NC	NC	NC	NC	ND
quinoxyfen (Quintec)	13	3	NC	P	NC	NC	NC	NC
streptomycin sulfate [3] (Agri-Mycin, Streptrol, Firewall)	25	Not for field use	NC	F	NC	NC	NC	NC
sulfur (various)	M	0	NC	NC	NC	NC	NC	NC

[1] Efficacy ratings do not necessarily indicate a labeled use for every disease.

[2] Copper tank-mixed with mancozeb enhances the efficacy against bacterial spot.

[3] Streptomycin may only be used on transplants; not registered for field use.

[F] To prevent resistance in pathogens, alternate fungicides within a group with fungicides in another group. Fungicides in the "M" group are generally considered "low risk" with no signs of resistance developing to the majority of fungicides.

[R] Resistance reported in the pathogen.

TABLE 3-29. IMPORTANCE OF ALTERNATIVE MANAGEMENT PRACTICES FOR DISEASE CONTROL IN PEPPER

B. Dutta, Extension Vegetable Pathologist, University of Georgia

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Strategy	Anthracnose (immature fruit)	Aphid-transmitted viruses (PVX,CMV,TEV,AMV,PVY)	Bacterial soft rot of fruit	Bacterial spot	Blossom-end rot	Phytophthora blight (fruit and foliage)	Phytophthora blight (root and crown)	Pythium damping off	Root-knot nematode	Southern blight	Tomato Spotted Wilt Virus
Avoid field operations when foliage is wet	F	NC	NC	G	NC	F	P	NC	NC	NC	NC
Avoid overhead irrigation	G	NC	F	G	NC	G	G	P	NC	NC	NC
Change planting date within a season	NC	F (early)	NC	F (early)	NC	NC	NC	P (late)	F (early)	P (early)	Variable
Cover cropping with antagonist	NC	NC	NC	NC	NC	NC	NC	NC	F	NC	NC
Rotation with non-host (2 to 3 years)	G	NC	NC	NC	NC	P	P	NC	F	P	NC
Deep plowing	F	NC	NC	NC	NC	NC	NC	NC	P	F	NC
Prompt destruction of crop residue	F	F	NC	P	NC	P	P	NC	F	P	NC
Promote air movement	P	NC	NC	F	NC	P	P	NC	NC	NC	NC
Use of soil organic amendments	NC	NC	NC	NC	NC	P	P	P	F	P	NC
Application of insecticidal/horticultural oils	NC	F	NC	NC	NC	NC	NC	NC	NC	NC	NC
pH management (soil)	NC	NC	NC	NC	F	NC	NC	NC	F	NC	NC
Plant in well-drained soil / raised beds	NC	NC	NC	NC	NC	NC	G	G	NC	NC	NC
Eliminate standing water / saturated areas	NC	NC	NC	NC	NC	NC	G	G	NC	NC	NC
Postharvest temp control (fruit)	NC	NC	G	NC	NC	NC	NC	NC	NC	NC	NC
Use of reflective mulch	NC	F	NC	NC	NC	NC	NC	NC	NC	NC	G
Reduce mechanical injury	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Rogue diseased plants / fruit	NC	NC	NC	NC	NC	F	F	NC	NC	NC	NC
Soil solarization	NC	NC	NC	NC	NC	NC	P	NC	F	NC	NC
Use of pathogen-free planting stock	F	NC	NC	G	NC	NC	NC	NC	NC	NC	NC
Use of resistant cultivars	NC	NC	NC	G	F	F	F	NC	G	NC	G
Weed management	P	F	NC	NC	NC	P	P	NC	F	NC	P

TABLE 3-30. DISEASE CONTROL PRODUCTS FOR POTATO, IRISH

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Black scurf (*Rhizoctonia solani*) and Silver scurf (*Helminthosporium solani*)	azoxystrobin (various)	11	See label	See label	See label	See labels. Rates may vary depending on the product. Apply in furrow at planting according to label direction. Do not apply more than one application without alternating away from fungicides in Group 11.
	azoxystrobin + benzovindiflupyr (Elatus)	11 + 7	0.34 to 0.5 oz/1000 linear row feet	0.5	—	Limit 9.5 oz/acre per application.
	fludioxonil (Maxim PSP)	12	0.5 lb/100 lb seed pieces	—	0.5	Ensure thorough coverage of each seed piece.
	fludioxonil + mancozeb (Maxim MZ)	12 + M	0.5 lb/100 lb seed pieces	—	0.5	Ensure thorough coverage of each seed piece.
	fludioxonil + thiamethoxam (Cruiser Maxx Potato)	12 + insecti-cide	0.19 to .27 fl oz/100 lb seed pieces	—	0.5	Rate depends on seeding rate – see label. See label for additional restrictions.
	fludioxonil + difenoconazole + sedazane + thiamethoxam (Cruiser Maxx Vibrance Potato)	12 + 3 + 7 + in-sectcide	0.5 fl oz/100 lb seed pieces	—	0.5	See label for additional restrictions.
	fluopyram (Luna Privilege)	7	5.47 fl oz/acre (ground); 2.82 oz/acre (aerial)	7	0.5	Use on a 5 to 7-day interval. Do not apply more than 10.95 oz/acre/season for ground application and no more than 8.46 oz/acre/season for aerial application. Do not make more than 2 applications before alternating with a fungicide with a different mode of action. Labeled for **silver scurf only.**
	fluoxastrobin (Aftershock, Evito 480 SC)	11	0.16 to 0.24 fl oz/ 1,000 ft of row	7	0.5	Apply in furrow at planting according to label directions. Do not apply more than 22.8 fl oz of product per acre per year including seed treatment use. Alternate with fungicide from different resistance management group.

TABLE 3-30. DISEASE CONTROL PRODUCTS FOR POTATO, IRISH (cont'd)

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Black scurf (*Rhizoctonia solani*) and Silver scurf (*Helminthosporium solani*) (cont'd)	flutolanil (Moncut 70DF) (Moncut SC)	7	0.71 to 1.1 lb/acre 16.0 to 25.0 fl oz/acre	—	0.5	For **black scurf only**. Apply as an in-furrow spray by directing spray uniformly around and over the seed-piece inch a 4 to 8 in band prior to covering with soil.
	flutolanil + mancozeb (MonCoat MZ)	7 + M	0.75 lb to 1.0 lb/100 lb seed piece	—	1	Apply to seed-pieces immediately after cutting. Ensure thorough coverage.
	mancozeb (various)	M	See label	—	1	For **black scurf only.**
	penthiopyrad (Vertisan)	7	0.7 to 1.6 fl oz/1,000 ft of row	7	0.5	Maximum rate is 24 fl oz per acre per year. No more than 2 applications before switching to a different mode of action. Provides suppression of **black scurf only**.
	thiophanate-methyl (various)	1	0.5-0.7 fl oz/100 lb seed pieces	—	0.5	
Fusarium seedpiece decay, Rhizoctonia stem canker, Streptomyces common scab	fludioxonil (various)	12	See label	—	0.5	Label rates may vary depending on the product.
	fludioxonil + mancozeb (Maxim MZ)	12 + M	0.5 lb/100 lb seed	--	1	Do not use treated seedpieces for feed or food. NOT labeled for Streptomyces common scab. See label for treatment instructions.
	mancozeb (various)	M	See label	—	1	Label rates may vary depending on the product.
	penthiopyrad (Vertisan)	7	0.7 to 1.6 oz/ 1,000 ft of row	7	0.5	Maximum rate is 24 fl oz per application. Labeled for **Rhizoctonia stem canker only.**
Early blight, white mold	azoxystrobin + difenoconazole (Quadris Top)	11+3	8 to 14 fl oz/acre	14	0.5	Apply at 7 to 14 day-intervals. Apply no more than 2 sequential applications without alternating with a fungicide with a different mode of action. Limit of 55.3 lb product per acre per year. Limit of 0.46 lb a.i./acre /year of difenoconazole-containing products; limit of 2.0 lb a.i./acre /year of azoxystrobin-containing products**. Labeled for early blight only.**
	boscalid (Endura)	7	3.5 to 10 oz/acre	10	0.5	For control of Sclerotinia white mold, use 5.5 to 10 oz rate and begin applications prior to row closure or at the onset of disease. Make a second application 14 days later if conditions favor disease development. Do not exceed 2 applications per season. For Early blight control, use 3.5 to 4.5 oz rate. Do not exceed four applications per season. Limit of 20.5 oz of product per acre per season. Limit of 2 applications before alternating with a fungicide with a different mode of action.
	fluopyram (Luna Privilege)	7	4.0 to 5.47 oz/acre (ground); 2.82 oz/acre (aerial)	7	0.5	Use on a 5 to 7-day interval. Do not apply more than 10.95 oz/ acre/season for ground application and no more than 8.46 oz/ acre/season for aerial application. Do not make more than 2 applications before alternating with a fungicide with a different mode of action. For white mold, use 5.47 oz rate.
	fluopyram + pyrimethanil (Luna Tranquility)	7+9	11.2 oz/acre	7	0.5	Apply at 7 to 14 day intervals. Do not make more than 2 sequential applications without switching to a fungicide outside of Group 7 or Group 9.
	fluxapyroxad + pyraclostrobin (Priaxor)	7+11	4 to 8 oz/acre	7	0.5	Apply at 7 to 14 day intervals. Do not apply more than 24 oz/ acre/season including in furrow and foliar uses. Use 6 to 8 oz/ acre for SUPPRESSION of white mold. Maximum of 3 applications.
	iprodione (various)	2	See label	14	1	Rates may vary depending on the product.
	metconazole (Quash)	3	2.5 to 4 oz/acre	1	0.5	Limit 16 oz/acre/season. Make no more than 2 applications before changing modes of action. Limit to 4 applications per year. Use the 4 oz rate for white mold.
	metiram + pyraclostrobin (Cabrio Plus)	M+11	2.0 to 2.9 lb/acre	14	1	Apply at 7 to 14 day-intervals. Do not apply more than 17.4 lb/ acre product per season. Do not apply more than 2 sequential applications before alternating with a fungicide with a different mode of action. Use at 2.9 lb/acre rate for suppression of white mold.
	penthiopyrad (Vertisan)	7	10 to 24 oz/acre	7	0.5	Apply at 7-14 day intervals. Make no more than 2 applications before alternating with a fungicide with a different mode of action. For SUPPRESSION of white mold, use at 14 to 24 oz/ acre. Do not exceed 72 oz per acre per year. Do not apply more than 11.25 oz a.i. per acre per year in total from any combination of seed, soil, or foliar applications.
	pyraclostrobin (Headline; Headline SC)	11	6 to 12 fl oz/acre	3	0.5	**DO NOT** exceed more than six foliar applications or 72 total oz of product per acre per season. For early blight, use 6 to 9 oz rate; for SUPPRESSION of white mold, use 6 to 12 oz rate, depending on weather conditions and disease pressure. Do not apply more than one time before alternating with a fungicide with a different mode of action.
	pyrimethanil (Scala SC)	9	7 fl oz/acre	7	0.5	Apply at 7 to 14 day intervals. Do not apply more than 35 fl oz/ acre/season. For control of **early blight only.**
	thiophanate-methyl (various)	1	See label	See label	0.5	Rates may vary depending on the product.

TABLE 3-30. DISEASE CONTROL PRODUCTS FOR POTATO, IRISH (cont'd)

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Late blight, white mold	fluazinam (Omega) 500 F	29	5.5 to 8 fl oz/acre	14	0.5	Begin applications when plants are 6 to 8 in. tall or when conditions favor disease development. Repeat applications at 7 to 10 day intervals. For late blight, use the 5.5 fl oz rate. **DO NOT** apply more than 3.5 pt per acre during each growing season.
Early blight, late blight	azoxystrobin (various)	11	See label	14	4 hr	Rates may vary depending on the product. Do not apply more than one application without alternating away from fungicides in Group 11.
	azoxystrobin + chlorothalonil (Quadris Opti)	11+M	1.6 pt/acre	14	0.5	Apply at 5 to 7 day-intervals. Do not apply more than one application without alternating away from fungicides in Group 11. See label for limits of active ingredients.
	chlorothalonil (various)	M	See label	7	0.5	Rates may vary depending on the product.
	chlorothalonil + cymoxanil (Ariston)	M+27	2 pt/acre	14	0.5	Apply at 5-7 day intervals. Do not exceed 17.5 pt of product per acre per 12-month period.
	chlorothalonil + zoxamide (Zing!)	M+22	24 to 34 fl oz/acre	7	0.5	Apply at 5 to 7 day intervals. Do not make more than 2 sequential applications before alternating with a fungicide that has a different mode of action. Do not make more than 8 applications per acre per season. Use 30-34 fl oz rate for late blight.
	fixed copper (various)	M1	See label	0	1	See label. Rates vary depending on the formulation.
	cymoxanil + famoxadone (Tanos)	27 + C3	6 to 8 oz/acre	14	0.5	Use rate of 6 fl oz only for early blight. Do not apply more than 48 oz/acre per crop season and no more than 72 oz/acre per 12 months. Do not make more than one application before alternating with a fungicide with a different mode of action.
	dimethomorph (Forum)	40	4 to 6 fl oz/acre	4	1	Must tank mix if using less than 6 fl oz rate; if used alone, use 6 oz rate. **DO NOT** make more than 5 applications per season. Limit 30 fl oz/acre/season.
	fenamidone (Reason 500 SC)	11	5.5 to 8.2 fl oz/acre	14	0.5	Begin applications when conditions favor disease development, and continue on 5 to 10 day interval. Do not apply more than 24.6 fl oz per growing season. Alternate with fungicide from different resistance management group.
	fluoxastrobin (Aftershock, Evito 480 SC)	11	2 to 3.8 fl oz/acre	7	0.5	Begin applications when conditions favor disease development on 7 to 10 day intervals. Do not apply more than once before alternating with fungicides that have a different mode of action. Do not apply more than 22.8 fl oz per acre per season. For late blight, apply at full label rate.
	fluxapyroxad + pyraclostrobin (Priaxor)	7	4 to 8 fl oz/acre	7	0.5	Apply at 7 to 14 day intervals. Do not apply more than 24 oz/acre/season including in furrow and foliar uses.
	mancozeb + chlorothalonil (Elixir)	M + M	1.8 to 2.4 lb/acre	14	1	Do not apply more than 18 lbs product/crop/year.
	metiram (Polyram 80DF)	M	1.5 to 2 lb/acre	14	1	Do not apply more than 14 lb product/crop/year.
	mandipropamid + difenoconazole (Revus Top)	40 + 3	5.5 to 7 fl oz/acre	14	0.5	After 2 applications, switch to a different mode of action. Do not apply more than 28 fl oz/acre/season.
	mefenoxam + chlorothalonil (Ridomil Gold Bravo SC)	4 + M	2.5 pints/acre	14	2	See label for limits on application limits per season and application interval.
	mefenoxam + mancozeb (Ridomil Gold MZ WG)	4 + M	2.5 lb/acre	14	2	Apply at 14-day intervals for up to 3 applications.
	propamocarb hydrochloride (Previcur Flex)	28	0.7 to 1.2 pints/acre	14	0.5	Tank mix with a protectant fungicide such as mancozeb or chlorothalonil. Do not exceed 6 pints of product/acre/season.
	pyraclostrobin (Headline; Headline SC)	11	6 to 12 fl oz/acre	3	1	**DO NOT** exceed more than six foliar applications or 72 total oz of product per acre per season. For early blight, use 6 to 9 oz rate. Do not apply more than one time before alternating with a fungicide with a different mode of action.
	pyraclostrobin + chlorothalonil (Cabrio Plus)	11 + M	2.0 to 2.9 lb/acre	14	1	Do not apply more than 2 applications before switching to a different mode of action. Do not exceed 17.4 lbs/acre/season. For late blight, use 12 lb/acre rate.
	pyrimethanil (Scala 5F)	9	7 fl oz/acre	7	0.5	Labeled for **early blight only**. Do not apply more than 35 fluid ounces per crop.
	trifloxystrobin (Gem 500SC)	11	2.9 to 3.8 fl oz/acre	7	0.5	Must tank mix with a non-Group 11 fungicide for late blight. Use the 3.8 of oz rate for late blight. Do not make more than 1 application without switching to a different mode of action. Do not exceed 6 applications or 23 fl oz product/acre/season.
	triphenyltin hydroxide (Super Tin 4L) (Super Tin 80WP, Agri Tin)	30	4 to 6 fl oz/acre 2.5 to 3.75 oz/acre	7	2	For Super Tin 4L, the 3.0 fl oz rate may be used if tank mixed. Add to 3 to 15 gallons of water depending on method of application. Season application limits apply–see label.
	zoxamide + mancozeb (Gavel 75DF)	22 + M	1.5 to 2.0 lb/acre	14	2	Do not make more than 6 applications or apply more than 12 lbs product/acre/season.

TABLE 3-30. DISEASE CONTROL PRODUCTS FOR POTATO, IRISH (cont'd)

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Late blight	ametoctradin + dimethomorph (Zampro)	45 + 40	11 to 14 fl oz/acre	4		Do not make more than 2 applications without switching to a different mode of action. Do not exceed 42 fl oz/acre/season and 3 applications/season.
	cyazofamid (Ranman 400SC)	21	1.4 to 2.75 fl oz/acre	7	0.5	Do not apply more than 10 sprays per crop. Make no more than 3 consecutive applications, and then follow with 3 applications of another mode of action.
	cymoxanil (Curzate 60DF)	27	3.2 oz/acre	14	0.5	**USE ONLY WITH A PROTECTANT FUNGICIDE** such as mancozeb or chlorothalonil. No more than 7 applications/crop/year.
	dimethomorph (Forum)	40	4 to 6 fl oz/acre	4	0.5	If applying at less than 6 fl oz rate, must tank mix with a non-group 40 fungicide. Do not exceed 5 applications or 30 fl oz of product/acre/season.
	fluazinam (Omega)	29	5.5 to 8 fl oz/acre	14	0.5	Begin applications when plants are 6 to 8 in. tall or when conditions favor disease development. Repeat applications at 7 to 10 day intervals. For late blight, use the 5.5 fl oz rate. **DO NOT** apply more than 3.5 pt per acre during each growing season.
	mefenoxam + copper hydroxide (Ridomil Gold/ Copper)	4 + M	2 lb/acre	14	2	MUST tank-mix with a protectant fungicide. Apply at 14-day intervals for up to 3 applications; alternated and followed by the full rate of a protectant
	mono- and di-potassium salts of phosphorous acid (various)	33	See label	0	4h	Mix with a fungicide labeled for control of late blight. See label for in-furrow application or foliar application rates.
	oxathiapiprolin + chlorothalonil (Orondis Opti A + Orondis Opti B)	U15 + M	1.6 to 4.8 fl oz/acre 0.75 to 1.5 pints/acre	7	0.5	Do not make more than 2 sequential applications without switching to a different mode of action and no more than 6 total applications per season. Do not mix soil applications and foliar applications. Apply no more than 27.2 fl oz of Orondis Opti A per season and no more than 15 pints of Orondis Opti B per season. See label for pre-mix.
	oxathiapiprolin + mandipropamid (Orondis Ultra A + Orondis Ultra B)	U15 + 40	1.6 to 4.8 fl oz/acre 8.0 fl oz/acre	5 14	4 hr	Do not make more than 2 sequential applications without switching to a different mode of action and no more than 6 total applications per season. Do not mix soil applications and foliar applications. Apply no more than 27.2 fl oz of Orondis Ultra A per season and no more than 32 fl oz of Orondis Ultra B per season.
Pink rot, Pythium leak, tuber rot	azoxystrobin + mefenoxam (Quadris Ridomil Gold SL)	11+4	0.82 fl oz /1,000 ft of row	—	0	Apply as an in-furrow spray in 3 to 15 gal of water per acre at planting.
	cyazofamid (Ranman 400SC)	21	1.4 to 2.75 fl oz/ acre (foliar) 0.42 fl oz/1,00 ft (in-furrow)	7	0.5	For pink rot and Pythium leak, apply at the high rate. Do not apply more than 10 sprays per crop or more than 27.5 fl oz/acre/season. Make no more than 3 consecutive applications followed by 3 applications from a different resistance management group.
	mefenoxam (Ridomil Gold SL) (Ultra Flourish)	4	0.42 fl oz/1,000 ft of row 0.84 fl oz/1,000 ft of row	7	2	See labels for maximum amount of product allowable per season. PHI is based on foliar application for Ultra Flourish.
	mefenoxam + chlorothalonil (Ridomil Gold/ Bravo)	4 + M	2.5 pt/acre	14	2	Apply at flowering and then continue on a14-day interval. Do not exceed more than four applications per crop.
	mefenoxam + copper hydroxide (Ridomil Gold/ Copper)	4 + M	2 lb/acre	14	2	Apply at 14-day intervals for up to 3 applications. Alternate with a protectant fungicide.
	mefenoxam + mancozeb (Ridomil Gold MZ)	4 + M	2.5 lb/acre	14	2	Apply at 14-day intervals for up to 4 applications.
	metalaxyl (Metalaxyl 2E AG, MetaStar 2E)	4	12.8 fl oz/acre	14	2	Preplant incorporated or soil surface spray
	mono- and di-potassium salts of phosphorous acid (various)	33	2.5 to 10 pints/acre	0	4h	See label for in-furrow application or foliar application rates.

TABLE 3-30. DISEASE CONTROL PRODUCTS FOR POTATO, IRISH (cont'd)

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Powdery mildew	azoxystrobin (various)	11	See label	14	4h	See label. Rates may vary depending on the product. Apply in furrow at planting according to label direction. Do not apply more than one application without alternating away from fungicides in Group 11.
	azoxystrobin + chlorothalonil (Quadris Opti)	11 + M	1.6 pt/acre	14	0.5	Do not apply more than 1.5 lb a.i./ acre/year of azoxystrobin; do not apply more than 11.25 lb a.i./ acre /year of chlorothalonil. Do not make more than 1 application before alternating with a fungicide with a different mode of action. Do not apply this product or other fungicides in Group 11 more than 6 times in a season.
	azoxystrobin + difenoconazole (Quadris Top)	11 + 3	8 to 14 fl oz/acre	14	0.5	Apply at 7 to 14 day-intervals. Apply no more than 2 sequential applications without alternating with a fungicide with a different mode of action. Do not apply more than 55.3 lb product per acre per year. Do not apply more than 0.46 lb a.i./acre /year of difenoconazole-containing products; do not apply more than 2.0 lb a.i./acre /year of azoxystrobin-containing products.
	fluopyram + pyrimethanil (Luna Tranquility)	7 + 9	11.2 fl oz/acre	7	0.5	Do not make more than 2 sequential applications without switching to a fungicide outside of Group 7 or Group 9. Limit 54.7 fl oz/acre/season.
	fluxapyroxad + pyraclostrobin (Priaxor Xemium)	7 + 11	6 to 8 fl oz/acre	7	0.5	Limit 3 applications per season and no more than 2 applications before switching to a different mode of action. Do not apply more than 24 fl oz/ acre/season including in furrow and foliar uses.
	mandipropamid + difenoconazole (Revus Top)	40 + 3	5.5 to 7 fl oz/acre	14	0.5	Begin applications when conditions favor disease development, on 7 to 10 day intervals. Do not apply more than twice before alternating with fungicides that have a different mode of action. Do not apply more than 28 fl oz per acre per season.
	metiram + pyraclostrobin (Cabrio Plus)	M + 11	2.9 lb/acre	14	1	Apply at 7 to 14 day-intervals. Do not apply more than 17.4 lb/ acre product per season. Do not apply more than 2 sequential applications before alternating with a fungicide with a different mode of action.
	penthiopyrad (Vertisan)	7	10 to 24 fl oz/acre	7	0.5	Apply at 7-14 day intervals. Make no more than 2 applications before alternating with a fungicide with a different mode of action. Do not exceed 72 oz per acre per year. Do not apply more than 11.25 oz a.i. per acre per year in total from any combination of seed, soil, or foliar applications.
	pyraclostrobin (Headline; Headline SC)	11	6 to 12 fl oz/acre	3	0.5	**DO NOT** exceed more than six foliar applications or 72 total oz of product per acre per season. Do not apply more than one time before alternating with a fungicide with a different mode of action.
	sulfur (various)	M2	See label	—	1	Rates vary among products; see label.

PUMPKIN - SEE CUCURBITS

WINTER SQUASH - SEE CUCURBITS

SUMMER SQUASH - SEE CUCURBITS

RADISH - SEE ROOT VEGETABLES

SCALLION - SEE ONION, GREEN SHALLOT - SEE ONION, DRY

TABLE 3-31. DISEASE CONTROL PRODUCTS FOR ROOT VEGETABLES (EXCEPT SUGAR BEET)

E. Pfeufer, Plant Pathologist, University of Kentucky

Disease	Material	FRAC	Rate of Material	Minimum days		Method, Schedule, and Remarks
				Harv.	Reentry	
Beet (red, garden or table), Carrot, Parsnip, Radish, Turnip – Harvested for roots only						
Alternaria leaf blight, Cercospora leaf spot	azoxystrobin (various)	11	9.0 to 15.5 fl oz/ acre	0	4 hr	No more than 1 application before alternating with a fungicide with a different mode of action. Make no more than 123 fl oz per acre per year.
	azoxystrobin + chlorothalonil (Quadris Opti)	11 + M	2.4 pt / acre	0	0.5	**FOR USE ON CARROTS ONLY**.
	azoxystrobin + difenoconazole (Quadris Top)	11 + 3	12 to 14 fl oz / acre	7	0.5	**FOR USE ON CARROTS ONLY**.
	azoxystrobin + propiconazole (various)	11+3	14 fl oz	14	0.5	**FOR USE ON CARROTS ONLY**. No more than 1 application before alternating with a non-Group11 fungicide. Make no more than 55 fl oz per acre per year.
	boscalid (Endura)	7	4.5 oz/acre	0	0.5	**FOR USE ON CARROTS ONLY.** Not for *Cercospora*. Do not make more than 2 consecutive applications or more than 5 applications per season.
	chlorothalonil (various)	M	1.4 to 1.8 lb/acre	—	0.5	**FOR USE ON CARROTS ONLY.** Spray at first appearance, 7 to 10 day intervals.
	cyprodinil + fludioxonil (Switch)	9+12	11 to 14 oz/acre	7	0.5	**Not for Cercospora.** Apply when disease first appears, and continue on 7 to 10 day intervals if conditions remain favorable for disease development. Do not exceed 56 oz of product per acre per year.
	fixed copper (various)	M	See labels	0	1 to 2	**FOR USE ON CARROTS AND GARDEN BEETS ONLY.**
	fluazinam (Omega)	29	1 pt / acre	7	0.5	**FOR USE ON CARROTS ONLY.**
	fluopyram + trifloxystrobin (Luna Sensation)	7+11	4.0 to 7.6 fl oz/acre	7	0.5	**FOR USE ON CARROTS ONLY.** Do not make more than 2 consecutive applications before rotating to a labeled non-Group 7 or non-Group 11 fungicide.
	fluopyram + pyrimethanil (Luna Tranquility)	7 + 9	11.2 fl oz/acre	7	0.5	Do not make more than 2 consecutive applications before rotating to a labeled non-Group 7 or non-Group 9 fungicide.
	fluxapyroxad + pyraclostrobin (Merivon)	7+11	4 to 5.5 fl oz/acre	7	0.5	Do not make more than 2 consecutive applications before rotating to a labeled non-Group 7 or non-Group 11 fungicide. Make no more than 3 applications per season. Use maximum rate for Cercospora leaf spot.
	iprodione (various)	2	1 to 2 pt/acre	0	1	**FOR USE ON CARROTS ONLY.** Make no more than 4 applications per season.
	penthiopyrad (Fontelis)	7	16 to 30 fl oz/acre	0	0.5	Make no more than 2 consecutive applications before alternating with a fungicide with a different mode of action. Apply no more than 61 fl oz/ acre per year.
	propiconazole (various)	3	3 to 4 fl oz/acre	14	0.5	**FOR USE ON GARDEN BEETS AND CARROTS** ONLY. Use higher rate for carrots. Make no more than 2 consecutive applications before alternating with a fungicide with a different mode of action. Apply no more than 16 fl oz/acre/ season.
	pyraclostrobin (Cabrio)	11	8 to 12 oz/acre	0	0.5	Alternate with a fungicide with a different mode of action.
	pyraclostrobin + boscalid (Pristine)	11+7	8 to 10.5 oz/acre	0	0.5	**FOR USE ON CARROTS ONLY.** Make no more than 2 consecutive applications before alternating with a different mode of action. Use no more than 63 oz or make no more than 6 applications per season.
	sulfur (various)	M	3 to 10 lb/acre		1	**POWDERY MILDEW ONLY.** Spray at first appearance. Avoid applying on days over 90°F.
	trifloxystrobin (Flint) (Gem)	11	 2 to 3 oz/acre 1.9 to 2.9 fl oz/acre	7	0.5	**NOT FOR RADISHES.** Make no more than 1 application before alternating with a fungicide with another mode of action. Make no more than 4 applications of trifloxystrobin or other strobilurin fungicides per season.
Cercospora leaf spot or blight, powdery mildew	tebuconazole (various)	3	4 to 7.2 fl oz/acre	7	0.5	**FOR USE ON TURNIP AND GARDEN BEETS ONLY**. Repeat applications at 12 to 14 day intervals. Apply no more than 28 fl oz/ acre/season.
Phytophthora basal stem rot	mefenoxam (Ridomil Gold) 4 SL (Ultra Flourish) 2 EC	4	 1 to 2 pt/trt acre 2 to 4 pt/trt acre	—	2	Apply preplant incorporated into top 2 inches or as a pre-emergent soil spray. Surface spray must be incorporated by rainfall or irrigation
	metalaxyl (various)	4	4 to 8 pt/trt acre	—	2	
	fenamidone (Reason)	11	8.2 fl oz/acre	14	0.5	Make no more than 1 application before alternating with a mefenoxam-containing fungicide. Apply no more than 24.6 fl oz per growing season. Applied with sprayer or in sprinkler irrigation.
	fluazinam (Omega)	29	1 pt / acre	7	0.5	**FOR USE ON CARROTS ONLY.**

TABLE 3-31. DISEASE CONTROL PRODUCTS FOR ROOT VEGETABLES (EXCEPT SUGAR BEET) (cont'd)

E. Pfeufer, Plant Pathologist, University of Kentucky

Disease	Material	FRAC	Rate of Material	Minimum days Harv.	Minimum days Reentry	Method, Schedule, and Remarks
Beet (red, garden or table), Carrot, Parsnip, Radish, Turnip – Harvested for roots only (cont'd)						
Pythium root rot, root dieback, cavity spot (*Pythium* spp.)	azoxystrobin + mefenoxam (Uniform)	11 + 4	0.34 fl oz/1000 row ft	-	0	**NOT FOR CARROTS.** In-furrow treatment only.
	mefenoxam (Ridomil Gold) 4 SL (Ultra Flourish) 2 EC	4	 1 to 2 pt/trt acre 2 to 4 pt/trt acre	—	2	Apply preplant incorporated into top 2 inches, as a soil spray at planting. Surface spray must be incorporated by rainfall or irrigation.
	metalaxyl (various)	4	4 to 8 pt/trt acre	—	2	Apply preplant incorporated into top 2 inches, as a soil spray at planting. Surface spray must be incorporated by rainfall or irrigation.
	fenamidone (Reason)	11	8.2 fl oz/acre	14	0.5	Make no more than 1 application before alternating with a mefenoxam-containing fungicide. Apply no more than 24.6 fl oz per growing season. Applied with sprayer or in sprinkler irrigation.
	cyazofamid (Ranman)	21	6 fl oz/acre	14	0.5	**FOR USE ON CARROTS ONLY**. May be applied preplant incorporated, as a pre-emergent surface band, or in sprinkler irrigation. Applications can be repeated at 14- day intervals, but must alternate with a Pythium fungicide with a different mode of action.
	fluopicolide (Presidio)	43	3 to 4 fl oz/acre	7	0.5	Can be applied with a sprayer or in sprinkler irrigation. Regardless of method, must be applied in combination with a fungicide with a different mode of action and labeled for that method. No more than 2 consecutive applications before alternating with a Pythium fungicide with a different mode of action. Maximum of 12 fl oz/ acre/year. For carrots only, may also be applied preplant incorporated.
Rhizoctonia root canker (*Rhizoctonia* solani)	azoxystrobin (various)	11	0.4 to 0.8 fl oz/ 1000 row ft	0	4 hr	Make one application, applied either in-furrow at planting, in a 7-inch band over the row prior to or shortly after planting, or in drip irrigation.
Rust (*Puccinia* spp.)	penthiopyrad (Fontelis)	7	16 to 30 fl oz/acre	0	0.5	Make no more than 2 consecutive applications before alternating with a fungicide with a different mode of action. Apply no more than 61 fl oz/ acre per year.
	sulfur (various)	M	See label	0	1	
White mold (*Sclerotinia* spp.) and gray mold (*Botrytis* spp.)	boscalid (Endura)	7	7.8 oz	0	0.5	**FOR USE ON CARROTS ONLY.** No more than 2 applications before alternating with a fungicide with a different mode of action. Limit of 3 applications per season.
	penthiopyrad (Fontelis)	7	16 to 30 fl oz/acre	0	0.5	Make no more than 2 consecutive applications before alternating with a fungicide with a different mode of action. Apply no more than 61 fl oz/ acre per year.
White mold (*Sclerotinia* spp.) and gray mold (*Botrytis* spp.) (postharvest)	thiabendazole (Mertect)	3	41 fl oz/100 gal	—	0.5	Dip harvested roots 5 to 10 seconds. Do not rinse.
Southern blight (*Sclerotium rolfsii*)	dichloropropene (Telone) C-17 C-35	—	 10.8 to 17.1 gal/ acre 13 to 20.5 gal/acre	—	5	Fumigate soil in-the-row 3 to 6 weeks before seeding. Rate is based on soil type; see label for in-row rates.
	pyraclostrobin + boscalid (Pristine)	11+7	8 to 10.5 oz/acre	0	0.5	**FOR USE ON CARROTS ONLY.** Suppression only. Make no more than6 applications per season.
	azoxystrobin (various)	11	0.4 to 0.8 fl oz/1000 row ft	0	4 hr	Make one application, applied either in-furrow at planting, in a 7-inch band over the row prior to or shortly after planting, or in drip irrigation.
	fluazinam (Omega)	29	1 pt / acre	7	0.5	**FOR USE ON CARROTS ONLY.**
	penthiopyrad (Fontelis)	7	16 to 30 fl oz/acre	0	0.5	Make no more than 2 consecutive applications before alternating with a fungicide with a different mode of action. Apply no more than 61 fl oz/ acre per year.
White Rust (*Albugo* spp.)	azoxystrobin (various)	11	6.0 to 15.5 fl oz/ acre	0	4 hr	No more than 1 application before alternating with a fungicide with a different mode of action. Apply no more than 123 fl oz per acre per season.
	pyraclostrobin (Cabrio)	11	8 to 16 oz/acre	0	0.5	Alternate with a fungicide with a different mode of action. Apply no more than 48 oz/acre/season.
	mefenoxam + copper hydroxide (Ridomil Gold/Copper)	4+M	2 lb/acre	7	1	Spray leaves. Use with preplant Ridomil 2E soil applications. Make 2 to 4 applications if needed on 14-day intervals.

TABLE 3-32. IMPORTANCE OF ALTERNATIVE MANAGEMENT PRACTICES FOR DISEASE CONTROL IN CARROT

S. Bost, Plant Pathologist, University of Tennessee; E. Sikora, Plant Pathologist, Auburn University

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Strategy	Alternaria blight	Cercospora blight	Powdery mildew	Pythium cavity spot	Pythium damping off	Southern blight	Rhizoctonia cavity spot	Sclerotinia postharvest	Botrytis postharvest	Bacterial leaf blight	Root-knot nematode
Avoid field operations when leaves are wet	P	P	NC	NC	NC	NC	NC	NC	NC	F	NC
Avoid overhead irrigation	F	F	NC	NC	NC	NC	NC	F	NC	F	NC
Change planting date	P	P	NC	F	F	F	NC	NC	NC	NC	F
Cover cropping with antagonist	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	F
Crop rotation	F	F	NC	P	P	P	P	P	NC	F	P
Deep plowing	G	G	P	NC	NC	F	F	F	P	G	NC
Destroy crop residue	E	E	P	NC	NC	NC	P	NC	P	E	P
Encourage air movement	F	F	NC	NC	NC	NC	NC	F	NC	NC	NC
Plant in well-drained soil	NC	NC	NC	G	G	P	F	F	NC	NC	NC
Plant on raised beds	NC	NC	NC	F	F	NC	F	P	NC	NC	NC
Postharvest temperature control	NC	NC	NC	NC	NC	NC	NC	E	E	NC	NC
Reduce mechanical injury	NC	NC	NC	NC	NC	NC	NC	F	G	NC	NC
Destroy volunteer carrots	F	F	P	NC	NC	NC	NC	NC	NC	NC	NC
Pathogen-free planting material	E	E	NC	NC	NC	NC	NC	NC	NC	E	NC
Resistant cultivars	G	G	F	NC	NC	NC	NC	NC	NC	NC	NC

TABLE 3-33. DISEASE CONTROL PRODUCTS FOR SPINACH

E. Pfeufer, Plant Pathologist, University of Kentucky

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Damping off (*Pythium* spp.)	mefenoxam (Ridomil Gold) (Ultra Flourish)	4	1 to 2 pt/trt acre 2 to 4 pt/trt acre	21	2	Broadcast or banded over the row as a soil spray or pre-plant incorporation into the top two inches of soil.
	metalaxyl (various)	4	4 to 8 pt/trt acre	21	2	Broadcast or banded over the row as a soil spray or pre- plant incorporation into the top two inches of soil.
Seedling blight, damping off, root rot (*Pythium* spp., *Rhizoctonia solani*)	azoxystrobin + mefenoxam (Uniform)	11+4	0.34 fl oz/ 1000 ft of row	—	0	Apply as an in furrow spray in 5 gal of water per acre prior to covering seed. Make only 1 application per season.
Downy mildew (*Peronospora fainosa* f. sp. *spinaciae*)	ametoctradin + dimethomorph (Zampro)	45+40	14 fl oz/acre	0	0.5	Do not apply with or in rotation with mandipropamid or dimethomorph.
	cymoxanil (Curzate)	27	5 oz /acre	1	0.5	Apply with a protectant fungicide. Apply no more than 30 oz per acre in a 12-month period.
	dimethomorph (Forum)	40	6 fl oz/ acre	0	0.5	Do not apply with or in rotation with mandipropamid.
	mandipropamid (Revus)	40	8 fl oz/acre	1	4 hr	Make no more than 2 consecutive applications before alternating with a fungicide with a different mode of action. Apply no more than 32 fl oz/acre/ season. Do not apply with or in rotation with dimethomorph.
Downy mildew (*Peronospora fainosa* f. sp. *spinaciae*), white rust (*Albugo occidentalis*)	acibenzolar-*S*-methyl (Actigard)	21	0.5 to 0.75 oz/acre	7	0.5	Do not apply to young seedlings or plants stressed due to drought, excessive moisture, cold weather, or herbicide injury.
	famoxadone + cymoxanil (Tanos)	11+27	8 to 10 oz/acre	1	0.5	Must be tank-mixed with a contact downy mildew fungicide with a different mode of action. Make no more than 1 application before alternating with a fungicide with a different mode of action. Apply no more than 84 oz/acre per cropping season.
	fluopicolide (Presidio)	43	3 to 4 fl oz/acre	2	0.5	Tank mix with another downy mildew fungicide with a different mode of action. Apply as a foliar spray or in drip irrigation.
	fluxapyroxad + pyraclostrobin (Merivon)	7+11	4 to 11 fl oz/acre	1	0.5	**Do not tank-mix Merivon with any pesticides, adjuvants, fertilizers, nutrients, or any other additives.** Do not make more than 2 consecutive applications before rotating to a labeled non-Group 7 or non-Group 11 fungicide. Make no more than 3 applications per season.
	fixed copper (various)	M	See labels	0	2	Some formulations of copper may cause leaf flecking.
	pyraclostrobin (Cabrio)	11	12 to 16 oz/acre	0	0.5	Make no more than 2 consecutive applications before alternating with a fungicide with a different mode of action. Apply no more than 64 oz per acre per growing season.

TABLE 3-33. DISEASE CONTROL PRODUCTS FOR SPINACH (cont'd)

E. Pfeufer, Plant Pathologist, University of Kentucky

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Downy mildew, white rust (cont'd)	fosetyl-Al (Aliette)	33	2 to 5 lb/acre	3	0.5	Do not mix with surfactants, foliar fertilizers, or products containing copper.
	mefenoxam (Ridomil) 4 SL	4	0.25 pt/acre	21	2	Shank in 21 days after planting or after first cutting. Another application may be shanked in after the next cutting. A total of 2 shank applications may be made on 21-day intervals.
	mefenoxam + copper hydroxide (Ridomil Gold/Copper)	4+M	2.5 lb/acre	21	2	Spray to foliage. Use with preplant Ridomil Gold soil application.
	metalaxyl (MetaStar) 2 E	4	1 pt/trt acre	21	2	Shank in 21 days after planting. Apply no more than 2 shanked applications on 21-day intervals.
	oxathiapiprolin (Orondis Gold 200)	49	4.8 to 19.2 fl oz/ acre	0	4 hr	**DOWNY MILDEW ONLY.**
White rust	cyazofamid (Ranman)	21	2.1 to 2.75 fl oz/ acre	0	0.5	No more than 5 applications per crop. No more than 3 consecutive applications followed by at least three applications of a fungicide with a different mode of action. Do not apply more than 13.75 fl oz per acre per crop per growing season.
	fenamidone (Reason)	11	5.5 to 8.2 fl oz/ acre	2	0.5	Make no more than 1 application before alternating with a fungicide with a different mode of action. Apply no more than 24.6 fl oz/ acre per growing season.
Various leaf spots	azoxystrobin (various)	11	6 to 15.5 fl oz/acre	0	4 hr	Make no more than 2 consecutive applications before alternating with a fungicide with a different mode of action. Apply no more than 92.3 fl oz/ acre/season.
	azoxystrobin + flutriafol (Topguard)	11+3	6 to 8 fl oz/acre	7	0.5	Use a rotation partner outside of groups 3 and 11.
	cyprodinil + fludioxonil (Switch)	9+12	11 to 14 fl oz/acre	0	0.5	Make no more than 1 application before alternating with a fungicide with a different mode of action. Apply no more than 24.6 fl oz/ acre per growing season.
	fixed copper (various)	M	See labels	0	2	Some formulations of copper may cause flecking on the leaves.
	flutriafol (Rhyme)	3	5 to 7 fl oz/acre	7	0.5	
	fluopyram + trifloxystrobin (Luna Sensation)	7 + 11	7.6 fl oz/ acre	0	0.5	Use a rotation partner outside of groups 7 and 11.
	pyraclostrobin (Cabrio)	11	12 to 16 oz/acre	0	0.5	Make no more than 2 consecutive applications before alternating with a fungicide with a different mode of action. Apply no more than 64 oz per acre per growing season.
	penthiopyrad (Fontelis)	7	14 to 24 fl oz/acre	3	0.5	Make no more than 2 consecutive applications before alternating with a fungicide with a different mode of action. Apply no more than 72 fl oz/acre/year.

TABLE 3-34. DISEASE CONTROL PRODUCTS FOR SWEETPOTATO

L. Quesada-Ocampo, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Black rot (*Ceratocystis fimbriata*), scurf (*Monilochaetes infuscans*), and foot rot	thiabendazole (Mertect 340 F)	3	107 fl oz/100 gal	0.5	0.5	**Dip seed roots** 1 to 2 minutes and plant immediately.
Black rot (*Ceratocystis fimbriata*)	thiabendazole (Mertect 340 F)	3	0.42 fl oz per 2,000 lb of roots or 0.42 fl oz/gal	0.5	0.5	**SECTION 18 LABEL ONLY IN NORTH CAROLINA** (until December 31, 2017) Postharvest treatment of sweetpotato for control of black rot. Limit to one application during packing. Mist washed roots on a conveyor line, with tumbling action, before packing with 0.42 fl oz of Mertect to each 2,000 lb of roots in sufficient water for complete coverage. Alternatively, dip the roots for 20 seconds in 0.42 fl oz of Mertect per gal of water. Ensure roots are dry before packing.
Circular spot, Sclerotial blight, Rhizoctonia stem canker, Pythium root rot	azoxystrobin (Quadris) 2.08 F	11	0.4 to 0.8 fl oz/ 1,000 row feet	—	4 hr	Make in-furrow or banded applications shortly after transplanting.
	dichloran (Botran) 5F		0.6 qt/7.5 gal (Seed Dip) 5.73 oz in 14 gal/1000 linear feet of plant bed (Plant bed spray)	-	0.5	Labeled for Southern blight (*Sclerotium rolfsii*). Seed dip: Dip seed sweetpotatoes 10 to 15 seconds in a well-agitated fungicide suspension. Drain sweetpotatoes and bed promptly. Prepare fresh fungicide suspension daily. Plant bed spray: Spray or sprinkle over bedded sweetpotatoes before covering them with soil. **Note: May not be used in Virginia, Tennessee, or South Carolina.**
	fluazinam (Omega) 500F	29	5.5 to 8 fl oz/acre	14	0.5	Labeled for control of white mold (Sclerotinia). Begin applications when plants are 6 to 8 inches tall. Repeat applications at intervals of 7 to 10 days. See label for rate. Do not apply more than 3.5 pints per acre per year.

