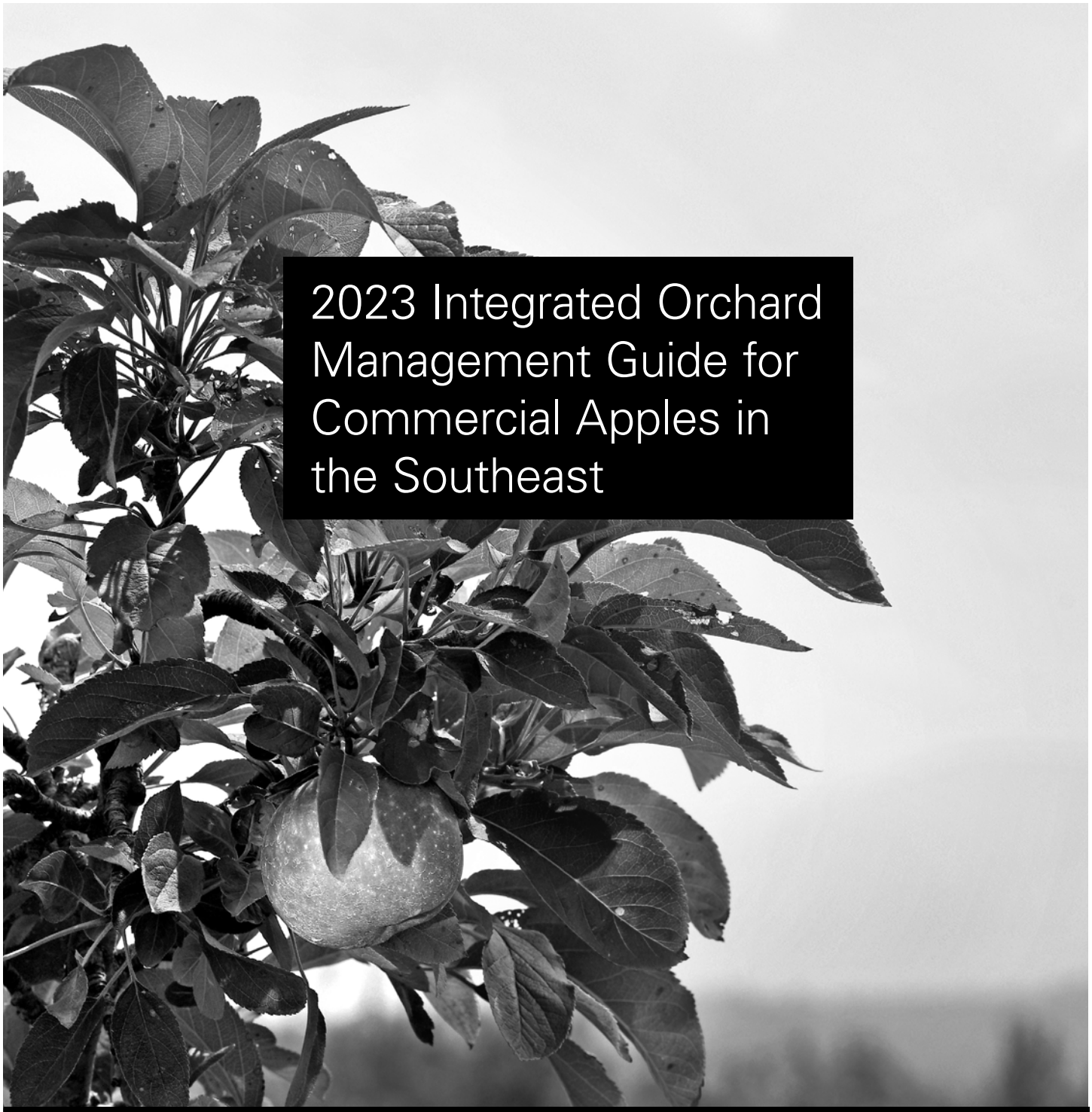


2023 Integrated Orchard Management Guide for Commercial Apples in the Southeast

Alabama Cooperative Extension System
Auburn University

University of Arkansas
Division of Agriculture
Cooperative Extension Service
University of Arkansas

Clemson Cooperative Extension Service
Clemson University

University of Georgia Cooperative
Extension Service
University of Georgia

NC State Extension
North Carolina State University

University of Tennessee Agricultural
Extension Service
University of Tennessee

2023 Integrated Orchard Management Guide for Commercial Apples in the Southeast

Table of Contents

Senior Editor: Jim Walgenbach, Extension Entomologist, NC State University

Section Editors:

Insect Management	Jim Walgenbach
Cultural	Mike Parker
Growth Regulators	Tom Kon
Disease Management	Sara Villani
Weed Management	Wayne Mitchem
Vertebrate Management	David Lockwood
Soils and Nutrition	David Lockwood

CONTRIBUTORS

AUBURN UNIVERSITY

Ed Sikora, *Plant Pathology*

UNIVERSITY OF ARKANSAS

Aaron Cato, *Horticulture IPM*
Amanda McWhirt, *Horticulture*

CLEMSON UNIVERSITY

Guido Schnabel, *Plant Pathology*

The University of Georgia

Keith Delaplane, *Apiculture*
Brett Blaauw, *Entomology*
Phillip Brannen, *Plant Pathology*
Paul Gulliebeau, *Safety*

NC STATE UNIVERSITY

David Tarpy, *Apiculture*
Jim Walgenbach, *Entomology*
Wayne Mitchem, *Horticulture*
Tom Kon, *Horticulture*
Mike Parker, *Horticulture*
Sara Villani, *Plant Pathology*

THE UNIVERSITY of TENNESSEE KNOXVILLE

Jennifer Tsuruda, *Apiculture*
Frank Hale, *Entomology*
David Lockwood, *Horticulture*
Zachariah Hanson, *Plant Pathology*
Darrell Hensley, *Safety*

Poison Control Centers and Emergency Facilities

PESTICIDE POISONING Symptoms of pesticide poisoning may include headache, blurred vision, weakness, nausea, cramps, diarrhea, and chest discomfort. If any of these symptoms occur during or after mixing or applying pesticides or if an unintended unprotected exposure such as a spill occurs, stop work at once and take appropriate action. If pesticide is spilled on the skin, immediately wash the area thoroughly with large amounts of soap and water. If pesticide is in the eye, flush the eye for 15 minutes with running water. If pesticide is inhaled, move to open, clean air. If pesticide is ingested, rinse out the mouth. Follow all first aid directions on the label. Give CPR if indicated. Get help. Contact your physician or poison control center (listed below or on WPS safety poster). Transport the victim to the closest medical care facility. Take the pesticide container or the label with you, or have others search for the label and get it to the facility.

Most pesticide poisonings are due to overexposure to organophosphate and carbamate insecticides. Investigation indicates these are the result of misuse, disregard for safety precautions, and lack of proper hygiene during mixing and application. Ninety percent of occupational exposure is through the hands. Use neoprene or butyl rubber gloves. Rubber boots prevent acute exposure from spills and chronic exposure from accumulation of residues in the materials of boots and shoes.

State-Designated Poison Centers

Dialing 1-800-222-1222 reaches the poison control center for the state from which the call is made.

ALABAMA

800-222-1222

Children's of Alabama
1600 Seventh Avenue South
Birmingham, AL 35233
800-222-1222 (administration and emergency)
childrensal.org/apic

ARKANSAS

800-222-1222

Arkansas Poison Center
4301 West Markham, #522-2
Little Rock, AR 72205
501-686-6161 (administration)
arpoisoncenter.org

GEORGIA

800-222-1222

Georgia Poison Center Education Department
80 Jesse Hill Jr. Drive, SE
PO Box 26066
Atlanta, GA 30303
404-616-9237 (administration)
404-616-9000 (local)
404-616-9235 (education)
404-616-9287 (TDD)
www.georgiapoisoncenter.org

NORTH CAROLINA

800-222-1222

NC Poison Control
PO Box 32861
Charlotte, NC 28232-2861
800-222-1222 (administration and emergency)
ncpoisoncontrol.org

SOUTH CAROLINA

800-222-1222

Palmetto Poison Center
University of South Carolina
Columbia, SC 29208
803-777-7909 (business)
poison.sc.edu

TENNESSEE

800-222-1222

Tennessee Poison Center
Suite 501
1313 21st Avenue South
Nashville, TN 37232
615-936-2047 (TTY)
615-936-0760 (administration)
www.vumc.org/poisoncenter (search "poison center")

Pest and Orchard Management Program

DORMANT

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Cultural Management	Control canopy density, size, and shape for better light and spray penetration.	Conduct annual dormant pruning in central leader trees and appropriate high- density orchards.	*****	—	—	—	—	Younger trees should be pruned closer to bud break. Prune older and bearing trees first; prune one- to two-year-old nonbearing trees during the month before dormant bud break.
	Provide proper nutrition for moderate tree growth and good fruit quality.	Collect soil samples; establish and maintain a good lime and fertility program. Apply fertilizer to young, nonbearing trees, and half rate to mature, bearing trees in spring following bud break.	*****	—	—	—	—	See Fertility Management on page 52 for complete sampling, fertilizer rates, and application methods. Apply full rate to young, nonbearing trees to promote good tree growth.
	Increase lateral bud break and lateral shoot development on last year's leader growth to encourage scaffold limb development.	Bag last year's leader growth three to four weeks before anticipated dormant bud break.	*****	—	—	—	—	See Growth-Regulating Chemicals on page 79 for details.
Plant Growth Regulators	Control water sprout regrowth near pruning cuts and on tops of large scaffold limbs exposed to light by heavy dormant pruning.	Tre-Hold A-112	See comments.	Use 10,000 ppm (10 oz per gal) as a "sponge-on" application.		12	0	See Growth-Regulating Chemicals on page 79 for complete recommendation details. The need for this practice depends on heaviness of pruning, size of cuts, and potential growth vigor. Effectiveness depends on COMPLETE coverage.
	Control burr knot formation.	Gallex	**	Paint directly from can, full strength, on burr knots.		—	—	See Growth-Regulating Chemicals on page 79 for recommendation details.

DORMANT (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management	Reduce inoculum of apple scab fungus.	Remove leaves underneath canopy, shred with flail mower, or apply urea to fallen leaves prior to green tip. Try to apply when temps are >50°F.	*****	—	40 lb of urea	—	—	May also help reduce inoculum of fungi that cause Brooks spot, Alternaria blotch, Marssonina leaf blotch, and Glomerella leaf spot.
	Reduce inoculum of black, white, and bitter rot fungi.	Prune out dead wood and mummied fruit and destroy.	*****	—	—	—	—	Pruning is essential to combat these diseases. Don't stockpile prunings near orchard. Remove and burn, or chip with a flail mower.
	Reduce inoculum of fire blight bacteria.	Prune out cankers and old fire blight strikes and destroy.	*****	—	—	—	—	Will also reduce inoculum of black rot, white rot, and bitter rot.
	Reduce inoculum of powdery mildew fungus.	Prune out silver-colored terminal shoots.	***	—	—	—	—	Particularly useful on young trees of susceptible cultivars.
	Improve conditions for drying fruit and foliage, spray penetration.	Prune to open trees.	*****	—	—	—	—	Pruning is extremely important for good disease control inside the canopy and in the tops of large trees.
Weed Management	Control seedling perennials and winter annuals.	Apply *glyphosate* or *glyphosate + 2,4-D amine* or glufosinate + 2,4-D amine to control emerged winter annuals.	***** +++++	See product label.		See product label.		Apply nonselective postemergence herbicide alone (mid-March). When control from this breaks and summer weeds are 2 to 3 inches tall, apply a nonselective postemergence herbicide with a pre-emergence herbicide. This will likely be in early May, but may vary from year to year. Delaying PRE herbicide application results in residual control later in the summer
	Reduce dandelions, clover, and other broadleaf weeds.	*2,4-D* amine or 2,4-D amine + Stinger	+++	1 qt or 1 qt + 0.66 pt	1 lb	48	60	Apply at least two weeks before bloom to control flowering weeds. Reduces competition with apple blossoms to enhance bee pollination. Control of flowering weeds will also help control tarnished plant bug. Use the 2,4-D + Stinger tank mix in the orchards when clover is the primary weed to be controlled.

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row volume of 400 gal/acre.

SILVER TIP

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management	Control fire blight.	<u>Bactericides</u> copper hydroxide copper oxychloride sulfate Bordeaux (FRAC M1)	 ++++ ++++ ++++	 See label. See label. See label.		 See label. See label. See label.		This treatment targets bacterial ooze from overwintering cankers. It will not eliminate the need for blossom blight management. Applications later than 0.25- to 0.5-inch green tip may result in fruit russet. Most effective if applied dilute.
	Control black rot.	<u>Fungicides</u> Captan 50W or 4L or 80WDG (FRAC M4)	 ++++ ++++ ++++	 — —	 4 lb 2–4 qt 2.5–5 lb	 24 24 24	 0 0 0	**Warning:** Captan will cause injury when used with or too close to oil applications.
	Control crown rot (collar rot).	<u>Fungicides</u> Ridomil Gold SL (FRAC 4)	++++	See label.		48	N/A	Ridomil and Aliette applications are recommended on cultivars propagated on susceptible rootstocks planted in heavy or poorly drained soils. Apply Ridomil in the spring before growth starts, and repeat application after harvest. Apply three to five applications of Aliette a year. Make first application of Aliette after leaf emergence. Do not apply Aliette in tank mixture with copper or surfactants. **Note**: Ridomil and Aliette must be applied on a preventive basis. Treatment of trees exhibiting symptoms will not prevent further symptom development.
		Aliette 80WDG (FRAC P7)	+++	2.5–5 lb	—	12	14	
		Phosphite fungicides (e.g., Prophyt) (FRAC P7)	++++	See label.				Phosphite fungicides are registered for crown rot control and have activity similar to Aliette. See labels for use instructions and precautions.

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Plant Growth Regulators	Increase lateral branching	Maxcel Promalin/Perlan	++++	5,000–7,000 ppm (pending upon product) in latex paint. See label.				Make targeted applications to buds and bark on one-year-old wood where branching is desired. Apply at terminal bud swell but prior to visible lateral bud development. Use a narrow paint roller or paint brush for application. For best results use interior latex paint as the solution carrier. Do not use exterior latex paint or paint that includes anti-fungal additives. Do not apply after bud break, as late applications have been known to cause injury to tender shoot tips and fail to promote bud break. Apply at temperatures greater than 50°F

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row-volume of 400 gal/acre.

GREEN TIP TO HALF-INCH GREEN

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount Per[2] 100 gal	Amount Per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management	Control apple scab. See discussion in Fungicides and Bactericides on page 60 for information on postinfection control program. *(continued on next page)*	Fungicides Syllit FL (FRAC U12) + Manzate Pro-Stick (FRAC M3) **or** + Captan 80WDG (FRAC M4)	 +++++ +++++	—	1.5 pt 3 lb 2.5 lb	48 24 24	7 77 0	**Warning:** Captan will cause injury when used with or too close to oil applications. Syllit should not be applied after pink bud. Do not apply more than twice per year.
		Vangard WG (FRAC 9)	+++	—	5 oz	12	0	Vangard tends to be more active at cool temperatures.
		Vangard WG (FRAC 9) + Manzate Pro-Stick (FRAC M3) **or** + Polyram 80DF (FRAC M3)	 ++++ ++++	—	3–5 oz 3 lb 3 lb	12 24 24	0 77 77	
		Scala SC (FRAC 9)	+++	—	7–10 oz	12	72	Scala SC is not compatible with Captan 50WP at low application volumes.
		Scala SC (FRAC 9) + *mancozeb* 75DF (FRAC M3) **or** + Polyram 80DF (FRAC M3)	 ++++ ++++	—	5–10 oz 3 lb 3 lb	12 24 24	72 77 77	
		Captan 80WDG (FRAC M4)	++++	—	5 lb	24	0	—
		Captan 4L (FRAC M4)	++++	—	4 qt	24	0	
		Captan 50WP (FRAC M4)	++++	—	4–8 lb	24	0	
		Manzate ProStick (FRAC M3)	++++	—	3–6 lb	24	77, BL	
		Manzate Max (FRAC M3)	++++	—	2.8–4.8 lb	24	77, BL	
		Polyram 80DF (FRAC M3)	++++	—	3–6 lb	24	77, BL	
		Luna Tranquility (FRAC 7 + 9) + Manzate Max (FRAC M3)	++++ +++++	—	11.2–16 fl oz 2.4 qt	12 24	72 77	
		Fontelis SC (FRAC 7)	+++++	—	16–20 fl oz	12	28	Mixing Fontelis with captan or surfactants may cause phytotoxicity.
		Fontelis SC (FRAC 7) + Manzate Max (FRAC M3)	 +++++	—	16–20 fl oz 3 lb	12 24	28 77	Mixing Fontelis with captan or surfactants may cause phytotoxicity.
		Sercadis (FRAC 7)	++++	—	4.5 fl oz	12	0	Sercadis contains fluxapyroxad, an active ingredient in Merivon

GREEN TIP TO HALF-INCH GREEN (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount Per[2]		Re-entry Interval (hours)	Preharv. Interval (days)	Comments
				100 gal	Acre			
Disease Management (continued)	Control apple scab. (*continued*)	Sercadis + *mancozeb* 75DF (FRAC 7 + FRAC M3)	+++++	—	16–20 fl oz 3 lb	12 24	0 77	Sercadis contains fluxapyroxad, an active ingredient in Merivon
	Control fire blight.	Badge SC (FRAC M1)	++++	—	3.5–7 pt	48	See label.	Apply this rate between silver and green tip only.
		Badge X2 (FRAC M1)	++++	—	3.5–7 lb	48	See label.	Apply this rate between silver and green tip only. Some formulations are OMRI labeled.
		Kocide 3000-0 (FRAC M1)	++++	—	3.5–7 lb	48	See label.	Make application between silver and green tip; discontinue use at this rate at half-inch green. Some formulations are OMRI labeled.
		Nu-Cop XLR (FRAC M1	++++		8.4–16.8 lb	48	See label.	Make application between silver and green tip; discontinue use at this rate at half-inch green as severe phytotoxicity may occur.
		Cuprofix Ultra Disperss 40DF (FRAC M1)	++++	—	5–7.5 lb	48	See label.	Apply this rate between silver and green tip only.
		Champ Formula 2F (FRAC M1)	++++	—	5.3–10.5 pt	48	See label.	Apply this rate between silver and green tip only.
		Nu-Cop 50WP (FRAC M1)	++++	—	12 lb	48	See label.	Apply this rate between silver and green tip only.
	Control Phytophthora rots.	Phostrol (FRAC P7)	+++++	—	2–5 pt	4	0	See label for application interval guidelines.
		Prophyt (FRAC P7)	+++++	2–4 pt	—	4	0	

GREEN TIP TO HALF-INCH GREEN (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount Per[2] 100 gal	Amount Per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Insect Management	Control scales and reduce overwintering European red mite and rosy apple aphid eggs.	<u>Insecticides</u> Oil	+++++	2 gal	2–3% solution	12	0	Use a highly refined petroleum oil at 2 to 3% solution. If the oil application is delayed until tight cluster to pink, reduce the rate from 0.5 to 1%. **Do not use captan within two weeks of an oil application.**
	Improve scale control.	Oil + Esteem 35WP **or** Centaur 70WDG	+++++ +++++	— —	4–5 oz 9–12 oz	12 12	45 14	An insecticide with oil may be added at this time in orchards experiencing problems with scales. This option is recommended in orchards that experienced scale problems the previous year. The window of control with Esteem or Centaur can be extended to second cover. NOTE: If using Esteem or Centaur, applications after bloom will be more effective than at green tip. There have been some reports of problems mixing oil with Centaur.
	Initiate oriental fruit moth (OFM) monitoring program.	Erect pheromone traps.	*****	—	—	—	—	Erect pheromone traps no later than green tip to detect first emergence. See section on IPM Practices for Selected Pests on page 37 for monitoring information.
	Mating disruption for OFM and codling moth.	<u>Pheromones</u> Isomate CM/OFM TT CideTrak CM-OFM Combo CideTrak CMDA-OFM Messo CheckMate Puffer - CM/OFM	 +++++ +++++ ++++ ++++	—	*(number of dispensers)* 200/acre 200/acre 32/acre 1/acre	—	—	Now is the time to begin erecting pheromone dispensers for mating disruption. Combination dispensers that contain both OFM and codling moth pheromone are recommended. For best results, dispensers should be hung no later than first emergence of OFM. For codling moth, emergence begins about bloom. See section on "Mating Disruption" in IPM Practices for Selected Pests on page 37.

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row-volume of 400 gal/acre.

TIGHT CLUSTER TO PINK

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management	Control apple scab.	Fungicides						If Glomerella leaf spot and bitter rot are a concern, consider using a non-FRAC 11 fungicide or captan during these timings. Combine single-site fungicides (e.g., FRAC 3, 7, 11) with a half rate of mancozeb or captan for resistance management. Indar 2F rate is reflective of special local needs label. .
		Captan 80WDG (FRAC M4)	++++		2.5–5 lb	24	0	
		Captan 50WP (FRAC M4)	++++		8 lb	24	0	
		Captan 4L (FRAC M4)	++++		3–4 qt	24	0	
		Manzate ProStick (FRAC M3)	++++		3–6 lb	24	77, BL	
		Manzate Max (FRAC M3)	++++		2.4–4.8 qt	24	77, BL	
		Polyram 80DF (FRAC M3)	++++		3–6 lb	24	77, BL	
		Flint Extra (FRAC 11)	+++++		2.5–2.9 fl oz	12	14	
		Sovran WG (FRAC 11)	++++		3.2–6.4 oz	12	30	
		Indar 2F (FRAC 3)	++++		6–10 fl oz	12	14	
		Cevya (FRAC 3)	++++		4–5 fl oz	12	0	
		Luna Tranquility (FRAC 7 + 9)	+++++		11.2–16 fl oz	12	72	
		Luna Sensation (FRAC 7 + 11)	+++++		4–5.8 fl oz	12	14	
		Merivon (FAC 7 + 11)	+++++		4–5.5 fl oz	12	0	
		Fontelis (FRAC 7)	++++		16–20 fl oz	12	28	
		Inspire Super (FRAC 3 + 9)	++++		12 fl oz	12	14	
		Aprovia (FRAC 7)	+++++		5.5–7 fl oz	12	30	
		Miravis (FRAC 7)	+++++		3.4 fl oz	12	30	
		Excalia (FRAC 7)	++++		3–4 fl oz	12	PF	
		Sercadis (FRAC 7)	++++		4.5 fl oz	12	0	
	Control powdery mildew.	Fungicides		—				Tight cluster to petal fall are the most important sprays for the control of powdery mildew. If Glomerella leaf spot and bitter rot are a concern, consider using a non-group 11 fungicide during these timings. Do not use EC or solvent-based products, crop oil concentrate, or methylated seed oil adjuvants with Merivon. Indar 2F rate is reflective of special local needs label.
		Rally 40WSP (FRAC 3)	+++++		5–10 oz	24	14	
		Procure 480SC (FRAC 3)	+++++		6–16 oz	12	14	
		Indar 2F (FRAC 3)	++++		8 fl oz	12	14	
		Cevya (FRAC 3)	++++		4–5 fl oz	12	0	
		Topguard Fungicide (FRAC 3)	+++++		8–12 fl oz	12	14	
		Luna Sensation (FRAC 7 + 11)	+++++		4–5.8 fl oz	12	14	
		Luna Tranquility (FRAC 7 + 9)	++++		11.2–16 fl oz	12	72	
		Merivon (FRAC 7 + 11)	+++++		4–5.5 fl oz	12	0	
		Fontelis (FRAC 7)	+++		14–20 fl oz	24	28	

TIGHT CLUSTER TO PINK (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management (continued)	Control powdery mildew. (*continued*)	Flint Extra (FRAC 11)	+++++		2.5–2.9 fl oz	12	14	Applying Stylet Oil with or following an application of captan will cause severe phytotoxicity.
		Sovran 50WDG (FRAC 11)	+++++		4–6.4	12	30	
		Aprovia (FRAC 7)	++++		5.5–7 fl oz	12	30	
		Miravis (FRAC 7)	++++		3.4 fl oz	12	30	Microthiol Disperss is OMRI listed.
		Excalia (FRAC 7)	++++		3–4 fl oz	12	PF	
		Sercadis (FRAC 7)	++++	1–2 gal	4.5 fl oz	12	0	
		JMS Stylet Oil	+++			4	See label.	
		Microthiol Disperss (FRAC M2)	++++		10–20 lb	24	See label.	Application of Microthiol Disperss within three years.
	Control cedar apple rust and quince rust.	<u>Fungicides</u>		—				
		Use a DMI (FRAC 3) fungicide used for powdery mildew or apple scab, or:	+++++					DMI fungicides have post-infection activity on rusts.
		Manzate ProStick (FRAC M3)	+++		3 lb	24	77	Mancozeb and Polyram do not control powdery mildew.
	Control black rot and frogeye leafspot.	Captan 50WP (FRAC M4)	++++		4–8 lb	24	0	Captan does not control powdery mildew or rust diseases.
		Captan 4L (FRAC M4)	++++	0.5–1 qt	3–4 qt	24	0	
		Captan 80WDG (FRAC M4)	++++		2.5–5 lb	24	0	Many populations of apple scab are resistant to T-Methyl and Topsin fungicides.
		Thiophanate Methyl 85WDG (FRAC 1)	+++++	0.2–0.3 lb	0.6–0.8 lb	48	1	
		Topsin 4.5FL (FRAC 1)	+++++	3.8–5 fl oz	15–20 fl oz	48	1	Captan is important for summer applications later in the season, especially on GLS-susceptible cultivars. Consider relying on FRAC M1 fungicides for early season frogeye control.
		Topsin M WSB (FRAC 1)	+++++		¾–1 lb	48	1	
		Cevya	+++		4–5 fl oz	12	0	

TIGHT CLUSTER TO PINK (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Insect Management	Initiate codling moth and leafroller monitoring program.	Erect pheromone traps.	*****	—				Erect traps now to detect biofix because moths begin to emerge near bloom. See section on IPM Practices for Selected Pests on page 37 for information on monitoring programs.
Insect Management	Control rosy apple aphid and plant bugs.	<u>Insecticides</u> Assail 30SG Closer Sivanto Prime 200SL Asana XL Danitol 2.4EC Permethrin 3.2EC	 +++++ +++++ ++++ ++++ ++++ ++++	 — — — 2–5.8 fl oz 2.6–4.3 oz —	 2.5–4 oz 2.75–5.75 oz 7–10 oz 4.8–14.5 fl oz 10.6-21.3 oz 4–10 fl oz	 12 12 4 12 24 12	 7 7 14 7 14 *	Rosy apple aphid can be controlled now or at petal fall. **Caution:** See Rosy Apple Aphid on page 44 for resistance management considerations. Do not apply any insecticides within three days prior to bloom or until after petal fall. *Permethrin is for prebloom only.
	Control plant bugs and spotted tentiform leafminer (STLM).	Maintain clean groundcover. Insecticides listed for rosy apple aphid will aid in plant bug and leafminer control if plant bugs are readily seen.	*****	—	—	—	—	In many instances, a clean groundcover eliminates the need for insecticides to control bugs. If there is a history of plant bug problems, a second application at petal fall will improve control. Insecticides specifically targeting STLM are rarely needed because biological control agents are highly effective.
Plant Growth Regulators	To minimize blind wood by forcing break of paradormant buds on older wood (2+ years old) of apple trees	Maxcel + Promalin + notching	*****	See Maxcel label.				Make a notch immediately above dormant buds and apply up to 1500 ppm of MaxCel directly into the notch using a squirt bottle or paint brush. Adding 500 ppm Promalin/Perlan has also been beneficial. See Growth-Regulating Chemicals on page 79 for more information.