TABLE 3-34. DISEASE CONTROL PRODUCTS FOR SWEETPOTATO (cont'd)

L. Quesada-Ocampo, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Seed-borne and soil-borne fungi that cause decay, damping off or seedling blight	azoxystrobin (Dynasty) 0.83 F	11	0.19 to 0.38 fl oz per 100 lb of propagating roots	—	4 hr	Apply uniformly to seed roots as a water-based slurry.
	fludioxonil (Maxim 4 FS)	12	0.08 to 0.16 fl oz/100 lb of propagating roots	—	0.5	Apply uniformly to seed roots as a water-based slurry.
Damping off (*Pythium* spp.)	cyazofamid (Ranman 400 SC)	21	6/1 fl oz/acre	7	0.5	Apply at planting. Refer to label for details.
	fluopicolide (Presidio)	43	3 to 4 fl oz/acre	7	0.5	Must be tank mixed with a labeled rate of another fungicide active against the target pathogen, but with a different moved of action. Repeat applications at 10-day intervals.
	mefenoxam (Ridomil Gold) 4 SL	4	1 to 2 pt/treated acre	—	2	Incorporate in soil. See label for row rate.
	metalaxyl (MetaStar) 2 E	4	4 to 8 pt/treated acre	7	2	Preplant incorporated or soil surface spray.
Foliar diseases (*Alternaria* and powdery mildew)	azoxystrobin+ difenoconazole (Quadris Top)	11 + 3	8 to 14 fl oz/ acre	14	0.5	Begin foliar applications prior to disease and continue on a 7- to 14-day interval.
	cyprodinil + fludioxonil (Switch 62.5WG)	9 + 12	11 to 14 oz/acre	7	0.5	Begin foliar applications prior to disease and continue on a 7- to 10-day interval.
	fenamidone (Reason 500 SC)	11	5.5 to 8.2 fl oz/acre	14	0.5	Begin foliar applications prior to disease and continue on a 5- to 10- day interval.
	pyrimethanil (Scala SC)	9	7 fl oz/acre	7	0.5	Begin foliar applications prior to disease and continue on a 7- to 14- day interval.
Foliar (*Alternaria*) and soil-borne (*Rhizoctonia, Sclerotinia*) fungal diseases	azoxystrobin (Aframe, generic)	11	6 to 15.5 fl oz/acre	0	4 hr	Limit to 123 fl oz per acre per season. For soilborne disease control, refer to label. Begin foliar applications prior to disease and continue on a 5- to 7-day interval.
	boscalid (Endura)	7	2.5 to 10 oz/acre	10	0.5	For soilborne disease control, refer to label. Begin foliar applications prior to disease and continue on a 7- to 10-day interval.
	fluopyram (Velum Prime, Luna Privilege)	7	6.0 to 6.84 fl oz/acre	7	0.5	Limit to 0.466 lbs fluopyram per acre per year. Do not make more than two sequential applications of Group 7-containing fungicides. Labeled for Alternaria and Sclerotinia. **Note: Luna Privilege not available in Kentucky**
	fluoxastrobin (Aftershock)	11	2 to 3.8 fl oz/acre	7	0.5	Limit to 22.8 fl oz per acre per year. For soilborne disease control, refer to label. Begin foliar applications prior to disease and continue on a 7- to 10-day interval.
	metconazole (Quash)	3	2.5 to 4 oz/acre	1	0.5	Begin foliar applications prior to disease and continue on a 7- to 10-day interval.
	penthiopyrad (Vertisan)	7	0.7 to 24 fl oz/acre	7	0.5	For soilborne disease control, refer to label. Begin foliar applications prior to disease and continue on a 7- to 14-day interval.
Mottle necrosis (Pythium postharvest)	potassium phosphite (Allude)	33	1 ¼ quarts/acre	0	4 hr	Foliar spray at 5- to 14-day intervals depending on disease incidence.
Postharvest sanitation	calcium hypochlorite 65%		3 to 10 oz/100 gal	—	—	Dip or spray 2 to 5 minutes. Monitor chlorine concentration and add chlorine or change solution as needed.
Postharvest Rhizopus soft rot	dicloran (Botran) 75 W	14	1 lb/100 gal	—	—	Spray or dip. Dip for 5 to 10 seconds in well-agitated suspension. Add 1/2 pound Botran to 100 gallons of treating suspension after500 bushels treated. Do not rinse.
	fludioxonil (Scholar 1.9 SC)	12	16 to 32 fl oz/100 gal	—	—	Dip for approximately 30 seconds in well-agitated solution and allow sweetpotatoes to drain. Add 8 fl oz to 100 gals after 500 bushels are treated. ALTERNATIVELY, mix 16 fluid ounces in 7 to 25 gallons of water, wax/emulsion, or aqueous dilution of wax/oil emulsion. Can also be used to disinfest tanks, refer to label.
Scurf (*Monilochaetes infuscans*) and Sclerotial blight (*Sclerotium rolfsii*)	dicloran (Botran) 75 W	14	1 lb/100 gal	—	—	Seed dip: Dip seed sweetpotatoes 10 to 15 seconds in a well-agitated fungicide suspension. Drain sweetpotatoes and bed promptly. Prepare fresh fungicide suspension daily. Plant bed spray: Spray or sprinkle over bedded sweetpotatoes before covering them with soil.
White rust	azoxystrobin (Quadris) 2.08 F	11	6.2 to 15.4 fl oz/ acre	7	4 hr	Make no more than two sequential applications before alternating with fungicides that have a different mode of action. Apply no more than 2.88 quarts per crop per acre per season.
	fenamidone (Reason 500 SC)	11	5.5 to 8.2 fl oz/acre	14	0.5	Begin applications when conditions favor disease development, and continue on 5 to 10 day interval. Do not apply more than 16.4 fluid ounces per growing season. Alternate with a fungicide from different resistance management group.
	pyraclostrobin (Cabrio) 20 WG	11	8 to 16 oz/acre	0	0.5	Do not apply more than 48 ounces per acre per season. Alternate with a fungicide with a different mode of action after each use.
Nematodes	fluopyram (Velum Prime, Luna Privilege)	7	6.0 to 6.84 fl oz/acre	7	0.5	Limit to 0.466 lbs fluopyram per acre per year. Do not make more than two sequential applications of Group 7-containing fungicides. This is not effective in controlling *Meloidogyne enterolobii* nematodes. **Note: Luna Privilege not available in Kentucky.**

TABLE 3-35. EFFICACY OF PRODUCTS FOR DISEASE CONTROL IN SWEETPOTATO

L. Quesada-Ocampo, Plant Pathologist, NCSU

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Product	Nematicide (N) or Fungicide (F)	Bacterial stem and root rot (*E. chrysanthemi*)	Black rot (*C. fimbriata*)	Foot rot (*P. destruens*)	Fusarium root rot and stem canker (*F. solani*)	Fusarium surface rot (*F. oxysporum*)	Fusarium wilt (F. oxysporum *.f. sp. Batatas*)	Java black rot (*D. gossypina*)	Root-knot and Reniform nematodes (*Meloidogyne &. Rotylenchus* spp.)	Rhizopus soft rot (*R. stolonifer*)	Sclerotial blight/Circular spot (*S. rolfsii*)	Scurf (*M. infuscans*)	Soil rot/Pox (*S. ipomoea*)	Sweetpotato Feathery Mottle virus
aldicarb (Temik)	N	ND	ND	ND	ND	ND	ND	ND	G	ND	ND	ND	ND	ND
Pseudomonas syringae (Bio-Save)	F	ND	ND	ND	ND	ND	ND	ND	ND	P	ND	ND	ND	ND
chlorine	F	F	F	P	ND	ND	ND	P	ND	F	ND	P	NC	ND
chloropicrin	N, F	ND	P	P	F	P	F	F	F	ND	F	ND	F	ND
dicloran (Botran 75W)	F	NC	P	ND	ND	F	ND	P	ND	F	P	F	NC	ND
ethoprop (Mocap)	N	ND	ND	NC	ND	ND	ND	ND	P	ND	ND	ND	ND	ND
fludioxonil (Scholar)	F	NC	F	ND	ND	ND	ND	ND	NC	F	NC	ND	NC	ND
fluopyram (Velum)	N, F	ND	ND	ND	ND	ND	ND	ND	G	ND	ND	ND	ND	ND
metam sodium (Vapam)	N	ND	P	P	F	P	F	ND	F	ND	ND	ND	ND	ND
oxamyl (Vydate)	F	ND	ND	NC	ND	ND	ND	ND	F	ND	ND	ND	ND	ND
dichloropropene (Telone II)	N	ND	ND	NC	P	P	P	ND	G	ND	ND	ND	ND	ND
thiabendazole (Mertect 340-F)	F	NC	E	F	P	P	ND	F	ND	E	F	P	NC	ND

TABLE 3-36. IMPORTANCE OF ALTERNATIVE MANAGEMENT PRACTICES FOR DISEASE CONTROL IN SWEETPOTATO

L. Quesada-Ocampo, Plant Pathologist, NCSU

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Strategy	Bacterial stem & root rot (*E. chrysanthemi*)	Black rot (*C. fimbriata*)	Foot rot (*P. destruens*)	Fusarium root rot & stem canker (*F. solani*)	Fusarium surface rot (*F. oxysporum*)	Fusarium wilt (*F. oxysporum f. sp. batatas*)	Java black rot (*D .gossypina*)	Root-knot & Reniform nematodes (*Meloidogyne & Rotylenchus* spp.)	Rhizopus soft rot (*R. stolonifer*)	Sclerotial blight/Circular spot (*S. rolfsii*)	Scurf (*M. infuscans*)	Soil rot/Pox (*S .ipomoea*)	Sweetpotato Feathery Mottle virus
Crop rotation (3 to 4 years)	P	F	P	F	P	F	F	F	NC	F	P	F	NC
Disease-free planting stock	G	E	G	G	P	G	G	F	NC	P	E	P	G
Resistant cultivars	F	NC	P	F	P	G	F	F[S]	F	F	P	G	F
Careful handling to reduce mechanical injury	P	F	NC	F	E	NC	NC	NC	E	NC	NC	NC	NC
Cutting plants (in beds) above soil line	P	E	G	F	NC	F	F	NC	NC	NC	G	P	NC
Soil sample for nematode analysis	NC	NC	NC	NC	NC	NC	NC	G	NC	NC	NC	NC	NC
Sanitation (equipment, fields, storage houses)	F	E	F	P	F	NC	F	NC	E	NC	P	NC	NC
Manage insects that transmit pathogens	NC	E	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Sulfur added to soil to reduce pH	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	F	NC
Prompt curing and proper storage conditions	F	F	NC	F	E	NC	F	NC	E	NC	NC	NC	NC
Site selection (drainage)	P	NC	NC	F	F	F	F	NC	F	P	NC	P	NC
Manage insects that cause feeding injuries to roots	P	E	NC	NC	NC	NC	P	NC	P	NC	NC	NC	NC
Avoid harvesting when soils are wet	F	F	NC	NC	E	NC	F	NC	F	NC	NC	NC	NC

[S] Resistant cultivars for root knot nematode are susceptible to reniform nematode.

STORAGE HOUSE SANITATION **– SEE SANITATION**

TABLE 3-37. DISEASE CONTROL PRODUCTS FOR TOMATILLO

S. Bost, Plant Pathologist, University of Tennessee; M. Lewis Ivey, Plant Pathologist, The Ohio State University

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Early blight	azoxystrobin (various)	11	5 to 6.2 fl oz/acre	0	4 hr	Limit of 37 fl oz per crop per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action.
	azoxystrobin + difenoconazole (Quadris Top 2.72F)	11+3	8 fl oz/acre	0	0.5	Limit of 47 fl oz per acre per season. Do not apply until 21 days after transplanting or 35 days after seeding.
	boscalid (Endura 70WDG)	7	2.5 to 3.5 oz/acre	0	0.5	Limit of 21 oz per acre per season. Make no more than two sequential applications before alternating with fungicides that have a different mode of action.
	cyprodinil + difenoconazole (Inspire Super 2.82F)	9+3	16 to 20 fl oz/acre	0	0.5	Limit of 80 fl oz per acre per season.
	cyprodinil + fludioxonil (Switch 62.5 WG)	9+12	11 to 14 oz/acre	0	0.5	Limit of 56 oz per acre per year. After two applications, rotate to another fungicide with a different mode of action for two applications.
	difenoconazole + mandipropamid (Revus Top 4.16F)	3+40	5.5 to 7 fl oz/acre	1	0.5	Limit of 28 fl oz per acre per season. Make no more than two consecutive applications per season before alternating with fungicides that have a different mode of action.
	fenamidone (Reason 500SC)	11	5.5 to 8.2 fl oz/acre	14	0.5	Limit of 24.6 fl oz per growing season. Make no more than **one** applications before rotating to another effective fungicide with a different mode of action.
	fluoxastrobin (Aftershock, Evito 480SC 4F)	11	2.0 to 5.7 fl oz/acre	3	0.5	Limit of 22.8 fl oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action. **NOTE: Do not overhead irrigate for 24 hours following a spray application.**
	penthiopyrad (Fontelis 1.67F)	7	10 to 24 fl oz/acre	0	0.5	Do not exceed 72 fl oz of product per year. Make no more than two sequential applications per season before alternating with fungicides that have a different mode of action.
	polyoxin D zinc salt (Ph-D; OSO 5% SC) (OSO)	19	6.2 oz/acre (Ph-D) 3.75 to 13.0 fl oz/acre	0	4 hr	Limit of five applications per season. Make no more than **one** applications before alternating with fungicides that have a different mode of action.
	pyraclostrobin (Cabrio 20 EG)	11	8 to 16 oz/acre	0	4 hr	Limit of 96 oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action.
	trifloxystrobin (Flint 50WDG)	11	2 to 3 oz/acre	3	0.5	Limit of 16 oz per acre per year. Make no more than **one** application before alternating with fungicides that have a different mode of action.
Powdery mildew	azoxystrobin (various)	11	5 to 6.2 fl oz/acre	0	4 hr	Limit of 37 fl oz per crop per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action.
	azoxystrobin + difenoconazole (Quadris Top 2.72F)	11+3	8 fl oz/acre	0	0.5	Limit of 47 fl oz per acre per season. Do not apply until 21 days after transplanting or 35 days after seeding.
	chlorothalonil (Bravo Weather Stick 6F)	M	1.5 pt/acre	3	0.5	Limit of 12 pints per acre per season.
	chlorothalonil + cymoxanil (Ariston 4.34F)	M+27	2 to 2.44 pt/acre	3	0.5	Limit of 17.5 pt per acre per year.
	cyprodinil + difenoconazole (Inspire Super 2.82F)	9+3	16 to 20 fl oz/acre	0	0.5	Limit of 80 fl oz per acre per season.
	cyprodinil + fludioxonil (Switch 62.5WG)	9+12	11 to 14 oz/acre	0	0.5	Limit 56 oz per acre per year. After two applications, rotate to another fungicide with a different mode of action for two applications.
	penthiopyrad (Fontelis 1.67F)	7	16 to 24 fl oz/acre	0	0.5	Do not exceed 72 fl oz of product per year. Make no more than two consecutive applications per season before rotating to a fungicide with a different mode of action.
	polyoxin D (Ph-D 11.3WDG)	19	6.2 oz/acre	0	4 hr	Limit five applications per season. Make no more than **one** application before alternating with fungicides that have a different mode of action.
	pyraclostrobin (Cabrio 20EG)	11	8 to 16 oz/acre	0	4 hr	Limit of 96 oz per acre per season. Make no more than **one** application before alternating with fungicides that have a different mode of action.
	mandipropamid + difenoconazole (Revus Top 4.16F)	40+3	5.5 to 7 fl oz/acre	0	0.5	Limit of 28 fl oz per acre per season. Make no more than two consecutive applications before alternating with fungicides that have a different mode of action.

TABLE 3-38. DISEASE CONTROL PRODUCTS FOR TOMATO

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
TOMATO (transplants produced in a greenhouse or other controlled environment)						
Treating seed to eliminate plant pathogens on or within the seed is recommended. For a list of seed treatments that are compatible with raw (naked) seed see seed treatment table						
Bacterial canker	sodium hypochlorite (CPPC Ultra Bleach 2; 6.15%)	NC	1 qt + 4 qt water	NA	0	Wash seed for 40 min in solution with continuous agitation; air dry promptly. Use 1 gal of solution per 1 lb seed. **NOTE: Ultra Bleach 2 seed treatment is not compatible with pelleted (coated) seed.**
	streptomycin sulfate (various)	25	1 lb/100 gal	NA	0	Begin application at first true leaf stage; repeat weekly until transplant.
Bacterial spot, Bacterial speck	bacteriophage (AgriPhage)	NC	3 to 8 oz/9,600 sq ft	NA	0	Consult your vegetable Extension Specialist for information on requirements needed to use bacteriophage. Bacteriophages are most effective when applied during or after last watering of the day.
	copper (various)	M1	See label	NA	0	Begin application at first true leaf stage, repeat at 3 to 7 day intervals until transplanting. Alternating with streptomycin sulfate is recommended.
	mancozeb (various)	M3	See label	NA	1	For states East of the Mississippi, use 1.5-3 lb per acre of product. States West of the Mississippi use 1.5-2 lb per acre of product. **NOTE: Use a full rate of fixed copper in combination with mancozeb. Mancozeb alone does not control bacteria.**
	streptomycin sulfate (various)	25	1 lb/100 gal	NA	0	Begin application at first true leaf stage, repeat weekly until transplanting. For plant bed use only.
TOMATO (transplants produced in a greenhouse or other controlled environment)						
Treating seed to eliminate plant pathogens on or within the seed is recommended. For a list of seed treatments that are compatible with raw (naked) seed see seed treatment tables.						
Botrytis (gray mold), Botrytis stem canker, Early blight, Powdery mildew	cyprodinil + fludioxonil (Switch 62.5 WG)	9 + 12	11 to 14 oz/acre	NA	0.5	**DO NOT APPLY TO GRAPE OR CHERRY TOMATO.** After 2 applications, switch to a different mode of action for 2 applications.
	fluopyram + pyrimethanil (Luna Tranquility)	7 + 9	11.2 fl oz/acre	NA	0.5	See label for limits on application amounts per season. Do not make more than 2 applications of Group 7 or 9 fungicides without switching to a different mode of action.
	penthiopyrad (Fontelis 1.67 SC)	7	0.5 to 0.75 fl oz/gal	NA	0.5	Use 1 gallon of spray per 1,360 ft^2. Do not make more than 2 applications before switching to a different mode of action.
Early blight, Gray mold, Late blight	mancozeb (various)	M3	See label	NA	1	For states East of the Mississippi, use 1.5-3 lb per acre of product. States West of the Mississippi use 1.5-2 lb per acre of product**. NOTE: Use a full rate of fixed copper in combination with mancozeb if bacteria control is also required**.
Late blight	mandipropamid (Micora)	40	5.5-8.0 fl oz/acre (5,000 ft^2)	NA	4h	Apply no more than 2 applications before switching to another mode of action.
	propamocarb (Previcur Flex 6F)	28	0.7 to 1.5 pt/acre	NA	0.5	Can be used as a drench before or after transplanting.
Pythium damping off	cyazofamid (Ranman 400SC)	21	3.0 fl oz/100 gal	NA	0.5	Apply as a soil drench to seedling tray or at the time of transplant.
	propamocarb (Previcur Flex 6F)	28	1.5 pt/acre	NA	0.5	Limit of 7.5 pt per acre per season. Do not apply more than once before alternating with fungicides that have a different mode of action.
TOMATO (field)						
Anthracnose	azoxystrobin (various)	11	See label	0	4 hr	See label. Do not make more than one application before alternating to a fungicide with a different mode of action.
	azoxystrobin + difenoconazole (Quadris Top)	11 + 3	8 fl oz/acre	0	0.5	Do not make more than one application before alternating to a fungicide with a different mode of action. Limit 47 fl oz/acre/season. Do not apply within 21 days after transplanting or 35 days after seeding.
	azoxystrobin + chlorothalonil (Quadris Opti)	11 + M	1.6 pt/acre	0	0.5	Do not make more than one application before alternating to a fungicide with a different mode of action. Do not apply within 21 days after transplanting or 35 days after seeding.
	chlorothalonil (various)	M	See label	0	0.5	Refer to individual labels for rates and restrictions.
	azoxystrobin + benzovindiflupyr (Mural)	11 + 3	0.6 oz/5,000 ft^2	0	0.5	Make no more than 2 applications before switching to a different mode of action. Mixing with some adjuvants may cause phytotoxicity; see label. Limits of a.i.'s apply; see label.
	copper (various)	M	See label	3	2	
	difenoconazole + benzovindiflupyr (Aprovia Top)	7 + 3	10.5 to 13.5 fl oz/acre	0	0.5	Do not make more than 2 applications before switching to a non-Group 7 fungicide. See label for application intervals and limits per season.
	difenoconazole + cyprodinil (Inspire Super)	3 + 9	16 to 20 fl oz/acre	0	0.5	Limit of 80 fl oz /acre/season. Do not make more than 2 consecutive applications before alternating with fungicides that have a different mode of action. Limits of each a.i. apply – see label.

TABLE 3-38. DISEASE CONTROL PRODUCTS FOR TOMATO (cont'd)

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Anthracnose (cont'd)	fluopyram + trifloxystrobin (Luna Sensation)	7 + 11	7.6 fl oz/acre	3	0.5	Disease suppression ONLY. Do not exceed 5 applications or 27.1 fl oz/acre/season. Do not make more than 2 applications without switching to a different mode of action.
	flutriafol (Rhyme)	3	5 to 7 fl oz/acre	0	0.5	Do not exceed more than 4 applications or 28 fl oz product/ acre/season.
	fluxapyroxad + pyraclos- trobin (Priaxor)	7 + 11	4 to 8 fl oz/acre	7	0.5	Limit of 24 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	famoxadone + cymoxanil (Tanos)	11 + 27	8 oz/acre	3	0.5	Limit of 72 fl oz per acre per season (12-month cycle). Do not make more than one application before alternating to a fungicide with a different mode of action. **NOTE: Must be tanked mixed with a contact fungicide that has a different mode of action.**
	cymoxanil + chlorothalonil (Ariston)	27 + M	1.9 pt/acre	3	0.5	Check copper labels for specific precautions and limitations for mixing with this product.
	mancozeb (various)	M	See label	5	1	See label for rates.
	mandipropamid + difenoconazole (Revus Top)	40 + 3	5.5 to 7 fl oz/acre	1	0.5	Limit of 28 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	penthiopyrad (Fontelis)	7	24 fl oz/acre	0	0.5	**Disease suppression only.** Limit of 72 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	pyraclostrobin (Cabrio EG)	11	8 to 12 oz/acre	0	0.5	Limit of 96 fl oz per acre per season. Do not make more than 2 applications before alternating to a fungicide with a different mode of action.
	trifloxystrobin (Flint) (Gem 500 SC)	11	 3 to 4 oz/acre 3 to 3.8 fl oz/acre	3	0.5	**DISEASE SUPPRESSION ONLY.** Limit of 16 fl oz per acre per season. Do not make more than one application before alternating to a fungicide with a different mode of action.
Bacterial spot, Bacterial speck	acibenzolar-S-methyl (Actigard 50WG)	21	0.33 to 0.75 oz/acre	14	0.5	Should only be applied to healthy, actively growing plants. Do not exceed 8 applications per season.
	bacteriophage (AgriPhage)	NC	3 to 8 oz/9,600 sq ft	0	0	Consult your vegetable Extension Specialist for information on requirements needed to use bacteriophage. Bacteriophages are most effective when applied during or after last watering of the day.
	copper (various)	M	See label	0	0	Use a full rate of fixed copper in combination with mancozeb for best results.
	mancozeb (various)	M	See label	5	1	For states East of the Mississippi, use 1.5-3 lb per acre of product. **NOTE: Use a full rate of fixed copper in combination with mancozeb. Mancozeb alone does not control bacteria.**
Botrytis (gray mold)	boscalid (Endura 70WG)	7	9 to 12.5 oz/acre	0	0.5	Limit of 25 oz per acre per season. Make no more than 2 sequential applications and no more than 2 per crop year.
	chlorothalonil (various)	M	See label	0	0.5	Refer to individual labels for rates and restrictions.
	chlorothalonil + cymoxanil (Ariston)	M + 27	1.9 pt/acre	3	0.5	Limit of 17.5 pt per acre per season.
	cyprodinil + fludioxonil (Switch 62.5WG)	9 + 12	11 to 14 oz/acre	0	0.5	Limit of 56 oz per acre per season. After two applications alternate with another fungicide with a different mode of action for two applications.
	difenoconazole + cyprodinil (Inspire Super)	3 + 9	16 to 20 fl oz/acre	0	0.5	Limit of 80 fl oz per acre per season. Do not make more than 2 consecutive applications before alternating with fungicides that have a different mode of action.
	fluopyram + trifloxystrobin (Luna Sensation)	7 + 11	7.6 fl oz/acre	3	0.5	Do not exceed 5 applications or 27.1 fl oz/acre/season. Do not make more than 2 applications without switching to a different mode of action.
	fluxapyroxad + pyraclostrobin (Priaxor)	7 + 11	4 to 8 fl oz/acre	7	0.5	**DISEASE SUPPRESSION ONLY**. Limit of 24 fl oz and 3 applications per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	penthiopyrad (Fontelis)	7	16 to 24 fl oz/acre	0	0.5	Limit of 72 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	pyraclostrobin (Cabrio EG)	11	12 to 16 oz/acre	0	0.5	**Disease suppression only.** No more than 2 applications allowed before switching to a different mode of action. Do not exceed 96 oz/ acre/season.
	pyrimethanil (Scala SC)	9	7 fl oz/acre	1	0.5	Limit of 35 fl oz per acre per season.

TABLE 3-38. DISEASE CONTROL PRODUCTS FOR TOMATO (cont'd)

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Buckeye Rot	azoxystrobin (various)	11	See label	0	4 hr	Limit of 37 fl oz per acre per season. Do not make more than one application before alternating to a fungicide with a different mode of action. **NOTE: Under high temperatures, Satori in combination with some additives or adjuvants may cause crop injury.**
	azoxystrobin + chlorothalonil (Quadris Opti)	11 + M	1.6 pt/acre	0	0.5	Limit of five applications of any Group 11 fungicide. Do not make more than one application before alternating to a fungicide with a different mode of action. Do not apply earlier than 21 days after transplant.
	famoxadone + cymoxanil (Tanos)	11 + 27	8 oz/acre	3	0.5	**DISEASE SUPPRESSION ONLY**. Do not make more than one application before alternating to a fungicide with a different mode of action. **NOTE: Must be tanked mixed with a contact fungicide that has a different mode of action.**
	mancozeb + zoxamide (Gavel 75DF)	M + 22	1.5 to 2 lb/acre	5	2	Limit of 8 applications and 16 lb per acre per season East of the Mississippi River.
	mefenoxam + copper hydroxide (Ridomil Gold/ Copper)	4 + M	2 lb/acre	14	2	Tank mix with 0.8 lb a.i. of either maneb or mancozeb. Make up to 3 applications; alternate with full rate of protectant.
	oxathiapiprolin + chlorothalonil (Orondis Opti A + Orondis Opti B)	U15 + M	2.0 to 4.8 fl oz/acre 2.0 pints/acre	0	0.5	Do not make more than 2 sequential applications without switching to a different mode of action and no more than 6 total applications per season. Do not mix soil applications and foliar applications. See labels for application limits.
Powdery mildew	myclobutanil (various)	3	See label	1	0	Spray weekly beginning at first sign of disease. Do not apply more than 1.25 lb/acre. Observe a 30-day plant back interval between last application and planting new crop.
	azoxystrobin + difenoconazole (Quadris Top)	11 + 3	8 fl oz/acre	0	0.5	Do not apply until 21 days after transplanting or 35 days after seeding. Limit of 47 fl oz per acre per season. Make no more than 2 consecutive applications before rotating to another effective fungicide with a different mode of action. See label for tank mix cautions.
	azoxystrobin + benzovindiflupyr (Mural)	11 + 7	0.6 oz/5,000 ft^2	0	0.5	Do not apply until 21 days after transplanting or 35 days after seeding. Make no more than 2 applications before switching to a different mode of action. See label for tank mix cautions and application limits.
Damping-off *(Pythium)*, Root and fruit rots *(Phytophthora)*	fosetyl-Al (Aliette WDG, Linebacker WDG)	33	2.5 to 5 lb/acre	14	0.5	Do not tank mix with copper. Do not exceed 20 lbs product per season. Not for Phytophthora fruit rot. Check label for specific counties in each state where use is prohibited
	mefenoxam (various)	4	See label	7	2	Apply uniformly to soil at time of planting. Incorporate mechanically if rainfall is not expected before seeds germinate. A second application may be made up to 4 weeks before harvest. See labels for application limits.
	oxathiapiprolin + mefenoxam (Orondis Gold A + Orondi Gold B)	U15 + 4	2.4 to 19.2 fl oz/acre 1.0 to 2.0 pt/acre	28	4h	**APPLY ONLY TO THE GROUND; DO NOT APPLY TO FOLIAGE.** Maximum application rate for Root and Fruit rots is 1.0 pint/acre. Limits of a.i per season apply – see label. Apply any Orondis product to soil OR foliage, but not both. Make no more than 2 sequential applications before switching to a different mode of action.
	propamocarb (Previcur Flex)	28	1.5 pt/acre	5	0.5	Limit of 7.5 pt per acre per season. Do not apply more than once before alternating with fungicides that have a different mode of action. For **Pythium (damping-off) only.**
Gray leaf spot (*Stemphylium* spp.)	azoxystrobin + difenoconazole (Quadris Top)	11 + 3	8 fl oz/acre	0	0.5	Do not apply until 21 days after transplanting or 35 days after seeding. Limit of 47 fl oz per acre per season. Make no more than 2 consecutive applications before rotating to another effective fungicide with a different mode of action. See label for tank mix cautions.
	azoxystrobin + benzovindiflupyr (Mural)	11 + 7	0.6 oz/5,000 ft^2	0	0.5	Do not apply until 21 days after transplanting or 35 days after seeding. Make no more than 2 applications before switching to a different mode of action. See label for tank mix cautions and application limits.
	chlorothalonil (various)	M	See label	0	0.5	Refer to individual labels for rates and restrictions.
	difenoconazole + benzovindiflupyr (Aprovia Top)	7 + 3	10.5 to 13.5 fl oz/ acre	0	0.5	Do not make more than 2 applications before switching to a non- Group 7 fungicide. See label for application intervals and limits per season.
	difenoconazole + cyprodinil (Inspire Super)	3 + 9	16 to 20 fl oz/acre	0	0.5	Limit of 47 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	fluopyram + trifloxystrobin (Luna Sensation)	7 + 11	7.6 fl oz/acre	3	0.5	Do not exceed 5 applications or 27.1 fl oz/acre/season. Do not make more than 2 applications without switching to a different mode of action.

TABLE 3-38. DISEASE CONTROL PRODUCTS FOR TOMATO (cont'd)

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Gray leaf spot (*Stemphylium* spp.) (cont'd)	fluopyram + pyrimethanil (Luna Tranquility)	7 + 9	11.2 fl oz/acre	1	0.5	See label for limits on application amounts per season. Do not make more than 2 applications of Group 7 or 9 fungicides without switching to a different mode of action.
	mancozeb (various)	M	See label	5	1	See label for limits on application amounts per season.
	mancozeb + copper (ManKocide)	M + M	1 to 3 lb/acre	5	2	Limit of 58 lb per acre per season East of the Mississippi River.
	mancozeb + zoxamide (Gavel 75DF)	M + 22	1.5 to 2 lb/acre	5	2	Limit of 16 lb per acre per season East of the Mississippi River.
	mandipropamid + difenoconazole (Revus Top)	40 + 3	5.5 to 7 fl oz/acre	1	0.5	Limit of 28 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	trifloxystrobin (Flint) (Gem 500 SC)	11	3 to 4 oz/acre 3.8 fl oz/acre	3	0.5	Limit of 16 oz Flint or 16 fl oz Gem per acre per season; do not exceed 5 applications per season. Do not make more than one application before alternating to a fungicide with a different mode of action.
Early blight, Powdery mildew, Septoria leaf spot, and Target spot	azoxystrobin (various)	11	5 to 6.2 fl oz/acre	0	4 hr	Limit of 37 fl oz per acre per season. Do not make more than one application before alternating to a fungicide with a different mode of action. **NOTE: Under high temperatures, azoxystrobin in combination with some additives or adjuvants may cause crop injury.**
	azoxystrobin + benzovindiflupyr (Mural)	11 + 7	0.6 oz/5,000 ft^2	0	0.5	Make no more than 2 applications before switching to a different mode of action. Mixing with some adjuvants may cause phytotoxicity; see label. Limits of a.i.'s apply; see label.
	azoxystrobin + chlorothalonil (Quadris Opti)	11 + M	1.6 pt/acre	0	0.5	Must alternate with a non-FRAC code 11; use of an adjuvant may cause phytotoxicity. Do not make more than 5 applications of a Group11 fungicide/acre/season.
	azoxystrobin + difenoconazole (Quadris Top)	11 + 3	8 fl oz/acre	0	0.5	Do not apply until 21 days after transplanting or 35 days after seeding. Limit of 47 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	chlorothalonil (various)	M	See label	0	0.5	Refer to individual labels for rates and restrictions.
	cyprodinil + fludioxonil (Switch 62.5 WG)	9 + 12	11 to 14 oz/acre	0	0.5	Limit of 56 oz per acre per season. After two applications alternate with another fungicide with a different mode of action for two applications. **For early blight and powdery mildew control only.**
	difenoconazole + benzovindiflupyr (Aprovia Top)	7 + 3	10.5 to 13.5 fl oz/acre	0	0.5	Do not make more than 2 applications before switching to a non- Group 7 fungicide. See label for application intervals and limits per season.
	difenoconazole + cyprodinil (Inspire Super)	3 + 9	16 to 20 fl oz	0	0.5	Limit of 47 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	famoxadone + cymoxanil (Tanos)	11 + 27	6 to 8 oz/acre	3	0.5	Limit of 72 fl oz per acre per season. Do not make more than one application before alternating to a fungicide with a different mode of action. **Must be tanked mixed with a contact fungicide that has a different mode of action. For Septoria leaf spot and target spot use 8 oz per acre.**
	cymoxanil + chlorothalonil (Ariston)	27 + M	1.9 to 3.0 pt/acre	3	0.5	Check copper labels for specific precautions and limitations for mixing with this product. Limit 17.5 pt/acre/season.
	fenamidone (Reason 500 SC)	11	5.5 to 8.2 fl oz/acre	14	0.5	Limit of 24.6 fl oz per acre per season. Do not apply more than once before alternating with fungicides that have a different mode of action. **NOT labeled for Target spot control.**
	fluopyram + trifloxystrobin (Luna Sensation)	7 + 11	5 to 7.6 fl oz/acre	3	0.5	Do not exceed 5 applications or 27.1 fl oz/acre/season. Do not make more than 2 applications without switching to a different mode of action. Use 7.6 fl oz rate for gray leaf spot and target spot.
	fluopyram + pyrimethanil (Luna Tranquility)	7 + 9	11.2 fl oz/acre	1	0.5	See label for limits on application amounts per season. Do not make more than 2 applications of Group 7 or 9 fungicides without switching to a different mode of action. Disease suppression for powdery mildew only.
	fluoxastrobin (Aftershock, Evito 480 SC)	11	2.0 to 5.7 fl oz/acre	3	0.5	Limit of 22.8 fl oz per acre per season. Do not apply more than once before alternating with fungicides that have a different mode of action. Controls **Target spot and Early blight only**.
	flutriafol (Rhyme)	3	5 to 7 fl oz/acre	0	0.5	Do not exceed more than 4 applications or 28 fl oz product/acre/season. **Not labeled for Septoria or Powdery mildew control**.

TABLE 3-38. DISEASE CONTROL PRODUCTS FOR TOMATO (cont'd)

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Early blight, Powdery mildew, Septoria leaf spot, and Target spot (cont'd)	fluxapyroxad + pyraclostrobin (Priaxor 500SC)	7 + 11	4 to 8 fl oz/acre	0	0.5	Limit of 24 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action. Use 6 to 8 fl oz rates for control of powdery mildew.
	mancozeb (various)	M3	See label	5	1	**Not labeled Powdery mildew control**.
	mancozeb + zoxamide (Gavel 75DF)	M + 22	1.5 to 2 lb/acre	5	2	Limit of 16 lb per acre per season East of the Mississippi River. **Not labeled for powdery mildew or target spot.**
	mandipropamid + difenoconazole (Revus Top)	40 + 3	5.5 to 7 fl oz/acre	1	0.5	Limit of 28 fl oz per acre per season. Do not apply more than two consecutive applications before alternating with a fungicide that have a different mode of action.
	penthiopyrad (Fontelis 1.67SC)	7	16 to 24 fl oz/acre	0	0.5	Limit of 72 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	propamocarb (Previcur Flex)	28	0.7 to 1.5 pt/acre	5	0.5	Limit of 7.5 pt per acre per season. Do not apply more than once before alternating with fungicides that have a different mode of action. Tank mix with a compatible fungicide for optimal Early blight control. **For Early blight control only.**
	pyraclostrobin (Cabrio EG)	11	8 to 12 oz/acre	0	0.5	Limit of 96 fl oz per acre per season. Do not make more than two applications before alternating to a fungicide with a different mode of action. Can use up to 16 oz rate for powdery mildew.
	pyrimethanil (Scala SC)	9	7 fl oz/acre	1	0.5	Limit of 35 fl oz per acre per season. Use only in a tank mix with another fungicide recommended for Early blight. **Labeled for early blight control only.**
	trifloxystrobin (Flint) (Gem 500 SC)	11	See label	3	0.5	Limit of 16 fl oz per acre per season. Do not make more than one application before alternating to a fungicide with a different mode of action. **Products are not labeled for Target spot management.**
	zinc dimethyldithiocarbamate (Ziram 76DF)	M	3 to 4 lb/acre	7	2	Limit of 24 lb per acre per season. **Do not use on cherry tomatoes. For early blight and Septoria leaf spot only.**
	zoxamide + chlorothalonil (Zing!)	22 + M	36 fl oz/acre	5	0.5	Do not use more than 2 sequential applications before alternating to a fungicide with a different mode of action. See label for application limits. **For early blight and Septoria leaf spot only.**
Powdery mildew	myclobutanil (various)	3	See label	0	1	Limit of 1.25 lb per acre per season.
	sulfur (various)	M	See label	See label	1	Follow labels; may cause leaf burn if used under high temperatures.
Late Blight	azoxystrobin (various)	11	6.2 fl oz/acre	0	4 hr	Limit of 37 fl oz per acre per season. Do not make more than one application before alternating to a fungicide with a different mode of action. **NOTE: Apply at 5 to 7 day intervals for effective late blight management.**
	chlorothalonil (various)	M	See label	0	0.5	Refer to individual labels for rates and restrictions.
	azoxystrobin + chlorothalonil (Quadris Opti)	11 + M	1.6 pts/acre	0	0.5	Must alternate with a non-FRAC code 11; use of an adjuvant may cause phytotoxicity. Do not make more than 5 applications of a Group11 fungicide/acre/season.
	cymoxanil + chlorothalonil (Ariston)	27 + M	1.9 to 3.0 pts/acre	3	0.5	Check copper labels for specific precautions and limitations for mixing with this product.
	cyazofamid (Ranman 400 SC)	21	2.1 to 2.75 fl oz/ acre	0	0.5	Limit of 16.5 fl oz per acre per season. Do not make more than one application before alternating to a fungicide with a different mode of action.
	cymoxanil (Curzate 60DF)	27	3.2 to 5 oz/acre	3	0.5	Limit of 30 oz per 12-month period. Use only in combination with a labeled rate of a protectant fungicide. If late blight is present, use 5 oz per acre on a 5-day schedule.
	dimethomorph (Forum 4.18F)	40	6 fl oz/acre	4	0.5	Limit of 30 fl oz and 5 applications per acre per season. Performance is improved if tanked mixed with another fungicide with a different mode of action.
	dimethomorph + ametoctradin (Zampro)	40 + 11	14 fl oz/acre	4	0.5	Limit of 42 fl oz per acre per season. Do not make more than two consecutive applications before alternating to a fungicide with a different mode of action. The addition of a spreading or penetrating adjuvant is recommended to improve product performance.
	fenamidone (Reason 500 SC)	11	5.5 to 8.2 fl oz/acre	14	0.5	Limit of 24.6 fl oz per acre per season. Do not apply more than once before alternating with fungicides that have a different mode of action.
	fluopicolide (Presidio 4F)	43	3 to 4 fl oz/acre	2	0.5	Do not make more than two consecutive applications before alternating to a fungicide with a different mode of action. Use only in combination with a labeled rate of another fungicide product with a different mode of action.

TABLE 3-38. DISEASE CONTROL PRODUCTS FOR TOMATO (cont'd)

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Late Blight (cont'd)	fluoxastrobin (Aftershock, Evito 480 SC)	11	5.7 fl oz/acre	3	0.5	**DISEASE SUPPRESSION ONLY**. Limit of 22.8 fl oz per acre per season. Do not apply more than once before alternating with fungicides that have a different mode of action.
	fluxapyroxad + pyraclostrobin (Priaxor 500SC	7 + 11	8 fl oz/acre	7	0.5	**DISEASE SUPPRESSION ONLY**. Limit of 24 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	mancozeb (various)	M	See label	5	1	
	mancozeb + copper hydroxide (ManKocide)	M + M	1 to 3 lb/acre	5	2	Apply at 7- to 10-day intervals.
	mancozeb + zoxamide (Gavel 75DF)	M + 22	1.5 to 2 lb/acre	5	2	Limit of 8 applications and 16 lb per acre per season East of the Mississippi River.
	mandipropamid + difenoconazole (Revus Top)	40 + 3	5.5 to 7 oz/acre	1	0.5	Limit of 28 fl oz per acre per season. Do not apply more than two consecutive applications before alternating with a fungicide that have a different mode of action.
	mefenoxam + chlorothalonil (Ridomil Gold Bravo)	4 + M	2.5 pt/acre	5	2	See label for application limits.
	mefenoxam + mancozeb (Ridomil Gold MZ)	4+M3	2.5 lb/acre	5	2	Do not make more than 3 applications or 7.5 lb/acre/season of Ridomil Gold MZ.
	oxathiapiprolin + chlorothalonil (Orondis Opti A + Orondis Opti B)	U15 + M	2.0 to 4.8 fl oz/acre 2.0 pints/acre	0	0.5	Do not make more than 2 sequential applications without switching to a different mode of action and no more than 6 total applications per season. Do not mix soil applications and foliar applications. See label for application limits.
	oxathiapiprolin + mandipropamid (Orondis Ultra A + Orondis Ultra B)	U15 + 40	2.0 to 4.8 fl oz/acre 8.0 fl oz/acre	1	4 hr	Do not make more than 2 sequential applications without switching to a different mode of action and no more than 6 total applications per season. Limit applications apply—see label. Do not mix soil applications and foliar applications.
	pyraclostrobin (Cabrio)	11	8 to 16 oz/acre	0	0.5	No more than 2 applications allowed before switching to a different mode of action. Do not exceed 96 oz/acre/season.
	propamocarb (Previcur Flex)	28	0.7 to 1.5 pt/acre	5	0.5	Limit of 7.5 pt per acre per season. Do not apply more than once before alternating with fungicides that have a different mode of action.
	trifloxystrobin (Flint 50WDG) (Gem 500 SC)	11	 4 oz/acre 3.8 fl oz/acre	3	0.5	Limit of 16 oz (or fl oz) or 5 applications per acre per season. Do not make more than one application before alternating with a protectant fungicide. Apply products with 75% of the labeled rate of a protectant fungicide.
	zoxamide + chlorothalonil (Zing!)	22 + M	36 fl oz/acre	5	0.5	Do not use more than 2 sequential applications before alternating to a fungicide with a different mode of action. Do not tank mix with another fungicide if the target pest is only late blight. Tank mix only if a partner product is required to control other diseases.
Leaf mold (*Fulvia fulva* = *Passalora fulva*)	azoxystrobin + difenoconazole (Quadris Top)	11 + 3	8 fl oz/acre	0	0.5	Do not apply until 21 days after transplanting or 35 days after seeding. Limit of 47 fl oz per acre per season. Make no more than two consecutive applications before rotating to another effective fungicide with a different mode of action.
	difenoconazole + benzovindiflupyr (Aprovia Top)	7 + 3	10.5 to 13.5 fl oz/acre	0	0.5	Do not make more than 2 applications before switching to a non- Group 7 fungicide. See label for application intervals and limits per season.
	difenoconazole + cyprodinil (Inspire Super)	3 + 9	16 to 20 fl oz/acre	0	0.5	Limit of 80 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	difenoconazole + mandipropamid	3 + 40	5.5 to 7 fl z/acre	1	0.5	Make no more than 2 consecutive applications before switching to another fungicide with a different mode of action. Application limits apply—see label.
	famoxadone + cymoxanil (Tanos)	11 + 27	8 oz/acre	3	0.5	Do not make more than one application before alternating to a fungicide with a different mode of action. **NOTE: Must be tank-mixed with a contact fungicide that has a different mode of action.** See label for application limits.
	mancozeb (various)	M	See label	5	1	
	mancozeb + copper hydroxide (ManKocide 61 DF)	M + M	1 to 3 lb/acre	5	2	Apply at 7- to 10-day intervals.
	mancozeb + zoxamide (Gavel 75DF)	M + 22	1.5 to 2 lb/acre	5	2	Limit of 16 lb per acre per season East of the Mississippi River.
Sour rot (*Geotrichum candidum*)	fludioxonil + propiconazole (Chairman)	3 + 12	See label	0	0	Use as a post-harvest dip, drench or high volume spray to control certain post-harvest rots. See label for details.
	propiconazole (various)	3	See label	0	0	Use Mentor as a post-harvest dip, drench, or high volume spray to control certain post-harvest rots. See label for details.
	fludioxonil (Scholar SC)	12	See label	0	0	Use as a post-harvest dip, drench or high volume spray to control certain post-harvest rots. See label for details.

TABLE 3-38. DISEASE CONTROL PRODUCTS FOR TOMATO (cont'd)

I. Meadows, Plant Pathologist, NCSU

Disease	Material	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
				Harv.	Reentry	
Southern blight	difenoconazole + benzovindiflupyr (Aprovia Top)	7 + 3	10.5 to 13.5 fl oz/ acre	0	0.5	**DISEASE SUPPRESSION ONLY.** Do not make more than 2 applications before switching to a non- Group 7 fungicide. See label for application intervals and limits per season.
	fluoxastrobin (Aftershock, Evito 480 SC)	11	2.0 to 5.7 fl oz/acre	3	0.5	**DISEASE SUPPRESSION ONLY.** Begin applications when conditions favor disease development, on 7- to 10-day intervals. Do not apply more than once before alternating with fungicides that have a different mode of action. Do not apply more than 22.8 fl oz per acre per season.
	fluxapyroxad + pyraclostrobin (Priaxor 500SC)	7 + 11	4 to 8 fl oz/100 gal	7	0.5	**DISEASE SUPPRESSION ONLY.** Limit of 24 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action.
	PCNB (Blocker 4F) (transplanting) (in furrow)	14	4.5 to 7.5 pt/100 gal; (apply 0.5 pt of solution per plant) 1.2 to 1.875 gal/ acre (10.6 to 16.7 fl oz/1000 ft of row	NA	0.5	Transplanting: Apply at the time of transplanting for Southern blight suppression. In furrow: Apply in 8 to 10 gals of water per acre based on 36-inch row spacing. Limit of 7.5 lb a.i. per acre per season.
	penthiopyrad (Fontelis)	7	1 to 1.6 fl oz/1000 row ft	0	0.5	Apply as a soil drench to seedling tray or at the time of trans-plant. See label for application limits.
	pyraclostrobin (Cabrio EG)	11	12 to 16 oz/acre	0	4 hr	**DISEASE SUPPRESSION ONLY.** Limit of 96 fl oz per acre per season. Do not make more than two applications before alternating to a fungicide with a different mode of action.
Timber rot, white mold, or Sclerotinia stem rot	fluxapyroxad + pyraclostrobin (Priaxor)	7 + 11	4 to 8 fl oz/100 gal	7	0.5	**DISEASE SUPPRESSION ONLY.** Limit of 24 fl oz per acre per season. Do not make more than two consecutive applications before alternating with fungicides that have a different mode of action. See label for application limits.
	pyraclostrobin (Cabrio EG)	11	12 to 16 oz/acre	0	4 hr	**DISEASE SUPPRESSION ONLY.** Limit of 96 fl oz per acre per season. Do not make more than two applications before alternating to a fungicide with a different mode of action.

TABLE 3-39. IMPORTANCE OF ALTERNATIVE MANAGEMENT PRACTICES FOR DISEASE CONTROL IN TOMATO

M. L. Lewis Ivey, Plant Pathologist, The Ohio State University; F. Louws, Plant Pathologist, NCSU; M. Paret, Plant Pathologist, UF

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; NA, not applicable; ND, no data.

Strategy	Bacterial canker*	Bacterial speck	Bacterial spot	Botrytis	Buckeye rot	Early blight	Late blight	Leaf Mold (greenhouse or open field)	Powdery mildew	Septoria leaf spot	Target Spot (greenhouse or open field)	Tomato spotted wilt virus**
Use of resistant cultivars	NC	P	F	NR	NR	F	F	P	F	NR	P	G
Use of disease free seed or transplants	G	G	G	NC	NC	NC	NC	F	NC	P	F	NA
Use of seed treatments	G	G	G	NC	NC	P	P	F	NA	P	ND	NA
Use of sanitation practices at the transplant stage	G	G	G	G	NC	NC	NC	F	NC	NC	F	NC
Crop rotation (3-4 years)	F	P	P	NC	F	F	NC	F	NC	P	P	NC
Control of solanaceous weeds	F	NC	NC	F	F	F	F	F	F	F	F	F
Fertility	NC	NC	NC	F	NC	F	NC	ND	NC	NC	ND	NC
Use of cover crops	NC	NC	NC	NC	F	P	NC	ND	NC	NC	ND	NC
Destroy crop residue	F	NC	NC	NC	NC	P	NC	F	NC	F	F	ND
Rogue plants	F	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Promote air movement	F	F	F	F	P	P	F	F	P	F	F	NA
Use of plastic or reflective mulches	NC	NC	NC	NC	F	F	NC	NC	NC	F	NC	G
Do not handle plants when wet	G	G	G	NC	NC	P	P	F	NC	P	F	NC
Use of drip irrigation (avoiding overhead irrigation)	F	F	F	F	P	F	F	F	NC	F	F	NC
Use of biological control or biorational products	P	P	F	P	NC	P	P	P	P	NC	P	NC
Use of foliar fungicides/bactericides	F	P	F	F	F	G	G	F	G	G	F	NA
Use of insecticides	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	F
Soil fumigation	NC	NC	NC	NC	F	P	NC	NC	NC	NC	NC	NC

* Bacterial canker (foliar or systemic) is rarely observed on open field grown tomatoes in Deep South states.

** Tomato spotted wilt virus is transmitted by thrips.

TABLE 3-40. EFFICACY OF PRODUCTS FOR DISEASE CONTROL IN TOMATO

I. Meadows, Plant Pathologist, North Carolina State University

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Product[1]	Fungicide Group [F]	Preharvest Interval (Days)	Bacterial Canker (foliar)	Bacterial Speck	Bacterial Spot	Botrytis Graymold	Buckeye Rot	Early Blight	Late Blight	Leaf Mold (*Fulvia fulva*)	Powdery Mildew	Septoria Leaf Spot	Target Spot
azoxystrobin[2] (Quadris)	11	0	NC	NC	ND	NC	ND	E[R]	F	NC	E	G	P[R]
azoxystrobin + benzovindiflupyr (Mural)	11 + 7	0	NC	NC	NC	ND	ND	G	ND	ND	ND	F	ND
azoxystrobin + difenoconazole (Quadris Top)	11 + 3	0	NC	NC	NC	ND	ND	G	F	ND	G	G	ND
acibenzolar-*S*-methyl[9] (Actigard)	21	14	ND	F	F	NC	NC	NC	NC	NC	NC	NC	NC
bacteriophage[3] (AgriPhage)	NG	0	NC	P	P	NC	NC	NC	NC	NC	NC	NC	NC
benzovindiflupyr + difenoconazole (Aprovia Top)	7 + 3	0	NC	NC	NC	ND	ND	G	ND	ND	ND	F	ND
boscalid (Endura)	7	0	NC	NC	NC	P	NC	G	NC	ND	ND	ND	P[R]
chlorothalonil (Bravo, Chloronil, Echo, Equus, Initiate)	M	0	NC	NC	NC	F	P	F	G	F	P	F	F
chlorothalonil + cymoxanil (Ariston)	M + 27	3	NC	NC	NC	F	P	F	G	F	P	F	F
cyazofamid (Ranman)	21	0	NC	NC	NC	NC	NC	NC	F	NC	NC	NC	NC
cymoxanil (Curzate)	27	3	NC	NC	NC	NC	P	NC	F	ND	NC	ND	NC
cyprodinil + fludioxonil (Switch)	9 + 12	0	NC	NC	NC	F	NC	F	NC	NC	F	NC	NC
dimethomorph (Forum)	40	4	NC	NC	NC	NC	NC	NC	F	NC	NC	NC	NC
difenoconazole + cyprodinil (Inspire Super)	3 + 9	0	NC	NC	NC	G	NC	G	NC	G	G	F	F
dimethomorph + ametoctradin (Zampro)	40 + 45	4	NC	NC	NC	NC	NC	NC	G	NC	NC	NC	NC
famoxadone + cymoxanil (Tanos)	11 + 27	3	P	P	P	NC	P	F	F	F	ND	F	F[R]
fenamidone (Reason)	11	14	NC	NC	NC	NC	P	F	F	NC	ND	P	NC
fixed copper[4]	M	1	F	F	P[R]	NC	P	F	F	F	P	F	NC
fluopicolide (Presidio)	43	2	NC	NC	NC	NC	P	NC	G	NC	NC	NC	NC
fluopyram + trifloxystrobin (Luna Sensation)	7 + 11	3	NC	NC	NC	NC	ND	G	ND	ND	G	ND	ND
fluopyram + pyrimethanil (Luna Tranquility)	7 + 9	1	NC	NC	NC	ND	ND	G	ND	ND	G	F	ND
fluxapyroxad + pyraclostrobin (Priaxor)	7 + 11	0	NC	NC	NC	P	NC	G	P	D	G	F	F
mancozeb (Dithane, Koverall, Manzate, Penncozeb)	M	5	NC	NC	P	P	P	F	F	F	NC	F	F
mancozeb + fixed copper (ManKocide)	M + M	5	NC	F	F	NC	NC	F	F	F	NC	F	NC
mancozeb + zoxamide (Gavel)	M + 22	3	NC	P	P	NC	P	F	F	F	NC	F	NC
mandipropamid + difenoconazole (Revus Top)	40 + 3	1	NC	NC	NC	NC	NC	F	G	F	F	F	G
mefenoxam[8] + chlorothalonil (Ridomil Gold Bravo)	4 + M	5	NC	NC	NC	P	E	P	E	F	NC	F	NC
mefenoxam + copper (Ridomil Gold/Copper)	4 + M	14	NC	NC	NC	NC	E	NC	E[R]	NC	NC	NC	NC
mefenoxam + mancozeb (Ridomil Gold MZ)	4 + M	5	NC	NC	NC	NC	NC	NC	G[R]	NC	NC	NC	NC
myclobutanil (Rally)	3	0	NC	NC	NC	NC	NC	NC	NC	NC	G	NC	ND
penthiopyrad (Fontelis)	7	0	NC	NC	NC	F	NC	G	NC	ND	F	F	F
polyoxin D zinc salt (Ph-D; OSO 5% SC)	19	0	ND	ND	ND	F	ND	F	ND	ND	F	ND	F
propamocarb (Previcur Flex)	28	5	NC	NC	NC	NC	NC	P	F	NC	NC	NC	NC
pyraclostrobin (Cabrio)	11	0	NC	NC	NC	P	NC	E[R]	F	NC	E	G	F[R]
pyrimethanil (Scala)	9	1	NC	NC	NC	F	NC	F	NC	ND	ND	ND	F
streptomycin[5] (Agri-Mycin 17, Ag-Streptomycin, Harbour)	25	0	NC	F	F	NC	NC	NC	NC	NC	NC	NC	NC
sulfur[6] (various)	M	0	NC	NC	NC	NC	NC	NC	NC	NC	F	NC	NC
zinc dimethyldithiocarbamate[10] (Ziram)	M	7	NC	NC	NC	NC	NC	F	ND	NC	ND	F	ND

[1] Efficacy ratings do not necessarily indicate a labeled use for every disease.

[2] Contact control only; not systemic.

[3] Biological control product consisting of a virus that attacks pathogenic bacteria.

[4] Fixed coppers include: Basicop, Champ, Champion, Citcop, Copper-Count-N, Kocide, Nu-Cop, Super Cu, Tenn-Cop, Top Cop with Sulfur, and Tri-basic copper sulfate.

[5] Streptomycin may only be used on transplants; not registered for field use.

[6] Sulfur may be phytotoxic; follow label carefully.

[7] Curative activity; not systemic.

[8] Curative activity; systemic.

[9] Systemic activated resistance.

[10] Do not use on cherry tomatoes.

[F] To prevent resistance in pathogens, alternate fungicides within a group with fungicides in another group. Fungicides in the "M" group are generally considered "low risk" with no signs of resistance developing to the majority of fungicides. "NG" indicates that the product has not been classified into a group.

[R] Resistance reported in the pathogen.

TABLE 3-41. EXAMPLE SPRAY PROGRAM FOR FOLIAR DISEASE CONTROL IN FRESH-MARKET TOMATO PRODUCTION WHEN LATE BLIGHT IS A CONSISTENT THREAT

I. Meadows, Plant Pathologist, NCSU; F. Louws, Plant Pathologist, NCSU

Week	Chemical[1] (Refer to the label for rates)	Number of Applications of Chemical Per Season[1]
BEFORE HARVEST (weeks 1 to 8)		
1	mancozeb + copper + Actigard	mancozeb, 1; Actigard, 1; copper, 1
2	mancozeb + copper	mancozeb, 2; copper, 2
3	mancozeb + Fontelis OR Endura[2] + Actigard	mancozeb, 3; Fontelis, 1; Endura, 1; Actigard, 2
4	mancozeb + copper	mancozeb, 4; copper, 3
5	mancozeb + Inspire Super + Actigard	mancozeb, 5; Inspire Super, 1; Actigard, 3
6	mancozeb + copper	mancozeb, 6; copper, 4
7	mancozeb + Fontelis OR Endura[2] + Actigard	mancozeb, 7; Fontelis, 2; Endura, 2; Actigard, 4
8	mancozeb + copper	mancozeb, 8; copper 5
DURING HARVEST (weeks 9 to 15)		
9	chlorothalonil + Inspire Super	chlorothalonil, 1; Inspire Super, 2
10	Revus Top OR Presidio OR Ranman	Revus Top, 1; Presidio, 1; Ranman, 1
11	chlorothalonil + Fontelis OR Endura[2]	chlorothalonil, 2; Fontelis, 3; Endura, 3
12	Revus Top OR Presidio OR Ranman	Revus Top, 2; Presidio, 2; Ranman, 2
13	chlorothalonil + Inspire Super	chlorothalonil, 3; Inspire Super, 3
14	Revus Top[1] OR Presidio OR Ranman	Revus Top, 3; Presidio, 3; Ranman, 3
15	chlorothalonil + (Fontelis[3]) OR Endura[2]	chlorothalonil, 4; Fontelis, 4; Endura, 4
	Finish season with chlorothalonil	

[1] For most products, the label restricts the number of applications or the amount of product applied per season.

[2] Strobilurins were removed from this guide due to widespread resistance in the pathogen that causes early blight. However, a strobilurin may be substituted for Fontelis OR Endura.

[3] This application exceeds the maximum allowable amount per season if the higher rate had been applied.

TABLE 3-42. EXAMPLE SPRAY PROGRAM FOR FOLIAR DISEASE CONTROL IN FRESH-MARKET TOMATO PRODUCTION WHEN EARLY BLIGHT IS A CONSISTENT THREAT

S. Bost, Plant Pathologist, University of Tennessee

Week	Chemical (Refer to the label for rates)	Number of Applications of Chemical Per Season[1]
BEFORE HARVEST (weeks 1 to 10)		
1	mancozeb + Actigard	mancozeb, 1; Actigard, 1
2	mancozeb + copper	mancozeb, 2; copper, 1
3	Fontelis + Actigard	Fontelis, 1; Actigard, 2
4	mancozeb+ copper	mancozeb, 3; copper 2
5	Inspire Super + Actigard	Inspire Super 1; Actigard, 3
6	mancozeb + copper	mancozeb, 4; copper 3
7	Fontelis + Actigard	Fontelis, 2; Actigard, 4
8	mancozeb + copper	mancozeb, 5; copper 4
9	Inspire Super + Actigard	Inspire Super 2; Actigard, 5
10	chlorothalonil + copper	chlorothalonil, 1; copper 5
DURING HARVEST (weeks 11 to 15)		
11	Fontelis	Fontelis, 3
12	chlorothalonil	chlorothalonil, 2
13	Inspire Super	Inspire Super, 3
14	chlorothalonil	chlorothalonil, 3
15	chlorothalonil	chlorothalonil, 4
	Finish season with chlorothalonil	

[1] For most products, the label restricts the number of applications or the amount of product applied per season.

[2] In areas or seasons in which bacterial spot or speck problems are not expected, Actigard and copper can be omitted.

Note: If late blight occurs, appropriate fungicides must be added. Fontelis and Inspire Super do not have any late blight activity.

TURNIP GREENS **– SEE GREENS AND LEAFY BRASSICAS**

TURNIP ROOTS **– SEE ROOT VEGETABLES**

WATERMELONS **– SEE CUCURBITS**

NEMATODE CONTROL IN VEGETABLE CROPS

Crop losses due to nematodes can be avoided or reduced by using the following management tactics.

1. Practice crop rotation.
2. Plow out and expose roots immediately after the last harvest.
3. Plow or disk the field two to four times before planting.
4. Use nematode-free planting material.
5. Sample soil and have it assayed for nematodes, preferably in the fall. There is a fee for each sample. Ship sample via DHL, FedEx, or UPS to: State Agency.
6. Where warranted, fumigate or use other nematicides according to guidelines listed on the label. (Soil should be warm, well worked, and free from undecomposed plant debris and have adequate moisture for seed germination.)
7. For in-row application, insert chisel 6 to 8 inches deep and throw a high, wide bed up over it; do not rework rows after fumigating.
8. For broadcast treatments, insert chisels 6 to 8 inches deep, and space chisels 12 inches apart for most fumigants; use 5-inch spacing for Vapam.
9. Row rates in this section are stated for rows on 40-inch spacing. For other row spacings, multiply the stated acre rate by the appropriate conversion factor to determine the amount of material applied per acre (Do not alter stated amount per 100-foot row). This will be a guide to the amount of material to purchase for the acreage you want to treat.

Your Row Spacing (inches)	Conversion Factor
24	1.67
26	1.54
28	1.43
30	1.33
32	1.25
34	1.18
36	1.11
38	1.05
40	1.00
42	0.952
44	0.909
46	0.870
48	0.833
5 ft	0.667
6 ft	0.556
7 ft	0.476
8 ft	0.417

For example, if 10 gallons per acre are used on 40-inch rows, for 36-inch rows, it will take 11.1 gallons to treat an acre.

CAUTION: Read labels carefully. Some products have restrictive crop rotations.

FUMIGANTS

New labels require extensive risk mitigation measures including fumigant management plans (FMPs), buffer restrictions, worker protection safety standards and other measures. Details are on the labels and see http://www2.epa.gov/soil-fumigants. Some fumigants are registered on many vegetable crops but with crop- or soil-type -specific rates; others are registered for specific crops and/or in certain states only. Follow all labels carefully. The label is the law.

TABLE 3-43. EFFICACY OF FUMIGANTS OR FUMIGANT COMBINATIONS FOR MANAGING SOILBORNE NEMATODES AND DISEASES, AND WEEDS [1]

F. Louws, Plant Pathologist, NCSU and Chuck Johnson, Plant Pathologist, Virginia Tech.

Scale: ranges from "—" = not effective to "+++++" = highly efficacious.

Product	Rate per Treated Acre [2]		Nematodes	Disease	Nutsedge	Weeds: Annual
	Volume (gal)	Weight (lb)				
Telone II (1,3-D)	15 to 27	153 to 275	+++++	+	—	—
Telone EC [3]	9 to 24 [4]	91 to 242 [4]	+++++	+	—	—
Telone C17 (1,3-D + chloropicrin)	32.4 to 42	343 to 445	+++++	+++	+	+
Telone C35 (1,3-D + chloropicrin)	39 to 50	437 to 560	+++++	+++++	+	++
InLine (1,3-D + chloropicrin) [3]	29 to 57.6 (*See Label*)	325 to 645 *(See Label)*	+++++	+++++	+	+++
Pic-Clor 60 (chloropicrin + 1,3-D)	48.6	588	+++++	+++++	+	+++
Pic-Clor 60 EC [3]	42.6	503	+++++	+++++	+	+++
Metam potassium [5]	30 to 62	318 to 657	++	+++	+	++++
Metam sodium [5] (MS)	37.5 to 75	379 to 758	++	+++	+	++++
Chloropicrin + MS [5]	19.5 to 31.5 + 37.5 to 75	275 to 444 + 379 to 758	++	+++++	++	++++
Chloropicrin	48.6	150 to 350	+	+++++	—	—
Tri-Pic 100EC [3]	8 to 24	100 to 300	+	+++++	—	—
Paladin (dimethyl disulphide) [6]	35.0 to 51.3	310 to 455	++++	++++	++++	+++ [5]
Paladin EC [3, 6]	37.0 to 54.2	326 to 479	++++	++++	++++	+++ [5]
Dominus (allyl isothiocyanate) [7]	25 to 40 [4]	212 to 340 [4]	++	+++	+	+++

[1] Fumigants with lower efficacy against weeds may require a complementary herbicide or hand-weeding program, although use of virtually impermeable film (VIF) or totally impermeable film (TIF) may increase weed control, particularly with Telone C35 or Paladin. Refer to the Herbicide Recommendation section of this guide for directions pertaining to herbicide applications. Telone can persist more than 21 days under cool or wet soil conditions.

[2] Rates can sometimes be reduced if products are applied with VIF or TIF.

[3] Product is formulated for application through drip lines under a plastic mulch; efficacy is dependent on good distribution of the product in the bed profile.

[4] Labelled rates are per *broadcast-equivalent* acre, NOT per treated acre.

[5] Metam potassium can be Metam KLR, K-Pam, Sectagon K54 or other registered formulations, and should be used in soils with high sodium content. Metam sodium can be Vapam, Sectagon 42, Metam CLR or other registered formulations.

[6] Paladin should be applied with 21% chloropicrin and VIF or TIF to enhance disease control, and has low efficacy on certain small seeded broadleaf weeds and grasses. Pala-din may not be registered in all States.

[7] Dominus is registered but there is limited experience with the product through University or independent trials in our region; growers may want to consider this on an experimental basis. Planting interval is 10 days. The active ingredient allyl isothiocyanate is similar to the active ingredient in metam sodium products (methyl isothiocyanate) and is likely to behave in a similar manner with a similar pest control profile.

TABLE 3-44. MANAGEMENT OF SOILBORNE NEMATODES WITH NON-FUMIGANT NEMATICIDES

F. Louws, Plant Pathologist, NCSU

Nematodes are best managed through an integrated program (IPM). Key management options may include securing advisory/predictive soil samples, crop rotation, fallow periods, host resistance, soil amendments, flooding, soil solarization, suppressive cover crops, and other options.

Commodity	Material	Application Method for Given Soils	Formulated Rate per Acre	Formulated Rate per 100 Sq Ft or 100 Ft Row	Schedule and Remarks
Most vegetables	Ditera DF Biological nematicide	Banded or low pressure drip irrigation	See label	See label	See label.
Bean (snap and lima)	ethoprop (Mocap) various formulations	Broadcast or banded	See label	See label	Incorporate 2 to 4 inches deep. See label.
Cabbage (transplants Florida only)	fenamiphos (Nemacur)	Banded	5.0 fl oz/1000 ft	—	Restricted use pesticide. **NOTE: For use on transplants only in FL.**
Cabbage	ethoprop (Mocap) various formulations	Broadcast or banded	See label	See label	Restricted use pesticide. Incorporate 2 to 4 inches deep.
Carrot	oxamyl (Vydate) L	Preplant broadcast	2 gal in 20 gal	1 gal in 20 gal	Apply (in furrow) within 1 wk of planting, and thoroughly incorporate into soil 4- to 6-in. deep. May be applied via chemigation or In-Furrow – see label. 14 days to harvest restriction.
		At planting seed furrow	1 to 2 gal in 20 gal	0.3 to 0.6 fl oz in 5.9 fl oz	
Cucumber	ethoprop (Mocap) various formulations	Banded only	See label	See label	Incorporate 2 to 4 inches deep. See label.
Cucurbits (cucumber, squash, cantaloupe, watermelon, honeydew, pumpkin)	oxamyl (Vydate) L	Preplant broadcast	1 to 2 gal	—	Incorporate 2 to 4 in. into soil.
		Foliar	2 to 4 pt	—	Apply by air or ground with the first spray 2-4 weeks after planting; apply second spray 2-3 weeks after first spray.
		Drip chemigation or Soil injection	2 to 4 pt	0.07 to 0.15 fl oz	Treatments should be initiated at the time of seedling emergence or transplanting, or within 14 days of seedling emergence or transplanting. Sequential applications should be made on 14 to 21 day intervals. Do not treat within one day of harvest.
Cucurbits (Group 9) including Cucumber, squash, honeydew, watermelon, and many others (see label) Fruiting Vegetables (Group 8) including tomato, pepper, eggplant, and many others (see label).	fluensulfone (Nimitz) NOTE: Nimitz received federal registration Sept 2014 – check registration status in your State.	3.5 to 5 pints/ treated acre (56 to 80 fl. oz./treated acre)	—	—	Applications must be broadcast incorporated, banded and incorporated, or by drip irrigation. Apply at a minimum of 7 days before transplanting. Do not apply more than one application per crop, and no more than 112 fl oz of product per acre, per year (365 days).
Cucurbits (Group 9) see label for list Fruiting Vegetables (Group 8) see label for list	heat-killed *Burkholderia* spp. strain A396	4 to 8 qt	—	—	Majestene is a biological nematicide approved for organic vegetable production. It has not been extensively field-tested in the Southeast and Mid-Atlantic states, but research to date suggests useful activity against root-knot, lesion, sting, stunt, ring, and reniform nematodes. Can be applied as a pre-plant incorporated, in-furrow or banded spray as long as spray volume is sufficient to thoroughly soak the root zone. However, Majestene can also be drip-applied prior to planting, at planting or shortly thereafter, and again later in the season. Higher rates are likely more effective, and repeated applications
Eggplant (also see Fruit Vegetable above)	fenamiphos (Nemacur)	Banded	5.9 fl oz/1000 ft		On narrow rows, do not let bands overlap. See label.
	oxamyl (Vydate) L	Banded on soil	—	1 gal	See label.
		Foliar	4 pt	—	Apply twice by ground equipment at 1 to 2 week intervals 2 to 4 weeks after the second soil treatment.
		Drip chemigation or Soil injection	2 to 4 pt	0.07 to .15 fl oz	Treatments should be initiated either at the time of transplanting, or within 14 days of transplanting. Sequential applications should be made on 10 to 14 day intervals. Do not treat within 7 days of harvest.
Pepper (bell & non-bell) (also see Fruiting Vegetables above)	oxamyl (Vydate) L	Transplant water	2 pt in 200 gal	—	
		Foliar	2 to 4 pt	—	Apply 14 days after transplant repeat 1 to 2 week intervals. Do not treat within 7 days of harvest.
		Drip chemigation or Soil injection	2 to 4 pt in	—	Treatments should be initiated either at the time of transplanting, or within 14 days of transplanting. Sequential applications should be made on 10 to 14 day intervals. Do not treat within 7 days of harvest.

TABLE 3-44. MANAGEMENT OF SOILBORNE NEMATODES WITH NON-FUMIGANT NEMATICIDES (cont'd)

F. Louws, Plant Pathologist, NCSU

Nematodes are best managed through an integrated program (IPM). Key management options may include securing advisory/predictive soil samples, crop rotation, fallow periods, host resistance, soil amendments, flooding, soil solarization, suppressive cover crops, and other options.

Commodity	Material	Application Method for Given Soils	Formulated Rate per Acre	Formulated Rate per 100 Sq Ft or 100 Ft Row	Schedule and Remarks
Potato	ethoprop (Mocap) various formulations	Broadcast or banded	See label	See label	Incorporate 2 to 4 in. deep. See label.
	oxamyl (Vydate) L	Furrow	1 to 2 gal in 20 gal	—	Apply to seed furrow at planting; begin foliar sprays when early season control has diminished.
		Foliar	2 to 4 pt		
Sweetpotato	aldicarb (Temik) 15 G	40-in. rows	10 to 20 lb	0.4 to 0.7 oz	Apply in a 12- to 15-in. band and incorporate 4 to 8 in. deep, plant. Do not harvest within 120 days of treatment. Do not use vines. **NOTE: For use ONLY in LA or MS.**
	ethoprop (Mocap) various formulations	Banded only	See label	See label	Incorporate 2 to 4 in. deep. See label.
	oxamyl (Vydate) L	Preplant broadcast	2 to 3 gal in 20 gal	—	Thoroughly incorporate into soil 4 to 6 in. deep and plant.
		Transplant water	1 to 2 gal in 200 gal		
Sweet corn	ethoprop (Mocap) various formulations	Broadcast or banded	See label	See label	Incorporate 2 to 4 in. deep. See label.
Sweet corn, Popcorn	terbufos (Counter) various formulations (see label)	Row, 30-in. min.	See label	See label	Apply in furrow
Tomato (also see Fruit Vegetables above)	oxamyl (Vydate) L	Foliar	2 to 4 pt	—	Spray when plants are established. Repeat 1- to2-week intervals.
		Drip irrigation	2 to 8 pt	—	Apply at first irrigation to field. Repeat every 1 to 2 weeks while plants are small. As plants enlarge, increase dosage progressively to 8 pt.

GREENHOUSE VEGETABLE CROP DISEASE CONTROL

Note: Follow manufacturer's directions on label in all cases.

Caution: At the time this table was prepared, the entries were believed to be useful and accurate. However, labels change rapidly and errors are possible, so the user must follow all directions on the pesticide container. See product labels for application limits per crop/season.

Information in the following table must be used in the context of a total disease control program. For example, many diseases are controlled by the use of resistant varieties, crop rotation, sanitation, seed treatment, and cultural practices. Always use top-quality seed or plants obtained from reliable sources. Seeds are ordinarily treated by the seed producer for the control of seed decay and damping-off.

Most foliar diseases can be reduced or controlled by maintaining relative humidity below 90 percent, by keeping the air circulating in the house with a large overhead polytube, and by avoiding water on the leaves.

Caution: The risk of pesticide exposure in the greenhouse is high. Use protective clothing laundered daily or after each exposure. Ventilate during application and use appropriate personal protective equipment (PPE).

TABLE 3-45. GREENHOUSE DISEASE CONTROL FOR VARIOUS VEGETABLE CROPS

R. A. Melanson, Extension Plant Pathologist, Mississippi State University; A. Keinath, Plant Pathologist, Clemson University; F. Louws, Plant Pathologist, NCSU; M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

Commodity	Disease	Product[1]	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
					Harv.	Reentry	
Greenhouse	Sanitation	Solarization	NA	140°F, 4 to 8 hr for 7 days	—	—	Close greenhouse during hottest and sunniest part of summer for at least 1 week. Greenhouse must reach at least 140°F each day. Remove debris, heat sensitive materials, and keep greenhouse and contents moist. Will not control pests 0.5 inches or deeper in soil. Not effective against TMV.
		Added heat	NA	180°F for 30 min	—	—	Remove all debris and heat-sensitive materials. Keep house and contents warm.
Soil	Soilborne diseases and weeds		--	See soil fumigants table and check soil fumigant label if registered for greenhouse use.			Preplant soil treatment.
Basil	Alternaria leaf spot (*Alternaria* spp.) Botrytis leaf blight (*Botrytis* spp.), Fusarium blight (*Fusarium* spp.)	cyprodinil + fludioxonil (Switch 62.5WG)	9 + 12	11 to 14 oz/acre	7	0.5	After two applications, alternate with another fungicide with a different mode of action for two applications. See label for application limits.

TABLE 3-45. GREENHOUSE DISEASE CONTROL FOR VARIOUS VEGETABLE CROPS (cont'd)

R. A. Melanson, Extension Plant Pathologist, Mississippi State University; A. Keinath, Plant Pathologist, Clemson University; F. Louws, Plant Pathologist, NCSU; M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

Commodity	Disease	Product[1]	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
					Harv.	Reentry	
Basil	Downy mildew (*Peronospora belbahrii*)	cyazofamid (Ranman, Ranman SC400)	21	2.75 to 3.0 fl oz/acre	0	5	Do not exceed 27 fl oz per acre per growing season. See label for surfactant recommendations. Alternate applications with fungicides that have a different mode of action. Do not make more than three consecutive applications before switching to products that have a different mode of action for three applications before returning to Ranman/Ranman 400SC.
		mandipropamid (Micora, Revus)	40	8.0 fl oz/acre	1	4 hr	**Micora: For basil grown for transplants and retail sale to consumers only.** Do not make more than two applications per crop. See label for additional restrictions and recommendations. **Revus:** Do not exceed 32 fl oz of product per acre per season. See label for additional limits when producing multiple croppings per year.
	Downy mildew, Pythium and Rhizoctonia root rots	phosphorous acid (various)	33	See label	See label	See label	See label for restrictions.
		potassium phosphite (various)	33	See label	See label	See label	See label for restrictions.
Cucurbits	Angular leaf spot, downy mildew	copper, fixed (various)	M1	See label	See label	See label	**Some products are OMRI-listed.** See product label for complete application instructions, specific crop and disease labels, and greenhouse usage.
	Downy mildew (*Pseudoperonospora cubensis)*	cymoxanil (Curzate 60DF)	27	3.2 to 5.0 oz/acre	3	12 hr	Always apply in a tank mix with the labeled rate of a protectant fungicide. Do not exceed 30 oz of product per 12-month period.
	Alternaria leaf blight and spot (*A. cucumerina* and *A. alternata)*, gummy stem blight (*Stagnosporopsis*[2]), powdery mildew (*S. fuliginea, E. cichoracearum*)	cyprodinil + fludioxonil (Switch 62.5WG)	9 + 12	11 to 14 oz/acre	1	0.5	After two applications, alternate with another fungicide with a different mode of action for two applications. See label for application limits.
	Alternaria leaf blight and spot (*A. cucumerina* and *A. alternata)*, anthracnose (*C. orbiculare*), Cercospora leaf spot (*C. citrullina*), gummy stem blight (*Stagnosporopsis*[2]), powdery mildew (*S. fuliginea, E. cichoracearum*), Septoria leaf blight (*S. cucurbitacearum*)	difenoconazole + cyprodinil (Inspire Super)	3 + 9	16 to 20 fl oz/acre	7	0.5	Do not apply more than 80 fl oz of product per acre per season. Make no more than two consecutive applications per season before alternating with fungicides that have a different mode of action.
	Alternaria leaf blight (*A. cucumerina*), anthracnose (*Colletotrichum* spp.), downy mildew (*P. cubensis*) Suppression: Phytophthora blight (*Phytophthora capsici*)	famoxadone + cymoxanil (Tanos)	11 + 27	8 oz/acre 8 to 10 oz/acre (for diseases listed under suppression)	3	0.5	Do not exceed 32 oz/acre of product per crop cycle or 72 oz/acre per 12-month period. Do not make more than one application of product before alternating with a fungicide that has a different mode of action. See label for tank mixing instructions. For suppression of foliar and fruit phases ONLY of Phytophthora blight.
	Botrytis gray mold	fenhexamid (Decree 50 WDG)	17	1.5 lb/acre (stand-alone) 1.0 to 1.5 lb/acre (tank-mix)	0	0.5	**Labeled for cucumbers ONLY.** For use in transplant production and greenhouse production. Do not make more than two consecutive applications. See labels for additional tank-mixing instructions. Do not exceed 6.0 lb product per acre (transplants) or per acre per season (greenhouse production).
	Alternaria leaf spot, anthracnose, Cercospora leaf spot, downy mildew, gummy stem blight, scab	mancozeb (various)	M3	See label	See label	See label	See product labels for complete application instructions, specific crop and disease labels, and greenhouse usage.
	Alternaria leaf spot, Cercospora leaf spot, downy mildew, Phytophthora rot (*Phytophthora capsici*)	mancozeb + zoxamide (Gavel 75SF)	M3 + 22	1.4 to 2.0 lb/acre	5	2	Do not exceed 16 lb per acre per season.
	***Suppression*:** Downy mildew (*P. cubensis*), Phytophthora blight (*P. capsici*)	mandipropamid (Revus)	40	8.0 fl oz/acre	0	4 hr	Do not exceed 32 fl oz of product per acre per season. See label for application instructions specific to each disease.
	Alternaria leaf spot and blight, Botrytis gray mold, gummy stem blight (*Didymella*), powdery mildew, Sclerotinia stem rot	penthiopyrad (Fontelis)	7	0.375 to 0.5 fl oz/gal to treat 1,360 sq ft	1	0.5	Do not exceed 67 fl oz of product per year. Make no more than two consecutive applications per season before alternating with fungicides that have a different mode of action. See label for cucurbit restrictions.

TABLE 3-45. GREENHOUSE DISEASE CONTROL FOR VARIOUS VEGETABLE CROPS (cont'd)

R. A. Melanson, Extension Plant Pathologist, Mississippi State University; A. Keinath, Plant Pathologist, Clemson University; F. Louws, Plant Pathologist, NCSU; M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

Commodity	Disease	Product[1]	FRAC	Rate of Material	Minimum Days Harv.	Minimum Days Reentry	Method, Schedule, and Remarks
Cucurbits (cont'd)	Botrytis gray mold, Corynespora leaf spot (*Corynespora cassiicola*), early blight (*Alternaria* sp.), gummy stem blight (*Stagnosporopsis*[2]), powdery mildew (*Sphaerotheca* sp.), scab (*Cladosporium* sp.)	polyoxin D zinc salt (Affirm WDG, OSO 5%SC)	19	6.2 oz/acre (Affirm) 3.75 to 13.0 fl oz/acre (OSO)	0	4 hr	Check products labels for maximum limits of product per season. Alternate with fungicides that have a different mode of action. Check product labels for other tomato diseases also on the label.
	Alternaria leaf spot, anthracnose, Cercospora leaf spot, downy mildew, gummy stem blight (GSB), scab, target spot	potassium phosphite + chlorothalonil (Catamaran)	33 + M5	4 pt/acre (anthracnose, downy mildew, target spot) 6 pt/acre (Alternaria and Cercospora leaf spot, gummy stem blight, scab)	1	0.5	Do not exceed 50 pt per acre per season. Phytotoxicity potential. Do not combine with other pesticides, surfactants, or fertilizers. Do not apply on the day of harvest.
	Damping off and root rots (*Phytophthora* spp., *Pythium* spp.)	propamocarb hydrochloride (Previcur Flex)	28	See label	2	0.5	Product applied through a drip system or as a soil drench. Do not apply more than four applications of product after transplanting per crop cycle. Do not mix with other products. Phytotoxicity may occur if applied to dry growing media.
	Powdery mildew	cyflufenamid (Torino)	U6	3.4 oz/acre	0	4	Do not make more than two applications per year. **Use with caution as resistance has been reported in Italy.**
		sulfur (various)	M2	See label	See label	See label	**Some products are OMRI-listed.** See product labels for complete application instructions, specific crop and disease labels, and greenhouse usage. Not all products are registered for use in all states.
		triflumizole (Procure 480SC, Terraguard SC)	3	4 to 8 fl oz/acre (Procure) 2 to 4 fl oz/100 gal (Terraguard)	1	0.5	**Procure:** Do not exceed 40 fl oz of product per acre per season. Label specifies the following powdery mildew species: *Erysiphe cichoracearum, Podosphaera xanthii*). **Not registered for use in all states. Terraguard SC:** For use only as a foliar spray. For use in commercial greenhouse production only. Can be used on greenhouse transplants. Do not exceed 40 fl oz of product per acre per cropping system. See label for additional application instructions. **Not registered for use in all states.**
		potassium bicarbonate (Milstop)	NC	1.25 to 5.0 lb/100 gal	0	1 hr	**OMRI-listed.** Do not exceed 0.5 lb of product per 4,350 sq ft or 1.15 lb product per 10,000 sq ft per application. Do not store unused spray solution. See label for additional diseases labeled.
Lettuce	Downy mildew (*Bremia lactucae*)	cymoxanil (Curzate 60DF)	27	3,2 to 5.0 oz/acre (head lettuce) 5.0 oz/acre (leafy lettuce)	3 (head) 1 (leafy)	12 hr	For use on head and leaf lettuce. Use with the labeled rate of a protectant fungicide. Do not exceed 30 oz of product per 12-month period.
	Alternaria leaf spot, Botrytis gray mold, Sclerotinia rot, basal rot (*Phoma*), Septoria leaf spot Suppression: Powdery mildew	cyprodinil + fludioxonil (Switch 62.5WG)	9 + 12	11 to 14 oz/acre	0	0.5	For use on head and leaf lettuce. After two applications, alternate with another fungicide with a different mode of action for two applications. See label for application limits.
	Botrytis gray mold rot, drop rot, *Sclerotinia minor*, watery soft rot (*Sclerotinia sclerotiorum*)	dicloran (Botran 5F)	14	0.6 qt/acre (at planting) 0.6 to 1.8 qt/acre (pre thinning) 1.8 to 3.2 qt/acre (post-thinning [direct seeded] and established transplants)	14	0.5	For use on head and leaf lettuce. See label for detailed instructions. Do not exceed 3.2 qt of product per acre per year or within 14 days of harvest. **Not registered for use in SC, TN, or VA.**
	Downy mildew (*B. lactucae*), white rust (*Albugo occidentalis*)	famoxadone + cymoxanil (Tanos)	11 + 27	8 to 10 oz/acre	1	0.5	For use on head and leaf lettuce. Do not exceed 48 oz/acre of product per crop season. Do not make more than one application of product before alternating with a fungicide that has a different mode of action. See label for tank mixing instructions.

TABLE 3-45. GREENHOUSE DISEASE CONTROL FOR VARIOUS VEGETABLE CROPS (cont'd)

R. A. Melanson, Extension Plant Pathologist, Mississippi State University; A. Keinath, Plant Pathologist, Clemson University; F. Louws, Plant Pathologist, NCSU; M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

Commodity	Disease	Product[1]	FRAC	Rate of Material	Minimum Days Harv.	Minimum Days Reentry	Method, Schedule, and Remarks
Lettuce (cont'd)	Botrytis gray mold	fenhexamid (Decree 50 WDG)	17	1.5 lb/acre (stand-alone) 1.0 to 1.5 lb/acre (tank-mix)	3	0.5	For use in transplant production and greenhouse production. Do not make more than two consecutive applications. See label for additional tank-mixing instructions. Do not exceed 3.0 lb product per acre (transplants) or per acre per crop (greenhouse production).
	Anthracnose, downy mildew	mancozeb (various)	M3	See label	See label	See label	See product labels for complete application instructions, specific crop and disease labels, and greenhouse usage.
		mandipropamid (Micora, Revus)	40	5.5 to 8.0 fl oz/acre (Micora) 8.0 fl oz/acre (Revus)	-- 1	4 hr	For use on head and leaf lettuce. **Micora**: **For lettuce grown for transplants and retail sale to consumers only.** Do not make more than two applications per crop. After making an application of Micora, alternate with a fungicide with a different mode of action. Apply in a tank-mix with another downy mildew fungicide with a different mode of action. **Revus**: Do not exceed 32 fl oz of product per acre per season. Do not make more than two applications before switching to a fungicide with a different mode of action.
	Alternaria leaf spot (*Alternaria sonchi*), Botrytis gray mold, Cercospora leaf spot (*Cercospora* spp.), powdery mildew (*Golovinomyces cichoracearum*), Septoria leaf spot (*Septoria* spp.)	penthiopyrad (Fontelis)	7	14 to 24 fl oz/acre	3	0.5	For use on head and leaf lettuce. Do not exceed 72 fl oz of product per year. Make no more than two consecutive applications per season before alternating with fungicides that have a different mode of action. See label for additional diseases that may be controlled.
	Alternaria leaf spot, anthracnose, Botrytis, Cercospora leaf spot, powdery mildew	potassium bicarbonate (Milstop)	NC	1.25 to 5.0 lb/100 gal	0	1 hr	**OMRI-listed.** Do not exceed 0.5 lb of product per 4,350 sq ft or 1.15 lb product per 10,000 sq ft per application. Do not store unused spray solution. See label for additional diseases labeled.
	Damping off and root rots (*Phytophthora* spp., *Pythium* spp.)	propamocarb hydrochloride (Previcur Flex)	28	See label	2	0.5	**For use on leaf lettuce only.** Product applied as a foliar treatment. Do not apply more than two applications of product per crop cycle. Do not mix with other products. Phytotoxicity may occur if applied to dry growing media.
	Powdery mildew	sulfur (various)	M2	See label	See label	See label	**Some products are OMRI-listed.** See product labels for complete application instructions, specific crop and disease labels, and greenhouse usage. **Not all products are registered for use in all states.**
	Alternaria leaf spot/black spot (*Alternaria* spp.), powdery mildew (*Golovinomyces* spp.)	triflumizole (Procure 480SC)	3	6 to 8 fl oz/acre	0	0.5	For use on head and leaf lettuce. Do not exceed 18 fl oz of product per acre per season. **Product not registered for use in all states.**
Tomato (transplant production)	Damping off (*Pythium* spp.)	cyazofamid (Ranman, Ranman 400SC)	21	3 fl oz/100 gal	--	0.5	**For transplant production only.** Apply as a soil drench. Do not use a surfactant. One fungicide application can be made to the seedling tray at planting or any time afterwards until one week before transplanting.
	Late blight (*Phytophthora infestans*)	mandipropamid (Micora)	40	5.5 to 8.0 fl oz/acre	--	4 hr	**For tomatoes grown for transplants and retail sale to consumers only.** Do not make more than two applications per crop. Do not make more than two consecutive applications before switching to a fungicide from a different FRAC group.
	Damping off and root rots (*Phytophthora* spp., *Pythium* spp.)	propamocarb hydrochloride (Previcur Flex)	28	See label.	--	0.5	**For pre seeding and/or seedling treatment (before transplanting).** Do not mix with other products. See label for specific use directions. Phytotoxicity may occur if applied to dry growing media.
	Bacterial canker, speck, and/or spot	*Streptomycin* sulfate (Agri-Mycin 17, Ag Streptomycin, Firewall 17 WP, Firewall 50 WP, Harbour)	25	See labels	--	0.5	**For transplant production only.** Begin applications at the first true leaf stage. Repeat at 4 to 5 day intervals until transplanting in the field. Check product labels for specific diseases labeled and application rates. Firewall 50 WP has a maximum of six applications per year.
	Crown and basal rot (*Fusarium* spp., *Rhizoctonia solani*, *Sclerotinia* spp.), damping off (*Pythium* spp., *Rhizoctonia* spp.), downy mildew (*Peronospora* spp., *Plasmopara* spp.), spots and blights (*Alternaria* spp., *Cercospora* spp., *Phoma* spp., *Septoria* spp.), Phytophthora blight, powdery mildew (*Leveilula* spp. and *Oidiopsis* spp.), rots and blights (*Botrytis* spp.)	pyraclostrobin + boscalid (Pageant Intrinsic)	7 + 11	See label	--	0.5	**For transplant production only.** Begin applications at the first true leaf stage. Repeat at 4 to 5 day intervals until transplanting in the field. Check product labels for specific diseases labeled and application rates. Firewall 50 WP has a maximum of six applications per year.