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row volume of 400 gal/acre.

BLOOM

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Cultural Management	Loosen bags on leaders to acclimate for 2 to 3 days; then remove bags from leaders and spray with Promalin or Perlan.	Leader bags must be removed when new lateral growth is 1 to 3 inches long.	*****	—	—	—	—	See the Growth-Regulating Chemicals on page 79 for complete details.
	Do leader selection and strip whorl on dormant headed tree leaders.	Select new shoot for central leader and remove competing shoots from first four nodes below new leader shoot.	—	—	—	—	—	—
Plant Growth Regulators	Improve fruit shape and increase fruit weight of Red and Golden Delicious and Gala.	($BA+GA_{4+7}$) Promalin Perlan	 +++ +++	 0.5–1 pt	 1–2 pt	 4 4	 None	See Growth-Regulating Chemicals on page 79. Apply as a fine mist application at 40 to 50% of Tree Row Volume (TRV) water rate between early king bloom and early petal fall of the side blossoms. Split applications during this period can be more effective.
	Increase lateral bud break and lateral shoot growth on one-year-old leader growth as a tool to encourage scaffold limb development, especially on those that were bagged before bud break. Use on nonbearing trees only.	Promalin Perlan	+++++ +++++	125–500 ppm (0.5–2 pt)/ 10 gal 125–500 ppm (0.5–2 pt)/ 10 gal	—	4 4	None	Apply to last year's leader growth at 1 to 3 inches of new terminal growth with a handheld nozzle. See Growth-Regulating Chemicals on page 79. Make one application when orchard trees have 1 to 3 inches of new growth or when the leader has reached the height where branching is required.

BLOOM (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Plant Growth Regulators (continued)	To increase fruit set after a frost.	Promalin	++	16-32 fl oz	—	—	—	Apply within 24 hours after a frost that occurs when most of the crop is between early bloom and full bloom. Apply in 75 to 150 gallons of water per acre. Do not apply to frozen foliage, blossoms, or developing fruit. Allow trees to completely thaw prior to application. Do not use a surfactant.
		Perlan	++	16–32 fl oz				
Disease Management	Control apple scab, rusts, powdery mildew, and black rot.	Fungicides Same fungicides as for tight cluster.	—	—	—	—	—	Avoid sprays in full bloom if possible. Do not overextend application intervals.
	Control fire blight. *(continued on next page)*	Bactericides						Apply antibiotics according to fire blight infection models such as Cougarblight or Maryblyt. It is very important to continue spraying through late "rat-tail" bloom, especially on susceptible varieties. See Pesticide Resistance Management on page 43 for timing sprays in conditions favorable to infection. LifeGard induces systemic resistance. If no prebloom applications have been made, include with an antibiotic such as streptomycin. LifeGard is OMRI approved. Cueva may result in phytotoxicity to fruit and leaves. If concerned, use lower rate. Cueva is OMRI approved. Serenade Optimum is approved for organic production.
		Streptomycin (FRAC 25) (i.e., Agri-mycin, Firewall, Harbour)	+++++		24 oz	12	50	
		Kasumin 2L (FRAC 24)	+++++	64 fl oz	-	12	90	
		Mycoshield 17WP (FRAC 41)	++++	1 lb	-	12	60	
		Fireline (FRAC 41)	++++			12	60	
		Actigard (FRAC P1)	+++	12 oz	-	12	50	
		LifeGard WG (FRAC P6)	++	0.13–0.8 oz	0.5–3.2 oz	4	0	
		Cueva (FRAC M1)	+++	4.5 oz	2–3 qt	4	0	

BLOOM (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management (continued)	Control fire blight (Blossom Blight). *(continued)*	Double Nickel LC	+++	—	1–2 qt	4	0	Serenade Optimum is approved for organic production.
		+ Cueva (FRAC 44 + M1)			2–3 qt			
		Serenade Optimum (FRAC 44)	+		14–20 oz	4	0	Badge X2 is OMRI approved.
		MasterCop (FRAC M1)	+++		0.5–1.5 qt	48	See label.	
		Badge SC (FRAC M1)	+++		0.5–1.5 pt	48	See label.	
		Badge X2 (FRAC M1)	+++		0.5–1.5 lb	48	See label.	

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row-volume of 400 gal/acre.

PETAL FALL

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Cultural Management	Reduce fruit corking.	Solubor **or** Borosol	+++ +++	1 lb at first cover.	1 pt	—	—	If boron is low in leaf sample or cork spot has been a problem in past years, a second and third application may be used. Dilute applications are necessary for good uptake. See Table 9, Fertility Management on page 52.
	Reduce fruit corking and bitter pit.	calcium chloride	+++	2 lb beginning at first cover.	—	—	—	Repeat calcium sprays in each cover spray all season. Do not apply calcium chloride when temperatures are above 85°F, and DO NOT tank-mix with Solubor or Apogee. All calcium sprays should be applied dilute for maximum response, especially for bitter pit control in late-season cover sprays when fruit are becoming waxy. See Table 9, Fertility Management on page 52.
Plant Growth Regulators	Reduce fruit russeting on susceptible cultivars (esp. Golden Delicious).	(GA_{4+7}) ProVide 10SG Novagib 10L	 ++++ ++++	 2.1–3.5 oz (60–100 g) 20–33 fl oz	—	 4 4	 None	At petal fall, begin the first of two to four applications at seven- to 10-day intervals. See Growth-Regulating Chemicals on page 79 for complete recommendations.
	Thin fruit to reduce crop load and encourage return bloom.	Depends on cultivar, fruit size, and thinning chemical. Applications from petal fall to about 8 mm would be applied during this time.	+++++	See thinning chart in the Growth-Regulating Chemicals section..	—	Check label for specific thinning chemical(s) to be used.		See "Chemical Fruit Thinning Spray" and "Apple Thinning" in the Growth-Regulating Chemicals on page 79.

PETAL FALL (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management	Initiate vegetative growth control applications. Suppress shoot blight.	Prohexadione Calcium (Apogee or Kudos)	++++	Use at TRV calculated a.i./acre.	9–24 fl oz	12	45	See prohexadione calcium table in Growth-Regulating Chemicals on page 79.
	Control apple scab.	Fungicides Same as recommended for tight cluster, pink, and bloom stages.	—	—	—	—	—	Plant tissue during early shoot growth can be very sensitive to injury by captan. Be careful with tank mixtures containing captan and adjuvants.
	Control black rot and white rot.	Fungicides		—				Black rot is caused by the same pathogen as frogeye leaf spot.
		Captan 50 WP (FRAC M4)	++++		8 lb	24	0	
		Captan 4L (FRAC M4)	++++		4 qt	24	0	
		Captan 80WDG (FRAC M4)	++++		2.5–5 lb	24	0	
		Sovran 50WG (FRAC 11)	++++		4–6.4 oz	12	30	
		Flint Extra (FRAC 11)	+++++		2.5–2.9 fl	12	14	
		Thiophanate Methyl 85WDG (FRAC 1)	+++++		0.6–0.8 lb	48	1	
		Topsin 4.5FL (FRAC 1)	+++++		15–20 fl oz	48	1	
		Topsin M WSB (FRAC 1)	+++++		0.75–1 lb	48	1	
		Cevya (FRAC 3)	+++		4–5 fl oz	12	0	
	Control *Colletotrichum* pathogens: Glomerella leaf spot or bitter rot.	Fungicides		—				Mancozeb is not specifically labeled for *Colletotrichum* pathogens on apple, but is highly efficacious against bitter rot and GLS when applied for other diseases.
		Captan 50 WP (FRAC M4)	++++		8 lb	24	0	
		Captan 4L (FRAC M4)	+++++		4 qt	24	0	
		Captan 80WDG (FRAC M4)	+++++		2.5–5 lb	24	0	
		Ziram 76 DF (FRAC M3)	++++		3–6 lb	48	14	
		ProPhyt			4 pt	4	0	ProPhyt can also be applied in a tank mixture with mancozeb (3 lb rate) if mancozeb is applied for protection against apple scab and cedar apple rust.
		+ Captan 80 WDG (FRAC P7 + M4)	+++++	—	2.5–3.75 lb	24	0	
		or						
		+ Ziram 76 DF (FRAC M3)	+++		3–6 lb	48	14	

PETAL FALL (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management (continued)	Control *Colletotrichum* pathogens: Glomerella leaf spot or bitter rot. (*continued*)	Flint Extra (FRAC 11)	+++++	—	2.9 fl oz	12	14	—
		Pristine 38W (FRAC 7 + 11)	+++++	—	14.5–18 oz	12	0	—
		Merivon 4.18SC (FRAC 7 + 11)	+++++	—	4–5.5 fl oz	12	0	Tank-mix with EBDC or captan for resistance management.
		Luna Sensation (FRAC 7 + 11)	+++++	—	4–5.8 fl oz	12	14	—
		Aprovia (FRAC 7)	+++	—	7 fl oz	12	30	For suppression only. Tank-mix with EBDC or captan for resistance management.
		Fontelis (FRAC 7)	++	—	20 fl oz	12	28	Tank-mix with EBDC for improved efficacy.
		Omega 500F (FRAC 29)	+++	—	13.8 fl oz	12	28	
	Control Brooks fruit spot.	Fungicides Use protectant fungicides (captan, mancozeb, Ziram) or benzimidazole fungicides (i.e., benzimidazoles) listed above for summer rots.	*****	—	—	—	—	Petal fall through third cover sprays are the most important sprays for Brooks spot control. Generally, the DMI and QoI fungicides may have limited Brooks spot activity. If one of them is used, combine it with a full rate of protectant.
	Control powdery mildew and cedar apple rust.	Fungicides See tight cluster to pink spray.	—	—	—	—	—	If captan alone is used in this application, fungicides with strong activity on powdery mildew and cedar apple rust should be included in this application.

PETAL FALL (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management (continued)	Control fire blight (shoot blight).	Apogee Kudos 27.5WDG LifeGard WG (FRAC P6) Actigard Cueva (FRAC M1) *or other low MCE product*	+++++ +++++ ++ +++ +++	6–12 oz 6–12 oz 4.5 oz See label.	 2 qt	12 12 4 12 4	45 45 0 See label. 0	Apply Apogee or Kudos when shoots are 1 to 3 inches long and 14 to 21 days after initial application. LifeGard and Actigard induce systemic resistance in shoots. They must be applied at early petal fall (prior to shoot blight symptoms) and during bloom in order to reduce shoot blight severity. If possible, apply Actigard as a drench. Cueva is OMRI approved. Make sure to use post-green tip/maintenance rates of coppers at this time. Even if using low rate, phytotoxicity may still occur, especially on sensitive cultivars.
Insect Management	Preventively control European red mite, spotted tentiform leafminer, and white apple leafhopper.	<u>Insecticides</u> Agri-Mek SC **or** Agri-Mek SC + horticultural oil	 +++++ +++++	 2.5 oz	 2.25–4.25 oz 1 qt	 12 12	 28 28	Preventive control of mites is most important when insecticides known to flare mites are anticipated to be used. An application of Agri-Mek at petal fall to first cover should provide season-long suppression of these pests. A non-ionic adjuvant or summer oil (0.25% or 1 gal/acre) **must** be tank mixed to ensure Agri-Mek's activity. **Do not use captan two weeks before or after applying oil with Agri-Mek. Read label for specific adjuvant ingredients to use as an alternative to oil.**

PETAL FALL (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Insect Management (continued)	Preventive control of European red mite.	Apollo SC	++++	—	4 oz	12	45	Apply one of these products between petal fall and third cover or when mites reach one adult per leaf. See page 44 for resistance management of European red mite.
		Savey 50WP	++++	—	3 oz	12	28	
		Zeal 72WDG	+++++	—	2–3 oz	12	28	
		Envidor 2SC	+++++	—	16–18 oz	12	7	
	Control plum curculio.	Insecticides						Adults begin to enter orchards during bloom, with most, but not all, adults present by late petal fall. An insecticide applied at petal fall is critical to minimizing damage. Cool weather during this period, or historically large populations, may extend adult activity, which may require a second application seven to 10 days later.
		Avaunt 30WG	++++	—	5–6 oz	12	28	
		Actara 25SDG	+++++	—	4.5 oz	12	35	
		Imidan 70WP	+++++	¾ lb	3 lb	24	7	
		Belay SC	++++	—	6 oz	12	7	
		Sevin 4F	+++		3 qt	12	3	
		Verdepryn 100SL	++++		11 oz	4	7	
		Voliam Flexi WDG	+++++		6 oz	12	35	
	Control oriental fruit moth.	Insecticides						A single application of an insecticide between 500 and 600 degree days (DD) after biofix (usually around petal fall) will control the first generation. Sevin applied for thinning will further help with OFM control. Petal fall is an important spray in orchards not using mating disruption or where dispenser application was delayed until bloom or later.
		Imidan 70WP	+++++	0.75 lb	3 lb	24	7	
		Avaunt 30WG	+++++	—	5–6 oz	12	28	
		Assail 30SG	+++++	—	5–8 oz	12	7	
		Sevin 4F	++++	—	3 qt	12	3	
		Verdepryn 100SL	+++++		5.5–11 oz	4	7	
		Voliam Flexi	+++++		6 oz	12	35	
		Mating Disruption	+++++		50–100 disp.	0	0	
		Isomate OFM-TT	+++++		1–2 fl oz	0	0	
		CheckMate OFM-F						

PETAL FALL (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Insect Management (continued)	Control rosy apple aphid.	Insecticides						If an insecticide was not applied for rosy apple aphid at pink, or if control was poor, an insecticide should be applied. An adjuvant must be applied with Movento. See the Rosy Apple Aphid on page 44.
		Admire 4.6SC	+++++	—	2.8 oz	12	7	
		Actara 25WP	+++++	—	4.5 oz	12	35	
		Assail 30SG	+++++	—	2.5–4.0 oz	12	7	
		Closer	+++++	—	1.5–2.75 oz	12	7	
		Sivanto Prime 200SL	+++++	—	7–10 oz	4	14	
		Versys DC	+++++	—	1.5 oz	12	7	
		Movento 2SC	++++	—	6–9 oz	24	7	
		Voliam Flexi	+++++	—	6 oz	12	35	
	Control green fruitworm.	Insecticides						Scout trees for feeding damage on shoots and new apples. An application of Intrepid at early petal fall will help to minimize damage to fruit. Intrepid is highly safe to bees and can be sprayed during bloom.
		Intrepid 2F	+++++	—	6–8 fl oz	4	14	
	Control white apple leafhopper.	Insecticides						Threshold level for first-generation white apple leafhopper is one nymph per leaf. Thinning apples with Sevin during this time controls leafhoppers. Leafhoppers may be present from petal fall to second cover spray. WALH is sporadic in occurrence.
		Sevin 50WP	+++++	0.5 lb	2 lb	12	1	
		Actara 25WDG	+++++	—	2–2.75 oz	12	35	
		Admire 4.6SC	+++++	—	2.8 oz	12	7	
		Assail 30SG	+++++	—	2.5–4 oz	12	7	
		Avaunt 30WG	+++++	—	5–6 oz	12	28	
		Closer	+++++	—	1.5–2.75 oz	12	7	
		Sivanto Prime 200SL	+++++	—	7–10 oz	4	14	
	Control spotted tentiform leafminer.	Insecticides						Threshold level for first generation leafminer is one mine per leaf. The need for leafminer control is rare, as biological control is highly effective.
		Actara 25WDG	++++	—	4.5 oz	12	35	
		Delegate WG	+++++	—	4.5 oz	4	7	
		Provado 1.6F	++++	1–2 oz	4–8 oz	12	7	
		Assail 30SG	++++	—	1.1 oz	12	7	

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row-volume of 400 gal/acre.

FIRST COVER

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Weed Management	Control weeds.	Check orchards for weed populations.	*****	—	—	—	—	Identify weed problems so herbicide program can be adjusted for summer weed control.
	Apply PRE + Nonselective POST herbicide.	See herbicide guide.	*****	See product labels.		See product labels.		Apply when summer weeds are 2 to 3 inches tall. Delaying application of pre-emergence herbicides until early May extends summer weed control.
	Control white clover bloom to protect bees from insecticide sprays.	Stinger	***** +++++	—	0.66 pt	12	—	Apply Stinger 14 to 21 days before spraying insecticides to control clover and avoid bee exposure to insecticides.
Disease Management	Control apple scab.	<u>Fungicides</u> Scout for secondary apple scab. See comments.	*****	—	—	—	—	If primary apple scab is controlled early, continue to protect with captan or mancozeb. Products used for summer disease control, with the exception of benzimidazoles (due to resistance concerns), should also generally be effective against apple scab. DMI fungicides will provide post-infection activity as well.
	Control blister spot.	<u>Fungicides</u> Aliette WDG (FRAC P7) Phostrol (FRAC P7)	 ++++ ++++	 0.5–1 gal	 2.5–5 pt	 12 4	 14 0	Fruit are most susceptible to blister spot two to eight weeks following petal fall.
	Control flyspeck or sooty blotch. *(continued on next page)*	<u>Fungicides</u> Captan 50WP (FRAC M4) Captec 4L (FRAC M4) Captan 80WDG (FRAC M4) Sovran 50WG Flint Extra Thiophanate Methyl 85WDG Topsin 4.5FL Topsin M WSB	 ++++ ++++ ++++ ++++ ++++ ++++ ++++ ++++	—	 4–8 lb 2–4 qt 2.5–5 lb 4–6.4 oz 2.5–2.9 fl oz 0.6–0.8 lb 15–20 fl oz 0.75–1 lb	 24 24 24 12 12 48 48 48	 0 0 0 30 14 1 1 1	For resistance management, it is recommended that single-site fungicides be applied in tank mixture with a protectant fungicide such as captan.

FIRST COVER (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management	Control flyspeck/sooty blotch *(continued)*.	Ziram 76 DF (FRAC M3)	++++	—	3–6 lb	48	12	
		Inspire Super (FRAC 3 + 9)	+++++		12 fl oz	12	14	
		Cevya (FRAC 3)	+++++		4–5 fl oz	12	0	
		Indar 2F (FRAC 3)	+++++		6–10 fl oz	12	14	Indar 2F rate is reflective of special local needs label.
		Aprovia (FRAC 7)	++++		5.5–7 fl oz	12	30	
		Miravis (FRAC 7)	+++++		3.4 fl oz	12	30	
		Luna Sensation (FRAC 7 + 11)	++++		4–5.8 fl oz	12	14	
		Merivon (FRAC 7 + 11)	+++++		4–5.5 fl oz	12	0	
		Pristine (FRAC 7 + 11)	+++++		14.5–18.5 oz	12	0	
		Cueva (FRAC M1)	+++		2–3 qt	4	0	
		Double Nickel LC + Cueva (FRAC 44 + M1)	+++		1–2 qt 2–3 qt	4	0	Cueva may result in phytotoxicity to some apple cultivars.
	Control fire blight.	Refer to products used for Petal Fall application.						
	Control Alternaria leaf blotch, black rot, white rot.	Refer to fungicides used for Petal Fall application.						
	Control *Colletotrichum* pathogens: Glomerella leaf spot/ Bitter rot.	Refer to fungicides used for Petal Fall application.						
	Control powdery mildew.	Refer to fungicides used for Petal Fall application.						

FIRST COVER (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Insect Management	Control codling moth.	Monitor codling moth adult activity.	*****	—	—	—	—	See section covering IPM Practices for codling moth (page 38) to determine how to minimize insecticide applications for codling moth control.
		Insecticides						CYD-X is a virus that controls only codling moth. Frequent applications (7 to 10 days) at low rates (1 to 2 oz per acre) have worked well in field trials. HP is a high potency formulation. Insecticide-resistant codling moth populations exist in some orchards and can affect the performance of certain products.
		Delegate 25WP	+++++	—	4.5–7 oz	4	7	
		Altacor 35WDG	+++++	—	2.5–4.5 oz	4	5	
		Exirel 0.83SE	+++++	—	8.5–17 oz	12	3	
		Verdepryn 100SL	+++++	—	5.5–11 oz	4	7	
		Intrepid 2F	++++	—	10–16 oz	4	14	
		Rimon 0.83EC	++++	—	20–40 oz	12	14	
		Imidan 50WP	++++	0.75 lb	3 lb	24	7	
		Assail 30SG	+++	—	4–8 oz	12	7	
		CYD-X	+++	—	1–3 oz	4	0	
		CYD-X HP	++++	—	0.5–1	4	0	
	Control San Jose scale.	Insecticides						Where scales were a problem the previous year, apply an insecticide for first generation crawlers, which are active from late petal fall through fourth cover. For Movento, use a penetrating adjuvant and apply at first cover. Yellow crawlers can be detected by wrapping double-stick tape around infested limbs after bloom and inspecting weekly. **Caution:** Diazinon or oil applied with captan or Captec may cause phytotoxicity.
		Diazinon 50WP	+++++	1 lb	4 lb	96	21	
		Esteem 35WP	+++++	—	4 oz	12	45	
		Centaur 70WP	+++++	—	34.5 oz	12	14	
		Movento 2SC	++++	—	6–9 oz	24	7	
		Assail 30SG	++++	—	8 oz	12	7	
		summer oil	+++	—	1%	12	0	
	Control rosy apple aphid, plum curculio, white apple leafhopper, and spotted tentiform leafminer.	Monitor orchards for these insects. Insecticides (See page 14)	*****	—	—	—	—	Infestations of these insects may occur anytime from petal fall to the second cover spray. Early detection is important for effective control.