TABLE 3-45. GREENHOUSE DISEASE CONTROL FOR VARIOUS VEGETABLE CROPS (cont'd)

R. A. Melanson, Extension Plant Pathologist, Mississippi State University; A. Keinath, Plant Pathologist, Clemson University; F. Louws, Plant Pathologist, NCSU; M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

Commodity	Disease	Product[1]	FRAC	Rate of Material	Minimum Days Harv.	Minimum Days Reentry	Method, Schedule, and Remarks
Tomato (after transplanting in a greenhouse) Tomato (after transplanting in a greenhouse) (cont'd)	Anthracnose (*Colletotrichum* spp.), black mold (*Alternaria alternata*), early blight (*Alternaria solani*), gray leaf spot (*Stemphylium botryosum*), powdery mildew (*Leveilula taurica*), Septoria leaf spot (*Septoria lycopersici*), target spot (*Corynespora cassiicola*)	azoxystrobin + difenoconazole (Quadris Top)	11 + 9	8 fl oz/acre	0	0.5	***Not prohibited for greenhouse use.*** **Do not use for transplant production.** Do not make more than two consecutive applications before switching to a fungicide with a different mode of action. Do not exceed 47 fl oz of product per acre per season. Do not apply until 21 days after transplanting or 35 days after seeding. Do not use with adjuvants or tank mix with any EC product on fresh market tomatoes. Plant injury may occur with the use of adjuvants. See label for specifics.
	Botrytis gray mold, powdery mildew	Banda de Lupinus albus doce (BLAD) (Fracture)	BM01	24.4 to 36.6 fl oz/acre	1	4 hr	***Not prohibited for greenhouse use.*** Do not make more than two sequential applications before alternating to a fungicide with a different mode of action.
	Anthracnose, bacterial speck and spot, early blight, gray leaf mold, late blight, Septoria leaf spot	copper, fixed (various)	M1	See label	See label	See label	**Some products are OMRI-listed.** See product labels for complete application instructions, specific crop and disease labels, and greenhouse usage.
	Late blight (*P. infestans*), Phytophthora blight (*P. capsici*)	cyazofamid (Ranman 400SC)	21	2.1 to 2.75 fl oz/acre (late blight) 2.75 fl oz/acre (Phytophthora blight)	0	0.5	Do not exceed 16.5 fl oz per acre per year. See label for surfactant recommendations. Alternate applications with fungicides that have a different mode of action. Do not make more than three consecutive applications before switching to products that have a different mode of action for three applications before returning to Ranman 400SC. See label for application instructions specific to target disease.
	Late blight (*Phytophthora infestans*)	cymoxanil (Curzate 60DF)	27	3,2 to 5.0 oz/acre	3	12 hr	***Not prohibited for greenhouse use.*** Use with the labeled rate of a protectant fungicide. Do not exceed 30 oz of product per 12-month period.
	Early blight (*A. solani*), Botrytis gray mold, powdery mildew (*L. taurica*)	cyprodinil + fludioxonil (Switch 62.5WG)	9 + 12	11 to 14 oz/acre	0	0.5	***Not prohibited for greenhouse use.*** After two applications, alternate with another fungicide with a different mode of action for two applications. See label for application limits. Do not apply to small tomatoes such as cherry or grape-type tomatoes in the greenhouse.
	Anthracnose (*Colletotrichum* spp.), black mold (*A. alternata*), Botrytis gray mold, early blight (*A. solani*), gray leaf spot (*S. botryosum*), leaf mold (*Fulvia fulva*), powdery mildew (*L. taurica*), Septoria leaf spot, target spot (*C. cassiicola*)	difenoconazole + cyprodinil (Inspire Super)	3 + 9	16 to 20 fl oz/acre	0	0.5	***Not prohibited for greenhouse use.*** Do not apply more than 47 fl oz of product per acre per season. Make no more than two consecutive applications per season before alternating with fungicides that have a different mode of action.
	Phytophthora and Pythium root rots	etridiazole (Terramaster 4EC)	14	6 to 7 fl oz/acre	3	0.5	For application by drip irrigation. Apply as a 0.01% solution (6.5 fl oz/500 gal water) no sooner than 3 weeks after trans- planting or a previous application. Do not exceed 27.4 fl oz of product per acre per crop season. Additional indoor restrictions regarding REI are provided on the label. **Product has a Section 24c registration for this use on greenhouse tomatoes in FL, KY, MS, OK, TN, TX, and VA. Product is not registered for this use in AL, GA, LA, NC, or SC.**
	Anthracnose (*Colletotrichum* spp.), early blight (*A. solani*) late blight (*P. infestans*), leaf mold (*Cladosporium fulvum*), Septoria leaf spot (*S. lycopersici*), target spot (*C. cassiicola*) ***Suppression:*** Bacterial canker, bacterial speck, bacterial spot, buckeye rot (*Phytophthora* spp.)	famoxadone + cymoxanil (Tanos)	11 + 27	6 to 8 oz/acre (early blight) 8 oz/acre (other labeled diseases)	3	0.5	***Not prohibited for greenhouse use.*** Do not exceed more than 72 oz/acre per crop cycle or 12-month period. Do not make more than one application of product before alternating with a fungicide that has a different mode of action. See label for tank mixing instructions.
	Botrytis gray mold	fenhexamid (Decree 50 WDG)	17	1.5 lb/acre (standalone) 1.0 to 1.5 lb/acre (tank-mix)	0	0.5	Do not make more than two consecutive applications. See label for additional tank-mixing instructions. Do not exceed 6.0 lb product per acre per season for greenhouse production.

TABLE 3-45. GREENHOUSE DISEASE CONTROL FOR VARIOUS VEGETABLE CROPS (cont'd)

R. A. Melanson, Extension Plant Pathologist, Mississippi State University; A. Keinath, Plant Pathologist, Clemson University; F. Louws, Plant Pathologist, NCSU; M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

Commodity	Disease	Product[1]	FRAC	Rate of Material	Minimum Days		Method, Schedule, and Remarks
					Harv.	Reentry	
Tomato (after transplanting in a greenhouse) (cont'd)	Damping off (*Pythium* spp.), root rots (*Phytophthora* spp.)	fosetyl-Al (various)	33	2.5 to 5.0 lb/acre	14	0.5	***Not prohibited for greenhouse use. For foliar application.*** Do not exceed 20 lb of product per acre per season. Phytotoxicity may occur if tank-mixed with copper products, if applied to plants with copper residues, or if mixed with adjuvants. Do not tank-mix with copper products. See label for additional restrictions and application instructions. **Products are not labeled for use on tomato in certain counties in AL, KY, LA, NC, and TN.**
	Anthracnose, bacterial speck and spot, Botrytis, early blight, late blight, powdery mildew, and Rhizoctonia fruit rot	hydrogen dioxide (OxiDate)	NG	1/3 to 1 gal/100 gal water (foliar spray)	0	See label	See label for additional information regarding rate usage, including rates specific to non-foliar applications and other labeled diseases. **Toxic to bees and other beneficial insects exposed to direct contact on blooming crops.**
	Anthracnose, bacterial speck and leaf spot, Botrytis gray mold, Cladosporium mold, early blight (*Alternaria*), *Fusarium*, late blight, *Pythium*, *Rhizoctonia*, powdery mildew	hydrogen peroxide + peroxyacetic acid (OxiDate 2.0)	NG	32 to 128 fl oz/100 gal water (foliar spray)	0	See label	See label for additional information regarding rate usage, including rates specific to non-foliar applications and other labeled diseases. Do not apply as a foliar spray sooner than at least 24 hrs following application of a metal-based product. Under some conditions, phytotoxicity may result when tank-mixed with metal-based chemicals. **Toxic to bees and other beneficial insects exposed to direct contact on blooming crops.**
	Anthracnose, bacterial speck and spot, early blight, gray leaf spot, late blight, leaf mold, Septoria leaf spot	mancozeb (various)	M3	See label	See label	See label	See product labels for complete application instructions, specific crop and disease labels, and greenhouse usage.
	Anthracnose, bacterial speck and spot, early blight, gray leaf spot, late blight, leaf mold, Septoria leaf spot	mancozeb + copper (ManKocide)	M3 + M1	1.7 lb/acre (processing) 1 to 3 lb/acre (fresh market)	5	2	***Not prohibited for greenhouse use.*** Do not exceed 58 lb product per acre per crop east of the Mississippi River or 42.66 lb product per acre per crop west of the Mississippi River. Phytotoxicity may occur when spray solution has a pH of less than 6.5 or when certain environmental conditions occur.
	Anthracnose, bacterial speck and spot, buckeye rot, early blight, gray leaf spot, late blight, leaf mold, Septoria leaf spot	mancozeb + zoxamide (Gavel 75DF)	M3 + 22	1.5 to 2.0 lb/acre	5	2	***Not prohibited for greenhouse use.*** Do not exceed 8 lb per acre per season (west of the Mississippi River) or 16 lb per acre per season (east of the Mississippi River). For bacterial speck and spot, apply the full rate of product in a tank mix with a full rate of a fixed copper. See label for other application limits. **Product has a 2(ee) Recommendation for anthracnose management in AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, and VA.**
	Anthracnose (*Colletotrichum* spp.), black mold (*A. alternata*), early blight, (*A. solani*), gray leaf spot (*S. botryosum*), late blight (*P. infestans*), leaf mold (*F. fulva*), powdery mildew (*L. taurica*), Septoria leaf spot, target spot (*C. cassiicola*)	mandipropamid + difenoconazole (Revus Top)	3 + 40	5.5 to 7.0 fl oz/acre	1	0.5	***Not prohibited for greenhouse use.*** Do not make more than two consecutive applications per season before alternating with fungicides that have a different mode of action. Do not exceed 28 fl oz of product per acre per season.
	Late blight (*P. infestans*)	mefenoxam + mancozeb (Ridomil Gold MZ WG)	4 + M3	2.5 lb/acre	5	2	***Not prohibited for greenhouse use.*** Do not exceed 7.5 lb product per acre per crop per season. Do not exceed three applications per season. Apply a protectant fungicide in between applications of product. See label for other restrictions.
	Powdery mildew (*Leveilula* spp.), southern blight	myclobutanil (Rally 40WSP)	3	2.5 to 4 oz/acre	0	2	***Not prohibited for greenhouse use.*** Do not exceed 1.25 lb product per acre per crop. Do not exceed 21 days between applications.
	Alternaria blights and leaf spots, black mold (*A. alternata*), early blight, Botrytis gray mold, powdery mildew (*L. taurica*), basal stem rot (*Sclerotium rolfsii*), Septoria leaf spot, target spot (*C. cassiicola*) ***Suppression:*** Anthracnose	penthiopyrad (Fontelis)	7	0.5 to 0.75 fl oz/gal per 1,360 sq ft	0	0.5	Do not exceed 72 fl oz of product per year. Do not make more than two consecutive applications per season before alternating with fungicides that have a different mode of action. See label for specific instructions for basal stem rot.

TABLE 3-45. GREENHOUSE DISEASE CONTROL FOR VARIOUS VEGETABLE CROPS (cont'd)

R. A. Melanson, Extension Plant Pathologist, Mississippi State University; A. Keinath, Plant Pathologist, Clemson University; F. Louws, Plant Pathologist, NCSU; M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

Commodity	Disease	Product[1]	FRAC	Rate of Material	Minimum Days Harv.	Minimum Days Reentry	Method, Schedule, and Remarks
Tomato (after transplanting in a greenhouse) (cont'd)	Root rot (*Phytophthora* spp.)	phosphorus acid (mono- and di-potassium salts) (various)	33	See label	See label	See label	See product labels for complete application instructions, specific crop and disease labels, and greenhouse usage.
	Botrytis rot, early blight, powdery mildew (*L. taurica*, *Oidiopsus sipula*) ***Suppression:*** Anthracnose	polyoxin D zinc salt (Affirm WDG, OSO 5%SC)	19	6.2 oz/acre (Affirm) 3.75 to 13.0 fl oz/acre (OSO)	0	4 hr	Check products labels for maximum limits of product per season. Alternate with fungicides that have a different mode of action. Check product labels for other tomato diseases also on the label. **OSO 5%SC is not registered for use in AR, KY, MS, or OK.**
	Alternaria leaf spot, anthracnose, Botrytis, Cercospora leaf spot, powdery mildew, Septoria leaf spot	potassium bicarbonate (Milstop, Carb-O-Nator)	NC	1.25 to 5.0 lb/100 gal water (MilStop) 2.5 to 5.0 lb/100 gal water (Carb-O-Nator)	0	1 hr (MilStop) 4 hr (Carb-O-Nator)	**OMRI-listed.** Do not exceed 0.5 lb of MilStop per 4,350 sq ft or 1.15 lb MilStop per 10,000 sq ft per application. Do not exceed a mix rate of 5 lb of Carb-O-Nator per 100 gal water. Do not store unused spray solution. See label for additional diseases labeled.
	On foliage: Early blight, gray leaf mold, gray leaf spot, late blight, Septoria leaf spot, target spot *On fruit:* Anthracnose, Alternaria fruit rot, Botrytis, late blight rot, Rhizoctonia rot	potassium phosphite + chlorothalonil (Catamaran)	33 + M5	4.5 to 5.5 pt/acre (foliage diseases) 7 pt/acre (fruit diseases)	0	0.5	***Not prohibited for greenhouse use.*** Do not exceed 50 pt per acre per season. Phytotoxicity potential. Do not combine with other pesticides, surfactants, or fertilizers. May be applied on the day of harvest.
	Damping off and root rots (*Phytophthora* spp., *Pythium* spp.)	propamocarb hydrochloride (Previcur Flex)	28	See label	5	0.5	Product applied through a drip system or as a soil drench. Do not apply more than four applications of product after transplanting per crop cycle. Do not mix with other products. Phytotoxicity may occur if applied to dry growing media.
	Botrytis gray mold	pyraclostrobin + boscalid (Pageant Intrinsic)	7 + 11	23 oz/acre	0	0.5	Do not tank mix with adjuvants or other agricultural products. Do not exceed 69 oz/acre of product per crop cycle. Do not make more than one application of product before switching to a fungicide with a different mode of action.
	Botrytis gray mold, early blight	pyrimethanil (Scala SC)	9	7 fl oz/acre	1	0.5	Plant injury may occur in non-ventilated houses; ventilate for at least 2 hours after application of product. Use only in a tank mix with another fungicide for early blight. Do not exceed 35 fl oz per acre per crop.
	Powdery mildew	sulfur (various)	M2	See label	See label	See label	**Some products are OMRI-listed.** See product labels for complete application instructions, specific crop and disease labels, and greenhouse usage. **Not all products are registered for use in all states.**
		triflumizole (Terraguard SC)	3	2 to 4 fl oz/100 gal	1	0.5	For use only as a foliar spray. For use in commercial greenhouse production only. Can be used on greenhouse transplants. Do not exceed 40 fl oz of product per acre per cropping system. See label for additional application instructions. Products not registered for use in all states.
	Anthracnose, early blight, Septoria leaf spot	zinc dimethyl-dithiocarbamate (Ziram 76DF)	M3	3 to 4 lb/acre	7	2	***Not prohibited for greenhouse use.*** Do not use on cherry tomatoes. Do not exceed 23.7 lb per acre per crop cycle. May be mixed with copper fungicides.

[1] Products registered for field use may be used on greenhouse crops (but not transplants) unless excluded on the label. Always check the label before applying a product.

[2] Former names of pathogens listed in this table that may be still be listed on fungicide labels are as follows; *Golovinomyces* spp. (formerly *Erysiphe* spp.) or *Golovinomyces cichoracearum* (formerly *Erysiphe cichoracearum*); *Passalora fulva* (formerly *Cladosporium fulvum* and *Fulvia fulva*); *Stagnosporopsis* (formerly *Didymella*).

TABLE 3-46. EFFICACY OF PRODUCTS FOR GREENHOUSE TOMATO DISEASE CONTROL

R. A. Melanson, Extension Plant Pathologist, Mississippi State University: F. Louws, Plant Pathologist, NCSU; M. Paret, Plant Pathologist, UF; M. L. Lewis Ivey, Plant Pathologist, The Ohio State University; A. Keinath, Plant Pathologist, Clemson University

Scale: E, excellent; G, good; F, fair; P, poor; NC, no control; ND, no data.

Product[1]	Fungicide Group [F]	Preharvest Interval (Days)	Anthracnose (*Colletotrichum coccodes*)	Bacterial Soft Rot (*Erwinia* spp.)	Bacterial Canker (*Clavibacter michiganensis* subsp. *michiganensis*)	Botrytis Gray Mold (*Botrytis cinerea*)	Early Blight (*Alternaria linariae* = *A. tomatophila*)	Leaf Mold (*Passalora fulva*[3])	Powdery Mildew (*Leveillula taurica*)	Phytophthora Root Rot (*Phytophthora* spp.)	Pythium Root Rot (*Pythium* spp.)	Rhizoctonia Root Rot (*Rhizoctonia solani*)	Septoria Leaf Spot (*Septoria lycopersici*)	Target Spot (*Corynespora cassiicola*)	Timber Rot (White Mold) (*Sclerotinia sclerotiorum*)
acibenzolar-*S*-methyl (Actigard)	P01	14	NC	F	F	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
bacteriophage (AgriPhage)	NC	0	NC	P	F	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Bacillus subtilis (various)	44	0	ND	ND	NC	P	P	ND	P	NC	NC	NC	ND	P	ND
BLAD (Fracture)	BM01	1	ND	NC	NC	F	ND	ND	F	NC	NC	ND	ND	ND	ND
cyprodinil + fludioxonil (Switch 62.5WG)	9 + 12	0	G	NC	NC	E	F	ND	G	NC	NC	F	F	ND	ND
difenoconazole + cyprodinil (Inspire Super)	3 + 9	0	G	NC	NC	E	G	ND	G	NC	NC	NC	ND	G	F
etridiazole (Terramaster)[2]	14	3	NC	NC	NC	NC	NC	NC	NC	F	F	ND	NC	NC	NC
famoxadone + cymoxanil (Tanos)	11 + 27	3	F	ND	P	ND	F	F	P	NC	NC	NC	F	F	ND
fenhexamid (Decree 50 WDG)	17	1	NC	NC	NC	NC	NC	NC	F	NC	NC	NC	NC	NC	NC
fixed copper	M1	0	P	F	F	P	F	P	P	NC	NC	NC	P	P	NC
hydrogen dioxide (Oxidate)	NC	0	ND	ND	NC	ND	ND	ND	P	P	P	ND	ND	ND	ND
mancozeb (Dithane 75 DF)	M3	5	G	NC	NC	F	G	F	ND	NC	NC	NC	F	F	ND
Neem oil (Trilogy, Triact 70)	NC	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
penthiopyrad (Fontelis)	7	0	P	NC	NC	F	G	G	G	NC	NC	NC	F	G	ND
polyoxin D zinc salt (OSO 5% SC)	19	0	F	NC	NC	F[R]	F	ND	F	ND	ND	ND	ND	F	ND
propamocarb hydrochloride (Previcur Flex)	28	5	NC	NC	NC	NC	NC	NC	NC	F	F	NC	NC	NC	NC
pyrimethanil (Scala)	9	1	NC	NC	NC	F[R]	NC	NC	NC	NC	NC	NC	NC	NC	NC
Streptomyces griseoviridis (Mycostop)	NC	0	NC	NC	NC	NC	NC	NC	NC	NC	F	F	NC	NC	NC
streptomycin sulfate (Agri-Mycin 17) [2]	18	0	NC	F	F	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
sulfur [P] (Microthiol Disperss)	M2	0	P	NC	NC	NC	NC	NC	F	NC	NC	NC	NC	NC	NC

[1] Efficacy ratings do not necessarily indicate a labeled use for every disease.

[2] For use on transplants only.

[3] Former names include *Cladosporium fulvum* and *Fulvia fulva*.

[P] Sulfur may be phytotoxic; follow label carefully.

[F] To prevent resistance in pathogens, alternate fungicides within a group with fungicides in another group. Fungicides in the "M" groups are generally considered "low risk" with no signs of resistance developing to the majority of fungicides. "NC" indicates that the product has not been classified into a fungicide group.

[R] Resistance reported in the pathogen

SEED TREATMENTS

Seed sanitation to eradicate bacterial or viral plant pathogens: When treating vegetable seeds, it is critical to follow the directions exactly, because germination can be reduced by the treatment and/or the pathogen may not be completely eliminated. The effect of a treatment on germination should be determined on a small lot of seeds prior to treating large amounts of seed. Treatments should not be applied to: 1) pelleted seed, 2) previously treated seed, or 3) old or poor quality seed. A protective fungicide treatment (see below) can be applied to the seed following treatment for bacterial pathogens.

Seed treatments to prevent damping off diseases: Most commercially available vegetable seeds come treated with at least one fungicide and/or insecticide. Vegetable producers who would like to apply their own seed treatment should purchase non-treated seed. While many fungicides are labeled for use on vegetable seed, most fungicides are restricted to commercial treatment only and should not be applied by producers. Labeled fungicides can be applied to seed following treatment for bacterial pathogens (see above). **Do not use fungicide treated seed for food or feed.**

HOT WATER TREATMENT

By soaking seed in hot water, seed-borne fungi and bacteria can be reduced, if not eradicated, from the seed coat. Hot water soaking will not kill pathogens associated with the embryo nor will it remove seed-borne plant viruses from the seed surface.

1. Place seed loosely in a weighted cheesecloth or nylon bag.
2. Warm the seed by soaking it for 10 minutes in 100°F (37°C) water.
3. Transfer the warmed seed into a water bath already heated to the temperature recommended for the vegetable seed being treated (Table 3-47). The seeds should be completely submerged in the water for the recommended amount of time (Table 3-47). Agitation of the water during the treatment process will help to maintain a uniform temperature in the water bath.
4. Transfer the hot water treated seed into a cold-water bath for five minutes to stop the heating action.
5. Remove seed from the cheesecloth or nylon bag and spread them evenly on clean paper towel or a sanitized drying screen to dry. Do not dry seed in areas where fungicides, pesticides or other chemicals are located.
6. Seed can be treated with a labeled fungicide to protect against damping off pathogens.

CHLORINE BLEACH TREATMENT

Treating seeds with a solution of chlorine bleach can effectively remove bacterial pathogens and some viruses (i.e. Tobacco Mosaic Virus) that are borne on the surface of seeds.

1. Add 1 quart (946 ml) of Clorox® bleach to 5 quarts (4.7 L) of potable water.
2. Add a drop or two of liquid dish detergent or a commercial surfactant such as Activator 90 or Silwet to the disinfectant solution. Add seed to the disinfectant solution (1 pound of seed per 4 quarts of disinfectant solution) and agitate for 1 minute.
3. Prepare fresh disinfectant solution for each batch of seeds to be treated.
4. Rinse the seed in a cold-water bath for 5 minutes to remove residual disinfectant.
5. Spread seeds evenly on clean paper towel or a sanitized drying screen to dry. Do not dry seed in area where fungicides, pesticides, or other chemicals are located.
6. Seed can be treated with a labeled fungicide to protect against damping off pathogens.

HYDROCHLORIC ACID TREATMENT

Tomato seed can be treated with a dilute solution of hydrochloric acid (HCl) solution to eliminate seed-borne bacterial pathogens such as *Xanthomonas* spp. (Bacterial leaf spot), *Pseudomonas syringae* pv. *tomato* (Bacterial speck) and *Clavibacter michiganensis* subsp. *michiganensis* (Bacterial canker). Hydrochloric acid can also be used to remove TMV from the surface of tomato seed. **Do not use HCL-treated seed for food or animal feed.**

1. Prepare a 5% solution of HCl by adding one part acid to 19 parts potable water. Prepare the acid solution in a well-ventilated area and avoid direct skin contact with the acid.
2. Soak seeds for 6 hours with gentle agitation.
3. Carefully drain the acid off of the seed and rinse seed under running potable water for 30 minutes. Alternatively, rinse the seeds 10 to 12 times with potable water to remove residual acid.
4. Spread seeds evenly on clean paper towel or a sanitized drying screen to dry. Do not dry seed in area where fungicides, pesticides, or other chemicals are located.
5. Seed can be treated with a labeled fungicide to protect against damping off pathogens.

TRISODIUM PHOSPHATE TREATMENT

Tomato seed can be treated with trisodium phosphate (TSP) to eradicate seed-transmitted

TMV. **Do not use TSP-treated seed for food or animal feed.**

1. Prepare a 10% solution of TSP (1 part TSP in 9 parts potable water). Trisodium phosphate is available at most home supply or paint stores. Avoid direct skin contact with the TSP solution.
2. Soak seed for 15 minutes in the disinfectant solution.
3. Rinse the seed in a cold-water bath for 5 minutes to remove residual disinfectant.
4. Spread seeds evenly on clean paper towel or a sanitized drying screen to dry. Do not dry seed in area where fungicides, pesticides, or other chemicals are located.
5. Seed can be treated with a labeled fungicide to protect against damping off pathogens.

TESTING SEED GERMINATION AFTER SEED TREATMENTS

1. Randomly select 100 seeds from each seed lot.
2. Treat 50 seeds using one of the sanitizers described above.
3. After the treated seed has dried and before application of a protectant fungicide, plant the treated and non-treated seed separately in flats containing planting mix according to standard practice. Label each group as treated or non-treated.
4. Allow the seeds to germinate and grow until the first true leaf appears (to allow for differences in germination rates to be observed).
5. Count seedlings in each group separately.
6. Determine the percent germination for each group: # seedlings emerged ÷ # seeds planted x 100.
7. Compare percent germination between the treated and non-treated groups. Percent germination should be within 5% of each other.

TABLE 3-47. RECOMMENDED TEMPERATURES & TREATMENT TIMES FOR HOT WATER DISINFESTATION OF VEGETABLE SEED

Vegetable Crop	Water Temperature (°F/°C)	Soaking Time (Minutes)
Broccoli	122/50	20 to 25
Brussels sprout	122/50	25
Cabbage	122/50	25
Carrot	122/50	15 to 20
Cauliflower	122/50	20
Celery	122/50	25
Chinese cabbage	122/50	20
Collard	122/50	20
Cucumber[1]	122/50	20
Eggplant	122/50	25
Garlic	120/49	20
Kale, Kohlrabi	122/50	20
Lettuce	118/48	30
Mint	112/44	10
Mustard, Cress, Radish	122/50	15
Onion	115/46	60
Pepper	125/51	30
Rape, Rutabaga	122/50	20
Shallot	115/46	60
Spinach	122/50	25
Tomato	122/50	25
Turnip	122/50	20

[1] Cucurbits other than cucumbers can be severely damaged by hot water treatment and should be disinfested using chlorine bleach.

TABLE 3-48. PRODUCTS FOR SEED TREATMENT

M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

	42-S Thiram (thiram)	Allegiance (metalaxyl)	Acquire (metalaxyl)	Apron (mefenoxam)	Belmont 2.7FS (metalaxyl)	Botran 75W (dicloran)	Captan 400 (captan)	Cruiser Maxx(thiamethoxam + mefenoxam + fludioxonil)	Cruiser Maxx Potato(thiamethoxam + fludioxonil)	Dyna-Shield (fludioxonil)	Dividend Extreme(difenoconazole+ mefenoxam)	Dynasty (azoxystrobin)	Emesto Silver (penflufen + prothioconazole)	Maxim 4FS (fludioxonil)	Maxim MZ(fludioxonil + mancozeb)	MetaStar 2E AG (metalaxyl)	MonCoat MZ (flutolanil + mancozeb)	Sebring 318S (metalaxyl)	Sebring 480S (metalaxyl)	Spirato 480 FS (fludioxonil)	Vitaflo-280 (carboxin + thiram)	Tops MZ-Gaucho (thiophanate-methyl + mancozeb)	Trilex (trifloxystrobin + metalaxyl)
Fungicide Group [F]	**M3**	**4**	**4**	**4**	**4**	**14**	**M3**	**4+12**	**12**	**12**	**3+4**	**11**	**3**	**12**	**12+M3**	**4**	**7+M3**	**4**	**4**	**M3**	**7+M3**	**1+M3**	**11+ 4**
Beans, Snap	X	X	X	X	X		X	X		X		X		X		X		X	X	X	X		X
Beans, Lima	X	X	X	X	X		X	X		X		X		X		X		X	X	X	X		X
Beets	X	X	X	X	X		X			X		X		X		X		X	X	X			
Broccoli	X		X	X	X		X			X		X		X				X	X	X			
Carrots	X	X	X	X	X					X		X		X		X		X		X			
Celery				X										X						X			
Chinese Cabbage	X		X	X	X							X		X						X			
Cole Crops	X		X	X	X		X			X		X		X						X			
Cucumbers	X	X	X	X	X		X			X		X		X		X		X	X	X			X
Eggplants	X		X	X	X					X		X		X				X		X			X
Garlic				X						X		X		X						X			
Greens, Mustard	X		X	X	X		X			X		X		X				X		X			
Greens, Turnip	X		X	X	X		X			X		X		X						X			
Horseradish			X	X	X					X		X		X						X			
Leeks				X						X		X		X									
Lettuce	X		X	X	X					X		X		X				X		X			
Muskmelons	X		X	X	X		X			X		X		X				X		X			
Okra	X		X		X							X		X		X		X	X				
Onions, Dry	X		X	X	X					X		X		X						X			
Onions, Green	X		X	X	X					X		X		X						X			
Parsley			X	X	X					X		X		X				X		X			
Parsnips			X	X	X					X		X		X				X		X			
Peas	X	X	X	X	X		X	X		X				X				X	X	X			X
Peppers	X		X	X	X		X			X		X		X				X		X			X
Pumpkins	X		X	X	X		X			X		X		X				X		X			X
Radish	X		X	X	X		X			X		X		X				X		X			
Spinach	X		X	X	X		X			X		X		X		X		X	X	X			
Squash, Summer	X		X	X	X		X			X		X		X				X		X			X
Squash, Winter	X		X	X	X		X			X		X		X				X		X			X
Sweet Corn	X	X		X			X			X	X	X		X				X		X	X		
Sweet Potatoes				X		X				X		X		X				X		X			
Tomatoes	X	X	X	X	X					X		X		X				X		X			X
Watermelon	X	X	X	X	X		X			X		X		X				X		X			X
White Potatoes (Irish)							X		X[2]	X		X	X[3]	X	X		X[3]			X		X[4]	X

[F] To prevent resistance in pathogens, alternate fungicides within a group with fungicides in another group. Fungicides in the "M" group are generally considered "low risk" with no signs of resistance developing to the majority of fungicides.

[2] Registered for use in Florida and North Carolina only.

[3] Registered for use in North Carolina only.

[4] Registered for use in Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina only.

TABLE 3-49. BIOCONTROL AGENTS AND DISINFESTANTS REGISTERED FOR SEED TREATMENT

M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

	Biocontrol Agents					Disinfectants				
	Actinovate STP (*Streptomyces lydicus* WYEC 108)	Kodiak HB (*Bacillus subtilis* GB03)	Mycostop (*Streptomyces griseoviridis* K61)	T-22 Planter Box (*Trichoderma harzianum*)	Yield Shield (*Bacillus pumilus* GB34)	Clorox	Hot water	Hydrochloric acid (HCl)	Oxidate 2.0 (hydrogen dioxide + peroxyacetic acid)	Trisodium phosphate (TSP)
Beans, Snap	X	X	X	X	X					
Beans, Lima	X	X	X	X	X					
Beets	X	X	X	X						
Broccoli	X	X					X			
Carrots	X	X	X	X			X			
Celery	X	X					X			
Chinese Cabbage	X	X					X			
Cole Crops	X	X	X				X			
Cucumbers	X	X		X		X	X			
Eggplants	X	X	X			X	X			
Garlic	X	X		X			X			
Greens, Mustard	X	X				X	X			
Greens, Turnip	X	X				X	X			
Horseradish	X	X								
Leeks	X	X	X							
Lettuce	X	X	X			X	X			
Muskmelons	X	X		X		X				
Okra	X	X								
Onions, Dry	X	X	X	X			X			
Onions, Green	X	X	X	X			X			
Parsley	X	X	X			X				
Parsnips	X	X		X						
Peas	X	X	X	X	X					
Peppers	X	X	X			X	X		X	
Pumpkins/Winter squash	X	X		X		X			X	
Radish	X	X	X	X			X			
Spinach	X	X	X				X			
Squash, Summer	X	X		X		X			X	
Sweet Corn	X	X		X						
Sweet Potatoes	X			X						
Tomatoes	X	X	X			X	X	X	X	X
Watermelon	X	X		X		X				
White Potatoes (Irish)				X						

TABLE 3-50. SWEETPOTATO STORAGE HOUSE SANITATION

Quesada-Ocampo, Plant Pathologist, NCSU

Material	Rate per 1,000 Cubic Feet of Space	Methods and Remarks
Heat	140°F 4 to 8 hr/day for 7 days or 180°F for 30 min	See remarks under sanitizing greenhouses. The storage house, ventilation system, and equipment must be very clean and moist during the procedure. *Caution:* rot-causing organisms inside a drain will probably not be exposed to lethal temperature.

TABLE 3-51. WATER, PRODUCE AND EQUIPMENT SANITATION

M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

Medium	Sanitizer	Contact time (min)	Rate of Material to Use		Method, Schedule, and Remarks
			Target Rate (ppm)	Formulation	
Wash water, dump tank water, or vegetable wash water*	calcium hypochlorite (Aquafit)	2	25	1 oz/200 gal	
	chlorine dioxide (Harvest Wash, ProOxine, Anthium Dioxide, Adox 750)	1 to 10	3 to 5	Varies between products; see product labels.	Maintain water pH between 6.0 and 10. Restricted to large operations. Requires automated and controlled injection systems. **NOTE: Chlorine dioxide is explosive.**
	chlorine gas (99.9%)	—	Contact supplier for rates.		Restricted to very large operations. Requires automated and controlled injection systems. Regulated by both the EPA (water) and FDA (food contact surfaces).
	hydrogen dioxide or peroxide (StorOx)	—	Varies based on method of application.		
	hydrogen peroxide + peroxyacetic acid	1	80 peroxyacetic acid	1 fl oz/16.4 gal	Contact times vary depending on the governing sanitary code. Post-sanitation rinse is not necessary.
	(BioSide HS)	1.5	80 peroxyacetic acid	1 fl oz/16.4 gal	
	(Keystone Fruit and Vegetable Wash)	0.75	88 to 130 (peroxyacetic acid, non-porous surfaces)	3 to 3.5 fl oz/16 gal	
	(PAA Sanitizer FP)	—	25 peroxyacetic acid	1 oz/20 gal	
	(Perasan A)	0.75	24 to 85 peroxyacetic acid	5.9 to 20.9 fl oz/100 gal	
	(SaniDate 5.0)	—	30 to 80	2.5 to 6.7 fl oz/100 gal	
	(Tsunami 100)	1.5	80	1 fl oz/16.4 gal	
	(Victory)	—	5 to 85 peroxyacetic acid (postharvest pathogens)	0.1 to 1 fl oz/16 gal	
	(VigorOx 15 F&V)	—	45 peroxyacetic acid (foodborne pathogens)	0.54 fl oz/16 gal	
	sodium hypochlorite (5.25%) (12.75%)	—	150 150	2.9 ml/L 1.18 ml/L	Maintain water pH between 6.0 and 7.5. Noxious chlorine gas can be released when the pH drops below 6.0. **NOTE: Household bleach is NOT registered for use with fresh produce.**
	sodium hypochlorite				Monitor residual chlorine or change solution when it is visibly dirty. Rinse produce with potable water prior to packing.
	(Agclor 310)	—	65 to 400	0.5 to 3 gal/1000 gal	
	(Dibac)	2	25	1 oz/20 gal	
	(Dynachlor)	2	25	5 oz/200gal	
	(Extract-2)	2	25	5 oz/200gal	
	(JP Optimum CRS)	—	25	0.75 oz/10 gal	
	(Maxxum 700)	2	25	8 oz/200gal	
	(Zep FS Formula 4665)	2	25	5 oz/200gal	
Equipment** (conveyors, scrubbers, plastic harvest containers, peelers, field equipment, etc.)	calcium hypochlorite (Aquafit)	2	600 (porous surfaces)	3 oz/20 gal	Do not rinse or soak equipment overnight.
	chlorine dioxide (ProOxine, Sanogene, Anthium Dioxide, Adox 750)	1 to 10	10 to 20 (porous or non-porous surfaces) 500 (ceilings, floors and walls)	Varies between products; see product labels.	
	hydrogen dioxide or peroxide (StorOx)	—	1 to 3 ppm (1:300 to 1:100) (non-porous surfaces)	0.5 to 1.25 fl oz/gal	Apply until run-off. Requires a thorough post-sanitation rinse with potable water.
	hydrogen peroxide + peroxyacetic acid				Contact time varies depending on the governing sanitary code. Consult labels as some products require a post-disinfection rinse with potable water.
	(BioSide HS)	1 or more	93 to 500 peroxyacetic acid	0.7 to 3.8 fl oz/10 gal	

TABLE 3-51. WATER, PRODUCE AND EQUIPMENT SANITATION (cont'd)

M. L. Lewis Ivey, Plant Pathologist, The Ohio State University

Medium	Sanitizer	Contact time (min)	Rate of Material to Use		Method, Schedule, and Remarks
			Target Rate (ppm)	Formulation	
Equipment** (conveyors, scrubbers, plastic harvest containers, peelers, field equipment, etc.) (cont'd)	(Oxidate 2.0)	See label	100 to 300	1.25 to 1.5 fl oz/gal	
	(PAA Sanitizer FP)	1 or more	88 to 130 peroxyacetic acid (non-porous surfaces)	1 to 1.5 fl oz/5 gal	
	(Perasan A)	1	82 to 500 peroxyacetic acid	1 to 6.1 oz/6 gal	
	(SaniDate 5.0)	1	approx. 128	1.6 fl oz/5 gal	
	(VigorOx 15 F&V)	1	85 peroxyacetic acid	3.1 fl oz/50 gal	
	sodium hypochlorite (5.25%)	2	100 to 200 (non-porous surfaces)	1.9 to 3.8 ml/L	Noxious chlorine gas can be released when the pH drops below 6.0. Porous surfaces require a thorough post-disinfection rinse with potable water. Allow all surface types to air-dry prior to re-use.
		2	600 (porous surfaces)	11.4 ml/L	
		—	1000 to 2000 (floors and walls)	1900 to 3800 ml/L	
	sodium hypochlorite (12.75%)	2	100 to 200 (non-porous surfaces)	0.78 to 1.56 ml/L	
		2	600 (porous surfaces)	4.68 ml/L	
		—	1000 to 2000 (floors and walls)	780 to 1560 ml/L	
	sodium hypochlorite (Agclor 310, Dibac, Dynachlor, Extract-2, JP Optimum CRS, Maxxum 700, Zep FS Formula 4665)	1	Varies based on method of application.		
	quaternary ammonia (DDAC) (KleenGrow)	10	—	1 fl oz/gal	Allow surfaces to air dry. If treated surfaces will contact food, thoroughly rinse surfaces with potable water.

* Recommendations are for potable water only. Recommended rates are not effective in reducing pathogen populations in non-potable water (i.e. surface or ground water).
** Recommendations are for potable water only. Always wash off organic debris and soil with water prior to sanitizing. Rates and contact time are dependent on surface type.

VARIOUS AND ALTERNATIVE FUNGICIDES

TABLE 3-52. VARIOUS FUNGICIDES FOR USE ON VEGETABLE CROPS

R. A. Melanson, Extension Plant Pathologist, Mississippi State University; R. Singh, Horticulture Extension Plant Pathologist, Louisiana State University Agricultural Center

Not all trade names are registered in all states. Check the label to confirm that the product is registered in your state and for your intended use.

Common Name	Trade Name(s)
azoxystrobin (FRAC 11)	A-Zox 25 SC (*Sharda USA LLC*)
	Aframe *(Syngenta)*
	Azoxy 2SC Prime (*Prime Source*)
	Azoxystar *(Albaugh, LLC)*
	Azoxystrobin 100 ST *(Albaugh, LLC)*
	Azoxyzone *(LG Life Sciences)*
	AZteroid 1.65 SC (*Vive Crop Protection, Inc*)
	AZteroid FC (*Vive Crop Protection, Inc.*)
	Dynasty *(Syngenta)*
	Equation *(Cheminova)*
	Equation SC *(Cheminova)*
	Gold Rush (*Altitude Crop Innovations, LLC*)
	Heritage (*Syngenta*)
	Quadris *(Syngenta)*
	Satori Fungicide *(Loveland Products)*
	Tetraban (*United Suppliers*)
	Trevo *(Innvictis Crop Care)*
	Willowood Azoxy 2SC (*Willowood USA*)
chlorothalonil (FRAC M5)	Bravo Ultrex *(Syngenta)*
	Bravo Weather Stik *(Syngenta)*
	Bravo Zn *(Syngenta)*
	Chloronil 720 *(Syngenta)*
	Echo 720 Agricultural Fungicide *(SipcamAdvan)*
	Echo 90DF *(SipcamAdvan)*
chlorothalonil (FRAC M5) (cont'd)	Echo Zn Agricultural Fungicide *(SipcamAdvan)*
	Equus 500 ZN *(Adama)*
	Equus 720 SST *(Adama)*
	Equus DF *(Adama)*
	Initiate 720 *(Loveland Products)*
	Initiate ZN *(Loveland Products)*
	Praiz (*Winfield Solutions LLC*)
	Vabro (*United Suppliers, Inc.*)
copper hydroxide (FRAC M1)	Americop 40 DF (*Industrias Quimicos del Valles, SA*)
	Champ Dry Prill *(Nufarm)*
	Champ Formula 2 Flowable *(Nufarm)*
	Champ WG *(Nufarm)*
	ChampION++ *(Nufarm)*
	Kentan DF *(Isagro USA)*
	Kocide 2000 *(DuPont; Certis USA)*
	Kocide 3000 *(DuPont; Certis USA)*
	KOP-Hydroxide *(Drexel)*
	KOP Hydroxide 50W *(Drexel)*
	Nu-Cop 3L *(Albaugh)*
	Nu-Cop 30 HB *(Albaugh)*
	Nu-Cop 50 DF *(Albaugh)*
	Nu-Cop 50 WP *(Albaugh)*
	Nu-Cop HB *(Albaugh)*
	Nu-Cop XLR *(Albaugh)*
	Previsto *(Gowan)*

TABLE 3-52. VARIOUS FUNGICIDES FOR USE ON VEGETABLE CROPS (cont'd)

R. A. Melanson, Extension Plant Pathologist, Mississippi State University; R. Singh, Horticulture Extension Plant Pathologist, Louisiana State University Agricultural Center

Not all trade names are registered in all states. Check the label to confirm that the product is registered in your state and for your intended use.