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row-volume of 400 gal/acre.

SECOND COVER AND LATER SPRAYS

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Cultural Management	Reduce fruit corking and bitter pit.	calcium nitrate calcium chloride	+++ +++	3 lb 2 lb	—	—	—	—
	Provide proper nutrition for moderate tree growth and good fruit quality.	Apply second half of fertilizer to mature, bearing trees if crop load is present, as soon as frost or freeze danger has passed (approximately second cover).	++++	—	—	—	—	See Table 9, Fertility Management on page 52 for fertilizer use suggestions and complete recommendations.
		Collect leaf samples in July to mid-August for leaf analysis.	+++++	—	—	—	—	See Table 9, Fertility Management on page 52 for complete details.
	Achieve proper tree training, and control tree size and density for good light and spray penetration.	Select lateral limbs, strip whorls, establish wide crotch angles with toothpicks or clothespins, and prop limbs to good limb angles (60° to 90° for central leader trees and 75° to 85° below vertical for high-density, slender, spindle-type trees).	++++	—	—	—	—	Tree training is mandatory to develop proper lateral branching and limb position.
		Do detailed young tree management (deshoot, position limbs, tie up leader) every six to eight weeks until full tree size and bearing are achieved (especially for high density orchards).	++++	—	—	—	—	Summer pruning is a necessary extension of tree training begun earlier. Summer pruning helps contain tree size and density, and proper limb selection and positioning encourage flower initiation.
		Remove water sprouts.	++++	—	—	—	—	Removing upright water sprout growth reduces canopy density, allowing greater spray penetration and better light distribution for fruit quality and color development. Summer pruning and removal of water sprouts also help control sooty blotch and flyspeck.
		Do leader manipulation, such as summer bending or snaking, every 18 inches of terminal growth extension.	++	—	—	—	—	

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row volume of 400 gal/acre.

SECOND COVER AND LATER SPRAYS (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Plant Growth Regulators	Thin to reduce crop load and encourage return bloom.	Depends on cultivar, fruit size, and thinning chemical selected. Application time from approximately 9 mm and larger would be applied from second cover on.	+++++	See thinning chart on page 84.	—	—	—	See the Chemical Fruit Thinning Sprays on page 79 and Apple Thinning Recommendations on page 84 in the Growth-Regulating Chemicals section.
	Enhance return bloom.	Fruitone L, PoMaxa, or ReFine Ethephon	+++ +++	—	2–8 fl oz 16–72 fl oz	48 48	2 7	Studies in the Southeast have found that NAA or Ethrel treatments can improve return bloom. Ethrel rate depends on many factors, including cultivar and crop load. Refer to Table 22 on page 83.
	Control ground suckers around base of trunk.	Tre-Hold A-112 Sprout Inhibitor. Also use herbicides approved for sucker control. See notes in Herbicides on page 75 for Rely, Gramoxone.	++++	Use 10,000 ppm (10 oz/1 gal) as a low-pressure, large-droplet handgun application.		12	0	See Sucker Control on page 86 for specific recommendation details.

SECOND COVER AND LATER SPRAYS (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Plant Growth Regulators (continued)	Delay preharvest fruit drop and delay fruit maturity.	ReTain	++++	—	Not more than one 333 g pouch (50 g a.i.) per acre	12	7	Single Pick Harvest: Applying one pouch of ReTain per acre three to four weeks prior to the anticipated beginning of the normal harvest period of untreated fruit will delay the harvest period by seven to 10 days. Timing of ReTain application is critical. Apply ReTain closer to harvest in hot years. Use a 100% organosilicone adjuvant at a final concentration of 0.05% to 0.1% (v/v) in the spray tank for optimal response. Reduce the amount of a.i. per acre to 25 g on sensitive varieties such as Gala. Consult the label. Multiple Pick Harvest: Applying one pouch of ReTain per acre one to two weeks prior to the anticipated beginning of the normal harvest period of untreated fruit will improve quality and storage potential of later-picked apples (second and third pick fruit). Applications at this time will not typically delay the start of the harvest, but will help control the maturation rate of the later harvests.
	Delay or reduce preharvest fruit drop or both. *(continued on next page)*	Preload NAA (Fruitone-L, PoMaxa, or ReFine 3.5WSG)	+++	2 oz	—	48	2	Make multiple applications of 5 ppm each week for the four-week period prior to the normal start of the harvest period for each variety.
		NAA (Fruitone-L, PoMaxa, or ReFine 3.5WSG)	+++	—	8–32 fl oz	48	2	Temporarily suppress any fruit drop by applying 10 to 20 ppm (depending on variety) of NAA. A second application can be applied seven to 10 days later. See the Growth-Regulating Chemicals on page 79 for details.

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row volume of 400 gal/acre.

SECOND COVER AND LATER SPRAYS (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Plant Growth Regulators (continued)	Delay or reduce preharvest fruit drop or both. *(continued)*	ReTain plus NAA (Fruitone-L, PoMaxa, or ReFine 3.5WSG)	+++++	—	One 333 g pouch of ReTain plus 8–16 fl oz Fruitone L or PoMaxa per 100 gal per acre	12	7	Apply the ReTain plus NAA combination (plus adjuvant) as a tank-mix two weeks prior to the start of the normal harvest. This combination can provide improved fruit drop control and firmness retention compared to ReTain or NAA alone.
	Reduce fruit russeting in susceptible varieties.	ProVide 10SG Novagib 10L (continue applications started at petal fall)	++++ ++++	2.1–3.5 fl oz (60–100 g)	20 oz per acre/appl.	4 4	0	See the Growth-Regulating Chemicals on page 79 for recommendation details.
	Reduce fruit cracking of susceptible varieties (e.g., Stayman).	Pro-Vide 10SG	+++	3.5–7.0 fl oz (100–200 g)	—	4	0	Make the first application at least two to three weeks before fruit cracking is likely to be observed in the orchard. Repeat at 14- to 21-day intervals until harvest. See Growth-Regulating Chemicals on page 79 for details. Do not apply to trees that received ProVide applications for russet suppression.
		Novagib 10L	+++	—	2–4 pt per acre/appl.	4		
	Promote lateral branching of current season's growth.	Promalin	+++	0.8 oz/gal of water (125 ppm)		12	None	See Growth-Regulating Chemicals on page 79 for recommendation details.

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row volume of 400 gal/acre.

SECOND COVER AND LATER SPRAYS (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management	Control summer diseases (white rot, black rot, sooty blotch, flyspeck, black pox). (*continued on next page*)	Scout orchard.	*****	—	—	—	—	Apply cover sprays at 10- to 14-day intervals. Use a seven- to 10-day interval during wet, rainy periods. Be sure to observe 77-day preharvest interval when using metiram or mancozeb. Use captan where there is a history of white rot.
		Prune out fire blight strikes.	*****	—	—	—	—	
		Fungicides		—				
		Captan 50W (FRAC M4)	++++		8 lb	24	0	
		Captan 4L (FRAC M4)	++++		2–4 qt	24	0	
		Captan 80WDG (FRAC M4)	++++		2.5–5 lb	24	0	
		Ziram 76DF (FRAC M3)	++++	—	3–6 lb	48	14	
		Sovran 50WG (FRAC 11)	++++	—	4–6.4 oz	12	30	A maximum of four applications and 25.6 oz of Sovran 50WG can be used per acre per season. It is weak on black pox.
		Flint Extra (FRAC 11)	+++++	—	2.5–2.9 fl oz	12	14	A maximum of four applications of Flint Extra or any FRAC 11 fungicide can be used per acre per season. For optimal control of white rot, tank-mix with captan. Flint is weak on black pox.
		Pristine (FRAC 11)	+++++	—	14.5–18 oz	12	0	A maximum of four applications and 72 oz of Pristine can be used per acre per season. It is weak on black pox.
		Thiophanate Methyl 85WDG	+++++		0.6–0.8 lb	48	1	—
		Topsin 4.5FL	+++++	—	15–20 fl oz	48	1	
		Topsin M WSB (FRAC 1)	+++++		0.75–1 lb	48	1	
		Captan 80WDG		—	3.75–5 lb	24	0	—
		+						
		ProPhyt[3] (FRAC M4 + P7)	++++		4 pt	4	0	
		Aprovia (FRAC 7)	++++	—	5.5–7 fl oz	12	30	Aprovia is not as effective as FRAC group 11 containing fungicides for controlling bitter rot.
		Cevya (FRAC 3)	++++	—	4–5 fl oz	12	0	Cevya will not control Glomerella leaf spot or bitter rot. Be sure to tank mix with EBDC or captan.

SECOND COVER AND LATER SPRAYS (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2]		Re-entry Interval (hours)	Preharv. Interval (days)	Comments
				100 gal	Acre			
Disease Management (continued)	Control summer diseases *(continued).*	Luna Sensation (FRAC 7 + 11)	++++	—	4–5.8 fl oz	12	14	Apply Luna Sensation in tank mixture with captan for optimal control of white rot.
		Merivon (FRAC 7 + 11)	+++++	—	4–5.5 fl oz	12	0	—
	Control *Colletotrichum* pathogens: Glomerella leaf spot, leaf rot, and bitter rot.	Refer to fungicides used for Petal Fall and first cover applications.	—	—	—	—	—	—
	Suppress necrotic leaf blotch on Golden Delicious.	Ziram 76DF (FRAC M3) zinc oxide 39.8%	+++++ +++++	—	6 lb 1 pt	48 0	14 0	Sprays from mid-June through early August are most important.
	Control powdery mildew.	Scout orchard.	*****	—	—	—	—	Need for additional fungicides is based on the number of infections on newly unfolded leaves and continued growth pressure. See recommendations for petal fall if powdery mildew is present.
	Control Alternaria blotch.	Pristine (FRAC 7 + 11)	+++++	—	14.5–18.5 oz	12	0	Make first application of Pristine around third or fourth cover (mid-June). Apply two additional applications at 10- to 14-day intervals. These applications will also control other summer diseases on Delicious. Rotations of Pristine and captan plus a phosphite fungicide are also effective and will help limit QoI fungicide use since only four applications are allowed by the label. Use in conjunction with a preventive mite management program. Do not make more than four applications or apply more than 72 oz of Pristine per season.
		Merivon (FRAC 7 + 11)	+++++	—	4–5.5 fl oz	12	0	
		Luna Sensation (FRAC 7 + 11)	+++++	—	4–5.8 fl oz	12	14	

SECOND COVER AND LATER SPRAYS (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management	Control blister spot.	Fungicides Aliette WDG Phostrol	 ++++ ++++	 0.5–1 gal	 2.5–5 pt	 12 4	 14 0	Fruit are most susceptible to blister spot two to eight weeks following petal fall.
Insect Management	Control codling moth and oriental fruit moth.	Monitor pheromone traps weekly for adult activity.	*****	—	—	—	—	See the IPM Practices section for codling moth (page 38) and oriental fruit moth (page 40) to determine the need for and timing of insecticide sprays. Keep trap bottoms clean, and replace lures at recommended intervals. The need for insecticides against codling moth should be based on pheromone trap captures and the degree-day model. In orchards where mating disruption for codling moth and OFM is not being used, sprays of CheckMate OFM-F are recommended for late-season control (August to September) of OFM. OFM populations often increase during August and September in apples.
		Insecticides (See First Cover)	*****	—	—	—	—	
		OFM Mating Disruption CheckMate OFM-F	++++	—	1–2 oz	—	—	
	Control tufted apple bud moth. *(continued on next page)*	Monitor pheromone traps weekly for adult activity.	*****	—	—	—	—	See the IPM Practices section for tufted apple bud moth (page 40) to determine the proper timing of insecticide applications.
		Thin fruit to avoid excessive clustering.	****	—	—	—	—	Clustering of fruit is conducive to higher levels of tufted apple bud moth injury.
		Insecticides Intrepid Delegate 25WG Altacor 35WDG Exirel 0.83SE Verdepryn 100SL	 +++++ +++++ +++++ +++++ +++++	 — — — — —	 6–10 oz 4.5–6 oz 2.5–3 oz 8.5–17 oz 5.5–11 oz	 4 4 4 12 4	 14 7 5 3 7	Insecticide sprays for TABM are recommended only in orchards with a history of damage. See the IPM Practices section for TABM (page 40) to properly time sprays. This spray often overlaps with the need for sprays of first-generation codling moth.

SECOND COVER AND LATER SPRAYS (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Insect Management (continued)	Control tufted apple bud moth. (*continued*)	*Bacillus thuringiensis* Dipel 2X CryMax XenTari	+++	— 	 1–2 lb 1–2 lb 1–2 lb	 4 4 4	 0 0 0	For best results apply *Bacillus thuringiensis* (*Bt*) products at no less than 2x concentration. **If using *Bt*s, it is important to monitor codling moth with pheromone traps because *Bt*s do not control CM.**
	Control apple maggot.	Erect red sticky spheres in early June to monitor adults.	****	—	—	—	—	Erect sticky traps baited with fruit essence lures on outside rows near abandoned orchards or other sources of flies. Check weekly. Threshold level is a cumulative of five flies per trap. If the threshold is exceeded two weeks after spraying, apply again. Adults can emerge from June through September. Historically, peak emergence is generally from late July to early August.
		<u>Insecticides</u> Imidan 70WP Admire 4.6SC Assail 30SG Surround WP Pyrethroids (see efficacy table)	 +++++ ++++ +++ +++ ++++	 0.75 lb — — — —	 3 lb 2.8 oz 8 oz 20–50 lb	 24 12 12 4	 7 7 7 —	Apply Surround at seven- to 14-day intervals, or after a heavy rain, because thorough, uniform, and consistent coverage is important. Rate of Surround will vary with tree size, and frequency of application will vary with rainfall.
	Control white apple leafhopper or potato leafhopper.	<u>Insecticides</u> Actara 25WDG Admire 4.6SC Assail 30SG Closer Sivanto Prime 200SL	 +++++ +++++ +++++ +++++ +++++	 — — — — —	 2–2.75 oz 2.8 oz 2.5–4 oz 1.5–2.75 oz 7–10 oz	 12 12 12 12 4	 14 7 7 7 14	Threshold level for second brood white apple leafhopper nymphs (which occur in late July to early August) is one nymph per leaf. Treatment will eliminate the need to treat for adults immediately before harvest. The need for late-season leafhopper control has declined in recent years.

SECOND COVER AND LATER SPRAYS (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Insect Management	Control brown stink bugs, including brown marmorated stink bug.	Insecticides						Brown marmorated stink bug is established throughout apple production areas in North Carolina, South Carolina, and Tennessee, but is most problematic at higher elevations (>1,000 ft). Problems are most intense from July to September.
		Actara 25 WDG	+++++		4.5–5.5 oz	12	35	
		Belay SC	++++		4–6 fl oz	12	7	
		Brigade 2EC	+++++		2.6–6.0 fl oz	12	14	
		Baythroid XL	+++++		2–2.4 oz	12	7	
		Danitol 2.4EC	++++		16–21 fl oz	24	14	
		Warrior 2.08CS	++++		1.28–2.56 fl oz	24	21	
		Mixtures						See Table 11, Relative Effectiveness of Insecticides and Miticides on page 54 for spectrum of insects controlled with mixture products. *Check with local Extension agent for Section 18 labels approved for BMSB.
		Endigo ZC	++++		5–6 fl oz	24	35	
		Besiege ZC	++++		6–12 fl oz	21	21	
		Voliam Flexi	++++		6 oz	12	35	
		Leverage 2.7SE	++++		3.6–4.4 fl oz	12	7	
	Control spotted tentiform leafminer.	Insecticides						Leafminers have become a rare occurrence in the past decade. A threshold level of two mines per leaf for second-generation larvae (June to July), or four mines per leaf for third generation (August), should be used to dictate the need for STLM control.
		Delegate WG	+++++	—	4.5–7 oz	4	7	
		Intrepid 2F	+++++	—	8–12 fl oz	12	14	
	Control green apple and spirea aphids, white apple leafhopper or potato leafhopper.	Insecticides						Threshold level for green apple aphid is 50% infested terminals, and for white apple leafhopper it is one nymph per leaf. Control is most important on young trees and in dwarf plantings. On mature trees, higher populations are tolerable. Biological control can often preclude the need for chemical control of aphids.
		Admire 4.6SC	+++++	—	2.8 oz	12	7	
		Actara 25WDG	+++++	—	4.5 oz	12	35	
		Assail 30SG	+++++	—	2.5–4.0 oz	12	7	
		Belay	+++++	—	4–6 fl oz	12	7	
		Sivanto Prime 200SL	+++++	—	7–10 oz	4	14	
		Closer SC	+++++	—	1.5–2.75 oz	12	7	
		Versys DC	+++++	—	1.5 oz	12	7	
	Control Comstock mealybug.	Insecticides						Applications should be made near the second or third cover spray. Comstock mealybug is an unpredictable pest, and orchards with a history of problems are most susceptible.
		Diazinon 50WP	+++++	1 lb	4 lb	96	21	
		Actara 25WDG	+++	—	4.5 oz	12	35	
		Assail 30SG	+++++	—	4–8 oz	12	7	
		Movento 2SC	+++	—	6–9 fl oz	24	7	

SECOND COVER AND LATER SPRAYS (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Insect Management	Control woolly apple aphid.	Insecticides Diazinon 50WP Movento 2SC Closer 2SC Versys DC	 +++++ ++++ +++ +++	 1 lb — — —	 4 lb 6–9 fl oz 2.75–5.75 oz 3.5 oz	 24 12 12 12	 21 7 7 7	Woolly apple aphid control can be difficult if insecticides are applied after populations reach large densities. Use a threshold of about 10% infested shoots. Movento applications need to be preventive in May or June for best results. Also, use a penetrating adjuvant with Movento.
	Control redbanded leafroller and other leafroller species.	Insecticides See insecticides for tufted apple bud moth.	—	—	—	—	—	Redbanded leafroller is a sporadic problem. If damage is done, it is usually by the last generation, which lays eggs from mid-August to mid-September.
	Control dogwood borer.	Insecticides Assail 30SG	 +++	 8 oz	—	12	7	Dogwood borer control is not recommended unless damaging populations have built in an orchard. Control with insecticides can be difficult. Assail targets adults to reduce egg laying and should be applied two or three times at 14-day intervals beginning in mid to late June, depending on location.
	Control European red mite and twospotted spider mite.	Monitor trees for mite activity.	*****	—	—	—	—	**See IPM practices for European red mite (page 44).** European red mite and twospotted spider mite threshold levels before July are 7 mites per leaf (85% infested leaves) and 10 mites per leaf (90% infested leaves) during July and August. If populations are near threshold level, check for predatory mites in three to four days to determine if biological control reduces mite populations. In orchards with Alternaria blotch, a threshold of one mite per leaf (50% infested leaves) should be used to minimize stress to trees.

SECOND COVER AND LATER SPRAYS (continued)

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Insect Management	Control European red mite and twospotted spider mite.	<u>Miticides</u>						
		Acramite 50WS	+++++	—	0.75–1.0 lb	12	7	If Apollo or Savey was used at petal fall, do not reapply at this time. Do not expect complete control with a single application of oil or sulfur; these materials must be applied multiple times for best results. Applying a highly refined summer oil when mite populations are beginning to increase (first and second covers) will help suppress European red mite infestations. **Do not apply captan two weeks before or after an oil spray.**
		Nexter 75WP	++++	—	4.4 oz	12	25	
		Portal 0.4EC	++++	—	1–2 pt	12	14	
		Apollo SC	++++	—	4 oz	12	45	
		Savey 50DF	++++	—	3 oz	12	28	
		Zeal 72WDG	+++++	—	2–3 oz	12	28	
		Envidor 2SC	+++++	—	16–18 oz	12	14	
		Kanemite 15SC	+++++	—	21–21 fl oz	12	14	
		Nealta 1.67SC	+++++	—	13.7 oz	12	7	
		wettable sulfur	+	1.5–3.5 lb	5–15 lb	12	7	
		summer oil	++	0.5–1.0 gal	0.5–1.0% soln	12	0	
Weed Management	Spot-treat with herbicide to control difficult-to-manage perennial weeds.	glyphosate	***** ++++	See Tables 14 and 15, Weed Response to Herbicide, on page 58.		4	1	Apple trees are especially sensitive to glyphosate applied in late summer and fall. Avoid contacting tree bark and especially foliage.
	bermudagrass control.	Poast	***** ++++	—	1.5 pt followed by 1 pt	12	14	Apply when bermudagrass has 4 to 6 inches of new growth in spring. Follow with a second application when bermudagrass has 4 inches of regrowth.

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.
[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row volume of 400 gal/acre.

POSTHARVEST

Category	Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Amount per[2] 100 gal	Amount per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Plant Growth Regulators	Control fruit storage scald.	DPA	++++	2.5 pt per one gal of water as a dip or spray to harvested fruit.		—	—	See the Growth-Regulating Chemicals on page 79 for complete details.
	To maintain apple flesh firmness, fruit acidity and minimize scald.	SmartFresh	++++	—		—	—	See the Growth-Regulating Chemicals on page 79 for complete details.
Weed Management	Apply POST or PRE + POST herbicide.	See herbicide guide.	***	See herbicide guide.		See product labels.		In areas where heavy populations of winter annual weeds are present, apply herbicide as part of vole management program. Application of a fall pre-emergence herbicide will delay the spring herbicide application to early May or later.

[1]Effectiveness ratings range from + = poor control to +++++ = excellent control. Importance ratings range from * = minor importance to ***** = very important.

[2]Rates expressed as amount per 100 gal for dilute and amount per acre are for concentrate applications based on a tree-row-volume of 400 gal/acre.

Tree Row Volume (TRV): A Model for Determining Spray Volume

The TRV model is a simple and objective method of determining (1) the volume of tree canopy on an acre of orchard, regardless of row spacing, tree size, age, or other factors; and (2) the dilute application water rate and chemical quantity for dilute (1×) applications or concentrate chemical load per acre needed to effectively spray each particular orchard, regardless of pruning and tree canopy density.

The TRV concept rests on these assumptions: each row of trees is a wall of foliage, and water and chemical loads required can be related to the volume and density of foliage within that wall. Only three measurements must be made: (1) the distance between rows of trees; (2) the maximum tree height to be sprayed; and (3) the spread from drip line to drip line, which must be accurately measured to at least the nearest foot. In addition, an assessment of tree density is needed to calculate the TRV of an orchard.

Using these measurements, the TRV of any orchard can be calculated using the following formula:

Step 1: $\dfrac{\textit{43,560 sq ft per acre}}{\textit{distance between rows (ft)}} = \textit{feet of row per acre}$

Step 2: *feet of row per acre (from Step 1)*

× *tree height (ft)*

× *cross-limb spread (ft)*

= *cu ft of foliage per acre.*

Steps 1 and 2 determine the volume of foliage canopy per acre in the orchard.

Step 3: Select the number from Table 1 (below) that best indicates the canopy density of each separate orchard or block.

The cubic feet of foliage volume from Step 2 and the tree density established in Step 3 are used to calculate the water volume required per acre for a dilute spray application to provide *maximum* chemical load with a dilute airblast sprayer (applied to runoff).

Step 4: $\dfrac{\textit{cu ft of foliage per acre (from Step 2)} \times \textit{canopy density (from Step 3)}}{\textit{1,000 cu ft}} = \textit{gallons of dilute solution to be applied per acre for a maximum application}$

Example:

Consider an orchard that has rows spaced 25 feet apart, trees 20 feet high, a spread of 17 feet from drip line to drip line, and a tree density of 0.85.

Step 1: $\dfrac{43{,}560 \text{ sq ft}}{25 \text{ ft}} = 1{,}742.4 \text{ ft}$

Step 2: $1{,}742.4 \text{ ft} \times 20 \text{ ft} \times 17 \text{ ft} = 592{,}416 \text{ cu ft}$

Step 3: Density has been given as 0.85 gal/1,000 cu ft

Step 4: $\dfrac{592{,}416 \text{ cu ft} \times 0.85 \text{ gal}}{1{,}000 \text{ cu ft}} =$ 503.5 gal per acre will apply a dilute application to runoff

However, general pesticide applications are not applied to runoff. Using 70% (0.70) of the "to runoff" calculated rate reduces the dilute application just to the point of drip, or what we call "pesticide dilute." Table 2 gives the *adjustments* to the "TRV-calculated water rates for dilute to runoff" water application rate for various chemicals used and types of spray applications. The 503.5 gallons per acre in the example above is used to illustrate the adjustments in Table 2.

Table 3 demonstrates how the chemical load and water volume for concentrate sprays can be easily calculated from the TRV model.

Table 1. Canopy density adjustments in tree row volume (TRV) model.

0.70 gal/1,000 cu ft	Trees extremely open, light visible through entire tree, less than 15 scaffold limbs per tree or young tree.
0.75 gal/1,000 cu ft	Trees very open, 18 to 21 scaffolds per tree, light penetration throughout tree, healthy spurs in tree canopy.
0.80 gal/1,000 cu ft	Trees well pruned, adequate light in trees for healthy spurs throughout trunk and scaffold limbs, many holes or openings in foliage where light is visible through tree.
0.85 gal/1,000 cu ft	Trees moderately well pruned, reasonable spur population within canopy, tree thick enough that light is not visible through bottom 2/3 of tree.
0.90 gal/1,000 cu ft	Trees pruned minimally, spurs inside canopy are weak due to limited light, very few openings where light is visible throughout the tree.
0.95 gal/1,000 cu ft	Little or no pruning, spurs dead or very weak in canopy, very little light visible throughout the tree.
1.00 gal/1,000 cu ft	Tree unpruned, extremely thick, no light visible anywhere through tree canopy, trees more than 20 ft high.

Table 2. Adjustments in TRV-calculated water rates per acre for various chemicals and spray applications.

Type of spray and chemical application	% of the calculated TRV dilute to runoff gallonage to be used for a dilute application	Actual gallons/acre to be used in previous TRV example orchard
[1]Pre-petal fall dilute pesticide application (adjusted because of incomplete foliage development).	56	282
Dilute pesticide application (from petal fall on and all other applications not specifically mentioned).	70	352
ProVide and Promalin (as a fine mist).	40 to 50	201 to 252
Spur Red Delicious thinners and dormant oil applications.	100	504
Thinners for other varieties.	70 to 90	352 to 453
Vegetative growth inhibitor.	80 to 90	403 to 453
Preharvest Ethrel plus stop-drop spray.	100 to 120	504 to 605

[1] To use this reduced gallonage requires accurate nozzling to top of trees and good air displacement within trees (i.e., reduced tractor speed).

The TRV model is accurate for dilute and concentrate chemical applications with conventional airblast sprayers, using water volumes as low as 150 gallons per acre. Below this gallonage, the physics of droplet size and impingement on the foliage can become a limiting factor in obtaining effective deposition on trees. Thus, if the TRV model calculates a water application rate of less than 150 gallons per acre, a 150- to 200- gallon rate should be considered a minimum in a conventional airblast sprayer, or be sure you are using a concentrate engineered sprayer (higher air speed) that will ensure adequate impingement of the spray solution on the tree surfaces at low water volume.

Table 3. How to calculate concentrate application rates.

Concentrate pesticide application (3× water rate)[1]	$\frac{\text{Dilute Pesticide TRV gallonage}}{\text{Concentrate rate}} = \frac{352 \text{ gal/acre}}{3\times} =$ **117 gal/acre**
Concentrate pesticide chemical load per acre (2× to 4×)[2]	$\frac{\text{Rate of pesticide per 100 gal} \times \text{Dilute pesticide TRV gal per acre}}{100 \text{ gal}} = \frac{2.0 \times 352}{100} =$ **7.1 lb/acre**
5× or greater[3]	$\frac{\text{Rate of pesticide per 100 gal} \times \text{Dilute pesticide TRV gal per acre} \times 0.8}{100 \text{ gal}} = \frac{2.0 \times 352 \times 0.8}{100} =$ **5.6 lb/acre**

[1]Assume the example orchard was to be sprayed at 3× concentration.
[2]Rate per 100 gal dilute. Example based on 2.0 lb pesticide/100 gal.
[3]This adjustment for concentrate application (5× or greater) should be made if spraying conditions are good and trees are properly matched to the sprayer. Adequate spray coverage cannot be assumed with concentrate application if sprays are applied during windy conditions or to thick, oversized trees.

Dwarf High-Density Orchards

Dwarf high-density orchards represent a special situation for TRV applications. Most high-density orchard TRV water application rates calculate out at well below the minimum desirable gallonage for good droplet impingement (below 150 gallons/acre). We have consistently found improved efficacy of pesticide application and improved time efficiency by calibrating for double the TRV. This raises the water application rate above the minimum desirable gallonage, after which you must drive every other row middle to reduce actual water volume per acre of orchard back to true TRV-calculated rate. Pesticides are applied on a normal interval, alternating drive middles.

The reality of sprayer calibration and nozzling for chemical applications is that until the proper chemical load is *appropriately* delivered and deposited on leaf and fruit surfaces, the spray you apply cannot be considered an effective pesticide application.

Plum Curculio

Adults overwinter in leaf litter in and around orchards. In the spring when the daily maximum temperature exceeds 70°F, adults emerge, mate, and lay eggs under fruit skin. Adults generally begin to enter orchards shortly before bloom, with most adults present by the end of petal fall. Depending on weather conditions and locations, new adults can continue to enter up to the first cover spray. Damage is observed as feeding or oviposition scars and is cosmetic. Larval development can occur in apples that drop off the tree but generally do not survive in apples attached to trees. Plum curculio adults are ¼-inch-long weevils with a curved snout; they are mottled black, gray, and brown with two bumps on each wing cover and a white marking across the back. The mature larva is ¼-inch long, white, slightly curved, and legless. First-generation adults usually emerge about eight to 10 weeks later: late June or July, depending on location. These adults will also feed on and damage fruit. Although plum curculio is capable of completing two generations per year in many southeastern locations, in most years only one is completed.

Scouting and Control: Plum curculio is very difficult to monitor, because traps are inconsistent and adults are difficult to observe and readily drop from trees when disturbed. After bloom, check twice weekly for plum curculio adults, feeding damage, and egg-laying scars. Typically, an insecticide at petal fall is sufficient for control, but occasionally emergence may be protracted under high population densities or cool conditions, necessitating a second application at first cover. A model developed in New York that predicts damage to apples by first-generation adults is based on accumulating degree-days (50°F base; use codling moth degree-day table below) beginning at petal fall (90 % of petals fallen) of 'Delicious' apples. The model predicts that insecticidal control is no longer necessary after 310 degree-days have accumulated from petal fall. First-generation adults emerge and can feed on apples from late June through July, depending on location. First-generation adult damage is negligible when adequately controlled at petal fall.

Apple Maggot

The apple maggot usually completes one generation per season, although a partial second generation can occur in certain years, particularly at elevations below 1,200 feet. Adult fly emergence from overwintering pupae in the soil is unpredictable and can occur from June through August, but the peak emergence is usually between mid-July and early August. About seven days after emergence, flies become sexually mature and mate, after which females deposit eggs under the skin of apples by puncturing them with their ovipositor. After a few days, a small maggot hatches from the egg and the maggot tunnels within the fruit, resulting in internal decay along the tunnels. When mature, the maggot exits the apple, drops to the ground, and burrows into the soil, where it completes development and forms a pupa. The pupa is the overwintering stage, and it emerges as a fly the following summer. If fly emergence is early in the season, some of their progeny emerge the same season rather than overwinter. In addition, a small percentage of flies may not emerge until two to four years later.

Weather conditions are important in dictating the timing and length of fly emergence. Pupae that are overwintering in lighter soils and in sunny areas emerge before those in heavier soils and shady areas. Sufficient soil moisture is also necessary for flies to emerge from soil-borne pupae. Drought delays or prevents many flies from emerging. Also, abandoned orchards (or even a few non-sprayed trees) and wild hawthorn trees adjacent to apples are potential sources of flies, and are a threat to commercial orchards located within a distance of about 400 yards.

Monitoring and Control: Monitor flies with red sticky spheres that are baited with a fruit essence lure. Baited spheres catch two to four times as many adults as non-baited spheres. In orchards with no history of maggot injury, a minimum of three red spheres should be placed on the outside row of an orchard closest to the suspected source of flies (e.g., an abandoned orchard). Hang spheres in trees with fruit, and remove fruit within 18 inches of the sphere so that the sphere is highly visible to flies. In orchards with a history of damage, traps can also be placed in the interior of orchards on the southern side of trees. When using baited spheres, apply an insecticide after catching five flies cumulatively. Repeat an application at 10- to 14-day intervals if captures again reach five flies. Although the timing of emergence can vary from year-to-year, the critical timing for insecticidal control in most years is late July to early August.

Brown Marmorated Stink Bug

The brown marmorated stink bug (BMSB) is an invasive pest native to Asia that has been a pest of apples in the Southeast since about 2015. Populations vary among production regions in the southeast. As of 2020, they posed the greatest threat in mountainous and piedmont regions of North Carolina, South Carolina, Georgia, Tennessee, and northern Alabama. In North Carolina,

most overwintering adults emerge in April and May, with the bulk of egg laying occurring from mid to late May through July, although egg laying can extend into August in some areas. Many of the eggs are laid in non-managed wooded areas, which offer nymphs a diversity of hosts for development. Some egg laying may also occur in apple orchards. In years when there is a high overwintering adult population, an insecticide may be necessary during peak egg laying of the overwintering generation, which coincides with about 300 DD (°C, lower and upper threshold temperatures of 14.2 and 35.6°C, respectively) after biofix (April 4). In North Carolina, this usually occurs near the second cover spray. BMSB reproduction and survival declines at high temperatures (>90°F), so extended periods of high temperatures will suppress population development, especially during key reproduction times in June and July.

First-generation adults, which develop from those nymphs hatching from eggs laid in May and June, begin to emerge anywhere from July to early August, depending on location. Early July emergence occurs in lower-elevation orchards such as the piedmont (about 1,000-ft elevation), and early to mid-August emergence occurs at higher-elevation (>1,800 feet) mountainous areas. First-generation adult emergence begins at about 700 DD from biofix (April 4) and continues through about 1,200 DD (°C). First-generation adults are the major cause of damage and should be targeted with insecticide sprays. Depending on the timing emergence, anywhere from one to three applications at seven- to 10-day intervals may be necessary.

Pheromone lures are available for monitoring BMSB. Several trap types are available, but sticky panel traps are easiest to use. Development of pheromone trap thresholds has been difficult to establish, but trap captures can provide estimates of local population abundance. Later-maturing cultivars harvested in September and especially October are most susceptible to damage, while early cultivars such as Ginger Gold and Gala rarely are affected.

Codling Moth

The codling moth (CM) begins to emerge and mate during April or early May, depending on location, and completes two generations. Depending on location and the year, a partial or complete third generation may occur, most commonly at elevations below about 1,000 feet. Eggs generally begin to hatch near the first cover spray, and larvae soon tunnel into and feed inside fruit. The mature larvae are similar to oriental fruit moth larvae, being ½-inch long and pinkish white with legs. Unlike the oriental fruit moth, CM larvae do not have an anal comb.

The codling moth can be a serious problem in orchards throughout the Southeast. Factors associated with problem orchards are (1) bin piles stored near orchards; (2) abandoned or poorly managed orchards; and (3) insecticide-resistant populations. Bins are an ideal environment for overwintering larvae and, when they complete their development the following spring, the adults disperse to nearby orchards. Orchards within 100 to 150 yards of bin piles or abandoned orchards are particularly prone to infestation. Insecticide resistance has been detected in a number of orchards where problems have persisted for one or two years.

Codling Moth Degree-Day Model

The CM DD model is used to predict adult emergence and egg hatch of each of the two to three generations that occur each year. The model has been in existence for more than 30 years and was recently modified to more accurately reflect southeastern populations. However, the model may not be accurate where moths emerging from nearby bins are a primary source of codling moth, because these individuals usually emerge later than those in natural habitats.

Base a decision to spray insecticides against codling moth on pheromone trapping and the codling moth degree-day model. Use pheromone traps to determine the starting point of the model (**biofix**) and to gauge the intensity of populations. The DD model predicts the percentage of adult emergence and egg hatch for each of the two to three generations of codling moth that annually occur in the Southeast. The model is quite accurate for the first generation but is less accurate for each successive generation.

To use the model, begin to accumulate DDs when male flight begins in the spring (i.e., biofix). The biofix date is determined with pheromone traps to detect the first sustained catch of two or more moths in the spring. Traps should be placed in orchards near the tight cluster stage of bud development and checked one to two times per week. Hang traps at a density of one trap per 10 acres of orchard. Traps hung in the upper third of the canopy catch more moths than those in the lower canopy and are a preferred location. Once biofix is determined, DD are calculated daily using upper- and lower threshold temperatures of 88 and 50°F, respectively. It is only necessary to check traps once per week after biofix is determined. There are several online sources to calculate DD for codling moth as well other key pests, such as oriental fruit moth and tufted apple bud moth.

These sources use real-time temperatures by accessing temperature data from weather stations across the country, so choose a weather station nearest your orchard. Two commonly used sources are:

NC State University Pest Risk site: **agroclimatenc.ncsu.edu/apple/pestrisk.aspx**.

NY State IPM NEWA: **cals.cornell.edu/new-york-state-integrated-pest-management/risk-assessment/newa**

First-Generation CM: Recommendations are provided for low- and moderate-to-high population densities. Low-density orchards are those where less than 0.2% of fruit were damaged the previous year and pheromone trap catches do not exceed one to two moths per trap per week anytime during the first generation (up to about 1,000 DD after biofix). Under these conditions, a single application at 350 DD after biofix is sufficient.

In moderate- to high-density orchards, apply two insecticide applications at 14 to 21 days apart, the first at 100 to 250 DDs after biofix: 100 to 150 if using a product that depends primarily on ovicidal activity for control (i.e., Intrepid or Rimon), and 250 if using other insecticides that target early stage larvae. Additional applications may be necessary if trap captures remain high (greater than seven moths per trap).

A second emergence of overwintering adults sometimes occurs between 500 and 800 DDs after biofix. This is often referred to as the "B peak" and may be associated with insecticide-resistant individuals in the population. Hence, pheromone trapping is important throughout the flight period.

Second-Generation CM: Recommendations are provided for extremely low-, low-, and moderate-to-high population densities. Extremely low-density orchards may not require an insecticide application (no first-generation damage is observed and pheromone trap catches remain below one moth per trap per week between 1,000 and 2,500 DD after biofix). Low-density orchards require one insecticide application, and recent research indicates the optimum timing is 1,400 to 1,500 DD. These orchards may have no sign of damage by first-generation larvae and trap catches between three to five moths per trap per week between 1,000 to 1,500 DD after biofix. Moderate- to high-density orchards will have fruit damage and higher pheromone trap catches requiring at least two insecticide applications at 14-day intervals, starting about 1,400 DD after biofix, and additional applications if trap captures remain greater than five to seven moths per trap per week.

Third Generation CM: The model should not be relied upon alone for timing insecticide applications for the third generation as the model becomes less accurate over time.

Exceptions to the Model: Where CM populations are extremely high and where pheromone trap catches remain high between generations, additional insecticide applications at shorter intervals may be necessary. This often occurs in orchards adjacent to abandoned orchards, orchards near bins, or in problem orchards with high populations.

Degree-day accumulations using temperatures from weather stations operated by the State Climate Office of North Carolina are available at agroclimatenc.ncsu.edu/apple/pestrisk.aspx. Using this model will require users to choose a weather station location (from a dropdown menu) and insert the biofix date for their orchards.

Table 4. Relationship between degree-day accumulations from biofix and percentages of codling moth adult emergence and egg hatch.

Cumulative Degree Days	% Adult Emergence	% Egg Hatch
0 (Biofix)	5	0
1	10	0
50	13	0
100	17	0
150	22	0
200	29	0
250	36	0
300	43	0
350	52	3
400	60	8
450	67	12
500	74	22
550	80	30
600	84	36
650	88	42
700	91	54
750	93	62
800	95	64
850	96	67
900	97	73
950	98	81
1,000	99	92
1,050	10	100
1,100	12	1
1,150	15	1
1,200	19	2
1,250	23	3
1,300	28	4
1,350	33	5
1,400	39	8
1,450	45	11
1,500	51	15
1,550	57	20
1,600	63	24
1,650	69	29

Cumulative Degree Days	% Adult Emergence	% Egg Hatch
1,700	74	35
1,750	78	38
1,800	82	48
1,850	86	64
1,900	88	65
1,950	91	68
2,000	93	71
2,050	94	73
2,100	95	75
2,150	96	78
2,200	97	81
2,250	98	84
2,300	98	84
2,350	99	85
2,400	99	90
2,500	10	95
2,550	15	98
2,600	20	99
2,650	25	100

Oriental Fruit Moth

Oriental fruit moths (OFMs) begin to emerge and mate before apple bloom, and eggs begin to hatch at petal fall. Variable spring temperatures cause erratic emergence and egg-laying by first-generation moths. The larvae feed on shoot tips and inside apple fruit. The mature larva is ½-inch long, pinkish-white, and has an anal comb and legs. The only way to distinguish between oriental fruit moth and codling moth larvae is to use a hand lens to examine mature larvae for the presence of an anal comb. Codling moth larvae do not have an anal comb.

Oriental Fruit Moth Degree-Day Model

Base a decision to spray insecticides against OFM on pheromone trap catches and a DD model. The model biofix is determined in the same manner as for the codling moth. Use pheromone traps to determine the starting point of the model and to gauge the intensity of populations. The DD model predicts adult emergence and egg hatch for the first three of the four or five generations that occur in the Southeast. However, generations overlap later in the season, which makes the DD model less useful at this time. The upper and lower development threshold for calculating OFM DD are 45° and 91°F, respectively. Place traps in the orchards near the green-tip stage of bud development and check one to two times per week. Hang traps at eye level at a density of one trap per 10 acres of orchard. Check traps weekly after the biofix date.

First-Generation OFM: Control of the first generation is often important to prevent first-generation damage and to reduce populations of subsequent generations. First-generation egg laying is usually low on apple, and only one insecticide application between 400 and 500 DD after biofix is necessary, which usually coincides with petal fall.

Second-Generation OFM: If first-generation control was successful, second-generation populations are usually very low. Extremely low-density orchards may not require an insecticide application (pheromone trap catches never exceed three moths per trap per week between 800 to 1,600 DD). In low-density orchards (three to five moths per trap per week between 800 and 1,500 DD), make a single insecticide application at 1,400 DD. Moderate- to high-density orchards will have fruit damage, higher trap catches, or both, and may need two insecticide applications 14 days apart starting at 1,100 DD.

Third and Fourth Generations: The DD model becomes less useful beginning in July and August due to overlapping of generations. For this reason, rely on pheromone trap captures to determine the need for control measures. Use of a threshold level of seven moths per trap per week has worked well to minimize damage. In situations where consistently high trap captures occur, mating disruption should be considered (see below).

Tufted Apple Bud Moth

The tufted apple bud moth (TABM) is the most common leafroller occurring on apples in the Southeast. In the 1990s it was the most destructive insect pest of southeastern apples due to insecticide resistance, but populations have greatly reduced since the introduction of new insecticides in the early 2000s. TABM completes two generations per year, with egg laying occurring during June (first generation) and August and September (second generation). Larvae feed on leaves and fruit, with fruit damage usually observed as surface feeding. However, second-generation larvae may also be found feeding within the calyx end of fruit. Unless an individual orchard has a history of damage by this insect, it is doubtful that special precautions need to be taken. Timing is critical to the successful management of this pest. In most instances, one well-timed insecticide application per generation will provide high levels of control. Cultural controls are also important. Maintain a clean orchard floor, particularly in the early spring before bloom, to minimize TABM populations by removing the food source for overwintering larvae. New apple sucker growth and broadleaf weeds are important food sources in the spring. Thinning apples to breakup clusters of fruit also reduces damage.

Tufted Apple Bud Moth Degree-Day Model

A TABM DD model similar to that of the oriental fruit moth and codling moth was developed specifically for populations in the Southeast. The same upper- and lower-threshold temperatures (45° and 91°F) used for OFM are also used for TABM. Place TABM pheromone traps at the tight cluster to pink stage of bud development at a density of one trap per 20 acres of orchard. Biofix is the first date on which a sustained catch occurs and may vary from two to five moths per trap per week. The cumulative number of DDs from the point of biofix is used to predict the percentage of egg hatch and to time insecticide applications against the first generation.

First-Generation Recommendation: When population densities are sufficiently high, or if a short residual insecticide is used (i.e., Bacillus thuringiensis), two insecticide applications per generation may be necessary; make the first application at about 10% egg hatch, which occurs at about 800 DD after biofix, and the second application 14 days later. Where populations are low or if using a long residual insecticide (Intrepid, Delegate, Altacor), one application per generation should be made anytime between 10 and 30% egg hatch of the first generation, or from 800 to 1,200 DD after biofix.

Second-Generation Recommendation: Population densities of second-generation TABM have been low since the registration of highly effective new insecticides such as Altacor, Intrepid, Delegate, and Rimon. In fact, insecticidal control of the second generation has not been necessary in many orchards when one of these products was used against the first generation. An insecticide application is recommended only if pheromone trap captures exceed about 15 moths per trap by 2,600 DD after biofix (time of 10% egg hatch of the second generation). Control is most important on later maturing apples that are harvested after mid-September.

Mating Disruption

Mating disruption consists of emitting relatively large amounts of an insect's sex pheromone into an orchard environment to disrupt the normal mate-location process. Mating disruption prevents or reduces mating and the subsequent laying of fertile eggs, which effectively reduces populations below economically damaging levels. It is effective only in blocks of 5 acres or more. In apples, mating disruption is registered for codling moth and oriental fruit moth. Because of different mechanisms in how mating disruption affects oriental fruit moth versus the codling moth, OFM is much easier to control with mating disruption even under high population densities. For success with codling moth, population densities need to be relatively low to be effective. Mating disruption will not control infestations resulting from immigrating fertilized female moths; hence, **mating disruption alone is not recommended in blocks located adjacent to a likely source of immigrating moths** (such as abandoned orchards or bin storage areas).

Pheromone Dispensers: Several companies market pheromone dispensers for mating disruption, including hand-applied dispensers that emit pheromones for relatively long periods and sprayable products that last for shorter periods and need to be reapplied. Companies are now marketing dispensers containing both CM and OFM pheromones so that a single dispenser type can be used for mating disruption of both insects. Dispensers vary in the amount of pheromone they contain and the length of time during which pheromone is emitted, so read the label beforehand to ensure that dispensers are used properly. Because both codling moth and oriental fruit moth are potential pests in the Southeast, it is highly recommended that dual pheromone dispensers be used in apples.

Timing of Applications: Pheromone dispensers should be applied before adults begin to fly in the spring. OFMs begin to emerge about green tip, so dispenser application should be completed by the pink stage of bud development. If dispenser application is delayed beyond this point, an insecticide effective against OFM should be applied at petal fall. First emergence of codling moth begins during late bloom or petal fall of Delicious cultivars. Hence, dispenser application should be completed by petal fall. For best results, hang dispensers in the upper third of the canopy as this is where mating occurs.

If using sprayable pheromone for season-long OFM mating disruption, begin applications just before emergence of second-generation adults, which occurs about 950 DD after biofix. Sprayable OFM pheromone may also be used later in the season (August and September) in non-mating-disruption orchards. OFM often increases in numbers in August and September, and applications in mid-August and again in mid-September (late-maturing cultivars) are highly effective. The residual activity of sprayable pheromone is between three and four weeks, so applications should be made at four-week intervals.

Monitoring Insects: Monitoring codling moth and oriental fruit moth populations is of critical importance to measure the effectiveness of mating disruption and to determine the need for insecticides. Pheromone traps

should be used to monitor moth populations, and fruit should also be examined for damage at periodic intervals. When properly used, pheromone trapping can be useful to determine the need for insecticides under mating disruption orchards. Hang traps in the upper third of the canopy as that is where codling moth activity is most intense. Traps should be hung at a density of no less than one trap per five acres and checked at weekly intervals. Each week, the average capture per trap in an orchard should be calculated and weekly means should be added. When the cumulative total exceeds three moths per trap, a supplemental insecticide application is recommended. Threshold levels are based on using large delta-style traps and Trece CM L2 lures, which should be replaced at 12-week intervals.

The type of pheromone lure used in traps is also important. Some lures contain a pear ester kairomone that enhances capture of codling moth and may capture female moths, and are sold as CMDA (Combo). Other lures that contain additional attractants, such as codling moth pheromone and acetic acid, are also available for monitoring.

European Red Mite Management

Several beneficial arthropods can help keep European red mite (ERM) populations below damaging levels. The most common in the Southeast are the phytoseiid mite (*Amblyseius fallacis*) and a complex of generalist predators (such as lady beetles and lacewings). However, recent research in North Carolina suggests that neither of these predators overwinters to any significant degree within orchards, so they must be reestablished in orchards in the spring. Hence, practices that delay the buildup of ERM and enable predators to increase before mites become a problem will favor biological control. The two most effective practices are applying a delayed dormant oil spray and avoiding insecticides toxic to these predators.