Common Name	Trade Name(s)
copper octanoate (FRAC M1)	Camelot-O *(SePRO)*
copper (cuprous) oxide (FRAC M1)	Nordox *(NORDOX Industrier AS)*
	Nordox 75 WG *(NORDOX Industrier AS)*
copper sulfate (basic) (FRAC M1)	Basic Copper 53 *(Albaugh)*
	Cuprofix Ultra 40 Disperss *(United Phosphorus)*
	Cuproxat *(NuFarm)*
	Cuproxat FL *(NuFarm)*
copper sulfate pentahydrate (FRAC M1)	Magna-Bon CS 2005 *(Magna-Bon II, LLC)*
	Mastercop *(Adama)*
fludioxonil (FRAC 12)	Cannonball *(Syngenta)*
	Cannonball WG *(Syngenta)*
	Cannonball WP *(Syngenta)*
	Dyna-Shield Fludioxonil *(Loveland Products)*
	Fludioxonil 4L ST *(Albaugh)*
	Maxim 4FS *(Syngenta)*
	Maxim PSP *(Syngenta)*
	Scholar SC *(Syngenta)*
	Spirato 480 FS *(Nufarm)*
fosetyl-Al (Aluminum tris (O-ethyl phosphate)) (FRAC 33)	Aliette WDG Fungicide *(Bayer)*
	Linebacker WDG *(NovaSource)*
iprodione (FRAC 2)	Iprodione 4L AG *(Arysta)*
	Meteor *(United Phosphorus)*
	Nevado 4F *(Adama)*
	Rovral 4 Flowable Fungicide *(FMC Corporation)*
mancozeb (FRAC M3)	Dithane F-45 Rainshield *(Dow)*
	Dithane M45 *(Dow)*
	Fortuna 75 WDG *(Agria Canada)*
	Koverall *(Cheminova, FMC Corporation)*
	Manzate Max *(United Phosphorus)*
	Manzate Pro-Stick *(United Phosphorus)*
	Nubark Gold *(Wilbur-Ellis)*
	Penncozeb 75DF *(United Phosphorus)*
	Penncozeb 80WP *(United Phosphorus)*
	Potato Seed Treater PS *(Loveland Products)*
	Potato Seed Treater 6% *(Loveland Products)*
	Roper DF Rainshield *(Loveland Products)*
mefenoxam (FRAC 4)	Apron XL *(Syngenta)*
	Ridomil Gold GR *(Syngenta)*
	Ridomil Gold SL *(Syngenta)*
	Ultra Flourish *(Nufarm)*
myclobutanil (FRAC 3)	Rally 40WSP *(Dow)*
	Sonoma 25EW AG (*Albaugh*)
	Sonoma 40WSP *(Albaugh)*
phosphite, potassium (FRAC 33)	Helena Prophyt *(Helena)*
	Reveille *(Helena)*
phosphite (mono- and dibasic salts) (FRAC 33)	Helena Prophyt *(Helena)*
	Phostrol *(Nufarm)*
	Phostrol 500 *(Nufarm)*
phosphorous acid (mono- and di-potassium salts) (FRAC 33)	Alude *(Nufarm)*
	Confine Extra *(Winfield Solutions)*
	Fosphite Fungicide *(JH Biotech)*
	Fungi-Phite *(Verdesian Life Sciences)*
	K-Phite 7LP AG *(Plant Food Systems)*
	Rampart *(Loveland Products)*
	Reliant (*Quest Products*)
propamocarb hydrochloride (FRAC 28)	Previcur Flex *(Bayer)*
	Promess *(Agriphar)*
propiconazole (FRAC 3)	AmTide Propiconazole 41.8% EC *(AmTide)*
	Bumper 41.8 EC *(Adama)*
	Bumper ES *(Adama)*
	Fitness *(Loveland Products)*
	Mentor *(Syngenta)*
	Propi-Star EC *(Albaugh)*
	Propicure 3.6 F *(United Supplies, Inc.)*
	PropiMax EC (*Dow*)
	Shar-Shield PPZ (*Sharda USA*)
	Tide Propiconazole 41.8% EC *(Tide International)*
	Tilt *(Syngenta)*
	Topaz *(Winfield Solutions)*
sulfur (FRAC M2)	Cosavet-DF *(Sulphur Mills Limited)*
	CSC 80% Thiosperse *(Martin Resources)*
	CSC Dusting Sulfur *(Martin Resources)*
	CSC Thioben 90 *(Martin Resources)*
	CSC Wettable Sulfur *(Martin Resources)*
	Dusting Sulfur *(Loveland Products; Wilbur-Ellis*)
	First Choice Dusting Sulfur *(Loveland Products)*
	IAP Dusting Sulfur *(Independent Agribusiness Professionals)*
	InteGro Magic Sulfur Dust (*InteGro Inc.*)
	Kumulus DF *(Micro Flo and Wilbur-Ellis)*
	Liquid Sulfur Six *(Helena)*
	Micro Sulf *(Nufarm)*
	Microfine Sulfur *(Loveland Products)*
	Microthiol Disperss *(United Phosphorus)*
	Special Electric Sulfur *(Wilbur-Ellis)*
	Spray Sulfur *(Wilbur-Ellis)*
	Sulfur 6 L *(Arysta and Micro Flo)*
	Sulfur 90 W *(Drexel)*
	Sulfur DF *(Wilbur-Ellis)*
	THAT Flowable Sulfur *(Stoller Enterprises)*
	Thiolux (*Loveland Products*)
	Yellow Jacket Wettable Sulfur II *(Georgia Gulf Sulfur)*
tebuconazole (FRAC 3)	Monsoon *(Loveland Products)*
	Onset 3.6 L *(Winfield Solutions)*
	Orius 3.6 F *(Adama)*
	Tebu-Crop 3.6 F (*Sharda USA*)
	Tebucon 3.6 F (*Repar Corp.*)
	Tebuconazole 3.6 F *(Solera Source Dynamics)*
	TebuStar 3.6 L *(Albaugh)*
	Tebuzol 3.6 F (*United Phosphorus*)
	Toledo 3.6 F *(Rotam)*
thiophanate-methyl (FRAC 1)	Cercobin *(Cheminova)*
	Incognito 4.5 F *(Makhteshim Agan of North)*
	Incognito 85 WDG *(MANA)*
	Thiophanate Methyl 85 WDG *(Makhteshim Agan of North)*
	T-Methyl 4.5 Ag *(Helena)*
	T-Methyl 4.5 F *(Nufarm)*
	T-Methyl 70 WSB *(Nufarm)*
	Topsin 4.5 FL *(United Phosphorus)*
	Topsin M WSB *(United Phosphorus)*
	3336 EG *(Cleary)*
	3336 F *(Cleary)*
	3336 WP *(Cleary)*

TABLE 3-53. BIOPESTICIDES AND FUNGICIDE ALTERNATIVES FOR VEGETABLES

R. A. Melanson, Extension Plant Pathologist, Mississippi State University

Active Ingredient[1]	Product[1]	Target Diseases/Pests	PHI (days)	REI	Greenhouse Use	OMRI-Listed	Comments[2]
allyl isothiocyanate	Dominus (*Isagro*)	Certain soil-borne fungi and nematodes	--	5 days	Yes	No	Preplant soil biofumigant. See label for other restrictions and application instructions. **Dominus is not registered for use in WV.**
acibenzolar-S-methyl	Actigard 50WG (*Syngenta*)	Bacterial blights and spots, downy mildew, powdery mildew (see label for crop specific diseases)	See label	12 hr	No	No	Do not apply to plants stressed by heat, cold, or moisture extremes. ***FRAC P01.***
Bacillus amyloliquefaciens strain D747	Double Nickel 55, Double Nickel LC (*Certis USA*)	Bacterial spots and speck, bacterial leaf spot, powdery mildew, white mold (timber rot), Botrytis gray mold, Alternaria leaf spot	0	4 hr	Yes	Yes	Multiple application methods. See label. **Double Nickel 55 is not registered for use in OK; Double Nickel LC is not registered for use in AR, KY, or OK.** ***FRAC 44.***
Bacillus mycoides isolate J	LifeGard WG (*Certis USA*)	Bacterial spot and speck, downy mildew, early blight, late blight, powdery mildew, white mold and others (see label for crop specific diseases)	0	4 hr	Yes	Yes	**LifeGard is not registered for use in LA, NC, or WV.** ***FRAC P06.***
Bacillus pumilus QST 2808	Ballad Plus, Sonata (*Bayer*)	Early blight, late blight, downy mildew, powdery mildew, leaf blights, rust	0	4 hr	Sonata	No	Products are not OMRI-listed, but labels state that they can be used for organic production. See labels for specifics of greenhouse use. Ballad Plus can be used on certain beans and sweet corn only.
Bacillus subtilis GB03	Companion (Liquid and WP formulations) (*Growth Products*)	Root and foliar diseases (see label for crop specific diseases)	0	See label	Yes	WP only	See product labels for instructions on various application uses. **Check state registration status prior to use.** ***FRAC 44.***
Bacillus subtilis strain MBI 600	Subtilex NG (*BASF*)	*Rhizoctonia, Pythium,* and *Fusarium* diseases, powdery mildew, and gray mold	See label	4 hr	Yes	No	For post-plant applications to the soil/planting medium or as a foliar spray on cucurbits and fruiting vegetables. ***FRAC 44.***
Bacillus subtilis strain QST 713	CEASE (*BioWorks Inc.*); Serenade ASO, Serenade MAX, Serenade Opti, Serenade Optimum, Serenade Soil (*Bayer*)	Various diseases – see label for crop specific diseases	0	4 hr	CEASE, Serenade ASO	Yes	Works best when applied prior to disease development and used in an integrated program. See label for product-specific instructions regarding product application. **Serenade Optimum has a 2(ee) Recommendation for reduced rates on fruiting vegetables in FL and GA.** ***FRAC 44.***
bacteriophage	AgriPhage (*Omni-Lytics*)	Bacterial spot and speck	0	4 hr	Yes (seedlings)	No	Product is strain specific (active against *Xanthomonas campestris* pv. *campestris* and *Pseudomonas syringae* pv. *tomato*) and is labeled for use on tomatoes and peppers. Do not tank-mix product with denaturing agents or copper salts. **Check state registration status prior to use.**
Banda de Lupinus albus doce (BLAD)	Fracture (*FMC Corporation*)	Botrytis gray mold and powdery mildew	1	4 hr	Yes	No	For use on tomato only. **Product has a 2(ee) Recommendation for use against southern blight in tomato in FL, GA, NC, and SC.** ***FRAC BM01.***
Coniothyrium minitans strain CON/M/91-08	Contans WG (*Bayer, SipcamAdvan*)	*Sclerotinia sclerotiorum* and *S. minor*	0	4 hr	Yes	Yes	Apply to soil or potting medium. Do not tank-mix products with other fungicides or apply products 7 days before or after the application of other fungicides. **Tomato is not included in the list of fruiting vegetables on this label.**
copper	See disease control tables for individual crops.						
extract of *Reynoutria sachalinensis*	Regalia, Regalia Rx (*Marrone Bio Innovations*)	Certain bacterial and fungal diseases (see label for crop specific diseases)	0	4 hr	Regalia	Yes	**Regalia Rx is only labeled for use on corn.** ***FRAC P5.***
Gliocladium cantenulatum strain J1446	PreStop (*AgBio, Inc.*)	Seed-borne, soilborne and wilt diseases and certain foliar diseases (*Botrytis* and *Didymella*)	See label	0 hr	Yes	--	Product should not be tank-mixed with pesticides or fertilizers. See label for crop restrictions for foliar application. Product should not be applied as a foliar application after fruiting. **Check state registration status prior to use.**
Gliocladium virens GL-21	SoilGard (*Certis USA*)	Damping-off and root rots	0	0 hr	Yes	Yes	Do not apply in conjunction with chemical fungicides. **Product is not registered for use in AL, AR, KY, MS, OK, TN, or WV.** ***FRAC BM02.***
harpin αβ protein	Employ, Messenger Gold, ProAct (*Plant Health Care, Inc*)	Nematode (suppression)	0	4 hr	See label	No	See label for instructions on various application uses. **Check state registration status prior to use.**
hydrogen dioxide	OxiDate (*BioSafe Systems, LLC*)	Various diseases – see label for crop specific diseases	0	See label	Yes	No	See label for instructions on various application uses.
hydrogen dioxide + peroxyacetic acid	OxiDate 2.0, TerraClean 5.0 (*BioSafe Systems, LLC*)	Various diseases – see label for crop specific diseases	0	See label	Oxidate 2.0	Yes	TerraClean is a soil treatment product. See label for instructions on various application uses.
hydrogen peroxide + peroxyacetic acid	Rendition (*Certis USA*)	Various diseases – see label for crop specific diseases	0	See label	See label	No	

TABLE 3-53. BIOPESTICIDES AND FUNGICIDE ALTERNATIVES FOR VEGETABLES (cont'd)

R. A. Melanson, Extension Plant Pathologist, Mississippi State University

Active Ingredient[1]	Product[1]	Target Diseases/Pests	PHI (days)	REI	Greenhouse Use	OMRI-Listed	Comments[2]
milk	N/A	Viruses (*tomato mosaic virus* (ToMV) and *tobacco mosaic virus* (TMV))	Until spray dries	0	Yes	Yes	Spray plants until runoff. Dip hands every 5 min while handlings plants. Dip tools for 1 min; do not rinse. Use in combination with seed treatments and sanitation practices. **Sooty mold may develop on treated plants.**
Myrothecium verrucaria strain AARC-0255 fermentation solids and solubles	DiTera DF (*Valent*)	Nematodes	--	4 hr	No	Yes	DiTera DF is a soil treatment product.
neem oil (extract)	Trilogy (*Certis USA*), Triact 70 (*OHP*)	Foliar fungal diseases – see label for specifics	0	4 h	See label	Yes	May cause leaf burn; test a small number of plants before spraying entire crop. **Toxic to honey bees. Trilogy is not registered for use in OK, MS, or WV.**
oils from cottonseed, corn, and garlic	Mildew Cure (*JH Biotech Inc*)	Powdery mildew	See label	See label	Yes	Yes	May cause leaf burn; test a small number of plants before spraying entire crop. **Product is not registered for use in AL, LA, SC, or WV.**
oil from soybean	Oleotrol-M (*NTS Research & Inc*)	Downy mildew, powdery mildew, Botrytis, rust, sour rot, gray mold	See label	See label	Yes	Yes	Tank-mix with a spreader-sticker. See product label for labeled crops.
Paecilomyces lilacinus	MeloCon WG (*Certis USA*)	Nematodes (see label for specific species)	--	4 hr	No	Yes	Bionematicide. See product label for mixing restrictions and application instructions. **Product is not registered for use in KY, OK, TN, or WV.**
phosphorous acid	See disease control tables for individual crops.						
polyoxin D zinc salt	See disease control tables for individual crops.						
potassium bicarbonate	Carb-O-Nator (*Certis USA*), Kaligreen,(*Otsuka AgriTechno Co, Ltd*), Milstop (*BioWorks, Inc*)	Various diseases – see label for crop specific diseases	1 (Kaligreen) 0 (others)	1 hr (Milstop) 4 hr (others)	Carb-O-Nator, Milstop	Yes	See label for instructions on various application uses and for any instructions regarding spray solution pH. ***FRAC NC (not classified).***
potassium salts of fatty acids	M-Pede (*Gowan Company*)	Powdery mildew	0	12 hr	Yes	Yes	See product label for notes regarding plant sensitivity.
potassium silicate	Sil-MATRIX (*Certis USA*)	Powdery mildew	0	4 hr	Yes	Yes	Avoid contact with glass. Tank-mix with a non-ionic surfactant for best results.
Streptomyces sp. strain K61	Mycostop (*AgBio, Inc*)	Seed, root, and stem rots and wilt diseases caused by certain pathogens; suppression of certain diseases (see label for crop specific diseases)		4 hr	Yes	Yes	Product can be incorporated into potting media, used as a seed treatment, or applied in-furrow to field soil, as a soil spray or drench or as a foliar application – see label for specific application instructions. Product should not be tank-mixed with pesticides or fertilizers.
Streptomyces lydicus WYEC 108	Actino-Iron, Actinovate AG (*Novozymes*)	Foliar diseases and/or damping-off and root rots, (see label for crop specific diseases)	See label	See label	Yes	Yes	See label for instructions on various application uses. Actino-Iron is a soil treatment product that includes iron, molybdenum, and humic acid.
sulfur	See disease control tables for individual crops.						
Trichoderma harzianum Rifai strain KRL-AG2	RootShield WP (*BioWorks, Inc*)	Root pathogens	See label	See label	See label	Yes	Product is for use in soil applications. Product should not be applied to chickpea. See label for instructions on various application uses.
Trichoderma harzianum Rifai strain T-22	RootShield AG, RootShield Granules (*BioWorks, Inc*)	Soilborne or root pathogens	See label	See label	See label	Yes	Products are for use in soil applications or seed treatments. Products should not be applied to chickpea. **RootShield AG should not be applied when aboveground harvestable food is present.** See product labels for instructions on various application uses and on compatibility with other products. **RootShield AG is not registered for use in AL, AR, KY, LA, MS, NC, OK, SC, TN, VA, or WV.**
Trichoderma harzianum Rifai strain T-22 + *T. virens* strain G-41	RootShield PLUS$^+$ Granules, RootShield PLUS$^+$ WP (*BioWorks, Inc*)	Soilborne or root pathogens	See label	See label	See label	Yes	Products are for use in soil applications or seed treatments. Products should not be applied to chickpea. **RootShield PLUS$^+$ WP should not be applied when aboveground harvestable food is present.** See product labels for instructions on various application uses and on compatibility with other products.
Trichoderma spp. (*T. asperellum* strain ICC012 and *T. gamsil* strain ICC 080)	BIO-TAM 2.0 (*Marrone Bio Innovations*)	Certain fungal diseases (see label)	0	4 hr	Yes	Yes	See label for a list of incompatible fungicides.
Ulocladium oudemansii strain U3	BotryStop (*BioWorks, Inc*)	*Botrytis* spp. and *Sclerotinia* spp. (see label for crop specific diseases)	0	4 hr	Yes	Yes	Product should be stored in a cool, dry place at or below 68°F.
Yeast extract hydrolysate from *Saccharomyces cerevisiae*	KeyPlex 350 OR (*KeyPlex*)	See label	See label	4 hr	See label	No	See product labels for instructions on various application uses. **Check state registration status prior to use.**

FUNGICIDE RESISTANCE MANAGEMENT

Fungicides are organized according to FRAC groups, chemical structure, and Mode of Action (MoA). Fungicides within a given FRAC group control fungi in a similar manner and share the same risk for fungicide resistance development. Some fungicides are referred to as high- or at-risk fungicides because of their specific MoA's and therefore have a high risk for resistance development.

Groups of fungicides, such as the QoI's (FRAC group 11) or Phenylamides (FRAC group 4) are prone to resistance development due to very specific MoA's. Fungicides in high- or at-risk groups should be rotated and/or tank-mixed with broad spectrum, protectant fungicides (FRAC group M3 or M5) to delay the development of resistant strains of fungi. For more information on fungicide resistance management see: http://www.frac.info/

TABLE 3-54. FUNGICIDE MODES OF ACTION FOR FUNGICIDE RESISTANCE MANAGEMENT

L. M. Quesada-Ocampo, Plant Pathologist, NCSU; M. Lewis Ivey, Plant Pathologist, The Ohio State University

FRAC Code	Fungicide Resistance Risk	Group Name	Example Active ingredients	Example Products
P1	Unknown	Benzo-thiadiazole (BTH)	Acibenzolar-S-methyl	Actigard
M1	Low	Inorganic copper	Fixed copper	Copper (various)
M2	Low	Inorganic sulfur	Sulfur	Sulfur (various)
M3	Low	Dithiocarbamates	Mancozeb	Mancozeb (various)
M5	Low	Chloronitriles	Chlorothalonil	Chlorothalonil (various)
1	High	Methyl benzimidazole carbamates (MBC)	Thiophanate-methyl	Topsin M
2	Medium to high	Dicarboximides	Iprodione	Rovral
3	Medium	Demethylation inhibitors (DMI)	Triflumizole	Procure
			Myclobutanil	Rally
4	High	Phenylamide	Mefenoxam	Ridomil Gold
7	Medium to high	Succinate dehydrogenase inhibitors (SDHI)	Boscalid	Endura
			Penthiopyrad	Fontelis
9	Medium	Anilino-pyrimidines (AP)	Pyrimethanil	Scala
11	High	Quinone outside inhibitors (QoI)	Pyraclostrobin	Cabrio
			Trifloxystrobin	Flint
			Azoxystrobin	Quadris
12	Low to medium	Phenylpyrroles (PP)	Fludioxinil	Maxim
13	Medium	Azaaphthalenes	Quinoxyfen	Quintec
14	Low to medium	Aromatic hydrocarbons (AH)	Dicloran	Botran
19	Medium	Polyoxins	Polyoxin D	OSO
21	Medium to high	Quinone inside Inhibitors (QiI)	Cyazofamid	Ranman
22	Low to medium	Benzamides (toluamides)	Zoxamide	Gavel (contains zoxamide and mancozeb)
25	High	Glucopyranosyl antibiotics	Streptomycin	Agri-Mycin 17
27	Low to medium	Cyanoacetamide-oximes	Cymoxanil	Curzate
28	Low to medium	Carbamates	Propamocarb	Presidio
29	Unknown	Dinitroanilines	Fluazinam	Omega
33	Low	Phosphonates	Fosetyl AL	Aliette
40	Low to medium	Carboxylic acid amides (CAA)	Dimethomorph	Forum
			Mandipropamid	Revus
43	High	Benzamides	Fluopicolide	Presidio
45	Medium to high	Triazolo-pyrimidylamine	Ametoctradin	Zampro (contains ametoctradin and dimethomorph)
49	Medium to high	Piperidinyl-thiazole-isoxazolines	Oxathiapiprolin	Orondis

Chemical Weed Control in Vegetable Crops

The following online databases provide current product labels and other relevant information:

Database[1]	Web Address
Agrian Label Database	https://home.agrian.com/
Crop Data Management Systems	http://www.cdms.net/Label-Database
EPA Pesticide Product and Label System	https://iaspub.epa.gov/apex/pesticides/f?p=PPLS:1
Greenbook Data Solutions	https://www.greenbook.net/
Kelly Registration Systems[2]	http://www.kellysolutions.com

[1]Additional databases not included in this list may also be available. Please read the database terms of use when obtaining information from a particular website.

[2]Available for AK, AL, AZ, CA, CO, CT, DE, FL, GA, IA, ID, IN, KS, MA, MD, MN, MO, MS, NC, ND, NE, NJ, NV, NY, OK, OH, OR, PA, SC, SD, VA, VT, WA, and WI. Kelly Registration Systems works with State Departments of Agriculture to provide registration and license information.

TABLE 4-1. CHEMICAL WEED CONTROL ASPARAGUS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
ASPARAGUS (seeded and new crown plantings), Preemergence				
Contact kill of all green foliage, stale bed	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	 1.7 to 2.7 pt 2.5 to 4 pt	0.6 to 1	Apply to emerged weeds before crop emergence as a broadcast or band treatment over a preformed row. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Perennial weeds may require higher rates. The need for an adjuvant depends on brand used.
Annual grasses and small-seeded broadleaf	linuron, MOA 7 (Lorox DF) 50 WDG	1 to 2 lb	0.5 to 1	***Preemergence application.*** Plant seed 0.5 in. deep in coarse soils. Apply to soil surface. See label for further instruction. ***Postemergence application***. Apply when ferns are 6 to 18 in. tall. Make one or two applications, but do not exceed 2 lb active ingredient total per acre. Do not use with fertilizer, surfactant, or crop oil, as injury will occur. Use the lower rate on coarse soils. Not recommended on sand or loamy sand soils. Do not apply within 1 d of harvest.
Annual grasses and certain broadleaf weeds	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	8.2 pt	3.9	Newly planted crown asparagus only. Do not apply to newly seeded asparagus. Newly planted crowns must be covered with at least 2 to 4 inches of soil prior to application. Do not apply Prowl H_20 at more than 2.4 pints per acre in sandy soils. See label for more information.
ASPARAGUS (seeded and new crown plantings), Postemergence				
Annual and perennial grasses	clethodim, MOA 1 (Intensity One, Select Max) 1 EC (Arrow) 2 EC	 9 to 16 oz 6 to 8 oz	 0.07 to 0.125 0.094 to 0.125	Apply to emerged grasses. Consult the manufacturer's label for best times to treat specific grasses. For Select Max, add 2 pt nonionic surfactant per 100 gal spray mixture. With sethoxydim, add 1 qt crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. With fluazifop, add 1 qt of nonionic surfactant or 1 gal crop oil concentrate per 100 gal of spray mix. PHI for Select Max is 21 d and for Arrow 2 EC is 1 d. Max is 21 days and for Arrow 2 EC is 1 day.
	fluazifop, MOA 1 (Fusilade DX) 2 EC	6 to 16 oz	0.1 to 0.25	
	sethoxydim, MOA 1 (Poast) 1.5 EC	1.5 to 2.5 pt	0.3 to 0.5	
ASPARAGUS, (established at least 2 yr. old), Preemergence				
Annual grasses and small-seeded broadleaf weeds	linuron, MOA 7 (Lorox DF) 50 WDG	1 to 2 lb	0.5 to 1	Apply before spear emergence or immediately after a cutting. Do not use a surfactant or fertilizer solution in spray mixture. Use the lower rates on coarse soils. Not recommended for sand or loamy sand soils. Repeat applications may be made but do not exceed 4 lb per acre per year. Lorox can also be applied as a directed spray to the base of the ferns. Make one application of 2 lb active ingredient per acre. Lorox will also control emerged annual broadleaf weeds up to 3 in. in height. Do not apply within 1 day of harvest.
	napropamide, MOA 15 (Devrinol, Devrinol DF-XT) 50 DF (Devrinol 2-XT) 2 EC	 8 lb 2 gal		Apply to the soil surface in spring before weed and spear emergence. Do not exceed 8 lb per acre per year. See XT labels for information regarding delay in irrigation event.

TABLE 4-1. CHEMICAL WEED CONTROL ASPARAGUS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
ASPARAGUS, (established at least 2 yr. old), Preemergence (cont'd)				
Annual grasses and small-seeded broadleaf weeds (cont'd)	trifluralin, MOA 3 (Treflan, Trifluralin, Treflan HFP, Treflan) 4 EC	1 to 4 pt	0.5 to 2	In winter or early spring, apply to dormant asparagus after ferns are removed but before spear emergence, or apply after harvest in late spring or early summer. In a calendar year, the maximum rate is 2 pints per acre for coarse soils, 3 pints on medium soils and 4 pints on fine soils. See label for further restrictions on rates for soil types. Apply at least 14 d prior to the first spear harvest or after final harvest. Do not apply over the top of emerged spears or severe injury may occur. Do not apply more than 2.4 pt/A in sandy soils.
	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	See labels	See labels	
Annual broadleaf and grass weeds	diuron, MOA 7 (Karmex) 80 DF (Direx) 4 L	1 to 4 lb 0.8 to 3.2 qt	0.8 to 3.2	Apply in spring before spear emergence but no *earlier* than 4 weeks before spear emergence. A second application may be made immediately after last harvest. Diuron also controls small emerged weeds but less effectively.
	flumioxazin, MOA 14 (Chateau) 51 SW	6 oz	0.188	Apply only to dormant asparagus no sooner than 14 days before spears emerge or after the last harvest. Do not apply more than 6 oz per acre during a single growing season. Provides residual weed control. Can be tank mixed with paraquat for control of emerged weeds. Apply in a minimum of 15-gal spray mix per acre. Add a nonionic surfactant at 1 qt per 100 gal of spray mix. A spray-grade nitrogen source (either ammonium sulfate at 2 to 2.5 lb per acre or 28 to 32 percent nitrogen solutions at 1 to 2 qt per acre) may be added to increase herbicidal activity.
	metribuzin, MOA 5 (Metribuzin) 75 WDG (Tricor DF) 75 WDG	1.3 to 2.67 lb 1.3 to 2.67 lb	1 to 2	Make a single application to small, emerged weeds and the soil surface in early spring before spear emergence or after final cutting. Do not apply within 14 days of harvest or after spear emergence. Do not make postharvest applications until after the last harvest of spears. A split application can be used. See label for rates.
	terbacil, MOA 5 (Sinbar) 80 WDG	See labels	See labels	Apply in spring before weed emergence and spear emergence or immediately after last clean-cut harvest. Use the lower rate on sandy soils and the higher rate on silty or clay soils. Do not use on soils containing less than 1% organic matter nor on gravelly soils or eroded areas where subsoil or roots are exposed. Do not harvest within 5 days after application. See label about rotation restrictions.
	norflurazon, MOA 12 (Solicam) 80 DF	2.5 to 5 lb	2 to 4	Rate is soil type dependent. See label for rates and tank mix information. PHI = 14 d.
	mesotrione, MOA 27 (Callisto) 4 F	See labels	See labels	Preemergence application. Apply as a spring application prior to spear emergence, after final harvest, or both. For optimum control apply after fern mowing, disking or other tillage operation but before spear emergence. Directed or semi directed application. Apply after final harvest with care to minimize contact with any standing asparagus spears to avoid crop injury. Do not make more than two applications per year or apply more than 7.7 oz/A per year.
ASPARAGUS (established at least 2 yrs. old), Postemergence				
Broadleaf weeds	2,4-D, MOA 4 (amine 4 and various others)	1.3 to 2.67 lb	1.5 to 2	Apply in spring before spear emergence or immediately following a clean cutting. Make no more than two applications during the harvest season and these should be spaced at least 1 month apart. Postharvest sprays should be directed under ferns, avoiding contact with ferns, stems, or emerging spears. Add a nonionic surfactant at a rate of 1 qt per 100 gal spray mix. Do not apply if sensitive crops are planted nearby or if conditions favor drift. PHI = 3 d.
	dicamba, diglycolamine salt, MOA 4 (Clarity) 4 L	8 to 16 oz	0.25 to 0.5	Apply to emerged and actively growing weeds in 40 to 60 gallons of diluted spray per treated acre immediately after cutting in the field but at least 24 hours before the next cutting. If spray contacts emerged spears, twisting of spears may occur. Discard twisted spears. See label for more information. Follow precautions on label concerning drift to sensitive crops. PHI = 1 d.
	carfentrazone-ethyl, MOA 14 (Aim) 2 EC	Up to 2 oz	Up to 0.031	Apply one to two applications. Use higher rate when weeds are under stress or are larger. See label for further instructions. PHI = 5 days.
Contact kill of emerged annual weeds, suppression of emerged perennial weeds, and contact kill of volunteer ferns	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.7 to 2.7 pt 2.5 to 4 pt	0.6 to 1	Apply to control emerged weeds (including volunteer ferns). Apply in a minimum of 20 gal spray mix per acre to control weeds before spears emerge or after last harvest. Do not apply within 6 days of harvest. Use a nonionic surfactant at a rate of 1 qt per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Volunteer ferns (seedling) and certain broadleaf weeds	linuron, MOA 7 (Lorox DF) 50 WDG	2 lb	1	Apply before cutting season or immediately after. Do not apply within 1 d of harvest. Lorox will also control emerged annual broadleaf weeds that are up to 3 in in height.
Annual and perennial grass and broadleaf weeds; Established volunteer ferns	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds up to 1 week before spear emergence or immediately after last cutting has removed all above-ground parts or as a directed spray under mature fern. Avoid contact with the stem to reduce risk of injury. Perennial weeds may re- quire higher rates of glyphosate. For spot treatment, apply immediately after cutting but prior to emergence of new spears. Certain glyphosate formulations may require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.

TABLE 4-1. CHEMICAL WEED CONTROL ASPARAGUS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
ASPARAGUS (established at least 2 yrs. old), Postemergence (cont'd)				
Yellow and purple nutsedge, wild radish, non-ALS resistant pigweed, cocklebur, ragweed and other broadleaf weeds	halosulfuron, MOA 2 (Profine 75, Sandea) 75 DF	0.5 to 1.5 oz	0.024 to 0.072	Postemergence and post-transplant. Apply before or during harvesting season. Do not use nonionic surfactant or crop oil because unacceptable crop injury may occur. Without the addition of a nonionic surfactant, postemergence weed control may be reduced. Do not exceed 1 oz per acre per year. Do not harvest within 24 hours of application. Post-harvest. Apply after final harvest with drop nozzles to limit contact with crop. Contact with the fern may result in temporary yellowing. Add a nonionic surfactant at 1 qt per 100 gal of spray mixture. Under heavy nutsedge pressure, split applications will be more effective; see label for details. Do not exceed 1 oz per acre per year.
	clethodim, MOA 1 (Intensity One, Select Max) 1 EC (Arrow) 2EC	9 to 16 oz 6 to 8 oz	0.07 to 0.125	For Select Max, add 2 pt nonionic surfactant per 100 gal spray mixture. **DO NOT USE CLETHODIM WITHIN 1 DAY OF HARVEST.**
	fluazifop, MOA 1 (Fusilade DX) 2 EC	6 to 16 oz	0.1 to 0.25	
	sethoxydim, MOA 1 (Poast) 1.5 EC	1.5 to 2.5 pt	0.3 to 0.5	
***Mode of action (MOA) code developed by the Weed Science Society of America.**				

TABLE 4-2. CHEMICAL WEED CONTROL IN BEANS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
BEANS, Preplant and Preemergence				
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Lima or snap beans only. Apply in a minimum of 10 gal spray mix per acre to emerged weeds before crop emergence as a broadcast or band treatment over a pre-formed row. Use sufficient water to give thorough coverage. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a non-ionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Legume vegetable group (Group 6) such as but not limited to edamame, kidney bean, lima bean, pinto bean, snap bean, soybean, and wax bean only. Apply prior to or no later than one day after planting. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Various beans are covered. Apply to emerged weeds before crop emergence. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations may require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control. See label for details.
Annual grasses and small-seeded broadleaf weeds	ethalfluralin, MOA 3 (Sonalan HFP) 3 EC	1.5 to 3 pt	0.6 to 1.1	Dry beans only. See label for specific bean. Apply preplant and incorporate into the soil 2 to 3 in. deep using a rototiller or tandem disk. If groundcherry or nightshade is a problem, the rate range can be increased to 3 to 4.5 pt per acre. For broader spectrum control, Sonalan may be tank mixed with Eptam or Dual. Read the combination product labels for directions, cautions, and limitations before use.
	dimethenamid, MOA 15 (Outlook) 6.0 EC	12 to 18 oz	0.55 to 0.85	Dry beans only. See label for specific bean. Apply preplant incorporated, preemergence to the soil surface after planting, or early postemergence (first to third trifoliate stage). Dry beans may be harvested 70 or more days after Outlook application. For soils having 3% or greater organic matter, see label for rate. See label for further instructions including those for tank mixtures.
	trifluralin, MOA 3 (Treflan, Trifluralin, Trifluralin HF, and other brands) 4 EC	1 to 1.5 pt	0.5 to 0.75	Dry, lima, or snap beans only. See label for specific bean. Apply preplant and incorporate into the soil 2 to 3 in. deep within 8 hr. Incorporate with a power-driven rototiller or by cross disking.
	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	1.5 to 3 pt	0.75 to 1.5	Edible beans: dry, lima, or snap beans and certain others. See label for specific bean. Apply preplant and incorporate into the soil 2 to 3 in. using a power-driven rototiller or by cross disking. **DO NOT APPLY AFTER SEEDING**.
	S-metolachlor, MOA 15 (Brawl, Dual Magnum, Medal) 7.62 EC (Brawl II, Dual II Magnum, Medal II) 7.64 EC	1 to 2 pt	0.95 to 1.91	Dry, lima, or snap beans and certain others. See label for specific bean, and specific rate based on soil texture. Apply preplant incorporated or preemergence to the soil surface after planting.
Annual grasses and broadleaf weeds	clomazone, MOA 13 (Command) 3ME	0.4 to 0.67 pt	0.15 to 0.25	Snap beans (succulent) only. Apply to the soil surface immediately after seeding. Offers weak control of pigweed. See label for further instructions. Do not apply within 45 days of harvest.

TABLE 4-2. CHEMICAL WEED CONTROL IN BEANS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
BEANS, Preplant and Preemergence (cont'd)				
Yellow and purple nutsedge, grasses and some small-seeded broadleaf weeds	EPTC, MOA 8 (Eptam) 7 EC	2.25 to 3.5 pt	2 to 3	Dry or snap beans only. See label for specific bean. Apply preplant and incorporate immediately to a depth of 3 in. or may be applied at lay-by as a directed application before bean pods start to form to control late season weeds. See label for instructions on incorporation. May be tank mixed with Prowl. Do not use on black-eyed beans, lima beans, or other flat-podded beans except Romano.
Many broadleaf weeds	fomesafen, MOA 14 (Reflex 2 EC)	1 to 1.5 pt	0.25 to 0.375	Dry bean and snap beans only. Apply preplant surface or preemergence. Total use per year cannot exceed 1.5 pt per acre. See label for further instructions and precautions.
Yellow and purple nutsedge, common cocklebur, and other broadleaf weeds	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 0.75 oz	0.024 to 0.036	Dry beans and succulent snap beans including lima beans only. Apply after seeding but prior to cracking. Do not apply more than 0.67 oz product per acre to dry bean. Data are lacking on runner-type snap beans. See label for other instructions.
Broadleaf weeds including morningglory, pigweed, smartweed, and purslane	imazethapyr, MOA 2 (Pursuit) 2 EC	1.5 oz	0.023	Dry beans and lima beans only. See label for specific bean. Apply preemergence or preplant incorporated. Pursuit should be applied with a registered preemergence grass herbicide. Snap beans only. Apply preemergence or preplant incorporated. For preplant incorporated application, apply within 1 week of planting. May be used with a registered grass herbicide. Reduced crop growth, quality, yield, and/or delayed crop maturation may result. Do not apply within 30 days of harvest of snap beans.
BEANS, Postemergence				
Annual broadleaf weeds and yellow nutsedge	bentazon, MOA 6 (Basagran) 4 SL	1 to 1.5 pt	0.5 to 1	Dry, lima, or snap beans only. Apply overtop of beans and weeds when beans have one to two expanded trifoliate leaves. Two applications spaced 7 to 10 days apart may be made for nutsedge control. Do not apply more than 2 qt per season or within 30 days of harvest. Use of crop oil as an adjuvant will improve weed control but will likely increase crop injury. See label regarding crop oil concentrate use. Do not apply within 30 days of harvest of snapbeans.
Many broadleaf weeds	fomesafen, MOA 14 (Reflex) 2 EC	0.75 to 1 pt	0.188 to 0.25	Dry or snap beans only. See label for specific bean. Apply postemergence to dry beans or snap beans that have at least one expanded trifoliate leaf. Include a non-ionic surfactant at 1 qt per 100 gal spray mixture. Total use per year cannot exceed 1.5 pt per acre. Do not apply within 45 days of dry bean harvest or 30 days of snap bean harvest. Postemergence application of fomesafen can cause significant injury to the crop. See label for further information.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter. Does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	**Edible beans: edamame, kidney bean, lima bean, pinto bean, snap bean, and wax bean only.** Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Yellow and purple nutsedge	EPTC, MOA 8 (Eptam) 7 EC	3.5 pt	3	**Green or dry beans only.** See label for specific bean. Do not use on lima bean or pea. Apply and incorporate at last cultivation as a directed spray to soil at the base of crop plants before pods start to form.
Yellow and purple nutsedge, common cocklebur, and other broadleaf weeds	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 0.66 oz	0.024 to 0.031	**Succulent snap beans, including lima beans.** Apply after crop has reached 2-to 4-trifoliate leaf stage but prior to flowering. Postemergence application may cause significant but temporary stunting and may delay crop maturation. Use directed spray to limit crop injury. Do not apply within 30 days of harvest. See label for further precautions. Data lacking on runner-type snap beans.
Annual broadleaf weeds, including morningglory, pigweed, smartweed, and purslane	imazethapyr, MOA 2 (Pursuit) 2 EC	1.5 to 3 oz	0.023 to 0.047	**Dry beans and snap beans only.** See label for specific bean. Use only 1.5 oz EC formulation on snap bean and up to 3 oz on dry beans. Apply postemergence to 1- to 3-in. weeds (one to four leaves) when dry beans have at least one fully expanded trifoliate leaf. Add nonionic surfactant at 2 pt per 100 gal of spray mixture with all postemergence applications. For snap beans, allow at least 30 days between application and harvest. For dry bean, do not apply within 60 days of harvest. See label for instructions on use.
Most emerged weeds	glyphosate, MOA 9 (Roundup PowerMax) 5.5L (Roundup WeatherMax) 5.5L	11 to 22 oz	0.5 to 0.94	**Row middles only.** See label for specific bean. Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or post- harvest. Spot treatment is allowed in some bean crops. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. Do not apply within 14 days of harvest.
Annual and perennial grasses	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	**Dry or succulent beans only. See label for specific bean.** For succulent beans, products with quizalofop are limited to snap beans. Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. With sethoxydim, add 1 qt of crop oil concentrate per acre. With quizalofop, add 1 gal oil concentrate or 1 qt nonionic surfactant per 100 gal spray. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply on days that are unusually hot and humid. Do not apply within 15 days and 30 days of harvest for succulent and dry beans, respectively.
	quizalofop p-ethyl, MOA 1 (Assure II) 0.88 EC (Targa) 0.88 EC	6 to 12 oz	0.04 to 0.08	**Dry or succulent beans only. See label for specific bean.** For succulent beans, products with quizalofop are limited to snap beans. Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. With sethoxydim, add 1 qt of crop oil concentrate per acre. With quizalofop, add 1 gal oil concentrate or 1 qt nonionic surfactant per 100 gal spray. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply on days that are unusually hot and humid. Do not apply within 15 days and 30 days of harvest for succulent and dry beans, respectively.

TABLE 4-2. CHEMICAL WEED CONTROL IN BEANS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
BEANS, Postemergence (cont'd)				
Annual and perennial grasses (cont'd)	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Intensity One, Select Max) 1 EC	6 to 16 oz 9 to 16 oz	0.094 to 0.25 0.07 to 0.125	**Dry or succulent beans.** See label for specific bean. Select is registered for dry beans only. Apply postemergence for control of emerged grasses. See label for specific rate for crop. For Arrow, Clethodim, or Select, add a crop oil concentrate at 1 qt per acre. For Select Max or Intensity One, add 2 pt nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. See label for minimum time from application to harvest.

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TABLE 4-3. CHEMICAL WEED CONTROL IN BEETS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
BEETS (Garden or Table), Preplant				
Annual and perennial grasses and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Garden beets only.** Apply to emerged weeds before seeding or after seeding but before crop emergence. Perennial weeds may require higher rates. Certain glyphosate formulations may require the addition of a surfactant. Adding non-ionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Emerged broadleaf and grass weeds	pelargonic acid, MOA27 (Scythe) 4.2 EC	3 to 10% v/v		Apply as a preplant burndown treatment.
Emerged broadleaf weeds	pyraflufen, MOA 14 (ET Herbicide) 0.208 EC	0.5 to 2 oz	0.008 to 0.003	**Garden beets only.** Apply as a preplant burndown treatment in a minimum of 10-gallon solution per acre.
BEETS (Garden or Table), Preemergence				
Annual grasses (crabgrass spp., foxtail spp., barnyardgrass, annual ryegrass, annual bluegrass) and broadleaf weeds (*Lamium* spp., lambsquarters, common purslane, redroot pigweed, shepherdspurse)	cycloate, MOA 3 (Ro-Neet) 6E	0.5 to 0.67 gal	3 to 4	Use on mineral soils only. Use higher dosage rate on heavier soils. Read label for further instructions.
BEETS (Garden or Table), Postemergence				
Broadleaf weeds including sowthistle clover, cocklebur jimsonweed, an ragweed	clopyralid, MOA 4 (Solix 3, Stinger) 3EC	0.25 to 0.5 pt	0.093 to 0.187	Apply to beets having 2 to 8 leaves when weeds are small and actively growing. Will control most legumes. Do not apply within 30 days of harvest. Do not apply more than 0.5 pt per acre per year. See label for information regarding rotational restrictions. PHI = 30 d.
Broadleaf weeds including wild mustard, common lambsquarters, common chickweed, purslane suppression	phenmedipham, MOA 6 (Spin-Aid) 1.3 EC	3 to 6 pt	0.5 to 1	Red garden beets only. Apply to red garden beets in the 2 to 6 leaf stage. Rate is dependent on crop stage. See label for specific rate. Best control occurs when applied to weeds in cotyledon to 2 leaf stage. Minor crop stunting may be observed for approximately 10 days. Do not add spray adjuvant. Do not apply within 60 days of harvest.
Broadleaf weeds including wild mustard, shepherd's purse	triflusulfuron, MOA 2 (Upbeet) 50 DF	0.5 oz	0.0156	Garden beets. Apply when beets are at the 2 to 4 lf stage. Additional applications may be made at the 4 to 6 and 6 to 8 lf stages. Total amount must not exceed 1.5 oz/A per growing season. PHI = 30 d.
Annual and perennial grasses	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. Do not apply within 60 days of harvest.
	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max, Intensity One) 1 EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Apply postemergence for annual grasses at 6 to 8 oz per acre or bermudagrass and johnsongrass at 8 oz per acre. For Arrow, Clethodim, or Select, add a crop oil concentrate at % per spray volume. For Select Max, add 2 pt nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. Do not apply within 30 days of harvest.
BEETS (Garden or Table), Row Middles Only				
Most emerged weeds except for resistant pigweed	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. The need for an adjuvant depends on brand used. Do not apply within 14 days of harvest.
Annual broadleaf weeds including morningglory, spiderwort, and very small pigweed	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a crop oil concentrate or a nonionic surfactant with Aim. See label for directions. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.

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BROCCOLI – SEE COLE CROPS

CABBAGE – SEE COLE CROPS

TABLE 4-4. CHEMICAL WEED CONTROL IN CANTALOUPES (MUSKMELONS)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CANTALOUPE (MUSKMELON), Preplant and Preemergence				
Suppression or control of most annual grasses and broadleaf weeds, full rate required for nutsedge control	metam sodium (Vapam HL) 42%	37.5 to 75 gal	15.7 to 31.5	Rates are dependent on soil type and weeds present. Apply when soil moisture is at field capacity (100 to 125%). Apply through soil injection using a rotary tiller or inject with knives no more than 4 in. apart; follow immediately with a roller to smooth and compact the soil surface or with mulch. May apply through drip irrigation prior to planting a second crop on mulch. Plant back interval is often 14 to 21 days and can be 30 days in some environments. See label for all restrictions and additional information.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	**Transplant crop.** Apply no later than one day before transplanting crop. **Seeded crop.** Apply no later than 7 days before seeding crop. Use a crop oil at up to 1 gal per 100 gal of spray solution or nonionic surfactant at 2 pt per 100 gal of spray solution. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 10 gal spray mix per acre to emerged weeds before crop emerges or before transplanting as a broadcast or band treatment over a preformed row. Seedbeds or plant beds should be formed as far ahead of treatment as possible to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds at least 3 days before seeding or transplanting. Perennial weeds may require higher rates of glyphosate. Consult manufacturer's label for rates for specific weeds. When applying Roundup before transplanting crops into plastic mulch, carefully remove residues of this product from the plastic prior to transplanting. To prevent crop injury, residues can be removed by 0.5 in. rainfall or by applying water via a sprinkler system. Certain glyphosate formulations may require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Emerged broadleaf weeds	pyraflufen, MOA 14 (ET Herbicide) 0.208 EC	0.5 to 2 oz	0.0008 to 0.003	Apply as a preplant burndown treatment in a minimum of 10 gallons per acre. **Addition of a crop oil concentrate at 1 to 2% is recommended for optimum weed control. See label for additional information.**
Emerged broadleaf and grass weeds	pelargonic acid, MOA 27 (Scythe) 4.2 EC	3 to 10% v/v		Apply before crop emergence and control emerged weeds. There is no residual activity. May be tank mixed with soil residual compounds. See label for instruction. May also be used as a banded spray between row middles. Use a shielded sprayer directed to the row middles to reduce drift to the crop.
Annual grasses and small-seeded broadleaf weeds	bensulide, MOA 8 (Prefar) 4 EC	5 to 6 qt	5 to 6	Apply preplant and incorporate into the soil 1 to 2 in. (1 in. incorporation is optimum) with a rototiller or tandem disk, or apply preemergence after seeding and follow with irrigation. Check re-plant restrictions for small grains and other crops on label.
Annual grasses and broadleaf weeds; weak on pigweed and morningglory	clomazone, MOA 13 (Command) 3 ME	0.4 to 0.67 pt	0.15 to 0.25	Apply immediately after seeding or just prior to transplanting with transplanted crop. Roots of transplants must be below the chemical barrier when planting. See label for further instruction.
Annual grasses and some small-seeded broadleaf weeds	ethalfluralin, MOA 3 (Curbit) 3 EC	3 to 4.5 pt	1.1 to 1.7	Apply post plant to seeded crop prior to crop emergence, or as a banded spray between rows after crop emergence or transplanting. See label for timing. Shallow cultivation, irrigation, or rainfall within 5 days needed for good weed control. Do not use under mulches, row covers, or hot caps. Under conditions of unusually cold or wet soil and air temperatures, crop stunting and injury may occur. Crop injury can occur if seeding depth is too shallow.
Annual grasses and broadleaf weeds	ethalfluralin, MOA 3 + clomazone, MOA 13	2 to 6 pt	0.4 to 1.2 + 0.125 to 0.375	Apply to the soil surface immediately after seeding crop for preemergence control of weeds. **DO NOT APPLY PRIOR TO PLANTING CROP. DO NOT SOIL INCORPORATE.** May also be used as a banded treatment between rows after crop emergence or transplanting. Do not apply over or under plastic mulch.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 0.75 oz	0.024 to 0.036	Apply after seeding or prior to transplanting crop. For transplanted crop, do not transplant until 7 days after application. Rate can be increased to 1 ounce of product per acre to middles between rows. Do not apply within 57 days of harvest.
Annual grasses, some small-seeded broadleaf weeds	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	Up to 2.1 pt	Up to 1	**Row middles only.** May be applied sequentially in bareground and plasticulture production systems at a minimum of 21 days apart. Refer to label for specific instructions.
Broadleaf weeds and yellow nutsedge	imazosulfuron, MOA 2 (League) 75% WDG	4 to 6.4 oz	0.19 to 0.3	**Row middle application only.** Use a shielded sprayer directed to the row middles to reduce drift to the crop. In plasticulture, prevent the spray from contacting the plastic. Consult label for further instructions. PHI = 48 d.

TABLE 4-4. CHEMICAL WEED CONTROL IN CANTALOUPES (MUSKMELONS) (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CANTALOUPE (MUSKMELON), Postemergence				
Annual grasses and small-seeded broadleaf weeds	DCPA, MOA 3 (Dacthal) W-75 (Dacthal) 6 F	 8 to 10 lb 6 to 10 pt	4.5 to 7.5	**Not labeled for transplanted crop.** To improve preemergence control of late emerging weeds. Apply only when crop has 4 to 5 true leaves, is well established, and growing conditions are favorable. Will not control emerged weeds. Incorporation not recommended.
	trifluralin, MOA 3 (Treflan HFP, Trifluralin, Trifluralin HF) 4EC	 1 to 2 pt	0.5 to 0.75	**Apply as a directed spray to soil between rows after crop emergence when crop plants have reached** three to four true leaf stage of growth. Avoid contacting foliage as slight crop injury may occur. Set incorporation equipment to move treated soil around base of crop plants. Do not apply within 30 days of harvest. Will not control emerged weeds.
	pendimethalin, MOA 3 (Prowl H_2O) 3.8	 Up to 2.1 pt	Up to 1	May be applied sequentially in bare ground and plasticulture production systems at a minimum of 21 days apart. Refer to label for specific instructions.
Yellow and purple nutsedge and broadleaf weeds including cocklebur, galinsoga, smartweed, ragweed, wild radish, and pigweed	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	 0.5 to 0.75 oz	0.024 to 0.036	Apply postemergence only after the crop has reached 3 to 5 true leaves but before first female flowers appear. Do not apply sooner than 14 days after transplanting. Use non- ionic surfactant at 1 qt per 100 gal of spray solution with all postemergence applications. Avoid over-the-top applications during late summer when temperature and humidity are high. Do not apply within 57 days of harvest.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	 Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a crop oil concentrate or a non-ionic surfactant with Aim. See label for directions. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. Do not apply within 14 days of harvest.
Annual and perennial grasses only	sethoxydim, MOA 1 (Poast) 1.5 EC	 1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. Do not apply within 3 days of harvest.
	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Intensity One, Select Max) 1 EC	 6 to 8 oz 9 to 16 oz	 0.094 to 0.125 0.07 to 0.125	Apply postemergence for control of grass in cantaloupes (muskmelons). For Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. For Select Max, add 2 pt nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. Do not apply within 14 days of harvest.

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TABLE 4-5. CHEMICAL WEED CONTROL IN CARROTS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CARROTS, Preplant				
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	 1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply to emerged weeds before crop emergence as a broadcast or band treatment over a preformed row. Use sufficient water to give thorough coverage. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before seeding or crop emergence. Perennial weeds may require higher rates. Certain glyphosate formulations require the addition of surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Emerged broadleaf and grass weeds	pelargonic acid, MOA 27 (Scythe) 4.2 EC	 3 to 10% v/v		Apply as a preplant burndown or prior to emergence of plants from seed. There is no residual activity. May be tank mixed with soil residual compounds. See label for instructions. May also be used as a banded spray between row middles. Use a shielded sprayer directed to the row middles to reduce drift to the crop.
CARROTS, Preplant incorporated (PPI) or Preemergence (PRE)				
Annual grasses and small-seeded broadleaf weeds	trifluralin, MOA 3 (Treflan, Trifluralin) 4 EC	 1 to 2 pt	0.5 to 1	Apply preplant and incorporate into the soil 2 to 3 in. within 8 hr. Use lower rate on coarse soils with less than 2% organic matter.
Broadleaf and grass weeds	prometryn, MOA 5 (Caparol) 4L	 2 to 4 pt	1 to 2	Apply as preemergence and or postemergence over the top to carrot. Make POST application through the six-leaf stage of carrot. See label for application rate and crop rotation restrictions. PHI is 30 days.
	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	 2 pt	0.95	Apply post plant within 2 days after planting but prior to crop emergence. See label for instruction on layby treatment. PHI = 60 days.

TABLE 4-5. CHEMICAL WEED CONTROL IN CARROTS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CARROTS, Postemergence				
Annual grasses and broadleaf weeds	linuron, MOA 7 (Lorox DF) 50 WDG	1.5 to 3 lb	0.75 to 1.5	Apply as a broadcast spray after carrots are at least 3 in. tall. If applied earlier crop injury may occur. Avoid spraying after three or more cloudy days. Repeat applications may be made, but do not exceed 4 lb of Lorox DF per acre per season. Do not use a surfactant or crop oil. Carrot varieties vary in their resistance; therefore determine tolerance to Lorox DF before adoption as a field practice to prevent potential crop injury. See label for further directions. PHI = 14 days.
Annual broadleaf weeds and some grasses	metribuzin, MOA 5 (Dimetric, Metribuzin, TriCor DF) 75 WDG (Metri, TriCor 4F) 4 F	0.33lb 0.5 pt	0.25 0.25	Apply overtop when weeds are less than 1 in. tall and carrots have 5 to 6 true leaves. A second application may be made after a time interval of at least 3 weeks. Do not apply unless 3 sunny days precede application. Do not apply within 3 days of other pesticide applications. PHI = 60 days.
Annual and perennial grasses	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max) 1 EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Apply to actively growing grasses not under drought stress. With Arrow, Clethodim or Select, add 1 gal crop oil concentrate per 100 gal spray mix. With Select Max, add 2 pt nonionic surfactant per 100 gal of spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Do not mix with other pesticides. Very effective in controlling annual bluegrass. PHI = 30 days.
	fluazifop, MOA 1 (Fusilade DX) 2 EC	6 to 16 oz	0.1 to 0.25	Apply to actively growing grasses not under drought stress. Up to 48 oz of Fusilade DX may be applied per year. See label for rates for specific weeds. Add 1 gal crop oil concentrate or 1 qt nonionic surfactant per 100 gal spray mix. Do not mix with other pesticides. PHI = 45 days.
	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to actively growing grasses not under drought stress. Consult manufacturer's label for specific rate and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Do not apply on days that are unusually hot and humid. Do not apply with other pesticides. PHI = 30 days.
CARROTS, Row Middles				
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply as a hooded spray in row middles for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a crop oil concentrate or a nonionic surfactant with Aim. See label for directions. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots or stems, exposed roots, or fruit of crop. PHI = 14 days.

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CAULIFLOWER – SEE COLE CROPS

TABLE 4-6. CHEMICAL WEED CONTROL IN CELERY

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CELERY, Preplant				
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Perennial weeds may require higher rates. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Cutleaf evening primrose, Carolina geranium, henbit, and a few grasses	oxyfluorfen, MOA 14 (Goaltender) 4 F (Goal 2 XL) 2 EC	Up to 1 pt Up to 2 pt	Up to 0.5	Transplants only. Apply to soil surface of pre-formed beds at least 30 days prior to transplanting.
Emerged broadleaf and grass weeds	pelargonic acid, MOA 27 (Scythe) 4.2 EC	3 to 10% v/v		Apply as a preplant burndown. There is no residual activity. May be tank mixed with soil residual compounds. See label for instructions. May also be used as a banded spray between row middles. Use a shielded sprayer directed to the row middles to reduce drift to the crop.

TABLE 4-6. CHEMICAL WEED CONTROL IN CELERY (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CELERY, Preplant incorporate (PPI) or Preemergence (PRE)				
Annual grasses and small-seeded broadleaf weeds	trifluralin, MOA 3 (Treflan, Treflan HFP, Trifluralin) 4 EC	1 to 2 pt	0.5 to 1	Apply incorporated to direct seeded or transplant celery before planting, at planting, or immediately after planting. Incorporate within 8 hours of application. Use lower rate on coarse soils with less than 2% organic matter.
	bensulide (Prefar) 4-E	5 to 6 qt	5 to 6	Transplants only. Apply after planting. Irrigate immediately after application. See label for rotation restrictions.
CELERY, Postemergence				
Annual broadleaf and grass weeds	linuron, MOA 7 (Lorox DF) 50 WDG	1.5 to 3 lb	0.75 to 1.5	Apply after celery is transplanted and established but before celery is 8 in. tall. Grasses should be less than 2 in. in height, and broadleaf weeds should be less than 6 in. tall. Do not tank mix with other products including surfactant or crop oil. Avoid spraying after 3 or more cloudy days or when temperature exceeds 85 F. Not recommended for sands or loamy sand soil. PHI = 45 days.
Annual and perennial grasses only	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max) 1 EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Apply to actively growing grasses not under drought stress. With Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. With Select Max, add 2 pt of nonionic surfactant per 100 gal spray mixture. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. Adding crop oil may increase the likelihood of crop injury at high air temperature. PHI = 30 days.
	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to actively growing grasses not under drought stress. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. PHI = 30 days.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a crop oil concentrate or a nonionic surfactant with Aim. See label for directions. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Row middles only.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.

***Mode of action (MOA) code developed by the Weed Science Society of America**

TABLE 4-7. CHEMICAL WEED CONTROL IN CILANTRO

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CILANTRO, Preemergence (PRE)				
Annual grasses and broadleaf weeds	prometryn, MOA 5 (Caparol) 4L	2 to 3.2 pt	1 to 1.6	Rates are soil-dependent. See label for more information. Do not use on sand or loamy soils. PHI = 30 d. Check label for crop rotation restrictions.
Annual grasses small-seeded broadleaf weeds	linuron, MOA 7 (Lorox DF) 50 WDG	1 to 2 lb	0.5 to 1	Some cultivars may be susceptible to injury. Do not use on sandy or loamy soils, or soils with less than 1% organic matter. Plant at least 0.5 inch deep. PHI for leaves = 21 d. PHI for coriander seed = 155 d
CILANTRO, Postemergence				
Annual grasses and small-seeded broadleaf weeds (1 to 3 leaf stage)	linuron, MOA 7 (Lorox DF) 50 WDG	1 to 2 lb	0.5 to 1	Apply to crop plants with a minimum of 3 true leaves to avoid significant injury. Early occurring minor injury should not affect yield. If no injury occurs after the initial application, a second may be made 14 d after the first. Injury may occur under high temperatures, following cloudy periods or when mixed with other pesticides or adjuvants (see label for details). PHI = 21 d.
Annual and perennial grasses	sethoxydim, MOA 1 (Poast) 1.5 EC	1.5 pt	0.185	Maximum use rate per season is 3 pt/A. PHI =15 d.

***Mode of action (MOA) code developed by the Weed Science Society of America.**

TABLE 4-8. CHEMICAL WEED CONTROL IN COLE CROPS: BROCCOLI, CABBAGE, CAULIFLOWER

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
COLE CROPS: BROCCOLI, CABBAGE, CAULIFLOWER — Preplant and Preemergence				
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 10 gal spray mix per acre to emerged weeds before crop emergence or transplanting as a broadcast or band treatment over a preformed row. Use sufficient water to give thorough coverage. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 2 EC	Up to 2 oz	Up to 0.031	Apply no later than one day before transplanting, or seven days before seeding. See label for rate for crop oil or nonionic surfactant. Coverage is essential for good weed control. See label for more information.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence or before transplanting. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. When applying Roundup before transplanting crops into plastic mulch, care must be taken to remove residues of this product from the plastic prior to transplanting. To prevent crop injury, residues can be removed by 0.5 in. natural rainfall or by applying water via a sprinkler system. Certain glyphosate formulations may require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Emerged broadleaf and grass weeds	pelargonic acid, MOA 27 (Scythe) 4.2 EC	3 to 10% v/v		Also labeled for collards, kale, mustard/turnip greens. Apply as a preplant burndown or prior to emergence of plants from seed. There is no residual activity. May be tank mixed with soil residual compounds. See label for instruction. May also be used as a banded spray between row middles. Use a shielded sprayer directed to the row middles to reduce drift to the crop.
Annual grasses and small-seeded broadleaf weeds	bensulide, MOA 8 (Prefar) 4 EC	5 to 6 qt	5 to 6	Also labeled for Chinese broccoli, broccoli raab, Chinese cabbage (bok choy, Napa), Chinese mustard cabbage (gai choy), and kohlrabi. Apply preplant or preemergence after planting. With preemergence application, irrigate immediately after application. See label for more directions.
	trifluralin, MOA 3 (Treflan HFP, Trifluralin, Trifluralin HF) 4 EC	1 to 1.5 pt	0.5 to 0.75	Also labeled for Brussels sprouts Apply and incorporate prior to transplanting. Caution: If soil conditions are cool and wet, reduced stands and stunting may occur. Direct seeded Cole crops exhibit marginal tolerance to higher than recommended rates.
	DCPA, MOA 3 (Dacthal) W-75 (Dacthal) 6 F	8 to 10 lb 8 to 10 pt	6 to 7.5	Also labeled for Brussels sprouts, and all other Brassica (Cole) leafy vegetables in this crop group. Apply immediately after seeding or transplanting. May also be incorporated.
Annual grasses and broadleaf weeds; weak on pigweed spp.	**Direct-seeded Cabbage** clomazone, MOA 13 (Command) 3ME	0.67 pt	0.25	Apply to the soil surface immediately after seeding. See label for further instructions.
	Transplanted Cabbage clomazone, MOA 13 (Command) 3ME	0.67 pt to 1.3 pt	0.25 to 0.5	Apply broadcast to the soil prior to transplanting cabbage. See label for further instructions.
Annual grasses and broadleaf weeds, yellow nutsedge suppression	*S*-metolachlor, MOA 15 (Dual Magnum) 7.62 EC	8 to 16 oz	0.47 to 0.96	**Cabbage, direct seeded and transplanted; Chinese cabbage (Napa); Chinese cabbage (Bok Choy); broccoli, and cauliflower.** Chinese cabbage may be more sensitive to injury from Dual magnum. This is a Section 24(c) Special Local Need Label. Growers must check *www.farmassist.com* website to make sure Dual Magnum is registered for use in their state. Obtain label from www.farmassist.com prior to making Dual Magnum application. Irrigation following the application of Dual Magnum will increase the risk of crop injury. Use lower rates on coarse-textured soils and higher rates on fine-textured soils. See label for more information. **Mulched Systems with Transplanted Crop.** ***Option 1:*** Apply 8 to 16 oz to the soil surface of pre-formed beds prior to laying plastic. Ensure the plastic laying process does not incorporate or disturb the treated bed. Unless restricted by other products, crops may be transplanted immediately following Dual Magnum application. ***Option 2:*** Apply 8 to 16 oz overtop of crop at least 10 days after transplanting to ensure root system is well developed. Does not control emerged weeds. Limited data are available for NC. Read label for further instructions. **Bare Ground Application for Transplanted Crop.** After transplanting, irrigate to seal the soil around the transplanted root ball. Five to ten days after transplanting and irrigating, apply Dual Magnum over the top of transplants. If soil is not sealed around the transplant root ball, crop injury may occur. **Direct Seeded Application.** May be applied over the top after the crop reaches inches tall. **Row Middle Application to Transplanted and Direct Seeded Crop.** Apply as a banded application at a rate up to 1.25 pt/A.
Hairy galinsoga, common lambsquarters, redroot pigweed, and Palmer amaranth	sulfentrazone, MOA 14 (Spartan) 4 F	2.25 to 4.5 oz	0.07 to 0.14	Cabbage (Transplanted Processing only). May be applied 60 days prior to planting up to planting time. Application rate depends on soil type.

TABLE 4-8. CHEMICAL WEED CONTROL IN COLE CROPS: BROCCOLI, CABBAGE, CAULIFLOWER (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
COLE CROPS: BROCCOLI, CABBAGE, CAULIFLOWER — Preplant and Preemergence (cont'd)				
Annual grasses and small-seeded broadleaf weeds, including galinsoga, common ragweed, and smartweed	napropamide, MOA 15 (Devrinol DF) 50 DF (Devrinol DF-XT) 50 DF (Devrinol 2-XT) 2 EC	 4 lb 4 lb 4 qt	 2 2 2	Includes Brussels sprouts. Apply to weed-free soil just after seeding or transplanting as a surface application. Light cultivations, rainfall, or irrigation will be necessary within 24 hr to activate this chemical.
Many broadleaf weeds, including galinsoga, common ragweed, and smartweed	oxyfluorfen, MOA 14 (Goal 2 XL, Galigan) 2 EC (GoalTender) 4 E	 1 to 2 pt 0.5 to 1 pt	0.25 to 0.5	**Transplants only.** Surface apply before transplanting. Do not incorporate or knock the bed off after application. ***Do not spray over the top of transplants.*** Oxyfluorfen is weak on grasses. Expect to see some temporary crop injury.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use crop oil concentrate at up to 1 gal per 100 gal solution or a nonionic surfactant at 2 pt per 100 gal of spray solution. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Broadleaf weeds including sowthistle, clover, cocklebur, jimsonweed, and ragweed	clopyralid, MOA 4 (Stinger) 3 EC	0.25 to 0.5 pt	0.09 to 0.187	Labeled for broccoli, cabbage, cauliflower, broccoli raab, Brussels sprouts, Cavalo broccoli, Chinese cabbage (bok choy), Chinese broccoli, Chinese mustard, and Chinese cabbage (Napa). Apply to crop when weeds are small and actively growing. Will control most legumes. PHI = 30 days.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Row middles only.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
Annual and perennial grasses only	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max) 1 EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. For sethoxydim, add 1 qt of crop oil concentrate per acre. For Arrow, Clethodim, or Select, add crop oil concentrate at 1 gal per 100 gal of spray solution. For Select Max, add 2 pt nonionic surfactant per 100 gal of spray mixture. Adding crop oil to Poast or Select may increase the likelihood of crop injury at high air temperature. Do not apply Poast or Select plus crop oil on days that are unusually hot and humid. PHI = 30 days.
	sethoxydim, MOA1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	

***Mode of action (MOA) code developed by the Weed Science Society of America.**

TABLE 4-9. CHEMICAL WEED CONTROL IN CORN, SWEET

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CORN, SWEET, Preplant Burndown				
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply prior to planting or within 24 hours after planting. Use a crop oil concentrate or a nonionic surfactant with Aim. For optimum performance, make applications to actively growing weeds up to 4 inches high or rosettes less than 3 inches across. Coverage is essential for good weed control. Optimum broad-spectrum control of annual and perennial weeds requires a tank mix with burndown herbicides such as glyphosate, paraquat or 2, 4-D. Must be applied prior to the pre-harvest interval of 14 leaf collars. See label for directions.
Contact kill of all green foliage, stale bed and minimum tillage application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.5 to 2.7 pt 2.4 to 4 pt	0.6 to 1	Apply in a minimum of 20 gal spray mix per acre to emerged weeds before crop emergence as a broadcast or band treatment over a preformed row. Seedbeds should be formed several days ahead of planting and treating to allow maximum weed emergence. Plant with a minimum of soil movement for best results. Use a nonionic surfactant at a rate of 16 to 32 oz per 100-gal spray mix or 1 woman approved crop oil concentrate per 100 gal spray mix. May be tank mixed with preemergence sweetcorn herbicides and herbicide combinations. See section on Corn (sweet), Preemergence. Check label for directions and specific rates.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Do not feed crop residue to livestock for 8 weeks following treatment. Perennial weeds may require higher rates of glyphosate. Consult manufacturer's label for rates for specific weeds. Check label for directions. Certain glyphosate formulations require addition of surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control. Glyphosate-resistant horseweed (marestail) is now common in eastern North Carolina counties. If horseweed is present at planting time, a tank mixture of paraquat and atrazine is suggested.
Broadleaf weeds	2,4-D amine 4, MOA 4 (various brands)	1 to 3 pt	0.5 to 1	May be tank mixed with glyphosate for broad-spectrum weed control including glyphosate-resistant horseweed (marestail). See label for planting restrictions if applied prior to planting.

TABLE 4-9. CHEMICAL WEED CONTROL IN CORN, SWEET (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CORN, SWEET, Preemergence				
Most annual grass weeds, including fall panicum, broadleaf signalgrass, and small-seeded broadleaf weeds	alachlor, MOA 15 (Micro-Tech) 4 FME	2 to 4 qt	2 to 4	Apply to soil surface immediately after planting. Higher rates will improve control of ragweed and lambsquarter. May be tank mixed with atrazine, glyphosate, or simazine. Various other brands are available. Check label for directions.
	dimethenamid, MOA 15 (Outlook) 6.0 EC	12 to 21 oz	0.56 to 1.0	Apply to soil surface immediately after planting. May be tank mixed with atrazine, glyphosate, or paraquat. See label for other herbicides that may be tank mixed to broaden weed control spectrum.
	metolachlor, MOA 15 (Me-Too-Lachlor II) 7.8 EC (Parallel) 7.8 EC	1 to 2 pt	0.98 to 1.98	See comments for *S*-metolachlor products. Products containing *S*-metolachlor are more active on weeds per unit of formulated product than those containing metolachlor. See label for all instructions.
	S-metolachlor, MOA 15 (Brawl II, Dual II Magnum, Medal II) 7.64 EC	1 to 2 pt	0.95 to 1.91	Apply to soil surface immediately after planting. May be tank mixed with atrazine, glyphosate, or simazine. Check label for directions. Rate is soil-texture and organic-matter dependent. See label for details.
	pyroxasulfone, MOA 15 (Zidua) 85 WG	1.5 to 4 oz	0.0796 to 0.213	Rate ranges based on soil texture. See label for specific rate relating to your fields. Sweet corn seed must be planted a minimum of 1-inch deep. Provides suppression of Texas panicum, seedling johnsongrass, and shattercane. Do not harvest sweet corn ears for human consumption less than 37 days after application of this herbicide. See label regarding tank mixtures for broader spectrum control and/or control of emerged weeds.
Most annual broadleaf and grass weeds	atrazine, MOA 5 (various brands) 4 F (various brands) 90 WDG	1 to 2 qt 1.1 to 2.2 lb	1 to 2	Apply to soil surface immediately after planting. Shallow cultivations will improve control. Check label for restrictions on rotational crops. See label for reduced rate if soil coverage with plant residue is less than 30% at planting. Does not control fall panicum or smooth crabgrass. May be tank mixed with metolachlor, alachlor, glyphosate, paraquat, bentazon, or simazine. Check label for directions.
	alachlor, MOA 15 + atrazine, MOA 5 (Bullet or Lariat) 4 F	2.5 to 4.25 qt	1.56 to 2.7 + 0.94 to 1.6	Apply to soil surface immediately after planting. Soil texture and organic matter influence application rate. See label for further instruction.
	dimethenamid, MOA 15 + atrazine, MOA 5 (Guardsman Max) 5 F	2.4 to 4.6 pt	0.5 to 1 + 1 to 1.9	Apply to soil surface immediately after planting. Does not control Texas panicum, seedling johnsongrass, or shattercane adequately. Adjust rate for soil texture and organic matter according to label. See label for reduced rate if soil coverage with plant residue is less than 30% at planting. See labels for comments on rotational crops. See label for additional instructions.
	S-metolachlor, MOA 15 + atrazine, MOA 5 (Bicep II Magnum) 5.5 F	1.3 to 2.6 qt	0.78 to 1.56 + 1 to 2	Apply to soil surface immediately after planting. Does not adequately control Texas panicum, seedling johnsongrass, or shattercane. May not adequately control cocklebur, morningglory, or sicklepod. Cultivation or other herbicides may be needed. See label for rates based on soil texture and organic matter and for information on setback requirements from streams and lakes. See label for reduced rate if soil coverage with plant residue is less than 30% at planting and for comments on rotational crops.
Small seeded broadleaf weeds and some annual grass weeds	saflufenacil, MOA 14 + dimethenamid, MOA 15 (Verdict) 5.57 EC	10 to 18 oz	0.43 to 0.78	Registered for processing sweet corn only. Apply preplant surface, preplant incorporated or preemergence after seeding. Do not apply to emerged sweet corn.
Broadleaf weeds and annual grass weeds and partial control of yellow nutsedge	bicyclopyrone, MOA 27 + mesotrione, MOA 27 +*S*-metolachlor, MOA 15 (AcuronFlexi) 2.86 L	2 to 2.25 qt	1.6 to 1.8	Apply preplant or preemergence to sweet corn. Severe injury will occur if applied to emerged sweet corn.
	S-metolachlor, MOA 15 + atrazine, MOA 5 +mesotrione, MOA 27 +bicyclopyrone, MOA 27 (Acuron) 3.44 L	2.5 to 3 qt	1.34 to 1.61 + 0.625 to 0.75 +0.15 to 0.18 +0.038 to 0.045	Apply preplant or preemergence to sweet corn. Severe injury will occur if applied to emerged sweet corn.
Grass and broadleaf weeds	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	2 to 4 pt	1 to 2	Apply preemergence before crop germinate or postemergence until sweet corn is 20 to 24 inches tall or in the V8 growth stage. Do not apply in reduced, minimum, or no-till sweet corn. Rate is dependent on organic matter content. See label for additional information. See label for tank mix options.
Broadleaf and grass weeds	simazine, MOA 5 (Princep) 4L	2 qt	2	Apply preemergence before weeds and crop emerge. See label for tank mix options. PHI = 45 days.

TABLE 4-9. CHEMICAL WEED CONTROL IN CORN, SWEET (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CORN, SWEET, Postemergence				
Most annual broadleaf and grass weeds	atrazine, MOA 5 (various brands) 4 L (various brands) 90 WDG	 2 qt 2.2 lb	2	Apply overtop before weeds exceed 1.5 in. in height. See label for additional information in controlling larger weeds. See label for amount of oil concentrate to add to spray mix. See label on setback requirements from streams and lakes.
Annual grasses and broadleaf weeds	dimethenamid, MOA 15 (Outlook) 6.0 EC + atrazine, MOA 5 (AAtrex) 4 F or 90 WDG	8 to 21 oz + See labels	0.375 to 1 + See labels	Apply overtop corn before crop reaches 12 inches tall and before weeds exceed the two-leaf stage. Larger weeds will not be controlled. Good residual control of annual grass and broadleaf weeds. Do not apply within 50 days of sweet corn ear harvest. Do not apply to corn 12 inches or taller. Also available as the commercial products Guardsman or LeadOff.
	S-metolachlor, MOA 15 (Dual II Magnum) 7.64 EC + atrazine, MOA 5 (AAtrex) 4 F (AAtrex) 90 WDG	1 to 1.67 pt + 1 to 2 qt 1.3 to 2.2 lb	0.95 to 1.58 + 1 to 2	Apply overtop corn (5 in. or less) before weeds exceed the two-leaf stage. Larger weeds will not be controlled. Do not apply within 30 days of sweet corn ear harvest. Good residual control of annual grass and broadleaf weeds. Also available as Bicep II or Bicep II Magnum.
Cocklebur, common ragweed, jimsonweed, Pennsylvania smartweed, velvetleaf, yellow nutsedge, and morningglory	bentazon, MOA 6 (Basagran) 4 SL	1 to 2 pt	0.5 to 1	Apply early postemergence overtop when weeds are small and corn has one to five leaves. See label for rates according to weed size and special directions for annual morningglory and yellow nutsedge control. Use a crop oil at a rate of 1 qt per acre.
Many broadleaf weeds	mesotrione, MOA 27 (Callisto) 4 EC	3 oz	0.094	Apply overtop corn 30 in. or less or 8 leaves or less to control emerged broadleaf weeds. Use nonionic surfactant at 2 pt per 100 gal of spray solution. DO NOT add VAN or AMS when making post application in sweet corn or severe injury will occur. Most effective on small weeds, however, if weeds are greater than 5 in. or for improved control of certain weeds, certain atrazine formulations may be mixed with this herbicide. See label for further information. PHI = 45 days.
Annual broadleaf weeds and some grasses	tembotrione, MOA 27 (Laudis) 3.5 L	3 oz	0.082	Can be applied overtop or with drop nozzles to sweet corn from emergence up to V7 stage. Controls most broadleaf weeds. Does not control sicklepod or prickly sida and only suppresses morningglory. Controls or suppresses some grasses. See label for weeds controlled and recommended size for treatment. Herbicide sensitivity in all hybrids and inbreds of sweet corn has not been tested. See label for information on adjuvant use. May be tank mixed with atrazine to increase weed spectrum and consistency of control. If tank mixed with atrazine, do not apply if corn is 12 inches tall or greater. See label for further restrictions and instructions.
	topramezone, MOA 27 (Impact) 2.8 L	0.75 oz	0.016	Can be applied overtop or with drop nozzles to sweet corn from emergence until 45 days prior to harvest. Does not control sicklepod and only suppresses morningglory. Controls or suppresses some grasses. See label for weeds controlled and recommended size for treatment. This product has not been tested on all inbred line for tolerance. See label for information on adjuvant use. See label for further restrictions and instructions. Do not apply within 45 days of sweet corn ear harvest.
	topramezone, MOA 27 + dimethenamid, MOA 15 (Armezon) 5.26 L	 14 to 24 oz	0.6 to 1	Do not apply to sand textured soils with less than 3% organic matter.
Velvetleaf, spreading dayflower, morningglory species, and redroot pigweed. Will not control grasses.	fluthiacet-methyl, MOA 14 (Cadet) 0.91 L	0.6 to 0.9 oz	0.0042 to 0.06	Processing sweet corn only. Apply to small weeds, generally about 2 inches tall. Will control large velvetleaf up to 36 inches. See label for information on adjuvant use. See label for further restrictions and instructions.
Annual broadleaf weeds	fluthiacet-methyl, MOA 14 + mesotrione, MOA 27 (Solstice)	 2.5 to 3.15 oz	0.004 to 0.0053 0.074 to 0.0931	Apply up to the V8 growth stage (or 30 inches tall). See label for crop rotation restrictions. Do not include nitrogen based adjuvants (UAN or AMS) when making postemergence application or severe injury will occur. Use nonionic surfactant at 1 qt per 100 gallons of spray. Do not apply within 40 days of sweet corn ear harvest. See label for further instructions.
Velvetleaf, pigweed, nightshade, morningglory, common lambsquarters	carfentrazone-ethyl, MOA 14 (Aim) 2.0 EC	0.5 oz	0.008	Apply postemergence to actively growing weeds less than 4 in. high (rosettes less than 3 in. across) up to the 14-leaf collar stage of corn. Rates above 0.5 oz will aid in controlling larger weeds and certain weeds (see label for specific rate). Directed sprays will lessen the chance of crop injury and allow later application. Coverage of weeds is essential for control. Use nonionic surfactant (2 pt per 100 gal of spray) with all applications. Under dry conditions, the use of crop oil concentrate may improve weed control. Mix with atrazine to improve control of many broadleaf weeds. Limited information is available concerning the use of this product in sweet corn. Do not apply more than 2 oz per acre per season. Do not apply within 3 days of sweet corn ear harvest.

TABLE 4-9. CHEMICAL WEED CONTROL IN CORN, SWEET (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CORN, SWEET, Postemergence (cont'd)				
Broadleaf weeds including sowthistle, clover, cocklebur, jimsonweed, ragweed, Jerusalem artichoke and thistle	clopyralid, MOA 4 (Stinger) 3 EC	0.25 to 0.67 pt	0.095 to 0.25	Processing sweet corn only. Apply to sweet corn when weeds are small (less than 5-leaf stage) and actively growing. Addition of surfactants, crop oils, or other adjuvants is not usually necessary when using Stinger. Use of adjuvants may reduce selectivity to the crop. Do not apply to sweet corn over 18 in. tall. Will control most legumes. PHI = 30 days.
Cocklebur, passion flower (maypop), pigweed, pokeweed, ragweed, smartweed (Pennsylvania), velvetleaf	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 WDG	0.67 oz	0.032	Apply over the top or with drop nozzles to sweet corn from spike to lay-by for control of emerged weeds. Add nonionic surfactant at 1 to 2 qt per 100 gal of spray solution. See label for all instructions and restrictions. PHI = 30 days.
Cocklebur, pigweed, lambsquarters, morningglory, sicklepod, and many other annual broadleaf weeds	2,4-D amine, MOA 4 (various brands) 3.8 SL	0.5 to 1 pt	0.24 to 0.48	Use 0.5 pt of 2, 4-D overtop when corn is 4 to 5 in. tall and weeds are small. Increase rate to 1 pt as corn reaches 8 in. Use drop nozzles and direct spray to- ward base if corn is over 8 in. tall. Do not cultivate for about 10 days after spraying, as corn may be brittle. Reduce rate of 2, 4-D if extremely hot and soil is wet. For better sicklepod and horsenettle control, add a nonionic surfactant when using a directed spray at a rate of 1 qt per 100 gal spray solution. Do not apply within 45 days of sweet corn ear harvest.
Annual grasses and broadleaf weeds	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	0.7 to 1.3 pt 1 to 2 pt	0.25 to 0.5	**DO NOT SPRAY OVERTOP OF CORN OR SEVERE INJURY WILL OCCUR.** Make a postdirected application in a minimum of 20 gal spray mix per acre to emerged weeds when the smallest corn is at least 10 in. tall. Use nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix. Use of a hooded or shielded sprayer will reduce crop injury.
Certain grasses, including barnyardgrass, foxtails, Texas panicum, and johnsongrass; and broadleaf weeds, including bur cucumber, jimsonweed, pigweed, pokeweed, and smartweeds	nicosulfuron, MOA 2 (Accent) 75 WDG	0.67 oz	0.031	Apply to sweet corn up to 12 in. tall or up to and including 5 leaf collars. For corn 12 to 18 in. tall, apply only with drop nozzles. Sweet corn hybrids vary in their sensitivity to Accent. Do not apply to Merit sweet corn. Contact company representative for information on other local hybrids that have been evaluated with Accent. Accent may be applied to corn previously treated with Fortress, Aztec, or Force, or non-organophosphate soil insecticides regardless of soil type. See label for more information on use of soil insecticides with Accent. Label prohibits application of Accent to corn previously treated with Counter insecticide, and also indicates that applying Accent to corn previously treated with Counter 20 CR, Lorsban, or Thimet may result in unacceptable crop injury, especially on soils with less than 4% organic matter. See label for information on use.
Certain grasses, including barnyardgrass, foxtails, Texas panicum, and johnsongrass; and broadleaf weeds including bur cucumber, jimsonweed, pigweed, pokeweed, and smartweed	nicosulfuron, MOA 2 75 WDG + mesotrione, MOA 27 (Revulin Q) 51.2 WDG	3.44 to 4 oz	0.031 to 0.036 + 0.078 to 0.092	Apply to sweet corn up to 12 in. tall or up to and including 5 leaf collars. For corn 12 to 18 in. tall, apply only with drop nozzles. Sweet corn hybrids vary in their sensitivity to Accent. Do not apply to Merit sweet corn. Contact company representative for information on other local hybrids that have been evaluated with Accent. Accent may be applied to corn previously treated with Fortress, Aztec, or Force, or non-organophosphate soil insecticides regardless of soil type. See label for more information on use of soil insecticides with Accent. Label prohibits application of Accent to corn previously treated with Counter insecticide, and also indicates that applying Accent to corn previously treated with Counter 20 CR, Lorsban, or Thimet may result in unacceptable crop injury, especially on soils with less than 4% organic matter. Postemergence applications of Revulin Q may cause crop bleaching in some sweet corn hybrids. Crop bleaching is usually transient. See label for further information.

***Mode of action (MOA) code developed by the Weed Science Society of America.**

TABLE 4-10. CHEMICAL WEED CONTROL IN CUCUMBER

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CUCUMBERS, Preplant and Preemergence				
Suppression or control of most annual grasses and broadleaf weeds, full rate required for nutsedge control	metam sodium (Vapam HL) 42%	37.5 to 75 gal	15.7 to 31.5	Rates are dependent on soil type and weeds present. Apply when soil moisture is at field capacity (100 to 125%). Apply through soil injection using a rotary tiller or inject with knives no more than 4 in. apart; follow immediately with a roller to smooth and compact the soil surface or with mulch. May apply through drip irrigation prior to planting a second crop on mulch. Plant back interval is often 14 to 21 days and can be 30 days in some environments. See label for all restrictions and additional information.
Emerged broadleaf and grass weeds	pelargonic acid, MOA 27 (Scythe) 4.2 EC	3 to 10% v/v		Apply before crop emergence and control emerged weeds. There is no residual activity. May be tank mixed with soil residual compounds. See label for further instructions. May also be used as a banded spray between row middles. Use shielded sprayer directed to the row middles to reduce drift to the crop.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter, does not control grasses.	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Aim 1.9 EW is registered for application in transplant production systems only. Aim 2 EC is registered in seeded and transplant production systems. Apply no later than one day before transplanting or no later than 7 days before seeding crop. See label for information about application timing. Use a crop oil at up to 1 gal per 100 gal of spray solution or a nonionic surfactant at 2 pt per 100 gal of spray solution. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.

TABLE 4-10. CHEMICAL WEED CONTROL IN CUCUMBER (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
CUCUMBERS, Preplant and Preemergence (cont'd)				
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 10 gal spray mix per acre to emerged weeds before crop emergence as a broadcast or band treatment over a preformed row. Use sufficient water to give thorough coverage. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds at least 3 days before seeding or transplanting. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. When applying Roundup before transplanting crops into plastic mulch, care must be taken to remove residues of this product from the plastic prior to transplanting. To prevent crop injury, residues can be removed by 0.5 in. natural rainfall or by applying water via a sprinkler system. Certain glyphosate formulations require the addition of surfactant. Adding nonionic surfactant to glyphosate formulated with non- ionic surfactant may result in reduced weed control.
Annual grasses and small-seeded broadleaf weeds	bensulide, MOA 8 (Prefar) 4 EC	5 to 6 qt	5 to 6	Registered for cucurbit vegetable group (Crop grouping 9). Apply preplant and incorporate into the soil 1 to 2 in. (1 in. incorporation is optimum) with a rototiller or tandem disk, or apply to the soil surface after seeding and follow with irrigation within 36 hours after application. Check re-plant restrictions for small grains on label.
Annual grasses and some small-seeded broadleaf weeds; weak on pigweed	clomazone, MOA 13 (Command) 3 ME	0.4 to 1 pt	0.15 to 0.375	Apply immediately after seeding. See label for further information.
Annual grasses and some small-seeded broadleaf weeds	ethalfluralin, MOA 3 (Curbit) 3 EC	3 to 4.5 pt	1.1 to 1.7	Apply post plant to seeded crop prior to crop emergence, or as a banded spray between rows after crop emergence or transplanting. See label for timing. Shallow cultivation, irrigation, or rainfall within 5 days is needed for good weed control. Do not use under mulches, row covers, or hot caps. Under conditions of unusually cold or wet soil and air temperatures, crop stunting or injury may occur. Crop injury can occur if seeding depth is too shallow.
Annual grasses and broadleaf weeds	ethalfluralin, MOA 3 + clomazone, MOA 13 (Strategy) 2.1 L	2 to 6 pt	0.4 to 1.2 + 0.125 to 0.375	Apply to the soil surface immediately after crop seeding for preemergence control of weeds. **DO NOT APPLY PRIOR TO PLANTING CROP. DO NOT SOIL INCORPORATE.** May also be used as a banded treatment between rows after crop emergence or transplanting. Do not apply over or under plastic mulch.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 0.75 oz	0.024 to 0.036	Apply after seeding or prior to transplanting crop. For transplanting, do not transplant until 7 days after application. For seeded or transplanting cucumbers in plasticulture, do not plant within 7 days of Sandea application. Rate can be increased to 1 ounce of product per acre to middles between rows. PHI = 21 days.
CUCUMBERS, Postemergence				
Annual grasses and small-seeded broadleaf weeds	trifluralin, MOA 3 (Treflan HFP, Trifluraline, Trifluralin HF) 4EC	1 to 2 pt	0.5 to 0.75	Will not control emerged weeds. Row middles only. To improve preemergence control of late emerging weeds apply as a directed spray to soil between rows after crop emergence when crop plants have reached three to four true leaf stage of growth. Avoid contacting crop foliage as slight crop injury may occur. Set incorporation equipment to move treated soil around base of crop plants. PHI = 30 days.
Yellow and purple nutsedge and broadleaf weeds including cocklebur, galinsoga, smartweed, ragweed, wild radish and pigweed	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 0.75 oz	0.024 to 0.036	Apply postemergence only after the crop has reached 3 to 5 true leaves but before first female flowers appear. Do not apply sooner than 14 days after transplanting. Use nonionic surfactant at 1 qt per 100 gal of spray solution with all postemergence applications. PHI = 14 days.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use crop oil concentrate at up to 1 gal per 100 gal solution or a nonionic surfactant at 2 pt per 100 gal of spray solution. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Row middles only. Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. Do not apply within 14 days of harvest.
	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max, Intensity One) EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Control of emerged grasses. For Arrow, Clethodim, and Select, add 1 gal crop oil concentrate per 100 gal spray mix. For Select Max and Intensity One, add 2 pt nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. PHI = 14 days.

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TABLE 4-11. CHEMICAL WEED CONTROL IN EGGPLANT

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
EGGPLANT, Preplant				
Suppression or control of most annual grasses and broadleaf weeds, full rate required for nutsedge control	metam sodium (Vapam HL) 42%	37.5 to 75 gal	15.7 to 31.5	Rates are dependent on soil type and weeds present. Apply when soil moisture is at field capacity (100 to 125%). Apply through soil injection using a rotary tiller or inject with knives no more than 4 in. apart; follow immediately with a roller to smooth and compact the soil surface or with mulch. May apply through drip irrigation prior to planting a second crop on mulch. Plant back interval is often 14 to 21 days and can be 30 days in some environments. See label for all restrictions and additional information. Chloropicrin (150 lb/A broadcast) will also be needed when laying first crop mulch to control nutsedge.
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 10 gal spray mix per acre to emerged weeds before transplanting as a broadcast or band treatment over a preformed row. Use sufficient water to give thorough coverage. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Aim 1.9 EW is registered for application in transplant production systems only. Aim 2 EC is registered in seeded and transplant production systems. Apply no later than one day before transplanting crop (Aim 1.9 EW or Aim 2EC) or no later than 7 days before seeding crop (Aim 2EC only). See label for information about application timing. Use a crop oil at up to 1 gal per 100 gal of spray solution or a nonionic surfactant at 2 pt per 100 gal of spray solution. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds at least 3 days before seeding or transplanting. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. When applying Roundup before transplanting crops into plastic mulch, care must be taken to remove residues of this product from the plastic prior to transplanting. To prevent crop injury, residues can be removed by 0.5 in. natural rainfall or by applying water via a sprinkler system. Certain glyphosate formulations require the addition of surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
EGGPLANT, Preemergence				
Annual grasses and small-seeded broadleaf weeds	bensulide, MOA 8 (Prefar) 4 EC	5 to 6 qt	5 to 6	Apply preplant incorporated (1 in. incorporation is optimum) or preemergence after planting. With preemergence application, irrigate immediately after application. See label for more directions.
Annual grasses and some broadleaf weeds	napropamide, MOA 15 (Devrinol, Devrinol DF-XT) 50 DF (Devrinol 2-XT) 2 EC	2 to 4 lb 2 to 4 qt	1 to 2	Transplanted eggplant only. Apply preplant and incorporate into soil 1 to 2 in. using a rototiller or tandem disk. Shallow cultivations or irrigation will improve control. See label for small grains replanting restrictions. May also be applied in the row middles between plastic covered beds. See label for more information. See XT labels for information regarding delay in irrigation event.
EGGPLANT, Postemergence				
Annual grasses and small-seeded broadleaf weeds	DCPA, MOA 3 (Dacthal) W-75 (Dacthal) 6 F	6 to 10 lb 6 to 10 pt	4.5 to 7.5	Application confined to a period of 4 to 6 weeks after transplanting. To improve preemergence control of late emerging weeds. Apply to weed-free soil over the top of transplants.
Annual and perennial grasses only	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. PHI = 20 days.
	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max, Intensity One) 1 EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Apply postemergence for control of grasses. With Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. With Select Max, add 2 pt of non-ionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperature. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. PHI = 20 days .
EGGPLANT, Row Middles				
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use crop oil concentrate at up to 1 gal per 100 gal solution or a nonionic surfactant at 2 pt per 100 gal of spray solution. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots or stems, exposed roots, or fruit of crop. PHI = 14 days.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 1 oz	0.024 to 0.048	Apply between rows as a postemergence spray. Do not allow spray to contact crop or plastic mulch. Early season application will give postemergence and preemergence control. For postemergence applications, use nonionic surfactant at 1 qt per 100 gal of spray solution. PHI = 30 days.
Contact kill of all green foliage	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 pt 2 pt	0.5	Apply in 10 gal spray mix as a shielded spray to emerged weeds between rows of eggplant. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix. Do not allow spray to contact crop or injury will result.