Monitoring Mite Populations: Use a regular monitoring program to follow the buildup of mite populations and to determine if and when supplemental applications of a miticide are necessary to avoid economic damage. Monitor each contiguous block of apples weekly beginning when adult mites first appear (which may vary from mid-May to late June). Within each block, examine five leaves from each of 10 trees with a visor lens or hand lens. Rather than counting the total number of mites on each leaf, record the number of leaves infested with one or more mites, and estimate mite density from the table below.

Determining the Need for Miticides: When mite populations reach a density of five to 10 mites per leaf (80% to 90% infested leaves), decide whether to rely on biological control or apply a miticide to prevent mites from increasing to damaging levels. To gauge the potential for biological control with predator mite *A. fallacis*, count the number of predator mites on sample leaves with a visor lens. If the ratio of *A. fallacis* to ERM is between 1 to 5 and 1 to 15, biological control is possible. If predators are not present and mite populations are between five to 10 mites per leaf, apply a miticide.

Where Alternaria blotch is a problem on Delicious apples, biological control is usually not an option. Alternaria blotch in the presence of mite injury can lead to premature defoliation, so mite populations must be maintained at very low levels. If preventive control measures are not used, miticides should be used when mites reach one to two mites per leaf.

Table 5. Relationship between European red mite density per leaf and percentage of infested leaves.

% Mite-Infested Leaves (>1 mite/leaf)	Expected No. Mites per Leaf
40	0.7
45	0.9
50	1.1
55	1.3
60	1.6
65	2.0
70	2.6
75	3.4
80	4.7
85	6.8
90	11.4
95	26.4

Pesticide Resistance Management

General Considerations

Pesticide resistance is a shift in the genetics of a pest population that allows individuals within a previously susceptible population to survive. Resistant pest populations have inherited traits that reduce their susceptibility to individual pesticides or groups of pesticides. Resistance develops in all agricultural pest groups—insects, mites, fungi, bacteria, nematodes, and weeds. Pesticide-resistant individuals are initially quite rare in pest populations. However, when a new pesticide is first used, a very low number of individual pests never previously exposed to the novel chemistry can be expected to be resistant. The frequency of resistant genes to novel chemistries varies tremendously, but history makes it clear that resistant individuals should be expected in all pest groups. By the nature of the process, resistance most often develops to pesticides that are initially very effective and frequently used.

Pesticide resistance management is an effort to slow or prevent the development of resistance. It relies on pest management and pesticide-use strategies to prolong the effective life of pesticides. Resistance management is difficult, especially in high-value crops such as fruit, where high quality standards and limited numbers of registered pesticides make the task more challenging.

Managing resistance requires an understanding of the factors that influence its development. **Selection** is the process of pesticide-induced selection for resistance. With regular pesticide use, those rare individuals that are naturally resistant survive and reproduce more successfully than their susceptible peers. **Resistance frequency** refers to the proportion of a pest population that is resistant. **Cross-resistance** refers to a type of resistance in which a pest population develops resistance to more than one pesticide within a chemical family (such as organophosphate insecticides or strobilurinfungicides). **Multiple resistance** involves multiple, independent resistance mechanisms, which often lead to resistance to chemicals from different families (organophosphate and carbamate insecticides, dodine and DMI fungicides). **Resistance stability** is a key factor in managing resistance. Stability is an estimate of how well resistance persists in a pest population once the pesticide is no longer used. The rate of reversion to a susceptible state varies enormously. But when pesticide use ceases, selective pressure for resistance is removed, and over time resistance will often be reduced. Resistance stability estimates may allow limited use of resistance-prone compounds.

It is important to emphasize that control failures do not confirm resistance. Other factors (poor timing, sprayer calibration or coverage, wash-off, high pH in spray tank water, inappropriate materials, etc.) should be eliminated as causes for control failures before resistance is seriously considered. Factors influencing the development of resistance can be grouped into biological and management categories. **Biological factors** include pest reproductive rate, mobility of the pest species into and out of untreated areas, and genetic factors such as number of resistance mechanisms, resistance frequency and intensity, and resistance stability. **Management factors** that influence resistance development include how materials are applied, how often they are used, rate selection, how long they persist in the field, treatment thresholds, and strategies for using available pesticides. Resistance management efforts study specific pest-pesticide interactions and focus on practical strategies that growers can implement.

Pest management is practical and works in concert with pesticide-use strategies to lessen resistance selection by facilitating prudent, as-needed pesticide use. Pesticide-use strategies work best when implemented as a new pesticide comes into commerce. Pesticide manufacturers, IPM scientists, and growers have come to recognize that using resistance management from the beginning works best. Identifying baseline susceptibilities, defining resistance risk beforehand, and proposing pesticide-use strategies to slow down resistance development are the province of manufacturers and IPM scientists. Biologically and economically sound resistance management plans offered pre-sale give growers the best hope for managing resistance. Pesticide-use strategies are often grouped as follows: (1) management by moderation; (2) rotation and mixtures; and (3) saturation.

Moderation means limiting the use of a pesticide. Moderation is employed in concert with IPM practices, such as using treatment thresholds, spraying only specific pest generations or growth stages, maintaining unsprayed wild host reservoirs to act as refuges for genetically susceptible individuals, using pesticides with shorter residual or lower toxicity to important beneficial populations, etc. Moderation should be used to the fullest extent that will provide commercially acceptable control.

Rotation, and in some cases **mixtures**, are the bulwarks of pesticide-use strategies because an individual pest is less likely to be resistant to two or more differing classes of toxins. In theory, most individual pests resistant to

one pesticide will be killed when exposed to a different class of toxin. Rotations depend on having effective, labeled materials with different modes of action. Material cost is a key practical consideration that favors rotation. Mixtures of fungicides have been used successfully to combat disease resistance, although cost lessens the attractiveness of this approach. Mixtures of insecticides and miticides have typically performed poorly. Rotation is seen as the desired approach for insecticides, miticides, and some fungicides. Many recently registered fungicides are marketed as premixed formulations containing two or more active ingredients with different modes of action. While these products may potentially assist with resistance management, often only one active ingredient has strong activity against the target pest or pathogen. Therefore, tank-mixing with a non-selective multi-site fungicide or insecticide may still be necessary.

Saturation, the use of higher pesticide rates to control resistant individuals, is the least attractive resistance management approach, although it has been used to manage resistance to DMI fungicides. Saturation is generally a last resort when there are no other effective, labeled alternatives. In this scenario, higher rates will often provide control for a time, although at greater cost. Synergists, chemicals that increase the toxicity of pesticides, have sometimes been effective in boosting the efficacy of resistance-prone pesticides. As with simple rate increases, saturation with synergists typically provides only short-term benefits.

Insecticide Resistance Management Strategies

In the past 20 years in the southeastern United States, pesticide resistance has been documented in the tufted apple bud moth, codling moth, rosy apple aphid, and European red mite. There is a good diversity of insecticides with different modes of action to combat resistance, but good resistance management strategies are required to preserve the susceptibility of pest populations to those insecticides currently available.

Codling Moth

Insecticide-resistant codling moth populations became prevalent throughout the Southeast in the early 2000s. Resistance to one or more registered insecticides, including Intrepid and Rimon, were detected in a number of orchards in Georgia and North Carolina. In situations where codling moth resistance occurs, populations usually increase to large numbers, and frequent insecticide applications at short intervals (seven to 10 days) are necessary at critical times (between 400 and 800 DD after biofix) to prevent damage. However, such intense insecticide use may lead to higher levels of resistance, so alternative management strategies should be used in conjunction with insecticides. Using mating disruption is strongly encouraged as a resistance management tactic, because this will help reduce population densities more quickly than insecticides alone and, subsequently, the need for insecticide applications. After two to three years of continuous mating disruption, codling moth population densities can be reduced so that only one or two total insecticide applications are needed for season-long control. In addition, try to avoid using more than two insecticide applications against a single codling moth generation by incorporating codling moth virus (Cyd-X or Carpovirusine) applications into the spray program after two applications have been made. When choosing insecticides, rotate insecticides with different modes of action against each generation. For example, make two applications of the same insecticide against the first generation, but use an insecticide with a different mode of action against the second generation. The two most effective groups of insecticides currently available for codling moth control are the diamides (Altacor, Exirel, and Verdepryn) and spinosyns (Delegate).

Rosy Apple Aphid

Rosy apple aphid control with pyrethroids can be inconsistent. Consequently, neonicotinoid insecticides are now most commonly used for control. It is important to remember that all neonicotinoids (Actara, Assail, Belay, and Provado) have a similar mode of action and should be considered the same material for rotational purposes.

The two best times to control rosy apple aphid on apple are (1) tight cluster to pink; or (2) petal fall. Do not apply any insecticide with the same mode of action more than once during this time frame, and if possible do not use the insecticide used for rosy apple aphid control more than once during the period when the aphids may occur in apple orchards (through the third or fourth cover spray).

European Red Mite

Avoiding unnecessary miticide applications is the most effective strategy for minimizing the potential for resistance development. A delayed dormant oil application is highly recommended to suppress overwintering populations of European red mite and to improve the potential for biological control to maintain mite populations below damaging levels. On Delicious cultivars, which are susceptible to Alternaria blotch and where preventive control or low threshold levels are recommended for control of European red mite, there is a high potential for developing resistant populations. To reduce this potential, in addition to a delayed dormant oil application, do not use the same miticide in successive years.

Resistance Management Strategies for Plant Pathogens

Resistance of plant pathogens to pesticides has become widespread over the past 40 years as site-specific (locally systemic) chemicals have been developed and used on many crops and against many pathogens. Alternatively, the broad-spectrum protectants (such as captan and mancozeb) have multiple sites of activity in the target pathogens, greatly reducing the likelihood of resistance development.

Resistance has become a problem in the United States in several pathogens that affect apples during the growing season, including *Venturia inaequalis*, the cause of apple scab; *Podosphaera leucotricha*, cause of powdery mildew; *Alternaria mali,* cause of Alternaria leaf blotch; *Colletotrichum fructicola*, cause of Glomerella leaf spot and bitter rot; *Erwinia amylovora*, cause of fire blight; and *Pseudomonas syringae* pv. *papulans*, cause of blister spot. Resistance of *V. inaequalis* to dodine (Syllit, initially sold as Cyprex) was first reported in New York in 1969. It has subsequently been reported in several states in the Northeast and Midwest but has not been found in orchards in the Southeast. Resistance of *V. inaequalis* to the benzimidazole fungicides (benomyl and thiophanate-methyl) was reported shortly after their introduction in 1971 and became widespread in the eastern United States, including the Southeast, in the mid-1970s. As a consequence they are no longer recommended for apple scab control in the Southeast. The demethylation inhibitor (DMI) fungicides were first introduced in the late 1980s, and resistance to populations of *V. inaequalis* has been reported or suspected in a number of orchards in the Northeast, Southeast, and Midwest. Resistance of *V. inaequalis* to strobilurin (QoI) fungicides (Flint and Sovran) has been reported in the northeastern and southeastern United States. Resistance of *Alternaria mali* to the QoI fungicides (Flint and Sovran) has been reported in North Carolina. Resistance of *Podosphaera leucotricha* to DMI and QoI fungicides is evident in Virginia. Resistance of *Colletotrichum fructicola* has been identified in orchards in North Carolina. Resistance of the fire blight bacterium, *E. amylovora*, to streptomycin (FireWall, Agri-mycin 17, Harbour) is present in several states but has not been reported in the Southeast. Resistance of *P. syringae* pv. *papulans* to streptomycin has been confirmed in an orchard in Tennessee and in New York. There is potential for resistance to the Group 9 fungicides (anilinopyrimidine, AP, cyprodinil, and pyrimethanil), which include Vangard and Scala and are components of Inspire Super and Luna Tranquility, and to the newer Group 7 fungicides (carboximide, SDHI, boscalid, fluopyram, fluxapyroxad, penthiopyrad, benzovindiflupyr, inpyrfluxam, and pydiflumetofen), which are included in Pristine, Luna Sensation, Luna Tranquility, Merivon, Fontelis, Aprovia, Excalia, and Miravis, respectively.

To avoid resistance development, minimize the use of fungicides and bactericides in which resistance is likely to develop. Additionally, combine site-specific fungicides with protectant fungicides that have broad spectrum activity. Limit dodine applications to two per year. In areas where dodine resistance first became a problem, it was often used 10 to 12 times throughout the growing season. Similarly, limit streptomycin use for fire blight control to two to four times a year and for control of blossom blight only. Make applications only during times favorable for infection. These periods are characterized by open blossoms, dew, or rainfall greater than 0.01 inch, an average daily temperature of 60°F or greater, and the accumulation of at least 198 degree-hours greater than 65°F since the first blossoms opened. Use the DMI, QoI, and SDHI fungicides only in combination with broad spectrum protectants, such as captan or EBDC fungicides. Avoid post-symptom applications of site-specific fungicides, such as dodine and the DMI fungicides, because this sets up an ideal situation for selection of resistant strains. Good orchard sanitation practices to maintain pathogen populations at low levels are also an important component of a resistance management program.

Herbicide Resistant Weeds

The reality of herbicide-resistant weeds infesting orchards is more likely today than ever. Populations of pigweed and goosegrass resistant to dinitroanaline herbicides (Prowl and Oryzalin) exist in the Southeast. Populations of johnsongrass resistant to carboxylase herbicides (Fusilade DX) also have been documented. Glyphosate-resistant weeds have been found across the United States. The two most notable species developing resistance to glyphosate are horseweed and Palmer amaranth. Glyphosate-resistant ragweed is suspected and being investigated as well. More recently there is concern about glyphosate-resistant species also developing resistance to the group 14 herbicides (see Table 8) resulting in a single species being resistant to two different herbicide modes of action. Growers should be aware that herbicide-resistant weeds are in apple production regions and, in the event of control failures, herbicide programs will have to be altered. If you suspect a problem or need additional information, you should contact your local Cooperative Extension agent.

To prevent the development of herbicide-resistant weeds, growers should take into consideration the following practices:

1. Rotate herbicides with different modes of action (see Table 8). For example, do not use simazine (Princep, Simazine) continuously. Consider other pre-emergence broadleaf herbicide options. Avoid making more than two applications of the same herbicide in the same year.
2. Scout orchards to identify weeds. Respond quickly to changes in weed populations by controlling weeds before they spread throughout the entire orchard.
3. Use non-selective post-emergence herbicides in a weed management program along with pre-emergence herbicides.
4. Use herbicides only as needed.

Table 8. Herbicide Mode of Action Table

MOA Group	Herbicide Members
1	Clethodim (Select, etc.), Fluazifop (Fusilade), Sethoxydim (Poast)
2	Rimsulfuron (Matrix, Solida, etc.) and Halosulfuron (Sandea)
3	Pendimethalin (Prowl)
4	2,4-D amine, clopyralid (Stinger), fluroxypyr (Starane)
5	Simazine and Terbacil (Sinbar)
6	Bentazon (Broadloom)
7	Diuron (Karmex, Direx)
9	Glyphosate (Roundup, etc.)
10	Glufosinate (Rely, etc.)
12	Norflurazon (Solicam)
14	Flumioxazin (Chateau or Tuscany), Carfentrazone (Aim, Zeus Prime), Salflufenacil (Treevix), Sulfrentrazone (Zeus Prime)
20	Dichlobenil (Casoron)
21	Isoxaben (Trellis)
22	Paraquat (Gramoxone, Firestorm, Parazone)
27	Mesotrione (Motif 4L)
29	Indaziflam (Alion)
2 and 14	Penoxsulam + Oxyfluorfen (Pindar GT)
2 and 29	Rimsulfuron + Indizaflam (Centrus)

Effect of pH on Pesticide Activity

Although the pH of spray water does not directly affect resistance development, it can affect the activity of some pesticides. The labels on dimethoate, phosmet, malathion, azinphos-methyl, formetanate, ethephon, NAA, and possibly others warn of this effect. When these materials, except NAA, are exposed to a pH above 7.5, they undergo hydrolysis and break down to products that are either less effective or not effective. Excessively acidic conditions may limit uptake of NAA and, therefore, its effectiveness. The actual rate of breakdown depends on solubility, temperature, and the total quantity broken down during a given period. For example, captan is hydrolyzed very quickly at alkaline pHs, but because it is very insoluble, the impact of pH is negligible unless captan is allowed to stand for a week or more. Hydrolysis increases with increased temperature. If the time in the spray tank is limited by applying pesticides immediately, then the quantitative amount broken down is limited.

Additives to the spray tank can also be a factor. Calcium chloride, especially when concentrated in the tank and applied in a low volume spray, can increase the pH. The greater the concentration, the greater the alkalinity. The manufacturing process for calcium chloride leaves residue of free lime (calcium hydroxide). The greater the purity of the calcium chloride, the lower the content of calcium hydroxide and the lower the effect on pH.

The water source can be a factor. Although most wells, streams, and rivers in apple-growing regions in the Southeast are mildly acidic (6.7 plus or minus 0.2), there are exceptions; check pH a few times before regular use. Ponds are more likely to be alkaline, especially those high in algae and other organisms. These ponds undergo diurnal pH changes as result of dissolved carbon dioxide. Levels greater than 10 have been observed. Alkalinity contributed by CO2 is weakly buffered and readily changed by acidifying agents.

Although not pH-related, some pesticides can be affected by other contaminants in the water. Still other compounds, such as 2,4-D, can be very difficult to wash out of the tank and can have a deleterious effect on apples at very low concentrations.

Orchard Floor Management

The best strategy for managing the orchard floor is to use a noncompetitive grass alley with a vegetation-free strip in the tree row. The vegetation-free strip can be established and maintained with herbicides as described in this section. The permanent grass sod between the tree rows will minimize soil erosion, increase soil aeration and permeability, and support equipment movement through the orchard during wet weather. The vegetation-free strip eliminates competition for water and nutrients, minimizes tree damage or loss from voles during the dormant season, and provides some radiant heat from the soil surface should a spring frost or freeze occur. Using herbicides applied as a directed spray beneath the trees is the most effective and economical method to control weeds in vegetation-free strip. Eliminating broadleaf weeds growing in the row middles (grass sod) lessens the potential damage to pollinating insects throughout the growing season.

The vegetation-free strip method is superior to all other orchard floor management options. Vegetation under the tree competes for nutrients and water, resulting in reduced growth, yield, and size of fruit. As previously mentioned, using herbicides to maintain the weed-free strip is the most effective and economical means of achieving a vegetation-free strip.

Growers opposed to using herbicides can eliminate vegetation in the tree row by using organic mulches or tillage. Examples of mulching materials include straw, wood chips, and grass residue from mowing. These mulches will suppress weed emergence, but weed removal by some means will still be necessary. Mulches can improve the water-holding capacity of some soils; however, there are several concerns regarding the use of organic mulches. The most significant problem is that mulches create an ideal habitat for voles. Also, additional nitrogen may be needed to support the microorganisms that drive decomposition of organic mulches. In poorly drained or waterlogged soils, organic mulches increase the likelihood of phytophthora root rot. Mulches can be expensive and difficult to obtain. Synthetic mulches made from polyethylene, polypropylene, or polyester can be placed in the tree row around the base of the trunk or as a narrow strip down the row. Some newer synthetics allow water and air to pass through the mulch. Using tillage can have a negative effect on soil structure, reduces soil organic matter, and will be detrimental to apple tree root growth. Specialty tillage equipment can work closely around tree trunks to eliminate weeds at the base of trees; however, additional hand removal may be necessary to prevent competition.

Herbicide Considerations

To ensure proper herbicide use, always read and follow the manufacturer's label before application. All statements on the manufacturer's label take precedence over any recommendations in this publication.

It is important that herbicide application equipment be properly calibrated to ensure that herbicides are applied at the correct rate. For questions about calibrating your sprayer, contact your local Cooperative Extension agent.

Remember that herbicides are applied as a directed spray along each side of the tree row. Flat fan nozzles are the most widely used nozzles for applying herbicides. They provide excellent spray coverage of weeds and come in several sizes with capabilities to apply a range of spray volumes. Some manufacturers make flat fan nozzles that minimize spray drift, allowing low-pressure spraying. Investing in such spray nozzles decreases the likelihood of off-target herbicide movement.

It is advisable to apply an exterior white latex paint to the bottom 2 to 3 feet of the tree trunk of newly planted trees before applying herbicides. Painting the tree trunks reduces the potential for winter as well as herbicide injury, especially from postemergence herbicides. Dip a car wash mitt (wear rubber gloves underneath the mitt) in paint and rub up and down the tree trunk until it is completely painted.

There are a number of herbicides registered for use in apple orchards that effectively control weeds. Some are pre-emergence herbicides that control emerging weed seedlings, while others are postemergence herbicides that control emerged weeds. Pre-emergence herbicides can have some postemergence activity but do not usually provide broad spectrum postemergence weed control. Pre-emergence herbicides require rainfall or overhead irrigation for activation. The time between application and the need for rainfall varies from one herbicide to another. Most herbicides need rainfall within seven to 14 days after application for optimum performance; however,

best control occurs when activation (rain or irrigation) occurs within a few days of application. Refer to the manufacturer's label for specific information.

Postemergence herbicides are most effective when applied to actively growing weeds. Weeds under stress from drought or mowing can be more difficult to control, resulting in reduced herbicide performance. Ideally, if weeds are stressed from drought, delay herbicide application until after adequate rainfall when weeds are no longer wilted. However, if weeds are at the appropriate growth stage or size and rainfall is not imminent, those weeds should be treated with the maximum-allowed herbicide rate according to label instructions. If weeds have been mowed, wait several days to allow regrowth before applying herbicides. Symptoms of herbicide activity may not be noticeable for up to 14 days after application of glyphosate, halosulfuron, sethoxydim, clethodim, or fluazifop (Roundup, Sandea, Poast, Select, or Fusilade DX, respectively). Effects of glufosinate, paraquat, 2,4-D amine or choline, and fluroxypyr (Rely, Gramoxone Max, and Starane Ultra, respectively) are noticeable in one to three days. Some postemergence herbicides require the addition of a surfactant or crop oil to improve herbicide activity. Remember, surfactants and crop oil differ from one another and may not be interchangeable. Glufosinate products and most glyphosate products have surfactant included in the herbicide mixture and no additional surfactant or crop oil is necessary. The addition of a spray grade ammonium sulfate fertilizer will enhance the activity of these herbicides, especially during dry conditions and when weeds are marginal (large) in size.

Herbicide Application Timing

The goal of an effective weed management program is to eliminate weed competition the first six to eight weeks after bud swell and keep the area under the trees weed-free through harvest. Timing of pre-emergence (PRE) herbicide application is important in accomplishing this goal. It has been typical to make a single PRE herbicide application in the spring followed by postemergence (POST) herbicide applications in the summer as needed. However, it can be difficult to spray underneath limbs loaded with fruit in mid and late summer. With appropriate PRE herbicide timing, POST herbicide applications in mid and late summer can be avoided. Listed below are several PRE herbicide timing options.

1. *Fall/Spring Split.* One approach is to apply a PRE herbicide with a nonselective burndown herbicide (glufosinate or paraquat) in the fall after harvest (November). The fall application will generally provide PRE control into the late spring (late May). When fall PRE treatment breaks and emerging weeds are 2 to 3 inches tall, another PRE herbicide application with a burndown herbicide should be applied. Fall herbicide application may be helpful in managing voles. In areas where erosion is a concern, this option may not be acceptable.
2. *Delayed Pre-emergence***.** This approach requires a burndown herbicide (glyphosate or glufosinate) application in March. The burndown herbicide eliminates winter annual weeds until summer annual weeds emerge in early to mid-May. Once summer annual weeds get 2 to 3 inches, apply a burndown with a PRE herbicide.
3. *Spring/Summer Sequential Pre-emergence.* The Chateau (non-bearing only), Alion, Zeus Prime + oryzalin and rimsulfuron labels allow for spring/summer split application times. A PRE herbicide tank-mixed with a non-selective POST herbicide can be applied in mid-March. This application will last through May and into June. In June when control from the initial application begins to fail, an additional PRE herbicide tank-mixed with paraquat or glufosinate for non-selective POST should be applied when emerging weeds are 2 to 3 inches tall. The Sinbar label for non-bearing orchards allows the same use pattern as well. Using a product like Chateau or Pindar GT in the initial application followed by another pre-emergence herbicide like Alion, diuron + rimsulfuron, or Zeus Prime + oryzalin would also be an option. Postemergence herbicides may be necessary to control escaped weeds or certain problem weeds like bermudagrass, johnsongrass, and mugwort.

It is important to scout orchards regularly to determine which weed species are present. Scouting allows growers to control escaped weeds with a timely herbicide application and identify difficult-to-control weeds early. Early identification of problem weeds can prevent them from becoming established in the orchard. If problem weeds are noticed for the first time in an orchard, they should be removed before they produce seed. Remove by hand or with a spot treatment with a nonselective postemergence herbicide like glyphosate (Roundup and others) or fluroxypyr (Starane Ultra). Scouting also helps growers recognize poorly controlled weeds and adjust their weed management program. Another aspect growers should consider is the potential for weed infestation from the border of the orchard. Weeds in these areas produce seeds that may find their way into the orchard.

Pre-emergence Herbicide Rotation

Rotating pre-emergence herbicides from year to year is highly recommended to ensure their continued effectiveness. The continued use of the same pre-emergence herbicide or combination of pre-emergence herbicides can result in the selection for weeds that the herbicide or combination of herbicides will not control (this is not the same thing as resistance). Growers need to have two or three pre-emergence herbicide programs to rotate from one year after the next. This prevents selecting for weed species that a program does not control and is a good practice to aid with the prevention of herbicide resistance. Pre-emergence herbicide rotation also benefits tree health, as some pre-emergence herbicides (i.e., Sinbar) can build up from repeated use over time and adversely impact tree growth and vigor.

Glyphosate Sensitivity

Glyphosate is a very effective weed management tool because it controls such an array of annual and perennial weeds. In recent years, concern has developed regarding tree health and the relationship with multiple glyphosate applications during the year. There is a potential for a buildup of sublethal levels of glyphosate in perennial crops like apple trees. Symptoms are very subtle and include reduced tree vigor, reduced yield, cankers at the base of trees, and weak graft unions. As a precaution, it is recommended that glyphosate be used no more than twice per season and glyphosate should not be applied later than June. If possible, a single application of glyphosate would be best. As an alternative, glufosinate is very effective on perennial weeds and of course paraquat is an option as well.

Chemical Mowing

Some herbicides can be used at sublethal doses to suppress orchard floor vegetation. Timing and rate will vary with the vegetation present. Generally, tall fescue can be used as the guiding species, because it is a major component in most orchards. Optimum timing for suppression is when tall fescue has 3 to 6 inches of new growth in the spring. The following herbicides and rates are suggested: glyphosate (various formulations and rates; see labels for details), and Poast 1.5E at 1 to 1.25 pints per acre. Chemical suppression of grasses should be done only to healthy, well-established sod. Refer to product labels for details.

Weed Management in Newly Planted Trees

Eliminating weed competition is an important part of minimizing post-transplant stress in newly planted trees. Research has shown that weed competition can reduce tree growth and development by 50%. Newly planted orchards are not nearly as competitive with weeds as older, established orchards. Young trees do not have well-developed limbs to shade the soil surface in late summer, which minimizes the competitiveness of late summer weeds. In general, pre-emergence herbicides registered for use after transplanting provide effective pre-emergence control of annual grasses and small-seeded broadleaf weeds. Painting the lower 18 inches of the tree trunk with a white latex paint is highly recommended. The paint provides a barrier to herbicides, protecting tender, green bark from serious injury.

Apple Pollination, Honeybees, and Pesticides

Most apple varieties are self-incompatible and require cross-pollination with a suitable pollinizer variety to obtain good fruit set. Honeybees and other native bees are the primary pollinators for apples.

Many insecticides used for insect control are toxic to bees, and precautions need to be taken to minimize the risk of exposing bees to those products. Those insecticides toxic to bees have a warning under the Environmental Hazards section, and include the following: "This product is highly toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops if bees are visiting the treatment area." Labels also have Bee Advisory Boxes to highlight product use restrictions and precautions to protect pollinators.

Any apiary within 2.5 miles of an orchard is at risk from insecticide applications. Bees are highly attracted to flowers in the ground cover. Before applying insecticides, reduce dandelion, clover, and other ground cover flowers by mowing or applying herbicide.

The following additional recommendations will help to minimize bee kills:

- Read and obey warning statements on pesticide labels regarding honeybees.
- Do not apply insecticides when blooms remain on trees and remove hives before making petal fall sprays.
- Select the safest available formulation. Emulsifiable concentrate (EC) formulations usually have shorter residual toxicity than wettable powder (WP) formulations.

- Insecticides applied during unusually low temperatures will remain toxic to bees for a much longer time than when applied in warm weather.
- Avoid applying insecticides to blooming cover crops, and avoid insecticide drift to nearby plants in bloom.
- If an insecticide hazardous to bees must be used, apply it in the early evening to minimize the hazard. Always check to make sure bees are not foraging when pesticides are applied.
- Never apply a pesticide directly over a beehive. Notify neighboring beekeepers when applying pesticides toxic to bees.
- Dispose of all unused pesticides safely so that pesticides do not end up in watering sources used by bees.

Soil and Plant Analysis Guidelines for Southeastern Apple Production

Preplant soil testing should be used extensively in preparing an orchard site. It is the only economically viable way to detect and amend issues with soil pH, phosphorous levels, and, to a lesser extent, potassium levels in the subsoil throughout the life of the orchard. Samples should be collected at both upper (0 to 8 inches) and lower (8 to 16 inches) depths.

Lime and phosphorus (P) applications should be determined by adding the recommendations for the upper and lower soil tests. For potassium (K), subtract the actual level of K from the desired level for both the upper and lower samples, then combine these amounts. Apply the total amount(s) of lime, P, and K, and incorporate by disking or rototilling followed by deep plowing to get the amendments into the subsoil.

When soil test results call for high application rates of lime, P or K, apply two-thirds of the total amount of each and incorporate by disking/rototilling and deep plowing. Then apply the remaining one-third and incorporate by disking or rototilling.

Routine nutrient analysis of soil and plant leaf tissue should be an integral part of any orchard management plan. Soils used for apple production in the Southeast vary greatly, especially in the mountains. Other factors, such as weather and crop history, can affect the trees' nutrient status. The only way to be sure your trees are being fertilized efficiently and properly is to use soil and plant analysis. Proper use of these tools will help ensure sustained yields while preventing unneeded fertilizer application. Ideally, both soil and plant sampling should be done every other year. On sites that have a history of nutritional problems, such as bitter pit, sampling every year may be needed.

While soil analysis estimates the soil's ability to supply a particular nutrient, the correlation between soil test results and the actual nutrient content of a plant can be poor. The primary value of postplant soil testing is that of monitoring soil pH as this will affect the availability of nutrients to plants. Tissue analysis, on the other hand, does reflect the true nutrient status of a plant. Through its use, potential nutrient problems (deficiencies, toxicities, and imbalances) can be identified before they become yield or quality limiting. A good orchard nutrition program includes preplant soil testing, postplant soil and tissue analysis, good record keeping from previous years, and observations including shoot growth, leaf color, and crop development in the orchard.

Sampling for Soil Analysis

A soil analysis report is only as good as the sample it represents. For soil analysis to be meaningful, the sample must be representative of the soils in the orchard. Due to soil variability, each sample should represent no more than a 5-acre block of similar terrain and soil type. Areas having obvious differences in the growth of ground cover, perhaps due to changes in soil types, soil drainage, or previous cropping history, should be sampled separately. A good sample consists of up to 20 sub-samples (cores). These should be thoroughly mixed in a clean, non-galvanized bucket before filling the soil sample box. As stated above, samples should be divided into two depths: 0 to 8 inches and 8 to 16 inches. This is easiest when using a soil sampling tube.

Sampling for Plant Analysis

Plant sampling needs to be carried out in a manner similar to soil sampling. For best results, plant sampling areas should be the same as selected for soil sampling. All trees utilized for a leaf sample should be the same age, variety, rootstock, and at the same relative state of vigor. Sample weak trees or trees showing obvious differences in growth separately. To make full use of published critical nutrient levels, and thus obtain the best information, routine plant samples should be taken during the last two weeks of July. Sample mid-shoot leaves of the current season's growth from the upper third of the tree and from all sides of the tree. Collect a total of 40 leaves taken from at least 10 trees selected randomly from the sample area.

Using Soil and Plant Analysis as an Aid in Troubleshooting

Soil and plant analysis can be invaluable in properly identifying and correcting nutrient deficiencies. In this case, samples are collected over a smaller area that represents the problem. If possible, it is advisable to collect samples from "good" areas adjacent to the problem areas. Both soil and plant samples need to be collected. Both "normal" and "affected" trees should be of the same age, variety, and rootstock.

Interpretation of Soil and Tissue Analysis

The laboratory analyzing soil and tissue samples should also be making the recommendations based on the results of their work. Soil and plant analysis laboratories differ in analytical procedures and report format. Southeastern laboratories, both private and public, use at least two different soil-extracting solutions. A single soil sample processed by these two methods could yield very different results, especially for phosphorus. Also, different laboratories report the results in different units—some use an index system while others report parts per million or pounds per acre. A given laboratory takes these factors into account when making fertility recommendations; in other words, their recommendations are calibrated to their methods. Thus, recommendations from different labs' soil analyses should be similar. However, the differences in reporting units make it difficult to compare results from different labs. To track the progress of a fertility program over the life of the trees, it is best to use either one laboratory or pick laboratories with the same methods and reporting units. Even though tissue analysis methods are more uniform, reporting units still differ between laboratories, making it difficult to track trends over time.

Special Considerations for Calcium and Boron

Calcium and boron deficiency can result in fruit being culled due to bitter pit (calcium deficiency) or cork spot (boron deficiency). In some years, the percentage of cull fruit exhibiting bitter pit or cork spot can be quite high. These nutrients can be difficult to supply in needed quantities, especially in older trees, large-fruited varieties, and highly vigorous trees. Pay particular attention to foliar applications of these nutrients. In the case of calcium, proper attention to liming can also help. If a pH change is not needed, gypsum can be used to supply soil calcium. With large-fruited varieties, both soil and foliar calcium applications may be needed to prevent bitter pit. Bitter pit can be especially difficult to control in Honeycrisp primarily due to the way calcium is partitioned within the tree and the cellular structure of the fruit. Bitter pit in Honeycrisp does not necessarily mean a deficiency of calcium. Rather, it could be excessively high levels of potassium interfering with calcium uptake.

Both Solubor and calcium chloride can cause toxicity if misused. To avoid tissue damage, be careful not to exceed recommended foliar application rates. Do not apply calcium chloride at temperatures above 85°F. Multiple calcium chloride applications uninterrupted by a significant rain event can result in leaf burn.

For Assistance

Your local Extension center can develop a fertility program for your trees based on your soil and tissue analysis results. They will also be happy to answer your questions about your fertility program. A fact sheet, Soil and Plant Analysis for Apple Trees, AG-439-47, is available. It is part of the SoilFacts series and can be accessed on the Extension Publications Catalog at **content.ces.ncsu.edu/soil-and-plant-analysis-for-apple-trees**.

Table 9. Fertility Management Recommendations for Apples

(Apply fertilizer based on results of leaf and soil nutrient analyses)

Purpose	Material	Amount	Comments
Apply preplant amendments based on soil test results.	Lime, phosphorus, and potassium	Depends on soil test.	Prepare soil as deeply as possible before planting. Take soil samples at 0- to 8-inch and 8- to 16-inch depths for lime, phosphorus, and potassium recommendations.
Maintain or improve growth of young trees.	Nitrogen	0.1 lb for each year of age until tree begins bearing, then as recommended from leaf analysis.	Apply during the period from budbreak to the beginning of rapid shoot growth (shortly after petal fall) or postharvest. Multiple applications of low nitrogen rates in the first half of the growing season are preferable to a single application.
Raise boron level of tree.	Solubor	1 lb/100 gal of spray at petal fall and possibly first cover.	If leaf analysis shows a deficiency, add cover sprays as recommended from leaf analysis to reduce "cork spot." Dry years and large fruit may increase the incidence of cork spot. Do not apply Solubor and calcium chloride in the same cover sprays as foliar damage may result.
Maintain vegetative growth and fruit development.	Nitrogen	1.25 lb of actual N for trees producing 10 to 15 bushels of apples. For high-density orchards, 50 to 100 lb of N per acre is recommended, depending on whether fertilizer is broadcast or banded in tree rows.	Annual terminal growth should be about 6 to 10 inches on spur varieties and 10 to 12 inches for non-spurs on bearing trees. Determine the actual yearly application through observations of leaf color, growth plus crop size, and fruit condition plus the leaf analysis.
Increase foliar level.	Potassium	Apply according to leaf analysis.	Leaf analysis is a good way to determine need for a ground application. In an established orchard, soil test results should not be used to determine whether applications of potassium are needed.
Increase calcium level of tree..	Gypsum ($CaSO_4$)	15 to 50 lb/tree with a 6- to 10-ft radius on semi-dwarf trees. Band applications for high density plantings.	Apply only as needed by low soil or tissue calcium. One application usually lasts three to five years.
	Calcium nitrate	Apply in early spring (NOT in fall) at rate to supply recommended nitrogen.	Make soil applications to increase calcium supply and reduce bitter pit. Foliar applications of calcium nitrate in cover sprays should not be used as a way to control bitter pit.
Reduce incidence of bitter pit.	Calcium chloride	2 lb/100 gal of water applied in the last few cover sprays. For severe bitter pit problems, include calcium chloride in earlier cover sprays.	Apply to reduce the incidence of bitter pit. DO NOT apply when temperature is 85°F or higher.

Table 10. Relative Effectiveness of Fungicides

(— = ineffective; 1 = slightly effective; 5 = very effective or very safe on fruit finish)

Fungicide and Amount per Acre of Dilute Spray	FRAC Group	Preharvest Interval (days)	Relative Control Rating							Fruit Finish
			Apple Scab	Rusts	Brooks Spot	Black Rot/ White Rot	Bitter Rot	Sooty Blotch and Flyspeck	Powdery Mildew	
benzoindiflupyr (Aprovia) 5.5 to 7 fl oz	7	30	5	3	ND	3	3-4	4	4	4
captan (Captan 80WDG) 5 lb	M4	0	4	1	4	4	5	4	—	3-4
captan (Captan 80WDG) 3.75 lb + potassium phosphite (ProPhyt 4 pt)	M4 + P7	0	4	1	3	4	5	5	—	3-4
cyprodinil (Vangard 75 W) 1.25 oz	9	0	2	—	—	—	—	—	—	5
difenoconazole+cyprodinil (Inspire Super 2.82EW) 12 fl oz	3 + 9	14	5	5	2	4	1	5	4	4
*dodine (*Syllit 3.4FL) 1.5 pt + *captan* (Captan 80WDG) 2.5 lb or *mancozeb* 75DF 3 lb	U12 M4 M3	see label	 5 5	 1 3	N/A	N/A	N/A	N/A	N/A	4
fenbuconazole (Indar 2F) 8 fl oz	3	14	5	5	2	3	1	5	4	5
fluazinam (Omega 500F) 13.8 fl oz	29	28	3	3	ND	3	3	3	2	5
fluopyram + *trifloxystrobin* (Luna Sensation) 4.0-5.8 fl oz	7 + 11	14	5	2	5	4	5	4	5	5
fluopyram + *pyrimethanil* (Luna Tranquility) 11.2 to 16 fl oz	7 + 9	72	5	2	ND	ND	ND	ND	4	5
fluxapyroxad (Sercadis) 4.5 fl oz	7	0	4	2	ND	ND	ND	ND	4	5
fluxapyroxad + *pyraclostrobin* (Merivon) 4.4 to 5.5 fl oz	7 + 11	14	5	2	5	4	5	4	5	5
inpyrfluxam (Excalia)	7	Petal Fall	5	3	N/A	N/A	N/A	N/A	4	5
kresoxim-methyl (Sovran 50WG)	11	30	5	2	4	4	4	4	4	5
mancozeb (Koverall) 3 lb (or 6 lb-see label)	M3	77	4	3	3	3	4	3	1	5
mefentrifluconazole (Cevya) 3 to 5 fl oz	3	0	5	5	ND	ND	1	5	4	5
metiram (Polyram 80DF) 3 to 6 lb	M3	see label	4	3	3	3	3	3	1	5
myclobutanil (Rally 40WSP) 5 to 10 oz	3	14	3	5	2	3	2	3	5	5
penthiopyrad (Fontelis SC) 14 to 20 fl oz	7	28	4	2	ND	3	3	3-4	3	4
pydiflumentofen (Miravis) 3.4 fl oz	7	30	5	3	ND	3	1	4	4	5
pyraclostrobin + *boscalid* (Pristine WG) 14.4 to 18.4 oz	11 + 7	0	4	2	5	4	5	4	4	5
pyrimethanil (Scala SC) 7 to 10 fl oz	9	72	3	—	—	—	—	—	—	5
sulfur (Microthiol Disperss) 10 to 20 lb	M2	see label	2	1	—	—	—	—	4	3
thiophanate methyl (Topsin 4.5FL) 15 to 20 fl oz	1	1	3	1	3	5	2	5	2	5
trifloxystrobin (Flint Extra) 2.5 to 2.9 fl oz	11	14	4	2	4	4	4-5	4	5	5
triflumizole (Procure 480SC) 8 to 16 fl oz	3	14	3	5	2	3	2	3	5	5
ziram (Ziram 76DF) 3 to 6 lb	M3	14	3	3	3	3	3-4	4	1	4

Table 11. Relative Effectiveness of Insecticides and Miticides

(— = no activity as labeled; 1 = least effective; 5 = most effective or best fruit finish)

MoA Group	Brand name	Chemical name	San Jose scale	Rosy apple aphid	Apple/spirea aphid	White apple/potato leafhopper	Plant bug	Plum curculio	Codling moth	Oriental fruit moth	Tufted apple bud moth	Variegated/red-banded leafroller	Spotted tentiform leafminer	Comstock mealy bug	Apple maggot	Japanese beetle	Woolly apple aphid	Brown marmorated stink bug	European red mite	Twospotted spider mite	Fruit Finish Quality
1A	Lannate	methomyl	3	3	3	5	4	3	3	3	3	4	4	2	2	2	—	2	—	—	4
	Sevin	carbaryl	2	—	—	5	3	3	4	3	2	2	2	—	3	5	—	1	—	—	4
	Vydate	oxamyl	3	4	3	5	3	1	1	1	1	1	4	2	—	2	2	2	2	3	4
1B	Diazinon	diazinon	5	5	1	1	4	3	4	4	3	3	2	5	2	3	5	2	—	—	3
	Imidan	phosmet	1	1	1	1	4	4	3	3	2	4	1	1	4	4	1	1	—	—	5
3A	Ambush	permethrin	—	3	4	5	3	3	—	—	—	—	4	—	—	—	—	2	—	—	4
	Asana	Esfenvalerate	—	3	4	5	3	3	2	4	4	5	4	—	3	4	—	2	—	—	4
	Baythroid XL	Beta cyfluthrin	—	4	4	5	5	3	2	5	4	5	3	2	3	5	—	4	—	—	5
	Danitol	Fenpropathrin	—	4	4	5	5	3	2	5	4	5	3	3	3	5	—	4	3	3	5
	Karate	Lambda-cyhalothrin	—	4	5	5	4	3	2	5	4	5	4	—	3	5	—	4	2	2	4
	Mustang Maxx	Zeta-cypermethrin	—	4	4	5	5	3	2	5	4	5	3	2	3	5	—	4	—	—	5
	Proaxis	Gamma cyhalothrin	—	4	4	5	5	3	2	5	4	5	3	2	3	5	—	4	—	—	5
4A	Actara	Thiamethoxam	—	5	5	5	4	5	2	2	1	1	3	3	1	4	2	4	—	—	5
	Admire	Imidacloprid	2	5	5	5	2	2	2	2	1	2	4	3	4	4	2	2	—	—	5
	Assail	Acetamiprid	4	5	5	5	3	3	4	4	2	2	4	5	3	4	2	2	—	—	5
	Belay	Chlothianidin	—	5	5	5	—	4	3	3	1	1	3	—	3	4	—	4	—	—	5
4C	Closer	Sulfoxaflur	3	5	5	5	5	—	—	—	—	—	—	—	—	—	3	2	—	—	5
4D	Sivanto Prime	Flupyradfurone	2	5	5	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	5
5	Delegate	Spinetoram	—	—	—	1	—	2	5	5	5	5	5	—	2	—	—	—	—	—	5
6	Agri-Mek	Abamectin	—	—	—	5	—	—	—	—	—	—	5	—	—	—	—	—	5	5	4
7C	Esteem	Pyriproxifen	5	2	2	—	—	—	3	4	2	2	4	—	—	—	—	—	—	—	5
9D	Versys	Afidopyropen	—	5	5	3	—	—	—	—	—	—	—	—	—	—	3	—	—	—	5
10A	Apollo	clofentezine	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	5
10A	Savey	hexythiazox	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	5

Table 11. Relative Effectiveness of Insecticides and Miticides (continued)

(— = no activity as labeled; 1 = least effective; 5 = most effective or best fruit finish)

MoA Group	Brand name	Chemical name	San Jose scale	Rosy apple aphid	Apple/spirea aphid	White apple/potato leafhopper	Plant bug	Plum curculio	Codling moth	Oriental fruit moth	Tufted apple bud moth	Variegated/red-banded leafroller	Spotted tentiform leafminer	Comstock mealy bug	Apple maggot	Japanese beetle	Woolly apple aphid	Brown marmorated stink bug	European red mite	Twospotted spider mite	Fruit Finish Quality
10B	Zeal	Etoxazole	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	5
11B	Dipel, Xentari	*B. thuringiensis*	—	—	—	—	—	—	1	1	3	3	—	—	—	—	—	—	—	—	5
12B	Vendex	hexakis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	5	5
15	Rimon	novaluron	—	—	—	—	—	—	4	4	4	5	—	—	—	—	—	1	—	—	4
16	Centaur	Buprofezin	5	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
18	Intrepid	Methoxyfenozide	—	—	—	—	—	—	4	3	5	5	4	—	—	—	—	—	—	—	5
20B	Kanemite	Acequinocyl	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	5
20D	Acramite	Bifenazate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	5
21A	Nexter	Pyribaden	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	4	3	5
	Portal	Fenpyroximate	—	—	—	5	—	—	—	—	—	—	—	3	—	—	—	—	5	5	4
22A	Avaunt	Indoxacarb	—	—	—	5	2	5	3	3	4	4	—	—	1	3	—	—	—	—	5
23	Envidor	Spirodiclofen	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	4	5
	Movento	Spirotetramat	4	4	4	—	—	—	—	—	—	—	—	4	—	—	4	—	—	—	5
25	Nealta	Cyflumetofen	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	5
28	Altacor	Chlorantraniliprole	—	—	—	—	—	1	5	5	5	5	5	—	1	—	—	—	—	—	5
	Exirel	Cyantraniliprole	—	3	3	—	—	3	5	5	5	5	5	—	2	—	—	—	—	—	5
	Verdepryn	Cyclaniliprole	3	—	—	—	—	4	5	5	5	5	5	—	—	—	—	2	—	—	5
29	Beleaf	Flonicamid	—	4	4	—	4	—	—	—	—	—	—	—	—	—	3	—	—	—	5
—	CYD-X, CYD-X HP	Cydia pomenella granulovirus	—	—	—	—	—	—	4	4	—	—	—	—	—	—	—	—	—	—	5
—	Surround	Kaolin	—	—	—	—	—	4	2	2	2	2	1	—	4	2	—	—	—	—	5
—	Oil		4	2	—	—	—	—	1	—	1	—	—	—	—	—	—	—	4	2	3

Table 12. Relative Effectiveness of Insecticide and Miticide Pre-mixtures

(— no activity as labeled; 1=least effective; 5 = most effective or best finish)