***Mode of action (MOA) code developed by the Weed Science Society of America.**

TABLE 4-12. CHEMICAL WEED CONTROL IN GARLIC

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
GARLIC, Preplant or Preemergence				
Annual and perennial grass and broadleaf weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Stale bed application. Apply to emerged weeds at least 3 days before planting. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	 1.7 to 2.7 pt 2.5 to 4 pt	0.6 to 1	Apply in a minimum of 20 gal spray mix per acre to emerged weeds before crop emergence as a broadcast or band treatment over a preformed row. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix. PHI = 60 days .
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 2.0 EC	Up to 2 oz	Up to 0.031	Apply no later than 30 days before planting. See label for specific Aim rate relating to weed species and proper adjuvant and rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual grasses and small-seeded broadleaf weeds	bensulide, MOA 8 (Prefar) 4 EC	5 to 6 qt	5 to 6	Apply preplant incorporated (1 in. incorporation is optimum) or preemergence after planting. With preemergence application, irrigate immediately after application. See label for more directions.
Annual broadleaf weeds	oxyfluorfen, MOA 14 (Galigan, Goal 2XL) 2 E	1 to 2 pt	0.25 to 0.5	Transplanted garlic only. For use on a fallow bed. Garlic may be planted immediately following application of 1 pt of product. For rates above 1 pt do not plant within 30 days. PHI=60 days.
Emerged broadleaf weeds	pyraflufen, MOA 14 (ET Herbicide) 0.208 EC	0.5 to 2 oz	0.0008 to 0.003	Apply as a preplant burndown treatment in a minimum of 10-gallons of solution per acre. See label for information on use of adjuvant.
Emerged broadleaf and grass weeds	pelargonic acid, MOA 27 (Scythe) 4.2 EC	3 to 10% v/v		Apply as a preplant burndown treatment or use in row middles using shielded sprayer.
GARLIC, Preemergence				
Annual grasses and small-seeded broadleaf weeds	dimethenamid-P, MOA 15 (Outlook) 6 EC	12 to 21 oz	0.6 to 1	For preemergence, weed control. Apply after crop has reached 2 true leaves until a minimum of 30 days before harvest. If applications are made to transplanted crop, DO NOT apply until transplants are in the ground and soil has settled around transplants with several days to recover.
	flumioxazin, MOA 14 (Chateau) 51 SW	6 oz	0.188	For preemergence, weed control. Apply prior to garlic and weed emergence. Application should be made within 3 days after planting garlic.
	pendimethalin, MOA 3 (Prowl) 3.3 EC (Prowl H_2O) 3.8 AS	1.2 to 3.6 pt 1.5 to 3 pt	0.5 to 1.5 0.75 to 1.5	For preemergence, weed control. Apply preemergence after planting but prior to weed and crop emergence or postemergence to garlic in the 1 to 5 true leaf stage. Prowl can be applied sequentially by applying preemergence followed by a postemergence application. PHI = 45 days.
GARLIC, Postemergence				
Most annual broadleaf weeds	oxyfluorfen, MOA 14 (Galigan) 2 E (Goal 2 XL) 2 EC (GoalTender) 4 E	 0.5 pt 0.5 pt 0.25 pt	0.12	Transplanted dry bulb only. May be used as a postemergence spray to both the weeds and crop after the garlic has at least two fully developed true leaves. Some injury to garlic may result. Injury will be more severe if the chemical is applied during cool, wet weather. Weeds should be in the 2- to 4-leaf stage for best results. PHI= 60 days.
Annual and perennial grasses only	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max, Intensity One) 1 EC	 6 to 16 oz 9 to 32 oz	 0.09 to 0.25 0.07 to 0.25	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. With Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. With Select Max, add 2 pt of nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Do not apply Arrow, Clethodim, or Select on unusually hot and humid days. PHI =45 days. Very effective in controlling annual bluegrass.
	fluazifop, MOA 1 (Fusilade DX) 2 EC	6 to 16 oz	0.1 to 0.25	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 gal crop oil concentrate or 1 qt nonionic surfactant per 100 gal spray mix. Do not apply on days that are unusually hot and humid. PHI = 45 days.
	sethoxydim, MOA 1 (Poast) 1.5 EC	1 pt	0.2	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. PHI = 30 days
GARLIC, Row Middles				
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Row middles only. Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or post-harvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.

***Mode of action (MOA) code developed by the Weed Science Society of America.**

TABLE 4-13. CHEMICAL WEED CONTROL IN GREENS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
GREENS (Collard, Kale, Mustard Greens, and Turnip), Preplant and preemergence				
Emerged broadleaf and grass weeds	pelargonic acid, MOA 27 (Scythe) 4.2 EC	3 to 10% v/v		Apply as preplant burndown to emerged weeds. See label for instruction. May also be used as a banded spray between row middles. Use a shielded sprayer directed to the row middles to reduce drift to the crop.
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	**Collard and turnip only.** Apply in a minimum of 10 gal spray mix per acre to emerged weeds before crop emergence or transplanting as a broadcast or band treatment over a preformed row. Use sufficient water to give thorough coverage. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Do not feed crop residue to livestock for 8 weeks following treatment. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Annual grasses and small-seeded broadleaf weeds	trifluralin, MOA 3 (Treflan, Treflan HFP) 4 EC	1 to 1.5 pt	0.5 to 0.75	**Greens: collard, kale, mustard, and turnip (fresh or processing).** Apply preplant and incorporate into the soil 2 to 3 in. within 8 hr using a rototiller or tandem disk. Do not use if turnip roots are to be consumed. Some states have a Section 24(c) Special Local Need Label for Treflan application in turnip roots. Growers must check *www.farmassist.com* website to make sure Treflan is registered for use in their state. Obtain label from *www.farmassist.com* prior to making application.
	bensulide, MOA 8 (Prefar) 4 EC	5 to 6 qt	5 to 6	**Brassica (Cole) leafy vegetable group.** Not labeled for turnip. Apply preplant or preemergence after planting. With preemergence application, irrigate immediately after application. See label for more directions.
	DCPA, MOA 3 (Dacthal) W-75 (Dacthal) 6 F	6 to 10 lb 6 to 10 pt	4.5 to 7.5	Also labeled for broccoli raab (raab, raab salad), and Hanover salad. Apply immediately after seeding. May also be incorporated.
Annual grasses and broadleaf weeds, yellow nutsedge suppression	*S*-metolachlor, MOA 15 (Dual Magnum) 7.62 EC	8 to 16 oz	0.47 to 0.96	**Collards and Kale only.** This is a Section 24(c) Special Local Need Label. Growers must check *www.farmassist.com* website to make sure Dual Magnum is registered for use in their state. Obtain label from *www.farmassist.com* prior to making Dual Magnum application. Irrigation following the application of Dual Magnum will increase the risk of crop injury. **Use lower rates on coarse-textured soils and higher rates on fine-textured soils. See label for more information.** **Mulched Systems with Transplanted Crop.** ***Option 1:*** Apply 8 to 16 oz to the soil surface of pre-formed beds prior to laying plastic. Ensure the plastic laying process does not incorporate or disturb the treated bed. Unless restricted by other products, crops may be transplanted immediately following Dual Magnum application. ***Option 2:*** Apply 8 to 16 oz overtop of crop at least 10 days after transplanting to ensure root system is well developed. Does not control emerged weeds. Limited data are available for NC. Read label for further instructions. **Bare Ground Application for Transplanted Crop.** After transplanting, irrigate to seal the soil around the transplanted root ball. Five to ten days after transplanting and irrigating, apply Dual Magnum over the top of transplants. If soil is not sealed around the transplant root ball, crop injury may occur. **Direct Seeded Application.** May be applied over the top after the crop reaches 3 inches tall. **Row Middle Application to Transplanted and Direct Seeded Crop.** Apply as a banded application at a rate up to 1.25 pt/A.
GREENS (Collard, Kale, Mustard Greens, and Turnip Greens or roots), Postemergence				
Broadleaf weeds including sowthistle clover, cocklebur, jimsonweed, and ragweed	clopyralid, MOA 4 (Stinger) 3 EC	0.3 to 0.5 pt	0.11 to 0.187	**Kale, collards, mustard, turnip, mizuna, mustard spinach, and rape. See label to determine if other Brassica (Cole) leafy vegetables are registered.** Apply to crop when weeds are small and actively growing. Will control most legumes. For kale, collards, mustard, and turnip (roots) PHI = 30 days. For turnip tops PHI = 15 days. Mustard green injury has been observed in some research trials.
Annual and perennial grasses only	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max) 1 EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Apply postemergence for control of grasses. With Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. With Select Max, add 2 pt nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. PHI for green crops is 14 days. PHI for turnips grown for roots is 30 days.
	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	**ALSO LABELED FOR RAPE GREENS**. PHI for turnip is 14 days. PHI for other greens = 14 days. Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures Do not apply on unusually hot and humid days.

TABLE 4-13. CHEMICAL WEED CONTROL IN GREENS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
GREENS (Collard, Kale, Mustard Greens, and Turnip Greens or roots), Row middles				
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Not labeled for turnip greens.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots or stems, exposed roots, or fruit of crop. PHI = 14 days.

***Mode of action (MOA) code developed by the Weed Science Society of America.**

TABLE 4-14. CHEMICAL WEED CONTROL IN HOPS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
HOPS, Preplant and Preemergence				
Broadleaf weeds including chickweed, wild radish, and henbit. Limited control of annual grasses such as barnyard grass and large crabgrass	flumioxazin, MOA 14 (Chateau) 51 SW	6 oz	0.188	Apply to dormant hops November through February.
Broadleaf weeds and annual grasses	norflurazon, MOA 12 (Solicam) 80 DF	2.5 to 5 lb	2 to 4	Apply as a directed treatment a minimum of 6 months after planting hops. Rate is soil texture dependent.
Annual grasses and small-seeded broadleaf weeds	trifluralin, MOA 3 (Treflan) 4 L or 4 EC	1 to 1.5 pt	0.5 to 0.75	See label for rate information. Shallow incorporate to established, dormant crop. Use equipment that will insure thorough soil mixing with minimal damage to crop.
Annual grasses and small-seeded broadleaf weeds	pendimethalin, MOA 3 (Prowl H_20) 3.8 AS	1.1 to 4.2 qt	1.1 to 4.0	See label for instructions.
HOPS, Postemergence				
Canada thistle	clopyralid, MOA 4 (Solix 3, Spur)	0.3 to 0.67	0.125 to 0.25	Some transient minor leaf cupping may occur to lower leaves and suckers if spray comes into contact with plant. PHI = 30 d.
Broadleaf weeds	2,4-D, MOA 4 (amine 4 and various other brands) 3.8 SL	See labels	See labels	Apply with a hooded sprayer for row middles. Hop foliage is susceptible to this product. PHI = 28 d.
Annual and perennial grasses	clethodim, MOA 1 (Select Max) 1 EC	9 to 16 oz	0.07 to 0.125	For repeat applications make on a minimum of a 14 day interval. PHI = 21 d.
Emerged broadleaf and grass weeds	pelargonic acid, MOA 27 (Scythe) 4.2 EC	3 to 10% v/v		Apply before crop emergence to control emerged weeds. There is no residual activity. Avoid contact with foliage and green bark. See label for further instructions. May be used to control basal sucker growth.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter, does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 2 EC	Up to 2 oz/A	Up to 0.031	Directed hooded spray for row middles. Most effective on broadleaf weeds less than 4 inches in height. Do not apply within 7 days of harvest.
Annual and perennial grass and broadleaf weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Directed hooded spray for row middles. Avoid contact with green shoots and foliage.

***Mode of action (MOA) code developed by the Weed Science Society of America.**

TABLE 4-15. CHEMICAL WEED CONTROL IN LETTUCE

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
LETTUCE, Preplant				
Suppression or control of most annual grasses and broadleaf weeds, full rate required for nutsedge control	metam sodium (Vapam HL) 42%	37.5 to 75 gal	15.7 to 31.5	Rates are dependent on soil type and weeds present. Apply when soil moisture is at field capacity (100 to 125%). Apply through soil injection using a rotary tiller or inject with knives no more than 4 in. apart; follow immediately with a roller to smooth and compact the soil surface or with mulch. May apply through drip irrigation prior to planting a second crop on mulch. Plant back interval is often 14 to 21 days and can be 30 days in some environments. See label for all restrictions and additional information.
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 10 gal spray mix per acre to emerged weeds before crop emerges as a broadcast or band treatment over a preformed row. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray solution or 1 gal approved crop oil concentrate per 100 gal spray mix.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Do not feed crop residue to livestock for 8 weeks following treatment. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
LETTUCE, Preplant or Preemergence				
Annual grasses and small-seeded broadleaf	benefin, MOA 3 (Balan) 60 WDG	2 to 2.5 lb	1.2 to 1.5	Apply preplant and incorporate 2 to 3 in. deep with a rototiller or tandem disk before seeding or transplanting.
	bensulide, MOA 8 (Prefar) 4 EC	5 to 6 qt	5 to 6	Apply preplant incorporated (1 in. incorporation is optimum) or preemergence after planting. With preemergence application, irrigate immediately after application. See label for more directions.
Most annual grasses and broadleaf weeds	pronamide, MOA 3 (Kerb) 3.3 SC	1.25 to 5 pt	0.5 to 2	**Kerb 3.3 SC has a supplemental label allowing application on leaf and head lettuce.** Also labeled in endive, escarole, or radicchio greens. Can be applied preplant, post plant, or postemergence in banded, bed-topped or broadcast applications or a split application can be made. See label for more information. Consult label for planting restrictions for rotational crops. PHI = 55 days.
LETTUCE, Postemergence				
Annual and perennial grasses only	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Arrow, Clethodim, and Select are only registered for leaf lettuce. Consult manufacturer's label for specific rates and best times to treat. For sethoxydim, add 1 qt of crop oil concentrate per acre. Use of Poast or clethodim with crop oil may increase the likelihood of crop injury at high air temperatures. For Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray solution. With Select Max, add 2 pt nonionic surfactant per 100 gal spray mixture. Do not apply on days that are unusually hot and humid. Do not apply sethoxydim within 30 days of harvest on head lettuce or within 15 days of harvest on leaf lettuce. For clethodim, do not apply within 14 days of harvest.
	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max, Intensity One) 1 EC	6 to 8 oz 9 to 16 oz	0.09 to 0.125 0.07 to 0.125	
Most annual grasses and broadleaf weeds	pronamide, MOA 3 (Kerb) 3.3 SC	1.25 to 5 pt	0.5 to 2	**Kerb 3.3 SC has supplemental label now allowing use on leaf lettuce as well as head lettuce.** Apply before weed germination if possible, no later than weeds in the 2-leaf stage. See label for restrictions and use patterns. Consult label for rotational restrictions and other restrictions.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Row middles only.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.

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TABLE 4-16. CHEMICAL WEED CONTROL IN OKRA

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
OKRA, Preplant and Preemergence				
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Perennial weeds may require higher rates. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply no later than 1 day before transplanting crop. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual grasses and small-seeded broadleaf weeds	trifluralin, MOA 3 (Treflan, Treflan HFP, Trifluralin) 4 EC	1 to 2 pt	0.5 to 1	Apply preplant and incorporate into the soil 2 to 3 in. within 8 hr using a rototiller or tandem disk.
Broadleaf and grass weeds	prometryn, MOA 5 (Caparol) 4L	1.5 to 3 pt	1 to 2	Apply preemergence and or post-directed application. Make a single preemergence application of Caparol at 3 pt/A after planting and before crop emergence or a sequential application (see label for further details). Do not exceed 3 pt/A of Caparol per season. See label for crop rotation restrictions. PH = 14 days.
Annual broadleaf weeds including pigweed spp.	mesotrione, MOA 27 (Callisto) 4 L	6 oz	0.19	May be applied as a row middle or hooded POST-directed application but not both. For preemergence row middle application, apply as a banded application to the row middles prior to weed emergence. Leave 1 ft. of untreated area over the okra row or 6 in. on each side of the planted row. Do not apply Callisto directly over the planted row or severe injury may occur. Injury risk is greatest on coarse textured soils (sand, sandy loam or loamy sand).
OKRA, Postemergence				
Annual and perennial grasses	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to actively growing grasses not under drought stress. Do not apply on days that are unusually hot and humid. PHI = 14 days.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply no later than 1 day before transplanting crop. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual and perennial grass and broadleaf weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Row middles only.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots or stems, exposed roots, or fruit of crop. PHI = 14 days.
Annual broadleaf weeds including pigweed spp. 3 inches or smaller	mesotrione, MOA 27 (Callisto) 4 L	6 oz	0.19	May be applied as a row middle or hooded POST-directed application but not both. For preemergence row middle application, apply as a banded application to the row middles prior to weed emergence. Leave 1 ft. of untreated area over the okra row or 6 in. on each side of the planted row. Do not apply Callisto directly over the planted row or severe injury may occur. Injury risk is greatest on coarse textured soils (sand, sandy loam or loamy sand).
Annual broadleaf weeds including pigweed 3 in. or less	mesotrione, MOA 27 (Callisto) 4 L	See label	See label	May be applied as a row middle or hooded POST-directed application but not both. For postemergence hooded application, okra must be at least 3 in. tall. Minimize amount of Callisto that contacts okra foliage or crop injury will occur. PHI = 28 days.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Sandea) 75 DG	0.5 to 1 oz	0.024 to 0.048	Apply to row middles as a postemergence shielded or hooded spray to avoid contact of herbicide with planted crop. In plasticulture, do not allow spray to contact plastic. Do not apply more than 2 oz/A per 12-month period. PHI = 30 days.

***Mode of action (MOA) code developed by the Weed Science Society of America.**

TABLE 4-17. CHEMICAL WEED CONTROL IN ONIONS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
ONIONS, Preplant and Preemergence				
Suppression or control of most annual grasses and broadleaf weeds, full rate required for nutsedge control	metam sodium (Vapam HL) 42%	37.5 to 75 gal	15.7 to 31.5	**Dry bulb and green onion.** Rates are dependent on soil type and weeds present. Apply when soil moisture is at field capacity (100 to 125%). Apply through soil injection using a rotary tiller or inject with knives no more than 4 in. apart; follow immediately with a roller to smooth and compact the soil surface or with mulch. May apply through drip irrigation prior to planting a second crop on mulch. Plant back interval is often 14 to 21 days and can be 30 days in some environments. See label for all restrictions and additional information.
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.7 to 2.7 pt 2.5 to 4 pt	0.65 to 1	**Seeded onion only.** Apply in a minimum of 20 gal spray mix per acre to emerged weeds before crop emergence or transplanting as a broadcast or band treatment over a preformed row. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.

TABLE 4-17. CHEMICAL WEED CONTROL IN ONIONS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
ONIONS, Preplant and Preemergence (cont'd)				
Annual and perennial grass and broadleaf weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Use on direct seeded onions only. Certain glyphosate formulations require the addition of surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 2.0 EC	Up to 2 oz	Up to 0.031	Apply no later than 30 days before planting. See label for specific Aim rate relating to weed species and proper adjuvant and rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual grasses and small-seeded broadleaf weeds	bensulide, MOA 8 (Prefar) 4 E	5 to 6 qt	5 to 6	**Dry bulb only.** Apply preplant incorporated (1 in. incorporation is optimum) or preemergence after planting. With preemergence application, irrigate immediately after application. See label for more directions and rotation restrictions.
	DCPA, MOA 3 (Dacthal) W-75 (Dacthal) 6 F	 8 to 10 lb 8 to 10 pt	6 to 7.5	**Dry bulb and green.** Apply immediately after seeding or transplanting and/or at layby. See label for timing of layby treatments.
Annual broadleaf weeds	oxyfluorfen, MOA 14 (Galigan) 2 E (Goal 2 XL) 2 EC (GoalTender) 4 E	 1 to 2 pt 1 to 2 pt 1 pt	 0.25 to 0.5 0.25 to 0.5 0.5	**Transplanted dry bulb only.** Apply as a single application immediately (within 2 days) after transplanting for preemergence control of weeds. Injury can occur if applications are made during cool, wet weather or prior to the full development of the true leaves. See label for rates and instructions for use. PHI = 45 days.
Most annual grasses and some broadleaf weeds	pendimethalin, MOA 3 (Prowl) 3.3 EC (Prowl) 3.8 AS	See label	See label	**Dry bulb and green onion (chives, leeks, spring onions, scallions, Japanese bunching onions, green shallots, and green eschalots). Prowl 3.3 EC is not registered for green onion.** For preemergence, weed control. Apply when onions have two to nine true leaves (dry bulb) and two to three leaves (green onion) but prior to weed emergence. For green onion, the soil must be a muck soil or be a mineral soil with at least 3% organic matter. See label for additional information on rate depending on soil type. PHI for dry bulb onion is 45 days. PHI for green onion is 30 days.
	dimethenamid-P, MOA 15 (Outlook) 6 EC	12 to 21 oz	0.6 to 1	**Dry bulb and green onion (leeks, spring onions or scallions, Japanese bunching onions, green shallots or eschalots).** For preemergence, weed control. Apply after crop has reached 2 true leaves until a minimum of 30 days before harvest. If applications are made to transplanted crop, DO NOT apply until transplants are in the ground and soil has settled around transplants with several days to recover.
Annual grasses and broadleaf weeds, yellow nutsedge suppression	*S*-metolachlor, MOA 15 (Dual Magnum) 7.62 EC	8 to 16 oz	0.47 to 0.96	**Dry bulb onion and green onion.** This is a Section 24(c) Special Local Needs Label. Growers must check *http:// www.farmassist.com* website to make sure Dual Magnum is registered for use in their state. Obtain label from *http:// www.farmassist.com* prior to making Dual Magnum application. Irrigation following the application of Dual Magnum will increase the risk of crop injury. **Use lower rates on coarse-textured soils and higher rates on fine-textured soils. See label for more information.** **Seeded Application.** Do not apply before 4-leaf stage. Once onion has reached the 4-leaf stage, apply 8 oz/A. When onions reach 6-leaf stage, rate can be increased to 12 oz/A. **Transplant Dry Bulb.** Transplant and then irrigate to seal soil around the root ball. Apply within 48 hrs of planting. Heavy irrigation following the application of Dual Magnum will increase the risk of crop injury.
ONIONS, Postemergence				
Most annual broadleaf weeds	oxyfluorfen, MOA 14 (Galigan) 2 E (Goal 2 XL) 2 EC (Goaltender) 4 E	 0.5 pt 0.5 pt 0.25 pt	0.12	**Dry bulb only.** May be used as a postemergence spray to both the weeds and crop after the onions have at least two fully developed true leaves. Some injury to onions may result. Injury will be more severe if the chemical is applied during cool, wet weather. Weeds should be in the two- to four leaf stage for best results. Do not make more than four applications per year. PHI = 45 days.
Common lambsquarters, common chickweed, common purslane, black nightshade, ladysthumb, Pennsylvania smartweed, redroot pigweed, and some annual grasses	ethofumesate, MOA 8 (Nortron) 4 SC	16 to 32 oz	0.5 to 1	Apply at planting or just after planting prior to weed emergence. Can be used postemergence at 16 oz per acre. See label for more information. Rainfall of at least 0.5 inch is needed for activation.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Row middles only.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
Annual and perennial grasses only	fluazifop, MOA 1 (Fusilade DX) 2 EC	6 to 16 oz	0.1 to 0.25	**Dry bulb only.** Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 gal crop oil concentrate or 1 qt nonionic surfactant per 100 gal spray mix. Do not apply on days that are unusually hot and humid. PHI = 45 days.

TABLE 4-17. CHEMICAL WEED CONTROL IN ONIONS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
ONIONS, Postemergence (cont'd)				
Annual and perennial grasses only	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	**Dry bulb and green.** Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. PHI = 30 days.
	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Intensity One, Select Max) 1 EC	6 to 16 oz 9 to 32 oz	0.09 to 0.25 0.07 to 0.25	**Dry bulb only.** Apply to emerged grasses. Consult the manufacturer's label for specific rates and best times to treat. With Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. With Select Max or Intensity One, add 2 pt non-ionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Do not apply Select on unusually hot and humid days. PHI = 45 days for dry bulb onion. Intensity One may be applied to dry bulb onions or green onions (leeks, scallions or spring onions, Japanese bunching onion, shallots or eschalots). Do not exceed 16 ounces of Intensity One per acre on green onions. Do not apply Intensity One herbicide within 14 days of green onion harvest.
***Mode of action (MOA) code developed by the Weed Science Society of America.**				

TABLE 4-18. CHEMICAL WEED CONTROL IN PEAS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
PEAS, GREEN/ENGLISH, Preplant and Preemergence				
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 10 gal spray mix per acre to emerged weeds before crop emergence as a broadcast or band treatment over a preformed row. Use sufficient water to give thorough coverage. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply prior to planting or emergence of crop. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual and perennial grass and broadleaf weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Do not feed crop residue to livestock for 8 weeks following treatment. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Broadleaf weeds	saflufenacil, MOA 14 (Sharpen) 3.42 SL	1 oz	0.027	**Dry field pea edible pea (sugar snap, English pea, garden pea, green pea, marrow fat pea) and chickpea only.** Apply as a preplant/preemergence burndown of small actively growing broadleaf weeds. Can also be used preplant incorporated or preemergence in edible pea. See label for directions. Do not apply more than 2 fluid ounces per acre per season. Apply as a preplant/preemergence burndown. Do not apply more than 2 oz/A per season.
Annual grasses and small-seeded broadleaf weeds	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	1.5 to 3 pt	0.75 to 1.5	**Southern peas (cowpeas) and snap beans only.** Apply preplant and incorporate into the soil 2 to 3 in. using a power driven rototiller or by cross disking. **DO NOT APPLY AFTER SEEDING. Do not apply when air temperature is below 45 F.**
	trifluralin, MOA 3 (Treflan, Trifluralin, Trifluralin HF, other brands) 4 EC	1 to 1.5 pt	0.5 to 0.75	**English peas only.** Apply preplant and incorporate to a depth of 2 to 3 in. within 8 hr with a rototiller or tandem disk.
Annual grasses and broadleaf weeds; weak on pigweed	clomazone, MOA 13 (Command) 3ME	1.3 pt	0.5	Apply to the soil surface immediately after seeding. See label for further instruction.
Annual grasses, small-seeded broadleaf weeds, and suppression of yellow nutsedge	*S*-metolachlor, MOA 15 (Brawl, Dual Magnum, Medal) 7.62 EC (Brawl II, Dual II Magnum, Medal II) 7.64 EC	1 to 2 pt	0.95 to 1.91	Apply to soil surface immediately after seeding. Shallow cultivations will improve control. See label for specific rate.
Annual broadleaf weeds including morningglory, pigweed, smartweed, and purslane	imazethapyr, MOA 2 (Pursuit) 2 EC	Up to 3 oz	Up to 0.047	**English peas only.** Apply preplant incorporated or to soil surface immediately after planting. See label for more details.

TABLE 4-18. CHEMICAL WEED CONTROL IN PEAS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
PEAS, GREEN, Postemergence				
Annual broadleaf weeds and yellow nutsedge	bentazon, MOA 6 (Basagran) 4 SL	1 to 2 pt	0.5 to 1	Apply overtop of peas when weeds are small and peas have at least three pairs of leaves (four nodes). **DO NOT ADD CROP OIL CONCENTRATE TO SPRAY MIX**. Do not apply when peas are in bloom. PHI = 10 days.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See Label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Row middles only.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or post-harvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots or stems, exposed roots, or fruit of crop. PHI = 14 days.
Annual and perennial grasses	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. With sethoxydim, add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast or Assure II may increase the likelihood of crop injury at high air temperatures. With quizalofop, add 1 gal oil concentrate or 1 qt nonionic surfactant per 100 gal spray. Do not apply Poast or Assure II on days that are unusually hot and humid. Do not apply sethoxydim within 15 days or Assure within 30 days of harvest.
	quizalofop p-ethyl, MOA 1 (Assure II) 0.88 EC (Targa) 0.88 EC	6 to 12 oz	0.04 to 0.08	
Annual broadleaf weeds including morningglory, pigweed, smartweed, and purslane	imazethapyr, MOA 2 (Pursuit) 2 EC	Up to 3 oz	Up to 0.047	**See label for pea type.** Apply postemergence to 1- to 3-in. weeds (one to four leaves) when peas are at least 3 in. high but prior to five nodes and before flowering. Add nonionic surfactant at 2 pt per 100 gal of spray mix. See label for crop rotation restrictions. PHI = 30 days.
Broadleaf and grass weeds	imazamox, MOA 2 (Raptor) 1 SL	4 oz	0.31	**Dry peas only.** Apply postemergence before bloom stage but after dry peas have at least 3 pairs of leaves. See label for further information.
PEAS, SOUTHERN (Cowpeas, Blackeyed peas), Preplant or Preemergence				
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 20 gal spray solution to emerged weeds before crop emergence as a broadcast or band treatment over a preformed row. Use sufficient water to give thorough coverage. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply prior to planting or emergence of crop. Use a nonionic surfactant or crop oil with Aim. See Label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual and perennial grass and broadleaf weeds, stale bed application.	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Do not feed crop residue to livestock for 8 weeks following treatment. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Annual grasses and small-seeded broadleaf weeds	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	1.5 to 3 pt	0.75 to 1.5	**NOT LABELED IN BLACKEYED PEAS.** Apply preplant and incorporate into the soil 2 to 3 in. using a power driven rototiller or by cross disking. **DO NOT APPLY AFTER SEEDING.**
	trifluralin, MOA 3 (Treflan HFP, Trifluralin, Trifluralin HF) 4 EC	1 to 2 pt	0.5 to 1	Apply preplant and incorporate into the soil 2 to 3 in. deep within 8 hr with a rototiller or tandem disk.
Annual grasses and broadleaf weeds	clomazone, MOA 13 (Command) 3ME	0.4 to 0.67 pt	0.15 to 0.25	**Succulent Southern peas only.** Apply to the soil surface immediately after seeding. Offers weak control of pigweed. See label for further instruction.
Annual grasses, small-seeded broadleaf weeds, and suppression of yellow nutsedge	*S*-metolachlor, MOA 15 (Brawl, Dual Magnum, Medal) 7.62 EC (Brawl II, Dual II Magnum, Medal II) 7.64 EC	1 to 2 pt	0.95 to 1.91	Apply to soil surface immediately after planting. Shallow cultivations will improve control. May also be soil incorporated before planting.
Annual grasses and broadleaf weeds including morningglory, pigweed, smartweed and purslane	imazethapyr, MOA 2 (Pursuit) 2 EC	Up to 4 oz	Up to 0.063	Apply preemergence or preplant incorporated. See label for rate for specific pea species.

TABLE 4-18. CHEMICAL WEED CONTROL IN PEAS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
PEAS, SOUTHERN, Postemergence				
Annual broadleaf weeds and yellow nutsedge	bentazon, MOA 6 (Basagran) 4 SL	1 to 2 pt	0.5 to 1	Apply overtop of peas when weeds are small and peas have at least three pairs of leaves (four nodes). **DO NOT ADD CROP OIL CONCENTRATE TO SPRAY MIX.** See label for weeds controlled with Basagran. Do not apply when peas are in bloom. PHI = 30 days.
Annual broadleaf weeds including morningglory, pigweed, smartweed, and purslane	imazethapyr, MOA 2 (Pursuit) 2 EC	Up to 4 oz	Up to 0.063	**Southern peas and certain dry peas.** Apply postemergence to 1- to 3-in. weeds (one to four leaves) when peas are at least 3 in. in height but prior to five nodes and flowering. Add nonionic surfactant at 2 pt per 100 gal of spray mixture with all postemergence applications. Do not apply within 30 days of harvest. See label for rate for specific pea species.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Row middles only.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or post-harvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
Annual and perennial grasses	quizalofop p-ethyl, MOA 1 (Assure II, Targa) 0.88 EC	6 to 12 oz	0.04 to 0.08	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. With sethoxydim, add 1 qt of crop oil concentrate per acre. With quizalofop, add 1 gal oil concentrate or 1 qt nonionic surfactant per 100 gal spray. Adding crop oil to Assure II or Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Assure II or Poast on days that are unusually hot and humid. With sethoxydim, do not apply within 15 days and 60 days of harvest succulent and dry peas, respectively. With quizalofop, do not apply within 60 days of harvest of dry Southern peas, or within 30 days of harvest of succulent Southern peas.
	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	
	clethodim, MOA 1 (Intensity One, Select Max) 1 EC	9 to 16 oz	0.07 to 0.125	

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TABLE 4-19. CHEMICAL WEED CONTROL IN PEPPERS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
PEPPERS, Preplant				
Suppression or control of most annual grasses and broadleaf weeds, full rate required for nutsedge control	metam sodium, (Vapam HL) 42%	37.5 to 75 gal	15.7 to 31.5	Rates are dependent on soil type and weeds present. Apply when soil moisture is at field capacity (100 to 125%). Apply through soil injection using a rotary tiller or inject with knives no more than 4 in. apart; follow immediately with a roller to smooth and compact the soil surface or with mulch. May apply through drip irrigation prior to planting a second crop on mulch however adhere to label guidelines on crop plant-back interval. Plant back interval is often 14 to 21 days and can be 30 days in some environments. See label for all restrictions and additional information. Chloropicrin (150 lb/A broadcast) will also be needed when laying first crop mulch to control nutsedge.
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 10 gal of spray mix per acre to emerged weeds before transplanting as a broadcast or band treatment over a preformed row. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Transplanted crop. Apply no later than 1 day before transplanting crop. Seeded crop. Apply no later than 7 days before planting seeded crop. Use a nonionic surfactant or crop oil. See label for rate. Coverage of weed is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds at least 3 days before seeding or transplanting. When applying Roundup before transplanting crops into plastic mulch, care must be taken to remove residues of this product from the plastic prior to transplanting. To prevent crop injury, residues can be removed by 0.5 in. natural rainfall or by applying water via a sprinkler system. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for specific weeds. Certain glyphosate formulations require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.

TABLE 4-19. CHEMICAL WEED CONTROL IN PEPPERS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
PEPPERS, Preplant (cont'd)				
Broadleaf weeds including Carolina geranium and cutleaf evening primrose and a few annual grasses	oxyfluorfen, MOA 14 (Goal) 2XL (GoalTender) 4 F	 Up to 2 pt Up to 1 pt	0.5	**Plasticulture only.** Apply to soil surface of pre-formed beds at least 30 days prior to transplanting crop. While incorporation is not necessary, it may result in less crop injury. Plastic mulch can be applied any time after application but best results are likely if applied soon after application.
Palmer amaranth, redroot pigweed, smooth pigweed, *Galinsoga* spp., black nightshade, Eastern black nightshade, common purslane, partial control of yellow nutsedge	fomesafen, MOA 14 (Reflex) 2 EC	1 to 1.5 pt	0.25 to 0.375	This is a Section 24(c) Special Local Need Label for transplanted pepper in NC. Growers must obtain the label at *http://www.farmassist.com* prior to making an application of Reflex. See label for further instructions. **Plasticulture In-row Application for Transplanted Pepper.** Apply after final bed formation and the drip tape is laid but prior to laying plastic mulch. Avoid soil disturbance after application. Unless restricted by other products such as fumigants, pepper may be transplanted immediately following the application of Reflex and the application of the mulch. **Bareground for Transplanted Pepper.** Apply pretransplant up to 7 days prior to transplanting pepper. Weed control will be reduced if soil is disturbed after application. During the transplanting operation make sure the soil in the transplant hole settles flush or above the surrounding soil surface. Avoid cultural practices that may concentrate Reflex-treated soil around the transplant root ball. An overhead irrigation or rainfall event between Reflex herbicide application and transplanting will ensure herbicide activation and will likely reduce the potential for crop injury due to splashing. **Plasticulture Row Middle Application.** Apply to row middles with a hooded or shielded sprayer. Avoid drift of herbicide on mulch. If drift occurs, 0.5 inch of rain or irrigation must occur prior to transplanting. Carryover is a large concern; see label for more information.
PEPPERS, Preplant and Preemergence				
Annual grasses and small-seeded broadleaf	clomazone, MOA 13 (Command) 3 ME	0.67 to 2.67 pt	0.25 to 1	**Not labeled for banana pepper.** Apply preplant before transplanting. Weak on pigweed. See label for instructions on use.
	napropamide, MOA 15 (Devrinol, Devrinol DF-XT) 50 DF (Devrinol, Devrinol 2-XT) 2 EC	2 to 4 lb 2 to 4 qt	1 to 2 1 to 2	**Bareground:** Apply preplant and incorporate into the soil 1 to 2 in. as soon as possible with a rototiller or tandem disk. Can be used on direct-seeded or trans- planted peppers. See label for instructions on use. **Plasticulture:** Apply to a weed-free soil before laying plastic mulch. Soil should be well worked yet moist enough to permit a thorough incorporation to a depth of 2 inches. Mechanically incorporate or irrigate within 24 hours after application. If weed pressure is from small seeded annuals, apply to the surface of the bed immediately in front of the laying of plastic mulch. If soil is dry, water or sprinkle irrigate with sufficient water to wet to a depth of 2 to 4 inches before covering with plastic mulch. **Between rows:** Apply to a weed free soil surface between the rows (bareground or plastic mulch). Mechanically incorporate or irrigate Devrinol into the soil to a depth of 1 to 2 inches within 24 hours of application. See XT labels for information regarding delay in irrigation event.
	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	1 to 3 pt	0.5 to 1.5	May be applied in chili pepper, cooking pepper, pimento, Jalapeno, and sweet pepper. Do not apply more than 3 pt per acre per season. See label for specific use rate for your soil type. Avoid direct contact with pepper foliage or stems. PHI = 70 days. See label for further instructions and precautions. **Between rows.** Can be applied as a post-directed spray on the soil at the base of the plant beneath plants and between rows. **In-row.** May be applied as a broadcast preplant incorporated surface application prior to transplanting peppers.
	trifluralin, MOA 3 (Treflan, Treflan HFP, Trifluralin HF) 4 EC	1 to 2 pt	0.5 to 1	Apply pre-transplant, and incorporate to a depth of 2 to 3 in. within 8 hr with a rototiller or tandem disk.
	bensulide, MOA 8 (Prefar) 4 EC	5 to 6 qt	5 to 6	Apply preplant incorporated (1 in. incorporation is optimum) or preemergence. With preemergence application, irrigate immediately after application. See label for directions.
Annual grass and broadleaf weeds, yellow nutsedge suppression	*S*-metolachlor, MOA 15 (Dual Magnum) 7.62 EC	8 to 12 oz	0.47 to 0.7	**Bell pepper transplants only.** This is a Section 24(c) Special Local Need Label. Growers must obtain label prior to making Dual Magnum applications. Growers must obtain label at http://www.farmassist.com ***Option 1:*** Apply 8 to 12 oz to the soil surface of pre-formed beds prior to laying plastic. Insure the plastic laying process does not incorporate or disturb the treated bed. ***Option 2:*** Apply 12 oz overtop of bell pepper between 1 and 3 weeks after planting. Does not control emerged weeds. Limited data are available for NC. Do not apply more than 12 oz/A as it is likely that injury will occur including decreased crop vigor. Read label for further instructions.

TABLE 4-19. CHEMICAL WEED CONTROL IN PEPPERS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
PEPPERS, Postemergence				
Broadleaf, grass (suppression only), and yellow nutsedge	imazosulfuron, MOA 2 (League) 0.5 DF	4 to 6.4 oz	0.19 to 0.3	**Pepper (Bell and non-bell).** Apply to pepper plants that are well established and at least 10 inches tall. Apply directed to the base of the plants stem, no higher than 2 inches from the soil surface and do not contact fruit. Consult label for approved surfactants and crop rotation restrictions. PHI = 21 days.
Annual and perennial grasses only	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. PHI = 7 days.
	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max, Intensity One) 1 EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Apply postemergence to control grasses. With Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. With Select Max, add 2 pt nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. PHI = 20 days.
PEPPERS, Row Middles				
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayer for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides. PHI = 0 days.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 1 oz	0.024 to 0.048	Apply to row middles as a postemergence spray. In plasticulture, do not allow spray to contact plastic. Early season application will give postemergence and preemergence control. Do not apply within 30 days of harvest. For postemergence applications, use nonionic surfactant at 1 qt per 100 gal of spray solution.
Contact kill of all green foliage	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 pt 2 pt	0.5	Apply in a minimum of 20 gal spray mix per acre as a shielded spray to emerged weeds between rows of peppers. Use a nonionic surfactant at a rate of 16 oz per 100 gal spray mix. Do not apply more than 3 applications per season.

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TABLE 4-20. CHEMICAL WEED CONTROL IN POTATOES, IRISH

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
POTATOES, IRISH, Preplant and Preemergence				
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	0.7 to 1.3 pt 1 to 2 pt	0.25 to 0.5	Apply in a minimum of 20 gal spray mix per acre to emerged weeds up to ground cracking before crop emergence. May be used instead of the drag-off operation to kill emerged weeds before the application of preemergence herbicides. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply prior to planting, or within 1 day after planting crop. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage of weed is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Do not feed crop residue to livestock for 8 weeks following treatment. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Annual grasses and small-seeded broadleaf weeds	pendimethalin, MOA 3 (Prowl) 3.3 EC	1.8 to 3.6 pt	0.75 to 1.5	Apply just after planting or drag-off to weed-free soil before crop emerges or from emergence until crop reaches 6 in. tall.
Annual grasses and small-seeded broadleaf weeds, plus yellow nutsedge suppression	*S*-metolachlor, MOA 15 (Brawl, Dual Magnum, Medal) 7.62 EC (Brawl II, Dual II Magnum, Medal II) 7.64 EC	1 to 2 pt	0.95 to 1.91	Apply just after planting or drag-off to weed-free soil before crop emerges. Dual Magnum can also be applied at lay-by for control of late season weeds. Do not apply within 60 days after the at-planting to drag-off application, or within 40 days after a lay-by application. See label for further instruction.
	dimethenamid-P, MOA 15 (Outlook) 6 EC	12 to 21 oz	0.6 to 1	Apply just after planting or drag-off to weed-free soil before crop emerges. See label for further instructions. PHI = 40 days.

TABLE 4-20. CHEMICAL WEED CONTROL IN POTATOES, IRISH (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
POTATOES, IRISH, Preplant and Preemergence (cont'd)				
Annual grasses, most broadleaf weeds, plus yellow and purple nutsedge suppression	EPTC, MOA 8 (Eptam) 7 EC	3.5 pt	3	Apply preplant and incorporate into the soil 2 to 3 in. with a rototiller or tandem disk. The variety "Superior" has been shown to be sensitive to Eptam. See label for specific methods of incorporation. For late season preemergence nutsedge control, apply and incorporate as a directed spray to the soil on both sides of the crop row. See label for more detail.
Most annual broadleaf weeds and some annual grasses	flumioxazin, MOA 14 (Chateau) 51 SW	1.5 oz	0.047	Apply immediately after hilling. A minimum of 2 in. of soil must cover the vegetative portion of the potato plant at the time of application of Chateau. **Do NOT apply to emerged potatoes. DO NOT incorporate Chateau or weed control will be reduced.** Can be tank mixed with burndown herbicides if weeds are present at application. See label for further instructions.
Most annual broadleaf weeds and some annual grasses	linuron, MOA 7 (Lorox DF) 50 WDG (Linex) 4L	1.5 to 3 lb 1.5 to 3 pt	0.75 to 1.5	Apply just after planting or drag-off or hilling but before crop emerges. If emerged weeds are present, add 1 pt surfactant for each 25 gal spray mixture. Weeds may be up to 3 in. tall at time of application.
	metribuzin, MOA 5 (TriCor DF, Dimetric DF, and other trade names) 75 WDG	0.33 to 1.33 lb	0.23 to 1	Apply just after planting or drag-off but before crop emerges. Weeds may be emerged at time of application. On sand soils or sensitive varieties, do not exceed 0.67 lb per acre. See label for list of sensitive varieties.
	rimsulfuron, MOA 2 (Matrix, Pruvin) 25 WDG	1 to 1.5 oz	0.016 to 0.023	Apply after drag-off or hilling but before potatoes and weeds emerge. If emerged weeds are present, add surfactant. See label for rate. Can be tank mixed with Eptam, Prowl, Sencor, Lorox, or Dual Magnum. See label for further instructions.
Broadleaf, grass and nutsedge weeds	fomesafen, MOA 14 (Reflex) 2 EC	1 pt	0.25	Apply preemergence after planting but prior to potato emergence. Do not apply as a preplant incorporated application or to emerged potato or severe crop injury may occur. Do not exceed rate of 1 pt/A per season. PHI = 70 days.
Broadleaf, grass (suppression) and yellow nutsedge	imazosulfuron, MOA 2 (League) 0.5 DF	4 to 6.4 oz	0.19 to 0.3	Apply as a preemergence application after crop has been planted but prior to emergence or immediately after hilling. Postemergence application (3.2 to 4 oz per acre) may be made after crop has emerged if weeds are less than 3 inches in height. Do not apply more than 6.4 oz per acre per season. Consult label for sequential application program and crop rotation restrictions. PHI = 45 days.
POTATOES, IRISH, Postemergence				
Most annual broadleaf weeds and some annual grasses	metribuzin, MOA 5 (TriCor DF and other trade names) 75 WDG	0.33 to 0.67 lb	0.25 to 0.5	Do not use on early maturing smooth-skinned white or red-skinned varieties. Apply only if there have been at least three successive days of sunny weather before application. Treat before weeds are 1 in. tall. Treatment may cause some chlorosis or minor necrosis. PHI = 60 days.
	rimsulfuron, MOA 2 (Matrix, Pruvin) 25 WDG	1 to 1.5 oz	0.016 to 0.023	Apply to young actively growing weeds after crop emergence. More effective on small weeds. Add nonionic surfactant at 1 to 2 pt per 100 gal water. Can be tank mixed with Eptam or Sencor or some foliar fungicides. See label for further instructions. PHI = 60 days.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage of weed is essential for good weed control. Can be tank mixed with other registered herbicides. PHI=7 days.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Row middles only.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
Annual and perennial grasses only	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select 2 EC (Intensity One, Select Max) 1 EC	6 to 8 oz 9 to 32 oz	0.094 to 0.125 0.07 to 0.25	Apply postemergence for control of grasses. With Arrow, Clethodim, Intensity or Select, add 1 qt crop of oil concentrate per acre. With Intensity One or Select Max, nonionic surfactant of 2 pt per 100 gal spray mixture can be used instead of crop oil concentrate. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. PHI = 30 days.
	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply on days that are unusually hot and humid. PHI = 30 days.
Annual broadleaf, grass and yellow nutsedge	*S*-metolachlor, MOA 15 (Brawl, Dual Magnum)	1 to 1.33 pt	0.95 to 1.26	Apply as interrow or interhill application. Leave a 1 ft untreated area over the seeded row (6 in on either side of the row). **Application made as a broadcast spray over the planted row or hill or directly to crop foliage will increase the risk of injury to the crop.** Apply before weeds emerge. See label for further instructions.