MoA Group	Brand name	Chemical name	San Jose scale	Rosy apple aphid	Apple/spirea aphid	White apple/potato leafhopper	Plant bug	Plum curculio	Codling moth	Oriental fruit moth	Tufted apple bud moth	Variegated/red-banded leafroller	Spotted tentiform leafminer	Comstock mealy bug	Apple maggot	Japanese beetle	Woolly apple aphid	Brown marmorated stink bug	European red mite	Twospotted spider mite	Fruit Finish Quality
6 + 4A	Agri-Flex	Abamectin + thiamethoxam	—	5	5	5	5	5	—	—	—	—	5	4	2	4	2	4	5	5	4
28 + 3A	Besiege	Chlorantraniliprole + lambda-cyhalothrin	—	5	5	5	5	4	5	5	5	5	5	—	4	5	—	4	2	2	5
15 + 4A	Cormoran	Novaluron + acetamiprid	4	5	5	5	3	3	4	4	5	5	5	5	3	4	2	2	—	—	5
3A + 4A	Endigo	Lambda-cyhalothrin + thiamethoxam	—	5	5	5	5	5	3	4	5	5	4	3	3	5	2	5	—	—	4
4+ 3A	Leverage	Imidacloprid + cyfluthrin	—	5	5	5	5	4	3	3	5	5	5	—	4	5	—	4	—	—	4
28 + 6	Minecto Pro	Cyantraniliprole + abamectin	—	3	3	—	—	3	5	5	5	5	5	—	2	2	—	—	5	5	5
28 + 4A	Voliam Flexi	Chlorantraniliprole + thiamethoxam	—	5	5	5	5	4	5	5	5	5	5	3	2	4	2	4	—	—	5

Table 13. Toxicity of Pesticides to Beneficial Arthropods

(— = no data, 0 = nontoxic, 1 = low toxicity, 2 = moderate toxicity, 3 = high toxicity)

	Mite Predators			Aphid Predator	Generalist predators	Parasitic Wasp
Material	***Stethorus punctum***	***Amblyseius fallacis***	***Zetzellia mali***	***A. aphidomyza***	**(lady beetles, lacewings, syrphids, *Orius*)**	***Trichogramma***
Actara	2	1	1	2	2	—
Agri-Mek	2	2	2	—	—	—
Altacor	1	0	0	0	1	0
Ambush	3	3	3	2	3	2
Apollo	0	1	1	1	1	—
Asana	3	3	3	2	3	2
Assail	3	1	1	2	2	—
Avaunt	2	1	1	2	2	—
Bacillus thuringiensis	0	0	0	0	2	0
Belay	3	1	1	—	2	—
Centaur	2	—	—	—	1	—
CYD-X	0	0	0	0	0	0
Danitol	3	3	3	3	3	3
Delegate	1	1	1	2	2	2
Diazinon	2	2	—	3	2	—
Endigo	3	3	3	3	3	3
Envidor	1	—	—	—	1	—
Esteem	2	0	0	1	2	—
Imidan	1	2	1	1	1	1
Intrepid	0	0	0	0	0	0
Karate	3	3	3	3	3	3
Lannate	3	3	2	3	3	3
Movento	0	0	0	1	1	0
Nealta	0	1	1	0	1	0
Nexter	2	1	—	—	2	—
Portal	1	2	1	1	1	—
Provado	2	1	1	—	2	1
Rimon	2	1	1	2	1	—
Sevin	3	3	2	3	2	3
Verdepryn	1	0	0	1	1	1
Voliam Flexi	2	1	1	2	2	—
Vydate	2	3	3	2	3	—
Zeal	0	1	1	—	1	—

Table 14. Weed Response to Pre-emergence Herbicides

(— = no data, 0 = no control; 1 = poor control; 5 = complete control)

Plant Type	Herbicides:	Flumioxazin	Diuron	Alion	Solicam	Prowl	Simazine	Sinbar	Pindar GT	Trellis	Pennant Magnum	Rimsulfuron	Motif	Zeus Prime
BIENNIAL AND PERENNIAL WEEDS	bermudagrass	0	0	0	0	0	0	2	0	0	0	0	0	0
	briars	0	1	—	0	0	0	—	0	0	0	—	0	0
	dallisgrass	2	2	0	2	1	1	—	2	0	0	—	0	—
	dogfennel	2	3	0	5	2	3	4	3	0	0	—	-	—
	horsenettle	2	1	—	0	0	1	3	0	0	0	—	3	—
	johnsongrass (rhizome)	0	0	0	0	2	2	—	0	0	0	—	0	0
	musk thistle	—	4	—	4	0	5	2	2	0	0	—	-	—
	plantains	4	0	1	4	2	4	4	2	0	0	—	-	4
	wild garlic	—	2	0	4	0	—	4	1	0	0	—	-	—
	yellow nutsedge	0	0	0	3	0	1	3	0	0	4	3	0	5
ANNUAL GRASSES	barnyard grass	4	4	5	4	4	3	4	3	0	5	3	0	—
	crabgrass	4	4	5	4	5	3	4	4	0	5	3	2	3
	fall panicum	4	3	4	4	4	3	5	3	0	5	—	0	—
	goosegrass	4	4	5	4	5	4	4	4	0	5	—	0	—
	johnsongrass (seedling)	4	2	—	3	4	2	5	2	0	3	—	0	—
	signalgrass (broadleaf)	4	3	5	3	5	2	4	2	0	4	—	0	—
BROADLEAF WEEDS	chickweed	5	4	5	5	5	4	5	5	4	—	—	5	4
	cocklebur	4	3	—	2	0	3	3	1	0	0	3	3	4
	evening primrose	4	3	4	—	2	4	5	5	4	—	—	5	4
	galinsoga	—	4	—	4	0	4	4	4	5	5	—	5	5
	horseweed	5	3	4	4	0	4	5	4	4	—	4	5	4
	jimsonweed	5	3	—	2	1	3	2	—	4	—	—	5	5
	lambsquarters	5	4	5	4	2	4	5	5	5	—	3	5	5
	morning-glories	5	4	4	1	2	4	5	2	3	0	4	2	5
	nightshades	5	3	—	4	1	3	5	4	5	5	3	5	5
BROADLEAF WEEDS	pigweeds	5	4	5	4	4	5	5	5	5	5	5	5	5
	prickly sida	4	2	1	4	1	4	5	4	4	0	3	-	5
	ragweed	5	5	4	4	1	5	5	5	5	—	3	4	4
	spotted spurge	5	0	5	3	3	2	5	—	4	—	5	-	—
	wild radish, mustards	5	4	4	4	2	5	5	4	5	0	—	-	5

Table 15. Weed Response to Postemergence Herbicides

(— = no data, 0 = no control; 1 = poor control; 5 = complete control)

Plant Type	HERBICIDES:	Glufosinate	Glyphosate	Paraquat	2, 4-D	Aim	Fusilade	Poast	Clethodim	Stinger	Treevix	Fluroxypyr	Motif	Sandea
BIENNIAL AND PERENNIAL WEEDS	bermudagrass	2	3	1	0	0	5	4	5	0	0	0	0	—
	briars	3	4	1	3	-	0	0	0	0	0	3	0	—
	dallisgrass	4	4	4	0	0	3	3	3	0	0	—	0	—
	dogfennel	—	5	0	3	—	0	0	0	0	—	—	0	—
	horsenettle	2	3	2	1	—	0	0	0	2	1	4	3	4
	johnsongrass (rhizome)	4	4	1	0	0	4	4	4	0	0	—	0	—
	musk thistle	4	5	2	5	—	0	0	0	5	3	—	0	—
	plantains	—	5	2	4	—	0	0	0	—	0	4	0	—
	wild garlic	4	3	1	3	—	0	0	0	0	0	—	0	—
	yellow nutsedge	2	4	1	0	0	0	0	0	0	0	—	0	4
ANNUAL GRASSES	barnyard grass	4	5	3	0	0	4	4	0	0	—	—	0	—
	crabgrass	5	5	4	0	0	5	5	0	0	—	—	0	—
	fall panicum	5	5	4	0	0	5	5	0	0	—	—	0	—
	goosegrass	5	5	4	0	0	4	4	0	0	—	—	0	—
	johnsongrass (seedling)	5	5	4	0	0	5	5	0	0	—	—	0	—
	signalgrass (broadleaf)	4	5	4	0	0	4	4	0	0	—	—	0	—
BROADLEAF WEEDS	chickweed	5	5	5	2	—	0	0	0	0	5	—	5	—
	cocklebur	5	5	5	5	4	0	0	4	5	5	5	1	—
	evening primrose	4	2	3	5	3	0	0	—	3	5	—	5	—
	galinsoga	5	5	5	3	—	0	0	—	—	—	—	5	—
	horseweed	3	5	2	3	1	0	0	—	5	5	—	5	—
	jimsonweed	4	5	5	5	4	0	0	4	—	—	4	5	—
	lambsquarters	4	5	5	5	5	0	0	—	5	—	3	5	—
	morning-glories	5	4	4	4	5	0	0	—	5	5	—	2	—
	nightshades	5	5	5	5	4	0	0	5	5	3	—	5	—
	pigweeds	5	5	5	4	4	0	0	0	5	3	4	4	—
	prickly sida	5	5	4	4	—	0	0	0	5	—	—	0	—
	ragweed	5	5	5	5	—	0	0	—	5	4	—	4	—
	spotted spurge	5	5	5	5	4	0	0	—	—	—	—	-	—
	wild radish, mustards	5	4	3	5	—	0	0	—	4	—	5	4	—

Fungicides and Bactericides

***Acibenzolar-S-methyl,* Actigard 50WG**

Actigard 50WG is an inducer of host plant resistance and has no direct activity against target pathogens. In apples, it is used for the suppression of fire blight. Actigard 50WG should be applied prior to a predicted fire blight infection event with the goal of stimulating plant defenses. Actigard may also be used in tank mixture with an antibiotic at a rate of 0.5 to 3.2 ounces per acre and applications should occur between 20% bloom and petal fall. When Actigard is applied directly to foliage, it may not be applied within 60 days of harvest (60-day PHI).

***Benzovindiflupyr,* Aprovia**

Aprovia is an SDHI fungicide (FRAC 7) containing benzovindiflupyr. Unlike many of the new SDHI fungicides, Aprovia is not premixed with another active ingredient. Aprovia is registered for use on apples for the control of apple scab, Alternaria blotch, Alternaria rot, cedar apple rust, quince rust, flyspeck and sooty blotch, powdery mildew, bitter rot, black rot, white rot, and Brooks fruit spot. Apply Aprovia at a rate of 5.5 to 7 fluid ounces per acre. If disease pressure is high, use the highest labeled rate and a shorter application interval. While Aprovia is most effective when used on a preventative application schedule, the fungicide does demonstrate curative activity against apple scab. No more than two applications of Aprovia may be applied on a seven-day interval, and all other applications must be applied on a 14-day interval. Do not apply more than two consecutive applications of Aprovia before switching to a different fungicide (FRAC) group. Aprovia cannot be applied within 30 days of harvest (30-day PHI).

***Captan*, Captan, Captec**

Captan is formulated as 50W, 80W, 80WDG, and 4L. Captan 50W at 1.5 pounds or 4L at 0.75 quart per 100 gallons is weak on sooty blotch and flyspeck, and will not provide satisfactory control of these diseases in wet weather when applied on a 14-day schedule. Captan does have good activity on bitter rot, white rot, and black rot. Captan is not effective against cedar apple rust, quince rust, or powdery mildew. During periods favorable for disease development, use 2.0 pounds of Captan 50W or 1.0 quart of Captec 4L per 100 gallons dilute on a 10- to 14-day interval. Check labels for the maximum amounts of each formulation that can be used each year. Powdery mildew may be more severe in trees sprayed with captan than non-sprayed trees. Captan results in excellent fruit finish. Captan is NOT safe with oil or within two weeks after an oil application. A leaf spot resembling frogeye leaf spot may result on Delicious and Stayman if captan is applied under slow drying conditions, especially if used with oil-based or EC-formulated insecticides or sulfur at high temperature and high relative humidity.

Copper Compounds

There are many formulations of copper, such as copper hydroxide (Kocide 101), copper oxychloride (C-O-C-S), and Bordeaux mixture, that can be used as a dormant spray for fire blight control. See the label for the correct rate. Bordeaux can also be made by adding 8 pounds copper sulfate plus 8 pounds spray lime to 100 gallons water. Include 1 quart oil per 100 gallons Bordeaux to increase efficacy. Add oil after adding lime but before mixing to final volume. Most apples are very sensitive to copper, and use after green tip will result in russet.

***Cyprodinil*, Vangard**

Cyprodinil 75WG has good protectant activity and some eradicant activity (up to 48 hours) on apple scab. It tends to be most active at cool temperatures. It is weak on powdery mildew and cedar apple rust and has little summer disease activity. Use Vangard 75WG on a seven-day interval in the first two sprays at 5 ounces per acre (1.25 ounces per 100 gallons). Subsequent sprays of Vangard 75WG should be made on a seven-day interval at 3 ounces per acre (0.6 ounces per 100 gallons) in combination with captan or an EBDC fungicide (mancozeb or metiram). Mix with captan where black rot is a problem and with a sterol-inhibiting fungicide where powdery mildew is a problem. Both EBDC and DMI fungicides will control rust diseases. Use a minimum of 100 gallons water per acre to ensure complete coverage. Do not apply more than 30 ounces of Vangard 75WG per acre per season. Do not apply within zero days of harvest. See discussion under pyrimethanil Scala SC for resistance management strategies.

***Difenoconazole+cyprodinil*, Inspire Super**

Inspire Super is a 2.82EW premix of the DMI fungicide difenoconazole and the aniline-pyrimidine (AP) fungicide cyprodinil. It has good activity on scab, powdery mildew, and the rust diseases, though it is not as active as some DMI fungicides on powdery mildew. It has been shown to provide control of apple scab in orchards where low levels of the apple scab fungus are resistant to other DMI fungicides. Although difenoconazole (as well as fenbuconazole; "Indar") may have higher intrinsic activity against scab than some earlier EBI compounds, both compounds in the Inspire Super mixture (Group 3 and Group 9) are at risk for development of resistance. To help prevent resistance, it is recommended to make no more than two consecutive applications with Inspire Super or another Group 3 (DMI) fungicide mixture before

alternating to a different mode of action. For improved scab control where resistance to DMI fungicides is suspected, combine Inspire Super with an EBDC fungicide or captan. When used in rotation with captan + a phosphite fungicide it provides good summer disease control (see "Disease Management" in Second Cover and Later Sprays on page 27). Use the 12-fluid-ounces-per-acre rate for summer disease control. Inspire Super does not have good activity on black pox, so in orchards where that is a problem, use an EBDC fungicide + captan or captan + thiophanate-methyl in the first two cover sprays. To help prevent resistance, do not make more than two consecutive applications of Inspire Super or other DMI fungicides. Do not apply more than 60 fluid ounces of Inspire Super per year. Do not apply within 14 days of harvest.

***Dodine*, Syllit**

Syllit 3.4FL is very effective for the control of apple scab but does not control rusts, powdery mildew, or summer diseases. Strains of the apple scab fungus resistant to dodine have been reported in many northeastern and North Central states but have not been found in the Southeast. Dodine is generally used at 1.5 to 3 pints per acre on a seven-day schedule in the prebloom sprays. It is effective 30 to 36 hours after infection. If scab lesions are visible, dodine is effective in limiting spore production and germination. When used for this purpose, apply 4.5 pints per acre. Dodine may cause fruit injury if applied at freezing or near-freezing temperatures, particularly if drying conditions are slow. Dodine may russet Golden Delicious, especially if applied during bloom, petal fall, or early cover sprays. It is usually compatible with oil and with most fungicides formulated as a wettable powder.

EBDC Fungicides (*mancozeb, metiram*)
***Mancozeb*, Dithane, Manzate, Penncozeb**
***Metiram*, Polyram**

Mancozeb is formulated as an 80WP, a 75DF, and a 4F, and Polyram as an 80DF. Mancozeb and metiram have a similar spectrum of activity. They are registered for use at 3.0 pounds per acre or 2.4 quarts per acre in tank mixtures with another fungicide. A maximum of seven applications (21 pounds or 16.8 quarts per acre per season) can be used with a 77-day preharvest interval. They can also be used alone before petal fall at 6.0 pounds or 4.8 quarts per acre. A maximum of four applications of the 6.0-pounds- or 4.8-quarts-per-acre rate (24 pounds or 19.2 quarts per acre per season) can be used. The two treatment schedules cannot be combined. In the Southeast, the 3.0-pounds- or 2.4-quarts-per-acre rate in a tank mix with captan is most useful. Combinations with a DMI fungicide before petal fall will aid in apple scab control, and combinations with captan after petal fall will aid in sooty blotch, flyspeck, Brooks fruit spot, black pox, and bitter rot control. Do not rely on combinations of the low-labeled rate of an EBDC fungicide + a DMI fungicide for scab control if resistance is suspected. Mancozeb and metiram are weak on white and black rot. Fruit finish with metiram is generally better than with mancozeb.

***Fenbuconazole*, Indar**

Indar 2F is a DMI fungicide and has activity similar to other DMI fungicides (myclobutanil, triflumizole, difenoconazole, flutriafol, and tebuconazole) on apple scab, powdery mildew, and the rust diseases. Indar does have more activity on sooty blotch and flyspeck, but when used alone, it should not be relied upon for control of these diseases in North Carolina (given the pressure typically present during the summer). Use Indar 2F at 8 fluid ounces per acre. Do not make more than four applications of Indar per season, and do not apply more than 32 fluid ounces per acre per season. Although fenbuconazole (like difenoconazole) may have higher intrinsic activity against scab than some earlier EBI compounds, it is at risk for development of resistance. To avoid the development of resistant strains of apple scab fungus, always use Indar in combination with captan, mancozeb, or metiram. Do not use Indar in orchards where EBI resistance is suspected.

***Fluazinam*, Omega 500F**

Fluazinam (Omega 500F) is registered on apples at the rate of 10 to 13.8 fluid ounces per acre for control of scab and sooty blotch and flyspeck. The rate is 13.8 fluid ounces per acre for control of bitter rot, black rot, Brooks spot, and cedar apple rust, and 13.8 fluid ounces for suppression of Alternaria blotch, white rot, and quince rust. Limitations include 10 applications or 8.625 pints per acre per year, REI of 48 hours, and PHI of 28 days. Caution: Omega 500F may cause allergic skin reactions in a small number of sensitive individuals. Observe all precautions for protective clothing and avoid contact of unprotected skin with treated foliage. People who have been sensitized to Omega 500F should not use or have further contact with the product.

***Fluopyram + trifloxystrobin*, Luna Sensation 500SC and *Fluopyram + pyrimethanil*, Luna Tranquility 4.16SC**

Fluopyram is registered on apples for several uses. Luna Sensation contains fluopyram (Group 7) and trifloxystrobin (Flint, Group 11) and is registered for apple scab, powdery mildew, cedar apple rust, sooty blotch and fly speck, bitter rot, and white rot. Use respective rates for scab, rust, sooty blotch and fly speck. Bitter rot is 4.0 to 5.8 fluid ounces per acre and for mildew the rate is 5.0 to 5.8 fluid ounces per acre. For white rot, combine Luna

Sensation with 1.5 pounds per acre of Captan 80WDG. Label restrictions include a maximum of 21 fluid ounces per acre per year, a 12-hour REI, and a 14-day PHI. Limit the number of applications per season to four, with no more than two applications made sequentially. Luna Tranquility contains fluopyram (Group 7) and pyrimethanil (Scala, Group 9) and is registered for apple scab and powdery mildew at the rate of 11.2 to 16 fluid ounces per acre. Label restrictions include a 54.7-fluid-ounce maximum per acre per year, a 12-hour REI, and a 72-day PHI. Limit the number of applications per season to four, with no more than two applications made sequentially.

***Flutriafol*, Topguard**

Topguard 1.04SC is a DMI fungicide with activity on scab, powdery mildew, cedar apple rust, and quince rust. It is somewhat weaker on apple scab than the other new DMI fungicides but has very good powdery mildew and rust activity. For scab control, combine 13.0 fluid ounces with 3.0 pounds per acre of captan, mancozeb, or metiram. *In orchards where EBI resistance is suspected, these combinations will not satisfactorily control scab under heavy disease pressure.* For powdery mildew control, use 8.0 to 12.0 fluid ounces per acre. Use the higher rate on susceptible cultivars where powdery mildew has been a problem. Do not use more than 52 fluid ounces per acre or make more than four applications of Topguard per season. Do not add adjuvants to the spray solution or make an application within 14 days of harvest.

***Fluxapyroxad*, Sercadis**

Sercadis is a next-generation SDHI (Group 7) with activity against apple scab, powdery mildew, black rot, frogeye leaf spot, flyspeck, and Alternaria blotch. It provides suppression against quince rust and cedar apple rust. Label restrictions include 18 fluid ounces maximum per acre per year, 12-hour REI, zero-day PHI, and a maximum number of four applications per season. Do not make more than two sequential applications of Sercadis before rotating to a non-Group 7 fungicide. There is a medium-to-high risk of resistance development with Sercadis, so tank-mixing with a multi-site protectant fungicide such as captan or mancozeb is recommended. Fluxapyroxad, the active ingredient in Sercadis, is also an active ingredient in Merivon SC.

***Fluxapyroxad + Pyraclostrobin*, Merivon 4.18SC**

Merivon is registered on pome fruits (apple, crabapple, Oriental pear, and pear) for Alternaria blotch, apple scab, bitter rot, Brooks spot, sooty blotch and fly speck, pear scab, powdery mildew, and white rot at 4.0 to 5.5 fluid ounces per acre. Merivon provides suppression only for rust diseases. Label restrictions include 22.0 fluid ounces maximum per acre per year, a 12-hour REI, and a zero-day PHI. Maximum number of applications per season is four. Do not use emulsifiable concentrates (EC) or solvent-based formulation products, crop oil concentrate (COC), or methylated seed oil (MSO) adjuvants with Merivon.

***Fosetyl-Al*, Aliette**

Aliette WDG is registered for crown (collar) rot control on apple trees in orchards and nurseries. Under conditions favorable for the disease (such as susceptible rootstock or heavy, poorly drained soils), apply 2.5 pounds per acre at 30-day intervals beginning after leaf emergence, or 5.0 pounds per acre at 60-day intervals. Aliette WDG can also be used in a root dip for nursery stock before planting to control root rot. Mix 3 pounds per 100 gallons and dip root system for 30 to 60 minutes before planting. The label for Aliette WDG use as a root dip is a Section 2(ee) registration, so be sure to obtain a copy of this label before use. Do not apply Aliette WDG within 14 days of harvest. Do not exceed 20 pounds per acre per season.

***Inpyrfluxam*, Excalia**

Excalia is an SDHI fungicide (FRAC 7) containing inpyrfluxam. Excalia is registered for use on apples to control apple scab, powdery mildew, cedar apple rust, and quince rust. Apply Excalia at a rate of 3 to 4 fluid ounces per acre on no shorter than a 10-day interval. For powdery mildew, include an adjuvant. If disease pressure is high, use the highest rate labeled. A maximum of two applications of Excalia is permitted per season. Do not apply Excalia before green tip or after petal fall. Do not apply more than 8 fluid ounces of Excalia per acre per year.

***Kasugamycin*, Kasumin 2L**

Kasumin 2L is an antibiotic that is registered for control of fire blight on apples and pears at the use rate of 64 fluid ounces per acre. Do not apply more than 256 fluid ounces per acre per year, more than four applications per year, and no more than two consecutive applications. Do not apply after petal fall or within 90 days of harvest. Do not use alternate tree-row application method. Do not apply kasugamycin in orchards in which the soil has been fertilized with animal waste/manure.

***Kresoxim-methyl*, Sovran**

Sovran 50WG is in the strobilurin (QoI) class of fungicides. It has both protectant and eradicant properties. It is very active on apple scab. Although it will eradicate infections within 48 hours of the beginning of an infection period, it is most effective when used on a protectant schedule. It will also provide good control of powdery mildew and will provide acceptable control of cedar apple rust. It also has good activity on Brooks fruit spot, flyspeck, sooty blotch, and white rot (Bot

rot). Resistance of strains of *Alternaria mali* to Sovran is widespread, and Sovran should not be relied upon to control Alternaria blotch. Sovran is also weak on black pox. It is registered for use at 1.0 to 1.6 ounces per 100 gallons (4.0 to 6.4 ounces per acre). Use the higher rate where summer diseases are a problem. Do not apply more than 6.4 ounces per acre per application. To avoid resistance development, do not make more than two consecutive applications of Sovran 50WG before switching to a non-strobilurin fungicide. Do not use Sovran 50WG in the final spray of the season. Do not make more than four applications of Sovran 50WG per season.

Lime Sulfur

Lime sulfur is most useful for controlling powdery mildew on Rome Beauty before bloom. Lime sulfur applied when temperatures are above 85°F or under slow drying conditions can result in fruit and leaf injury. A lime-sulfur spray is alkaline and is not compatible with oil, most insecticides, or other fungicides.

***Mefenoxam,* Ridomil Gold SL**

Mefenoxam is registered for Phytophthora crown, collar, and root rot control. The first application should be made before growth begins in the spring and the second in the autumn after harvest. Apply in a banded application under the canopy or as a drench around the trunk. Delay application on new plantings for two weeks after planting. See the label for correct use rates.