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TABLE 4-21. CHEMICAL WEED CONTROL IN PUMPKINS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
PUMPKINS, Preplant and Preemergence				
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 20 gal spray mix per acre to emerged weeds before crop emergence or transplanting as a band or broadcast treatment over a preformed row. Use sufficient water to give thorough coverage. Row should be formed several days ahead of planting or treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray solution or 1 gal approved crop oil concentrate per 100 gal spray mix.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	**Not registered for use on seeded crop.** Apply prior to transplanting crop. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds at least 3 days before seeding or transplanting. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Annual grasses and some small-seeded broadleaf weeds	bensulide, MOA 8 (Prefar) 4 EC	5 to 6 qt	5 to 6	Registered for cucurbit vegetable group (Crop grouping 9). Apply preplant and incorporate into the soil 1 to 2 in. (1 in. incorporation is optimum) with a rototiller or tandem disk, or apply to the soil surface after seeding and follow with irrigation. Check re-plant restrictions for small grains on label. See label for use rate if Prefar 4 EC is used.
	ethalfluralin, MOA 3 (Curbit) 3 EC	3 to 4.5 pt	1.1 to 1.7	Apply postplanting to seeded crop prior to crop emergence, or as a banded spray between rows after crop emergence or transplanting. See label for timing. Shallow cultivation, irrigation, or rainfall within 5 days is needed for good weed control. Do not use under mulches, row covers, or hot caps. Under conditions of unusually cold or wet soil and air temperatures, crop stunting or injury may occur. Crop injury can occur if seeding depth is too shallow.
	ethalfluralin, MOA 3 + clomazone, MOA 13 (Strategy) 2.1 L	2 to 6 pt	0.4 to 1.2 + 0.125 to 0.375	Apply to the soil surface immediately after crop seeding for preemergence control of weeds. **DO NOT APPLY PRIOR TO PLANTING THE CROP. DO NOT SOIL INCORPORATE.** May also be used as a **banded** treatment **between** rows after crop emergence or transplanting.
Yellow and purple nutsedge suppression, non-ALS resistant pigweed, wild radish, and ragweed	halosulfuron-methyl, MOA 2 (Profine 75) 75 DG (Sandea) 75 DG	0.5 to 0.75 oz	0.024 to 0.036 lb	**Direct-seeded pumpkin or winter squash.** Apply after seeding but prior to soil cracking. **Transplanted pumpkin and winter squash.** Apply 7 d prior to transplanting. See label for specific rate. See label for crop rotational restrictions and other information. **Post-transplant in pumpkin and winter squash.** Can be applied as an over-the-top application, a directed spray application, or with crop shields. Apply to transplants that are established, actively growing and in the 3 to 5 true leaf stage or no sooner than 14 days after transplanting unless local conditions demonstrate safety at an earlier interval, but before first female flowers appear. Row middle/furrow applications in direct-seeded and transplant pumpkin and winter squash. Apply between rows of direct-seeded or transplanted crop while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment's to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed. Rate can be increased to 1 oz per acre if needed for row middle/furrow applications.
Annual broadleaf, grass and yellow nutsedge	*S*-metolachlor, MOA 15 (Brawl, Dual Magnum)	1 to 1.33 pt	0.95 to 1.26	Apply as interrow or interhill application. Leave a 1-foot untreated area over the seeded row (6 in. on either side of the row). **Application made as a broadcast spray over the planted row or hill or directly to crop foliage will increase the risk of injury to the crop.** Apply before weeds emerge. See label for further instructions.
PUMPKINS, Postemergence				
Yellow and purple nutsedge suppression, non-ALS resistant pigweed, wild radish, and ragweed	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 0.75 oz	0.024 to 0.036 lb	**Direct-seeded pumpkin and winter squash.** Apply after crop has reached the 2 to 5 true leaf stage, preferably 4 to 5 true leaves, but before first female flowers appear. PHI=30 days. **Post-transplant in pumpkin and winter squash.** Can be applied as an over- the-top application, a directed spray application, or with crop shields. Apply to transplants that are established, actively growing and in the 3 to 5 true leaf stages or no sooner than 14 days after transplanting unless local conditions demonstrate safety at an earlier interval, but before first female flowers appear. PHI=30 days. **Row middle/furrow applications in direct-seeded and transplant pumpkin or winter squash.** Apply between rows of direct-seeded or transplanted crop while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment's to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed. Rate can be increased to 1 oz per acre if needed for row middle/furrow applications. PHI=30 days.
Annual and perennial grasses only	clethodim, MOA 1 (Arrow, Clethodim Intensity, Select) 2 EC (Intensity One, Select Max) 1 EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Apply postemergence for control of grasses. With Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. With Select Max or Intensity One, add 2 pt of nonionic surfactant per 100 gal spray mixture. Adding crop oil concentrate may increase the likelihood of crop injury at high air temperatures. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. PHI=14 days.

TABLE 4-21. CHEMICAL WEED CONTROL IN PUMPKINS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
PUMPKINS, Postemergence (cont'd)				
Annual and perennial grasses only (cont'd)	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Crop oil may increase the likelihood of crop injury at high temperatures. Do not apply Poast on days that are unusually hot and humid. PHI=14 days.
PUMPKINS, Row Middles				
Annual grasses and some small-seeded broadleaf weeds	trifluralin, MOA 3 (Treflan) 4 EC (Treflan HFP) 4 EC	1 to 1.5 pt	0.5 to 0.75	**Row middles only.** To improve preemergence control of late emerging weeds. Apply after emergence when crop plants have reached the three to four true leaf stage of growth. Apply as a directed spray to soil between the rows. Avoid contacting foliage as slight crop injury may occur. Set incorporation equipment to move treated soil around base of crop plants. PHI= 30 days.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides. PHI = 0 days.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Row middles only.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or post-harvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 1 oz	0.024 to 0.048	**Row middles only.** Apply to row middles as a postemergence spray. In plasticulture, do not allow spray to contact plastic. Early season application will give postemergence and preemergence control. Do not apply within 30 days of harvest. For postemergence applications, use nonionic surfactant at 1 qt per 100 gal of spray solution.

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TABLE 4-22. CHEMICAL WEED CONTROL IN RADISH

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
RADISH, Preplant				
Annual and perennial grass and broadleaf weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before planting. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations may require addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Annual grasses and broadleaf weeds	trifluralin, MOA 3 (Treflan, Treflan HFP, Trifluralin, Trifluralin HF) 4 EC	1 to 1.5 pt	0.5 to 0.75	Apply preplant and incorporate immediately after application for preemergence weed control. Low rate should be used on coarse-textured soil.
RADISH, Postemergence				
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Annual and perennial grasses	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max, Intensity One) EC	6 to 8 oz 9 to 16 oz	0.94 to 0.125 0.07 to 0.125	Apply postemergence to emerged grasses. See label for rates for specific grasses. With Arrow, Clethodim, or Select, add crop oil concentrate at 1 gal per 100 gal of spray solution. With Select Max, add nonionic surfactant at 2 pt per 100 gal spray mixture. PHI = 15 days.

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TABLE 4-23. CHEMICAL WEED CONTROL IN SPINACH

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
SPINACH, Preemergence				
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before crop emergence. Do not feed residue to livestock for 8 weeks. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Annual grasses (crabgrass spp., foxtail spp., barnyardgrass, annual ryegrass, annual bluegrass) and broadleaf weeds (*Lamium* spp., lambsquarters, common purslane, redroot pigweed, shepherds purse)	cyclohexylethylthiocarbamate, MOA 3	2 qt	3	Use on sandy mineral soils only. Read label for further instructions.
SPINACH, Postemergence				
Broadleaf weeds including sowthistle clover, cocklebur, jimsonweed, and ragweed	clopyralid, MOA 4 (Stinger) 3 EC	0.17 to 0.33 pt	0.0625 to 0.125	Apply to spinach in the 2- to 5-leaf stage when weeds are small and actively growing. Will control most legumes. See label for more precautions. PHI = 21 days.
Broadleaf weeds	phenmedipham, MOA 6 (Spin-aid) 1.3 EC	3 to 6 pt	0.5 to 1	**For processing spinach only.** Do not use when expected high temperatures will be above 75 degrees F. For best results, spray when weeds are in the two-leaf stage. Use the 6 pt rate only on well-established crops that are not under stress. Spinach plants must have more than six true leaves. PHI = 21 days.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Row middles only. Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or post-harvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
Annual and perennial grasses only	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. For sethoxydim, add 1 qt of crop oil concentrate per acre. For Arrow, Clethodim, or Select, add 1 gal of crop oil concentrate per 100 gal spray solution. For Select Max, add nonionic surfactant at 2 pt per 100 gal of spray mixture. Adding crop oil to Poast or Select may increase the likelihood of crop injury at high air temperatures. Do not apply Poast, Arrow, Clethodim, or Select on days that are unusually hot and humid. Do not apply sethoxydim within 15 days of harvest or clethodim within 14 days of harvest.

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TABLE 4-24. CHEMICAL WEED CONTROL IN SQUASH

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
SQUASH, Preplant and Preemergence				
Suppression or control of most annual grasses and broadleaf weeds, full rate required for nutsedge control	metam sodium (Vapam HL) 42%	37.5 to 75 gal	15.7 to 31.5	Rates are dependent on soil type and weeds present. Apply when soil moisture is at field capacity (100 to 125%). Apply through soil injection using a rotary tiller or inject with knives no more than 4 in. apart; follow immediately with a roller to smooth and compact the soil surface or with mulch. May apply through drip irrigation prior to planting a second crop on mulch. Plant back interval is often 14 to 21 days and can be 30 days in some environments. See label for all restrictions and additional information.
Emerged broadleaf and grass weeds	pelargonic acid, MOA 27 (Scythe) 4.2 EC	3 to 10% v/v		Apply before crop emergence to control emerged weeds. There is no residual activity. May be tank mixed with soil residual compounds. See label for more instructions. May also be used as a banded spray between row middles. Use a shielded sprayer directed to the row middles to reduce drift to the crop.
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 10 gal spray mix per acre to emerged weeds before transplanting or crop emergence as a band or broadcast treatment over a preformed row. Use sufficient water to give thorough coverage. Row should be formed several days ahead of planting or treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Not registered for seeded crop. Apply prior to transplanting crop. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides. PHI = 0 days.

TABLE 4-24. CHEMICAL WEED CONTROL IN SQUASH (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
SQUASH, Preplant and Preemergence (cont'd)				
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds at least 3 days before seeding or transplanting. When applying Roundup before transplanting crops into plastic mulch, care must be taken to remove residues of this product from the plastic prior to transplanting. To prevent crop injury, residues can be removed by 0.5 in. natural rainfall or by applying water via a sprinkler system. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Annual grasses and small-seeded broadleaf weeds	bensulide, MOA 8 (Prefar) 4 EC	5 to 6 qt	5 to 6	Registered for cucurbit vegetable group (Crop grouping 9). Apply preplant and incorporate into the soil 1 to 2 in. (1 in. incorporation is optimum) with a rototiller or tandem disk, or apply to the soil surface after seeding and follow by irrigation. Check re-plant restrictions for small grains on label.
	Bareground ethalfluralin, MOA 3 (Curbit) 3 EC	1.5 to 2 pt	0.56 to .75	**For squash grown on bareground only.** Apply to the soil surface immediately after seeding. Seed must be covered with soil to prevent crop injury. For coarse-textured soils, use lowest rate of rate range. Shallow cultivation, irrigation, or rainfall within 5 days is needed for good weed control. If weather is unusually cold or soil wet and cold, crop stunting or injury may occur. Crop injury can also occur if seeding depth is too shallow. See label for further precautions and instruction.
	Plasticulture ethalfluralin, MOA 3 (Curbit) 3 EC	3 to 4.5 pt	1.1 to 1.7	**For squash grown on plastic only**. Apply to soil surface between the rows of black plastic immediately after seeding or transplanting. **Do not use under mulches, row covers, or hot caps.** Do not apply prior to planting or over plastic. See label for further instruction.
Annual grasses and broadleaf weeds	ethalfluralin, MOA 3 + clomazone, 13 (Strategy) 2.1 L	2 to 6 pt	0.4 to 1.2 + 0.125 to 0.375	Apply to the soil surface immediately after crop seeding for preemergence control of weeds. **DO NOT APPLY PRIOR TO PLANTING CROP. DO NOT SOIL INCOPORATE.** May also be used as a **banded** treatment **between** rows after crop emergence or transplanting.
Suppression of annual grasses and broadleaf weeds; weak on pigweed and morningglory	clomazone, MOA 13 (Command) 3 ME	0.67 to 1.3 pt	0.25 to 0.48	Apply immediately after seeding or prior to transplanting. Seeds and roots of transplants must be below the chemical barriers when planting. Command should only be applied between rows when squash is grown on plastic. Some cultivars may be sensitive to Command (see label). Use lower rates on coarse soils. Higher rates can be used on winter squashes. See label about rotation restrictions.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Sandea, Profine 75) 75 DG	0.5 to 1 oz	0.024 to 0.048	**Row middles only.** Apply to row middles as preemergence spray. In plasticulture, do not allow spray to contact plastic. Early season application will give postemergence and preemergence control. Do not apply within 30 days of harvest. For postemergence applications, use nonionic surfactant at 1 qt per 100 gal of spray solution.
SQUASH, Postemergence				
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	**Row middles only.** Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or post-harvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. PHI = 14 days.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Sandea, Profine 75) 75 DG	0.5 to 1 oz	0.024 to 0.048	**Row middles only.** Apply to row middles as postemergence spray. In plasticulture, do not allow spray to contact plastic. Early season application will give postemergence and preemergence control. Do not apply within 30 days of harvest. For postemergence applications, use nonionic surfactant at 1 qt per 100 gal of spray solution.
Annual and perennial grasses only	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Intensity One, Select Max) 1 EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Apply postemergence for control of grasses. With Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. With Select Max or Intensity One, add 2 pt nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase likelihood of crop injury at high air temperatures. Very effective control of annual bluegrass. Apply to actively growing grasses not under drought stress. PHI = 14 days.
	sethoxydim, MOA 1 (Poast)1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerged grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. PHI = 14 days.

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TABLE 4-25. CHEMICAL WEED CONTROL IN SWEETPOTATOES

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
SWEETPOTATO, Preplant				
Annual and perennial grass and broadleaf weeds, stale seed bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds before transplanting. Perennial weeds may require higher glyphosate rates. Consult label for rates for specific weeds. Certain glyphosate formulations may require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Suppression or control of most annual grasses and broadleaf weeds, full rate required for nutsedge control	metam sodium (Vapam HL) 42%	37.5 to 75 gal	15.7 to 31.5	Rates are dependent on soil type and weeds present. Plant back interval is often 14 to 21 days and can be 30 days in some environments. See label for all restrictions and additional information.
Annual broadleaf weeds including Palmer amaranth and other pigweeds, smartweed, morningglory, wild mustard, wild radish, common purslane, common lambsquarters	flumioxazin, MOA 14 (Valor SX) 51 WDG	3 oz	0.094	Apply prior to transplanting crop for control of many annual broadleaf weeds. Movement of soil during transplanting should not occur or reduced weed control may result. Do not use on greenhouse-grown transplants. Do not apply postemergence or serious crop injury will occur. Do not use on transplant propagation beds. See label for further instructions.
SWEETPOTATO, Preemergence				
Annual grass and broadleaf weeds, Palmer amaranth, yellow nutsedge suppression	*S*-metolachlor, MOA 15 (Dual Magnum) 7.62 EC	0.75 pt	1.0	This is a Section 24(c) Special Local Need Label. Growers must check *http://www.farmassist.com* website to make sure Dual Magnum is registered for use in your state. Obtain label from *http://www.farmassist.com* prior to making Dual Magnum applications. Apply over top of sweetpotatoes after transplanting but prior to weed emergence. Do not apply preplant. Do not incorporate after application. Injury potential is greatest when applied to sands or loamy sands especially if a heavy rainfall event occurs following application. See label for further information.
Annual grasses such as large crabgrass and broadleaf weeds including velvetleaf, purslane, prickly sida	clomazone, MOA 13 (Command) 3 ME	Up to 2 pt	Up to 0.75	Apply preplant or after transplanting prior to weed emergence for preemergence control. Weak on pigweed. The label allows up to 4 pt per acre. See label for other instructions and precautions.
Annual grasses including large crabgrass and broadleaf weeds including purslane, Florida pusley, common lambsquarters	DCPA, MOA 3 (Dacthal) W-75 (Dacthal) 6 F	8 to 10 lb 8 to 10 pt	6 to 7.5	Apply to the soil surface immediately after transplanting. May also be applied at layby for preemergence weed control late in the growing season. Do not apply in plant beds or crop injury will occur.
Annual grasses including crabgrass, foxtail, goosegrass, fall panicum and broadleaf weeds including pigweed, Florida pusley, purslane	napropamide, MOA 15 (Devrinol, Devrinol DF-XT) 50 DF (Devrinol, Devrinol 2-XT) 2 EC	2 to 4 lb 2 to 4 qt	1 to 2	**PLANT BEDS.** Apply to the soil surface after sweetpotato roots are covered with soil but prior to soil cracking and sweetpotato plant emergence. Does not control emerged weeds. Check label for more information. **PRODUCTION FIELDS.** Apply to the soil surface immediately after transplanting. If rainfall does not occur within 24 hr, shallow incorporate or irrigate with sufficient water to wet the soil to a depth of 2 to 4 in. Check label for more information. See XT labels for information regarding delay in irrigation event.
SWEETPOTATO, Postemergence				
Annual and perennial grasses only	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max, Intensity One) 1 EC	6 to 16 oz 9 to 32 oz	0.094 to 0.25 0.07 to 0.25	Apply to actively growing grasses not under drought stress. For Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. For Select Max, add 2 pt nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Very effective in controlling annual bluegrass. Do not apply within 30 days of harvest.
	fluazifop, MOA 1 (Fusilade DX) 2 EC	6 to 16 oz	0.1 to 0.25	Apply to actively growing grasses not under drought stress. Consult manufacturer's label for specific rates and best times to treat. Add 1 gal crop oil concentrate or 1 qt nonionic surfactant per 100 gal spray mix. Do not apply Fusilade on days that are unusually hot and humid. Do not apply within 55 days of harvest.
	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to actively growing grasses not under drought stress. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. PHI = 30 days.
SWEETPOTATO, Row Middles				
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. May cause cracking of sweetpotato storage roots if spray solution comes in contact with sweetpotato foliage. PHI = 14 days.

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TABLE 4-26. CHEMICAL WEED CONTROL IN TOMATOES

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
TOMATO, Preplant				
Suppression or control of most annual grasses and broadleaf weeds, full rate required for nutsedge control	metam sodium, (Vapam HL) 42%	37.5 to 75 gal	15.7 to 31.5	Rates are dependent on soil type and weeds present. Apply when soil moisture is at field capacity (100 to 125%). Apply through soil injection using a rotary tiller or inject with knives no more than 4 in. apart; follow immediately with a roller to smoot and compact the soil surface or with mulch. May apply through drip irrigation prior to planting a second crop on mulch; however, adhere to label guidelines on crop plant back interval. Plant back interval is often 14 to 21 days and can be 30 days in some environments. See label for all restrictions and additional information. Chloropicrin (150 lb/A broadcast) will also be needed when laying first crop mulch to control nutsedge.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	**Transplanted crop.** Apply no later than 1 day before transplanting. **Seeded crop (Aim 2EC only). Apply no later than 7 days before planting seeded crop.** Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply to emerged weeds in a minimum of 20 gal spray mix per acre before crop emergence as a broadcast or band treatment over a preformed row. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Broadleaf weeds including Carolina geranium and cutleaf eveningprimrose and a few annual grasses	oxyfluorfen, MOA 14 (Goal) 2 XL	Up to 2 pt	0.5	**Plasticulture only.** Apply to soil surface of pre-formed beds at least 30 days prior to transplanting crop. While incorporation is not necessary, it may result in less crop injury. Plastic mulch can be applied any time after application but best results are likely if applied soon after application.
Annual grasses and small-seeded broadleaf weeds including common lambsquarters, pigweed, carpetweed, and common purslane	napropamide, MOA 15 (Devrinol, Devrinol DF-XT) 50 DF (Devrinol, Devrinol 2-XT) 2 EC	2 to 4 lb 2 to 4 qt	1 to 2	**Bareground:** Apply preplant and incorporate into the soil 1 to 2 in. as soon as possible with a rototiller or tandem disk. Can be used on direct-seeded or transplanted tomatoes. See label for instructions on use. **Plasticulture:** Apply to a weed-free soil before laying plastic mulch. Soil should be well worked yet moist enough to permit a thorough incorporation to a depth of 2 inches. Mechanically incorporate or irrigate within 24 hours after application. If weed pressure is from small seeded annuals, apply to the surface of the bed immediately in front of the laying of plastic mulch. If soil is dry, water or sprinkle irrigate with sufficient water to wet to a depth of 2 to 4 inches before covering with plastic mulch. **Between rows:** Apply to a weed free soil surface between the rows (bareground or plastic mulch). Mechanically incorporate or irrigate Devrinol into the soil to a depth of 1 to 2 inches within 24 hours of application. See XT labels for information regarding delay in irrigation event.
	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	1 to 3 pt	0.5 to 1.5	**Plasticulture In-row.** May be applied as a preplant surface application or a preplant incorporated application prior to transplanting tomato. **Bareground In-row.** May be applied as a broadcast preplant surface application or preplant incorporated application prior to transplanting tomato. **Post-directed spray.** May be applied as a post-directed spray on the soil at the base of the plant, beneath plants, and between rows. Avoid direct contact with tomato foliage or stems. Do not apply over the top of tomato. PHI=21 days. Do not apply more than 3 pt per acre per season. See label for specific use rate for your soil type. Emerged weeds will not be controlled. See label for further instructions and precautions.
	trifluralin, MOA 3 (Treflan HFP, Trifluralin, Trifluralin HF, various other trade names) 4 EC	1 pt	0.5	**Transplant tomato.** Apply pretransplant and incorporate into the soil 2 to 3 in. within 8 hr using a rototiller or tandem disk. Can be applied postplanting as a directed spray to soil between the rows and beneath plants and then incorporated.
Yellow and purple nutsedge and broadleaf weeds including pigweed, wild radish, common ragweed, suppression of purslane	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 1 oz	0.024 to 0.048	For pretransplant application under plastic mulch, apply to pre-formed bed just prior to plastic mulch application and delay transplanting at least 7 days. Can be applied for pretransplant application in bareground tomato. Early season application will give postemergence and preemergence control. The 1 oz rate is for preemergence and postemergence control in row middles only. For postemergence applications, use nonionic surfactant at 1 qt per 100 gal of spray solution. PHI = 30 days.
Yellow nutsedge, annual grasses, and broadleaf weeds including pigweed, Palmer amaranth, Florida pusley, Hairy galinsoga, Eastern black nightshade, and carpetweed	*S*-metolachlor, MOA 15 (Brawl, Dual Magnum) 7.62 EC	1 to 2 pt	0.95 to 1.50 lb	Apply preplant or postdirected to transplants after the first settling rain or irrigation. In plasticulture, apply to preformed beds just prior to applying plastic mulch. Lower rates of rate range for *S*-metolachlor are safest to tomato. May also be used to treat row middles in bedded tomato. Minimize contact with crop. Also registered for use in row middles, and in seeded crop. See label for further instructions. PHI = 90 days.

TABLE 4-26. CHEMICAL WEED CONTROL IN TOMATOES (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
TOMATO, Preplant (cont'd)				
Palmer amaranth, redroot pigweed, smooth pigweed, *Galinsoga* sp., black nightshade, Eastern black nightshade, common purslane, partial control of yellow nutsedge	fomesafen, MOA 14 (Reflex) 2 EC	1 to 1.5 pt	0.25 to 0.375	This is a Section 24(c) Special Local Need Label for transplanted tomato in NC. Growers must obtain the label at *http://www.farmassist.com* prior to making an application of Reflex. See label for further instructions. Carryover is a large concern. **Plasticulture In-row Application for Transplanted Tomato.** Apply after final bed formation and the drip tape is laid but prior to laying plastic mulch. Avoid soil disturbance after application. Unless restricted by other products such as fumigants, tomato may be transplanted immediately following the application of Reflex and the application of the mulch. **Bareground for Transplanted Tomato.** Apply pretransplant up to 7 days prior to transplanting tomato. Weed control will be reduced if soil is disturbed after application. During the transplanting operation, make sure the soil in the transplant hole settles flush or above the surrounding soil surface. Avoid cultural practices that may concentrate Reflex-treated soil around the transplant root ball. An overhead irrigation or rain- fall event between Reflex herbicide application and transplanting will ensure herbicide activation and will likely reduce the potential for crop injury due to splashing. **Plasticulture Row Middle Application.** Apply to row middles with a hooded or shielded sprayer. Avoid drift of herbicide on mulch. If drift occurs, 0.5 inch of rain or irrigation must occur prior to transplanting. Carryover is a large concern; see label for more information.
Annual grasses and broadleaf weeds including jimsonweed, common ragweed, smartweed, and velvetleaf	metribuzin, MOA 5 (TriCor DF, Metribuzin) 75 WDG	0.33 to 0.67 lb	0.25 to 0.5	Apply to soil surface and incorporate 2 to 4 in. deep before transplanting. See label for instructions.
Broadleaf weeds including Carolina geranium and cutleaf eveningprimrose and a few annual grasses	oxyfluorfen, MOA 14 (Goal) 2XL (GoalTender) 4 F	up to 2 pt up to 1 pt	0.5 lb	**Plasticulture (fallow beds) only.** Apply to soil surface of pre-formed beds at least 30 days prior to transplanting crop. While incorporation is not necessary, it may result in less crop injury. Plastic mulch can be applied any time after application but best results are likely if applied soon after application.
Broadleaf, grass (suppression),yellow nutsedge (PRE or POST), purple nutsedge (POST only)	imazosulfuron, MOA 2 (League) 0.5 DF	4 to 6.4 oz	0.19 to 0.3	Apply to planting beds before plastic is laid. Tomato may be transplanted 1 day after application. Refer to label for further application instructions. Consult label for approved surfactants and crop rotation restrictions. PHI 21 = days.
TOMATO, Postemergence				
Annual grasses and small-seeded broadleaf weeds	DCPA, MOA 3 (Dacthal) W-75 (Dacthal) 6 F	6 to 10 lb 6 to 10 pt	4.5 to 7.5	Apply over the top of transplants only between 4 to 6 wk after transplanting to improve preemergence control of late emerging weeds. Will not control emerge weeds.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 1 oz	0.024 to 0.048	Apply no sooner than 14 days after transplanting. For postemergence applications, use nonionic surfactant at 1 qt per 100 gal of spray solution. Some weeds, such as nutsedge, may require two applications of Sandea; if a second application is needed, spot-treat only weed-infested areas. See label for further instructions. PHI = 30 days.
Annual grasses and broadleaf weeds, including cocklebur, common ragweed, smartweed, velvetleaf, jimsonweed, yellow nutsedge, and morningglory	metribuzin, MOA 5 (TriCor DF, Metribuzin) 75 WDG	0.33 to 1.33 lb	0.25 to 1	Use either as a broadcast or directed spray but do not exceed 0.5 lb a.i. with a broadcast spray. Do not apply within 7 days of harvest. Do not exceed 1 lb a.i. per year. Do not apply as a broadcast spray unless 3 sunny days precede application.
Most broadleaf weeds including wild radish, common purslane, redroot and smooth pigweed	rimsulfuron, MOA 2 (Matrix) 25 WDG (Pruvin) 25 WDG	1 to 2 oz	0.25 to 0.5	Apply in tomatoes after the crop has at least two true leaves and weeds are small (1 in. or less) and actively growing. Add nonionic surfactant at 1 qt per 100 gal of spray solution. Do not apply within 45 days of tomato harvest. See label for further instruction.
Yellow nutsedge, morningglory, common cocklebur, common lambsquarters, and other broadleaf weeds	trifloxysulfuron-sodium, MOA 2 (Envoke) 75 DG	0.1 to 0.2 oz	0.0047 to 0.0094	Apply post-directed to tomato grown on plastic for control of nutsedge and certain broadleaf weeds. Crop should be transplanted at least 14 days prior to application The application should be made prior to fruit set and at least 45 days prior to harvest. Use nonionic surfactant at 1 qt per 100 gal spray solution with all applications.
Annual and perennial grasses only	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Select Max, Intensity One) 1 EC	6 to 16 oz 9 to 32 oz	0.094 to 0.25 0.07 to 0.25	Apply to actively growing grasses not suffering from drought stress. With Arrow, Clethodim, or Select, add a crop oil concentrate at 1% by volume (1 gal per 100 gal spray mix). With Select Max, add 2 pt of nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Do not apply on unusually hot and humid days. Very effective in controlling annual bluegrass. PHI = 20 days.
	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to actively growing grasses not under drought stress. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. PHI = 20 days.

TABLE 4-26. CHEMICAL WEED CONTROL IN TOMATOES (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
TOMATO, Row Middles				
Yellow nutsedge, morningglory, common cocklebur, common lambsquarters, and other broadleaf weeds	trifloxysulfuron-sodium, MOA 2 (Envoke) 75 DG	0.1 to 0.2 oz	0.0047 to 0.0094	Crop should be transplanted at least 14 days prior to application. Use nonionic surfactant at 1 qt per 100 gal spray solution with all applications. The application should be made prior to fruit set and at least 45 days prior to harvest. See label for information on registered tank mixes. Tank mixtures with Select or Poast may reduce grass control. See label for more information.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 1 oz	0.024 to 0.048	For postemergence applications, use nonionic surfactant at 1 qt per 100 gal of spray solution. Some weeds, such as nutsedge, may require two applications of Sandea; if a second application is needed, spot-treat only weed-infested areas. Do not apply within 30 days of harvest. See label for further instructions.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides.
Annual grasses and small-seeded broadleaf weeds	napropamide, MOA 15 (Devrinol, Devrinol DF-XT) 50 DF (Devrinol, Devrinol 2-XT) 2 EC	2 to 4 lb 2 to 4 qt	1 to 2	**Plasticulture.** Apply to a weed-free soil surface. Apply within 24 hours of rainfall, or mechanically incorporate or irrigate into the soil to a depth of 1 to 2 in.
	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	1 to 3 pt	0.5 to 1.5	Post-directed spray on the soil at the base of the plant, beneath plants and between rows. Avoid direct contact with tomato foliage or stems. Do not apply more than 3 pt per acre per season. See label for specific use rate for your soil type. Emerged weeds will not be controlled. Avoid direct contact with tomato foliage or stems. Do not apply within 21 days of harvest. See label for further instructions and precautions.
Contact kill of all green foliage	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 pt	0.5 to 1	Apply for control of emerged weeds between rows of tomatoes. Do not allow spray to contract crop or injury will occur. Do not make more than 3 applications per season. Do not apply within 30 days of harvest.

***Mode of action (MOA) code developed by the Weed Science Society of America.**

TABLE 4-27. CHEMICAL WEED CONTROL IN WATERMELONS

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
WATERMELON, Preplant				
Suppression or control of most annual grasses and broadleaf weeds, full rate required for nutsedge control	metam sodium, (Vapam HL) 42%	37.5 to 75 gal	15.7 to 31.5	Rates are dependent on soil type and weeds present. Apply when soil moisture is at field capacity (100 to 125%). Apply through soil injection using a rotary tiller or inject with knives no more than 4 in. apart; follow immediately with a roller to smooth and compact the soil surface or with mulch. May apply through drip irrigation prior to planting a second crop on mulch. Plant back interval is often 14 to 21 days and can be 30 days in some environments. See label for all restrictions and additional information.
Contact kill of all green foliage, stale bed application	paraquat, MOA 22 (Firestorm, Parazone) 3 SL (Gramoxone SL) 2 SL	1.3 to 2.7 pt 2 to 4 pt	0.5 to 1	Apply in a minimum of 10 gal spray mix per acre to emerged weeds before crop emergence or transplanting as a broadcast or band treatment over a preformed row. Row should be formed several days ahead of planting and treating to allow maximum weed emergence. Plant with a minimum of soil movement for best results. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gal spray mix or 1 gal approved crop oil concentrate per 100 gal spray mix.
Morningglory and small pigweed	pyraflufen ethyl, MOA 14 (ET Herbicide) 0.208 L	1 to 2 oz	0.0016-0.0032	**Bareground.** Wait 1 day following preplant burndown application before planting. **Plastic Mulch Production.** May apply over mulch; however, a single 0.5 inch irrigation/rain event plus a 7 day waiting period must occur before transplanting. Apply ET with a crop oil concentrated at 1% v/v to sensitive weeds that are less than 3 inches.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	**Transplants only.** Apply prior to transplanting of crop. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered burndown herbicides.
Annual and perennial grass and broadleaf weeds, stale bed application	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply to emerged weeds at least 3 days before seeding or transplanting. When applying Roundup before transplanting crops into plastic mulch, care must be taken to remove residues of this product from the plastic prior to transplanting. To prevent crop injury, residues can be removed by 0.5 in. natural rainfall or by applying water via a sprinkler system. Perennial weeds may require higher rates of glyphosate. Consult the manufacturer's label for rates for specific weeds. Certain glyphosate formulations require the addition of a surfactant. Adding nonionic surfactant to glyphosate formulated with nonionic surfactant may result in reduced weed control.
Annual grasses	bensulide, MOA 8 (Prefar) 4 E	5 to 6 qt	5 to 6	Registered for cucurbit vegetable group (Crop grouping 9). Apply preplant and incorporate into the soil 1 to 2 in. (1 in. incorporation is optimum) with a rototiller or tandem disk, or apply to the soil surface after seeding and follow with irrigation. Check replant restrictions for small grains on label.

TABLE 4-27. CHEMICAL WEED CONTROL IN WATERMELONS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
WATERMELON, Preemergence				
Annual grasses and broadleaf weeds	clomazone, MOA 13 (Command) 3 ME	0.4 to 0.67 pt	0.15 to 0.25	Apply immediately after seeding, or just prior to transplanting. Roots of transplants must be below the chemical barrier when planting. Offers weak control of pigweed. See label for further instructions.
Annual grasses and some small-seeded broadleaf weeds	ethalfluralin, MOA 3 (Curbit) 3 EC	3 to 4.5 pt	1.1 to 1.7	Apply postplanting to seeded crop prior to crop emergence, or as a banded spray between rows after crop emergence or transplanting. Apply to the soil surface immediately after seeding. May also be used as a banded spray between rows of plastic mulch. See label for timing. Shallow cultivation, irrigation, or rainfall within 5 days is needed for good weed control. Do not use under mulches, row covers, or hot caps. Under conditions of unusually cold or wet soil and air temperatures, crop stunting or injury may occur. Crop injury can occur if seeding depth is too shallow.
Annual grasses and broadleaf weeds	ethalfluralin, MOA 3 + clomazone, MOA 13 (Strategy) 2.1 L	2 to 6 pt	0.4 to 1.2 + 0.125 to 0.375	Apply to the soil surface immediately after crop seeding for preemergence control of weeds. **DO NOT APPLY PRIOR TO PLANTING. DO NOT INCORPORATE. DO NOT APPLY UNDER MULCH.** May also be used as a banded treatment between rows after crop emergence or transplanting.
Broadleaf weeds	terbacil, MOA 5 (Sinbar) 80 WP	2 to 4 oz	0.1 to 0.2	Apply after seeding but before crop emerges, or prior to transplanting crop. With plasticulture, Sinbar may be applied preemergence under plastic mulch or to row middles. May be applied over plastic mulch prior to transplanting, or prior to punching holes into the plastic mulch for transplanting. Sinbar must be washed off the surface of the plastic mulch with a minimum of 0.5 in. of rainfall or irritation prior to punching transplant holes or transplanting watermelon. Do not apply within 70 days of harvest. See label for further instructions.
Yellow and purple nutsedge suppression pigweed and ragweed control	**Bareground/Plasticulture** halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 0.75 oz	0.024 to 0.036	**Bareground.** Apply after seeding but before cracking or prior to transplanting crop. **Plasticulture.** Application may be made to preformed beds prior to laying plastic. If application is made prior to planting, wait 7 days after application to seed or trans- plant. Stunting may occur but should be short lived with no negative effects on yield or maturity in favorable growing conditions. **SEE LABEL FOR INFORMATION ON ROTATION RESTRICTIONS AND OTHER RESTRICTIONS.**
	Row Middles Only halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 1 oz	0.024 to 0.048	**Row middles only.** Apply to row middles as a preemergence spray. In plasticulture, do not allow spray to contact plastic. Early season application will give postemergence and preemergence control. Do not apply within 57 days of harvest. For postemergence applications, use nonionic surfactant at 1 qt per 100 gal of spray solution.
WATERMELON, Postemergence				
Annual grasses and some small seeded broadleaf weeds	DCPA, MOA 3 (Dacthal) W-75 (Dacthal) 6 F	8 to 10 lb 8 to 10 pt	6 to 7.5	**Not labeled for transplanted crop.** To improve preemergence control of late emerging weeds, apply only when crop has 4 to 5 true leaves, is well-established, and growing conditions are favorable. Will not control emerged weeds. Incorporation not recommended.
Annual and perennial grasses only	clethodim, MOA 1 (Arrow, Clethodim, Intensity, Select) 2 EC (Intensity One, Select Max) 1 EC	6 to 8 oz 9 to 16 oz	0.094 to 0.125 0.07 to 0.125	Apply postemergence for control of grasses. With Arrow, Clethodim, or Select, add 1 gal crop oil concentrate per 100 gal spray mix. With Select Max, add 2 pt nonionic surfactant per 100 gal spray mixture. Adding crop oil may increase the likelihood of crop injury at high air temperatures. Very effective in controlling annual bluegrass. Apply to actively growing grasses not under drought stress. PHI = 14 days.
	sethoxydim, MOA 1 (Poast) 1.5 EC	1 to 1.5 pt	0.2 to 0.3	Apply to emerge grasses. Consult manufacturer's label for specific rates and best times to treat. Add 1 qt of crop oil concentrate per acre. Adding crop oil to Poast may increase the likelihood of crop injury at high air temperatures. Do not apply Poast on days that are unusually hot and humid. PHI = 14 days.
WATERMELON, Row Middles				
Annual grasses and some small-seeded broadleaf weeds	trifluralin, MOA 3 (Treflan HFP, Trifluralin, Trifluralin HF) 4 EC	1 to 2 pt	0.5 to 0.75	To improve preemergence control of late emerging weeds. Apply after emergence when crop plants have reached the three to four true leaf stage of growth. Apply as a directed spray to soil between the rows. Avoid contacting foliage as slight crop injury may occur. Set incorporation equipment to move treated soil around base of crop plants. Do not apply within 60 days of harvest. Will not control emerged weeds.
	pendimethalin, MOA 3 (Prowl H_2O) 3.8 AS	Up to 2.1 pt	Up to 1	May be applied sequentially in bareground and plasticulture production systems at a minimum of 21 days apart. Refer to label for specific instructions.
Broadleaf weeds	terbacil, MOA 5 (Sinbar) 80 WP	2 to 4 oz	0.1 to 0.2	With plasticulture, Sinbar may be applied to row middles. Do not apply within 70 days of harvest. See label for further instructions.
Most broadleaf weeds less than 4 in. tall or rosettes less than 3 in. in diameter; does not control grasses	carfentrazone-ethyl, MOA 14 (Aim) 1.9 EW or 2 EC	Up to 2 oz	Up to 0.031	Apply post-directed using hooded sprayers for control of emerged weeds. If crop is contacted, burning of contacted area will occur. Use a nonionic surfactant or crop oil with Aim. See label for rate. Coverage is essential for good weed control. Can be tank mixed with other registered herbicides. PHI = 0 days.
Most emerged weeds	glyphosate, MOA 9 (numerous brands and formulations)	See labels	See labels	Apply as a hooded spray in row middles, as shielded spray in row middles, as wiper applications in row middles, or postharvest. To avoid severe injury to crop, do not allow herbicide to contact foliage, green shoots, stems, exposed, roots, or fruit of crop. Do not apply within 14 days of harvest.
Yellow and purple nutsedge and broadleaf weeds	halosulfuron-methyl, MOA 2 (Profine 75, Sandea) 75 DG	0.5 to 1 oz	0.024 to 0.048	Apply to row middles as a postemergence spray. In plasticulture, do not allow spray to contact plastic. Early season application will give postemergence and preemergence control. For postemergence applications, use nonionic surfactant at 1 qt per 100 gal of spray solution. PHI = 57 days.

TABLE 4-27. CHEMICAL WEED CONTROL IN WATERMELONS (cont'd)

Weed	Herbicide, Mode of Action Code* and Formulation	Amount of Formulation Per Acre	Pounds Active Ingredient Per Acre	Precautions and Remarks
WATERMELON, Row Middles (cont'd)				
Broadleaf, grass (suppression), yellow nutsedge (PRE and POST), purple nut-sedge (POST)	imazosulfuron, MOA 2 (League) 0.5 DF	4 to 6.4 oz	0.19 to 0.3	**ROW MIDDLE APPLICATION ONLY.** Use a shielded sprayer directed to the row middles to reduce drift to the crop. In plasticulture, prevent the spray from contacting the plastic. Consult label for further instructions. PHI = 48 days.

***Mode of action (MOA) code developed by the Weed Science Society of America.**

Emergency Numbers by State

POISON CONTROL CENTERS

Poison Centers maintain a 24-hour consultant service in diagnosis and treatment of human illness resulting from toxic substances. Make sure that your physician knows tthe Poison Center's telephone number and do not hesitate to call in case of an emergency.

Alabama Poison Control Center
1-800-222-1222

Arkansans Poison Control
1-800-222-1222

Florida
1-800-222-1222

Georgia
1-800-222-1222

Kentucky
1-800-222-1222

Louisiana Poison Control Center
1-800-222-1222

Mississippi AgroMedicine Program
1-800-738-9898 or (601) 354-7660

North Carolina – Carolinas Poison Center
1-800-222-1222

Oklahoma Poison Control Center
1-800-222-1222

South Carolina – Palmetto Poison Center
1-800-222-1222

Tennessee Poison Control Center
1-800-222-1222

Texas Poison Control Network
1-800-222-1222

Virginia Poison Control Center
1-800-222-1222

PESTICIDE SPILLS

Alabama – CHEMTREC
1-800-424-9300 (24 hours)

Arkansas Department of Emergency Management
1-800-322-4012

Florida
1-800-424-9300 (24 hours)

Georgia
1-800-241-4113 (24 hours)

Kentucky – CHEMTREC
1-800-424-9300 (24 hours)

Louisiana -- Louisiana Department of Ag & Forestry
1-855-452-5323

Mississippi – CHEMTREC
1-800-424-9300 (24 hours)

North Carolina
1-800-262-8200 (24 hours)

South Carolina – SCDHEC
1-888-481-0125 (24 hours)

Oklahoma - DEQ
1-800-522-0206

Tennessee – CHEMTREC
1-800-424-9300 (24 hours)

Texas – CHEMTREC
1-800-424-9300 (24 hours)

Virginia – CHEMTREC
1-800-424-9300 (24 hours)

HAZARDOUS MATERIAL CLEANUP

Alabama
(334) 260-2700 after 5 pm (334) 242-4378

Arkansas Department of Emergency Management
1-800-322-4012

Florida – Florida Highway Patrol
(850) 617-2000

Georgia – Georgia Highway Patrol
*GSP (*477)

Kentucky
1-800-928-2380

Louisiana -- Louisiana Department of Ag & Forestry
1-855-452-5323

Mississippi Highway Patrol
(601) 352-9100

North Carolina – NC Highway Patrol
1-800-662-7956

South Carolina – SCDHEC
1-888-481-0125 (24 Hours)

Oklahoma – Oklahoma Highway Patrol
*55 (or DEQ Land Protection Div. (405) 702-5100)

Tennessee
(615) 741-0001

Texas
1-800-424-9300 (24 hours)

Virginia
1-800-424-8802

PESTICIDE CONTAINER RECYCLING

Alabama
(334) 242-2640

Arkansas
(501) 225-1598 See note below*

Florida
(352) 392-4721

Georgia
(404) 656-4958

Kentucky
1-800-205-6543

Louisiana -- Louisiana Department of Ag & Forestry
1-855-452-5323

Mississippi
(601) 961-5171

North Carolina
(919) 733-3556

South Carolina
1-800-654-3145

Oklahoma
(405) 744-5531

Tennessee
1-800-654-3145

Texas
See note below*

Virginia
(804) 371-6560

MISUSE OF PESTICIDES

It is a violation of law to use any pesticide in a manner not permitted by its labeling. To protect yourself, never apply any pesticide in a manner or for a purpose other than as instructed on the label or in labeling accompanying the pesticide product that you purchase. Do not ignore the instructions for use of protective clothing and devices and for storage and disposal of pesticide wastes, including containers. All recommendations for pesticide use included in this manual were legal at the time of publication, but the status of registration and use patterns are subject to change by actions of state and federal regulatory agencies.

* In Arkansas and Texas, pesticide container recycling is not required as according to state law "properly rinsed agricultural chemical containers are not classified as hazardous waste."

Recommendations for the use of agricultural chemicals and other products are included in this publication as a convenience to the reader. The use of brand names and any mention or listing of commercial products or services in this publication does not imply endorsement by Auburn University, Clemson University, Louisiana State University, Mississippi State University, North Carolina State University, Oklahoma State University, Texas A&M, University of Arkansas System Division of Agriculture, University of Georgia, University of Kentucky, University of Tennessee, and Virginia Tech nor discrimination against similar products or services not mentioned. Recommendations and labels will vary from state to state, and we have made every attempt to assure that these exceptions are noted. However, individuals who use agricultural chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label in their respective home state. Be sure to obtain current information about usage regulations and examine a current product label before applying any chemical. For assistance, contact your county Cooperative Extension Service agent.

Notes

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