***Mefentrifluconazole*, Cevya**

Cevya is a DMI fungicide (FRAC 3) containing mefentrifluconazole. Cevya is registered for use on apples for the control of apple scab, Alternaria blotch, black rot/frogeye leaf spot, cedar apple rust, flyspeck, sooty blotch, and white rot. It is labeled for the suppression of powdery mildew and quince rust. Apply Cevya at a rate of 4 to 5 fluid ounces per acre. If disease pressure is high, use the highest labeled rate and a shorter application interval. Since Cevya is a group 3 fungicide, it should provide 24 to 48 hours of curative activity when applied to a sensitive population following an infection event. Do not apply more than 15 fluid ounces of Cevya per acre per year. Cevya can be applied up to the day of harvest.

***Myclobutanil*, Rally**

Myclobutanil 40W is registered for control of apple scab, powdery mildew, and cedar apple rust. Use 1.25 to 2.0 ounces per 100 gallons in combination with 0.75 pounds captan 50W or mancozeb 80W or 75DF or metiram 80W or with 0.6 quart mancozeb 4F on a seven- to 10-day schedule beginning at green tip for the control of scab. Use the higher rate of myclobutanil 40W during periods favorable for scab or in orchards with a history of scab. This combination will also control mildew and rust diseases. Use the higher labeled rate if mildew has been a problem. Myclobutanil 40W acts as an eradicant for scab and will provide 96-hour after-infection activity. Myclobutanil 40W will also suppress sporulation of established scab lesions when used in two back-to-back sprays. Use 2.0 ounces per 100 gallons in the first application, and make a second application at 1.25 ounces per 100 gallons in five to seven days. Include a full rate of a protectant fungicide in the first spray of the eradicant program. Avoid eradicant applications to reduce the likelihood of resistance developing. In orchards where EBI resistance is present, myclobutanil + 3.0 pounds per acre of mancozeb, captan, or metiram will not satisfactorily control scab. Myclobutanil 40W, when used alone, has very little activity on any summer diseases.

***Oxytetracyline*, Fireline 17WP**

Fireline 17WP is an antibiotic that is registered for the control of fire blight on apples and pears at an application rate of 16 ounces per 100 gallons. Do not apply Fireline 17WP more than six times per year. One application of Fireline 17WP is permitted after the end of bloom, however it may not be applied within 60 days of harvest. Fireline 17WP may cause phytotoxicity to fruit and foliage of sensitive cultivars.

***Penthiopyrad*, Fontelis 1.67SC**

Penthiopyrad is registered for apple scab and powdery mildew at the rate of 14 to 20 fluid ounces per acre. Label restrictions include a maximum of 61 fluid ounces per acre per year, a 12-hour REI, and a 28-day PHI on pome fruits. Fontelis is in the same fungicide group (Group 7) as boscalid (Endura), which is one of the two components in Pristine; fluopyram, which is one of the two components in Luna Tranquility and Luna Sensation; and fluxapyroxad, which is one of the two components in Merivon. Group 7 fungicides are considered to be at risk for development of resistance. Limit the number of applications to four and utilize fungicides with other modes of action for different diseases throughout the season as appropriate. Limit the potential for resistance to all products by not exceeding the total number of sequential applications of Group 7 fungicides or their total number of applications per season.

Phosphite fungicides (phosphonate fungicides)

Phosphite fungicides are composed of salts and esters of phosphorous acid. The most common products contain mono- and di-potassium salts of phosphorous acid and are often referred to as potassium phosphite. A closely related product is fosetyl Al (see Aliette,

above), which is formed from the reaction of phosphonic acid with ethanol. Phosphite fungicides should not be confused with phosphate-derived fertilizers, such as ammonium phosphate and triple super phosphate, which do not have any fungicide activity. When used alone, phosphite fungicides do not provide satisfactory disease control. However, in combination with a broad-spectrum protectant fungicide such as captan or ziram, they significantly improve the activity of both captan and ziram. Phosphite fungicides are most useful in the Southeast in the management of summer diseases. While phosphite fungicides plus a protectant can be used in all cover sprays, this combination is most effectively used when rotated with a QoI fungicide (Pristine, Flint, Sovran) in the cover sprays. The rotation has given good broad-spectrum control of diseases including Glomerella leaf spot and Alternaria leaf spot (rotation with Pristine). There are several different phosphite fungicides on the market including ProPhyt, K-Phite, Agri-Fos, and Phostrol. *In order to achieve satisfactory disease control, the fungicide formulation should contain approximately 50% of salts or esters of phosphorous acid.* The rates may vary depending on the phosphite fungicide, so follow the label directions when using them.

***Pyraclostrobin + boscalid*, Pristine**
Pristine is a premix of 12.8% of the strobilurin fungicide pyraclostrobin plus 25.2% of the carboxyanilide fungicide boscalid. It has very good activity on apple scab but is most effective when used on a protectant schedule. It has good activity on powdery mildew and will control and prevent cedar apple rust if the pressure is not high. Its activity on summer diseases is similar to that of the other strobilurin fungicides kresoxim-methyl (Sovran) and trifloxystrobin (Flint), except that it is more active on *Alternaria mali*, the cause of Alternaria blotch on Delicious. The boscalid component has good activity on *A. mali* and will also control strains of *A. mali* that have developed resistance to strobilurin fungicides. Use 14.5 to 18.5 ounces per acre. Use the higher rate on large trees or during weather favorable for disease development. Do not use less than 14.5 ounces per acre regardless of tree-row volume. Do not make more than four applications of Pristine per season. Do not make more than two sequential applications of Pristine before alternating to a labeled fungicide with a different mode of action. Pristine has a 0 PHI.

***Pydiflumetofen*, Miravis**
Miravis is an SDHI fungicide (FRAC 7) containing pydiflumetofen. Miravis is registered for use on apples for the control of apple scab, Alternaria blotch, powdery mildew, cedar apple rust, quince rust, and flyspeck/sooty blotch. It is labeled for the suppression of Brooks spot, black rot, white rot, and bitter rot. Apply Miravis at a rate of 3.4 fluid ounces per acre. Miravis does provide approximately 24 hours of curative activity against apple scab when applied to a sensitive population following an infection event. Do not apply more than 13.6 fluid ounces of Miravis per acre per year, and do not make more than two consecutive applications before switching to an alternate FRAC group. For resistance management, be sure to tank-mix with a multi-site protectant fungicide such as captan or mancozeb. Miravis has a pre-harvest interval of 30 days.

***Pyrimethanil*, Scala**
Scala SC, an anilinopyrimidine (AP) fungicide, contains 45.4% of the active ingredient pyrimethanil. It has little activity on foliar apple diseases other than apple scab. It is active on scab in cool weather and is most effectively used as a protectant in the early-season sprays. It is not a strong eradicant. Use 7 to 10 fluid ounces per acre alone or 5 fluid ounces per acre in combination with 3 pounds per acre of mancozeb or metiram on a five- to seven-day interval, depending on conditions favorable for scab infection. It is not compatible with captan. It is in the same chemical group as cyprodinil Vangard, so resistance management strategies need to consider both products collectively. Do not apply more than four sprays of either product alone or five sprays in mixture with a fungicide with a different mode of action. Do not apply more than two sprays of Scala or Vangard in sequence before rotating with a similar number of fungicides with a different mode of action. Do not use more than 40 ounces of Scala SC per season. Do not apply Scala SC within 72 days of harvest.

***Streptomycin*, Agri-Mycin 17, Ag Streptomycin, FireWall**
Streptomycin is an antibiotic that is used in bloom sprays for fire blight control. Use streptomycin at 60 to 100 parts per million (ppm) in three sprays applied at four- or five-day intervals during bloom. Apply the first spray when the first blooms open. Streptomycin is not especially effective for shoot blight control; however, a spray within 24 hours of a hailstorm may help reduce blight on fire-blight-susceptible cultivars or orchards with blossom blight. Streptomycin is not compatible with lime-sulfur. It is more effective when applied alone and under damp conditions. Some temporary marginal or veinal leaf yellowing has occurred when high rates are used. The effectiveness of streptomycin can be increased by including the adjuvant Regulaid at the rate of 1 pint per 100 gallons of tank mix, however, the increased uptake of streptomycin with Regulaid is more likely to result in streptomycin injury. Streptomycin is registered for use at 50 to 100 ppm to within 50 days of harvest. The effectiveness of streptomycin is reduced when applied at

6x concentration or greater. Limit streptomycin sprays to three per year to avoid resistance.

Sulfur

Sulfur is effective against powdery mildew when used at 1 to 3 pounds (active) per 100 gallons on a seven-day schedule. Scab control is not very good at this rate. Avoid using sulfur after bloom for best fruit finish on Golden Delicious, Red Delicious, and Stayman. For powdery mildew control after bloom on Rome Beauty, include 1 to 3 pounds (active) per 100 gallons with another fungicide for summer disease control. Do not apply sulfur within two weeks before or after an oil spray. Sulfur is not safe to use above 90°F. Many formulations of sulfur are available; check label for rates.

***Trifloxstrobin*, Flint Extra**

Flint Extra is in the strobilurin (QoI; FRAC 11) class of fungicides. It has both protectant and curative properties, and is very active against apple scab, powdery mildew, and bitter rot and Glomerella leaf spot. Although it will eradicate infections within 24 to 48 hours of the beginning of an infection period, it is most effective when used on a protectant schedule. Flint Extra also has good to excellent activity on Brooks fruit spot, flyspeck, sooty blotch, white rot, and black rot. Flint Extra is registered for use at 2.5 to 2.9 fluid ounces per acre. Use the higher rate where summer diseases are a problem. Do not apply more than four applications of Flint Extra or ANY other strobilurin in a season. To mitigate resistance development, do not make more than two consecutive applications of Flint Extra before switching to a non-strobilurin fungicide, and be sure to tank-mix with a multi-site protectant fungicide such as captan or mancozeb. Flint Extra has a 14-day PHI.

***Ziram*, Ziram**

Ziram, formulated as 76DF, is a dithiocarbamate fungicide in the same group as thiram and ferbam. It is registered for control of apple scab, cedar apple rust, quince rust, sooty blotch, flyspeck, bitter rot, and necrotic leaf blotch. It is most useful for summer disease control and it has good activity on sooty blotch, flyspeck, bitter rot, and black pox and suppresses necrotic leaf blotch on Golden Delicious. It is not particularly effective on white or black rot. The 76DF formulation should be used at 2 pounds per 100 gallons. White rot, black rot, sooty blotch, and flyspeck control will be improved if Ziram is combined with thiophanate-methyl 85WDG at 2 to 3 ounces per 100 gallons. Ziram applications have resulted in good fruit finish. Do not apply more than 42.2 pounds of the 76DF per acre per season.

Insecticides and Miticides

Insecticides and miticides are grouped according to the Insecticide Resistance Action Committee (IRAC) mode of action categories. Pesticides within the same Mode of Action (MoA) group have the same mode of action.

MoA 1A (Carbamates)

***Carbaryl*, Sevin**

Carbaryl is formulated as a 50 WP and XLR (4 pounds active ingredient per gallon). For insect control, the 50WP should be used at a rate of 0.5 to 1.0 pounds per 100 gallons, and the XLR formulation should be used at 0.25 to 1 quart per 100 gallons. Carbaryl gives excellent control of leafhoppers and Japanese beetles, and good control of cicadas and redbanded leafrollers. Carbaryl is also used as a fruit thinner on several apple varieties. Carbaryl may be applied within three days of harvest. Carbaryl may roughen the lenticels of fruit.

***Methomyl*, Lannate**

Methomyl is formulated as a 90SP and should be used at the rate of 0.25 to 0.5 pound per 100 gallons. Methomyl provides good control of aphids, leafminers, and many other pests of apples, and is an ovicide to leafroller eggs. However, methomyl has short residual activity (about 24 hours) and is highly toxic to mite predators, and biological mite control is less likely to occur with postbloom use of this product. Methomyl is highly toxic to humans and should be used with extreme care. It has a four-day re-entry interval. Do not apply within 14 days of harvest.

***Oxamyl*, Vydate**

Oxamyl is formulated as a 2L and should be used at 1 to 2 pints per 100 gallons. It is most effective when used for spotted tentiform leafminer and white apple leafhopper shortly after bloom, and is effective against rosy apple aphid when applied before bloom. Oxamyl is also a fruit thinner when applied within 30 days after bloom and is toxic to mite predators. Do not apply more than 1 gallon of Vydate 2L per acre per season, and do not apply within 14 days of harvest.

MoA 1B (Organophosphates)

***Diazinon*, Diazinon**

Diazinon is formulated as a 50WP (1 pound per 100 gallons). It is a broad-spectrum insecticide, which is particularly effective against rosy apple aphids, woolly apple aphid, San Jose scale, and Comstock mealybugs. The 50WP formulation may be applied up to 21 days before harvest, but it has a four-day re-entry interval. Do not apply more than 4 pounds per acre per application or more than 12 pounds per acre per season. Diazinon may cause some russeting on Golden Delicious, especially when used in early cover sprays. **Caution:** Diazinon applied with Captan or Captec may cause phytotoxicity or russeting.

***Phosmet*, Imidan**

Phosmet is formulated as a 70WP and is used at a rate of 0.75 to 1 pound per 100 gallons. Phosmet is a broad-spectrum insecticide that is effective against many direct pests of apples. However, it will not provide adequate control of codling moth, tufted apple bud moth, San Jose scale, or aphids. It is one of the safest organophosphates to beneficial arthropods. It has a re-entry interval following application of three days, and a preharvest interval of seven days. Do not allow persons not covered by worker protection standards (i.e., general public as in you-pick operations) to enter orchards for 14 days after application.

MoA 3A (Pyrethroids)

This group of insecticides is broad spectrum in activity, has good residual activity, is recommended at low dosages, and is relatively safe. **However, applications of pyrethroid insecticides at any time during the season may aggravate or induce mite, woolly apple aphid, Comstock mealybug, and San Jose scale outbreaks.** Limiting their use to the period before bloom is less disruptive to secondary pests than post-bloom applications. This is one of the few groups of insecticides that provide good control of brown marmorated stink bug, which unfortunately poses the greatest threat to apples in August and September.

***Beta-cyfluthrin*, Baythroid**

Beta-cyfluthrin is formulated as Baythroid XL, a 1EC formulation that is recommended at rates ranging from 1.4 to 2.8 fluid ounces per acre. The lowest rates are for leafhoppers, and the higher rates are for plum curculio, codling moth, apple maggot and stink bugs. It has a 14-day PHI. The maximum amount allowed is restricted to 2.8 fluid ounces per application or per season.

***Esfenvalerate*, Asana**

Esfenvalerate is formulated as a 0.66EC (Asana XL) and used at 2.5 to 5.8 ounces per 100 gallons. Esfenvalerate is compatible with other insecticides and fungicides. Esfenvalerate is a broad spectrum insecticide that controls many pests and is the most effective insecticide registered on apples for control of cicada. Esfenvalerate has a 21-day interval between the last application and harvest. Do not exceed 101 ounces per acre per season.

Esfenvalerate is toxic to fish and may also cause skin irritation.

***Fenpropathrin*, Danitol**
Fenpropathrin is formulated as a 2.4EC (Danitol 2.4EC) and is used at a rate of 10.66 to 21.33 ounces per acre. Danitol is a broad spectrum insecticide that can be used before bloom for control of rosy apple aphid or postbloom for control of beetles, lepidopterous pests, and mites. For delayed dormant or prepink applications, the lower rate can be used, but for postbloom applications a minimum rate of 16 ounces per acre should be used. Although Danitol is a pyrethroid and toxic to mite predators, it also controls European red mite. However, multiple applications per season should be avoided to prevent the development of resistance. Danitol has a 14-day preharvest interval. Do not apply more than 42.66 ounces per acre per season.

***Gamma-cyhalothrin*, Proaxis**
Gamma-cyhalothrin is formulated as a 0.5EC and recommended at 2.56 to 5.12 fluid ounces per acre. It has broad-spectrum activity and a 21-day PHI.

***Lambda-cyhalothrin*, Warrior, Karate**
Lambda-cyhalothrin is formulated as Warrior and contains 2.08 pounds of active ingredient per gallon in a capsule suspension. It has activity against a broad range of insect pests and is recommended at rates of 1.58 to 2.56 ounces per acre. Do not apply closer than 21 days before harvest.

***Permethrin*, Ambush, Pounce**
Permethrin is formulated as a 2E (Ambush) and 3.2EC (Pounce). Ambush is used in the range from 6.4 to 12.8 fluid ounces per acre, and Pounce may be used in the range from 4 to 8 fluid ounces per acre. Both products are also formulated as 25WP and should be used in the range from 6.4 to 12.8 ounces per acre. Do not exceed three applications of either Ambush or Pounce per season, and do not apply either after petal fall.

***Zeta-cypermethrin*, Mustang Maxx**
Zeta-cympermethrin is formulated as a Mustang Maxx 0.8EC and is recommended at the rates of 1.28 to 4.0 fluid ounces. It has broad-spectrum activity with a preharvest interval of 14 days and a 12-hour re-entry interval.

MoA 4A (Neonicotinoids)

***Acetamiprid*, Assail**
Acetamiprid is formulated as Assail 30SG and is recommended at rates of 2.5 to 8.0 ounces per acre. It is registered for use on aphids, leafhoppers, leafminers, plum curculio, codling moth, oriental fruit moth, and apple maggot. For control of the latter three insects, use a minimum of 5 ounces per acre. As with other neonicotinoid insecticides, it is toxic to coccinelids (lady beetles) upon contact. Do not make more than four applications per season or exceed 13.5 ounces per acre per season. Do not apply more than once every 12 days, and do not apply less than seven days before harvest. Among the neonicotinoids, it is the least toxic to honeybees.

***Clothianidin*, Belay**
Clothianidin is formulated as Belay 2.13SC, containing 2.13 pounds active ingredient per gallon. It is recommended at 4 to 6 ounces per acre for control of aphids and leafhoppers, and 6 ounces per acre for plum curculio, apple maggot, and stink bugs. It is toxic to coccinelid predators (lady beetles) upon contact, and to honeybees for up to five days after application. Do not apply closer than seven days before harvest or more than 12 ounces per acre per year.

***Imidacloprid*, Admire, various generics**
Imidacloprid has several different formulations, including Admire 4.6SC and several 2F generic formulations. Be sure to read the label as rates will vary with different formulations. It is a systemic insecticide that affects the nervous system of insects and is recommended at rates of 0.075 to 0.1 pound active ingredient per acre. Imidacloprid is effective against aphids, leafhoppers, leafminers, and apple maggot. It is toxic to the mite predator Stethorus punctum when applied directly but has short residual activity against this predator. Do not exceed 40 ounces per acre per season, and do not apply within seven days of harvest.

***Thiamethoxam*, Actara**
Thiamethoxam is formulated as Actara 25WDG and is a systemic insecticide that affects the nervous system of insects. It is recommended at rates of 4.5 to 5.5 ounces per acre for most insects, but only 2.0 to 2.75 ounces per acre are recommended for leafhoppers. It may be used once before bloom at 4.5 ounces per acre for control of rosy apple aphid, leafminers, and Mullein bugs, or postbloom for control of plum curculio, aphids, leafminers, and leafhoppers. It is highly toxic to bees exposed to direct treatment on crops or weeds. Do not exceed 8.0 ounces per acre per season. Do not apply within 14 days of harvest at rates equal to or less than 2.75 ounces per acre, or within 35 days of harvest at greater than 2.75 ounces per acre.

MoA 4C (Sulfoximines)

***Sulfloxaflor,* Closer 2SC**

Sulfloxaflor is formulated as Closer 2SC, and is recommended at 1.5 to 5.75 fluid ounces per acre. It is effective against rosy apple aphid and apple aphids at a rate of 1.5 ounces per acre. It also has good activity against plant bugs at rates equal to or higher than 2.75 fluid ounces per acre, and has activity against woolly apple aphid and San Jose crawlers at 5.75 ounces per acre. It has a 12-hour re-entry interval and seven-day preharvest interval.

MoA 4D (Butenolides)

***Flupyradifurone*, Sivanto Prime**

Flupyradifurone is formulated as a 1.67SL (Sivanto Prime) and is recommended at rates of 7 to 14 fluid ounces per acre. It is effective against aphids (except for woolly apple aphid) and leafhoppers as well as scales. At higher rates (12 to 14 fluid ounces per acre), it will suppress woolly apple aphid. It is considerably less toxic to bees than neonicotinoids. It has a re-entry interval of 4 hours, and a preharvest interval of 14 days. Do not apply more than 28 fluid ounces per acre per season.

MoA 5 (Spinosyns)

***Spinetoram*, Delegate WG (MoA group 5)**

Spinetoram is active via ingestion and, to a lesser extent, by contact, and affects the nervous system of insects in a manner different from other insecticides. It is formulated as a 25WP and is effective against key lepidopteran pests of apples (codling moth, oriental fruit moth, tufted apple bud moth, spotted tentiform leafminer) when applied at 4.5 to 7 ounces per acre. When targeting codling moth, the initial application should be made at first egg hatch, which begins at 250 degree days after biofix. It will suppress apple maggot populations residing in a treated orchard when applied at 6 to 7 ounces per acre, but not adults emigrating from outside the orchard because it must be ingested by adults. Do not apply against more than one generation per season of codling moth or tufted apple bud moth, make more than four applications per season, or apply seven days before harvest.

MoA 6 (Avermectins)

***Abamectin*, Agri-Mek**

Abamectin is a naturally derived substance produced by a soil microorganism. Agri-Mek is synthetic abamectin. It provides long residual control of European red mite, two-spotted spider mite, spotted tentiform leafminer, and white apple leafhopper when used at 2.5 to 5.0 ounces per 100 gallons. Excellent results have been obtained at a rate of 10 ounces per acre on a variety of tree sizes. Agri-Mek should be applied at petal fall for best results. Agri-Mek is locally systemic (translaminar activity) and must be tank-mixed with a paraffinic spray oil at 0.25% or 1 gallon per acre, or with a penetrating adjuvant to enable movement of the chemical into the leaf. The efficacy of this product is dependent on movement into the leaf, and it may not adequately move into leaves damaged by either insects or frost. Do not spray captan for two weeks before or after applying Agri-Mek and oil.

MoA 7 (Juvenile Hormone Mimics)

***Pyriproxyfen*, Esteem (MoA group 7C)**

Pyriproxyfen is formulated as a 35WP (Esteem) and is registered for use at 4 to 5 ounces per acre. Esteem interrupts normal development of eggs and immatures so that individuals do not complete development. It is effective against San Jose scale, codling moth, rosy apple aphid (if applied no later than half-inch green tip), and spotted tentiform leafminer. For San Jose scale, apply as either a delayed-dormant with oil or against crawlers in cover sprays. For codling moth, it must be applied prior to egg-laying, or about 100 degree days after biofix, and a second application should be made 14 days later. Do not apply within 45 days of harvest or use more than 32 ounces per acre per season.

MoA 9 (Pyridine Azomethine derivatives)

***Afidopyropen*, Versys (MoA 9D)**

Afidopyropen is formulated as a dispersal concentrate (DC) and is an aphicide with a unique mode of action. It is recommended at 1.5 ounces per acre and is effective against rosy apple aphid and green apple and spirea aphid. At 3.5 ounces per acre, it will suppress, but not control, woolly apple aphid. It is safe to beneficials, including bees. It has a re-entry interval of 12 hours and a preharvest interval of seven days.

MoA 10 (Mite Growth Inhibitors)

***Clofentezine*, Apollo (MoA 10A)**

Clofentezine is formulated as an SC and is recommended at a rate of 4 ounces per acre. Although it has a 45-day preharvest interval, the most effective timing is usually at petal fall or first cover. It is toxic to European red mite eggs and larvae and will not directly affect mite predator populations. To minimize the potential for resistance development, do not use Apollo or Savey in successive years.

***Hexythiazox*, Savey (MoA group 10A)**

Hexythiazox is formulated as a 50WP and is recommended at the rate of 3 ounces per acre. It is labeled for a single application per season, which should

provide season-long control of European red mite and two-spotted spider mite. It is toxic to European red mite eggs and larvae and will not directly affect mite predator populations. It is most effective if applied when mite populations are low, or at petal fall or first cover. To minimize the potential for resistance, do not use Savey or Apollo in the same orchard.

***Etoxazol*, Zeal (MoA group 10B)**
Etoxazol is formulated as Zeal 72WDG and is recommended at 2 to 3 ounces per acre. It is an insect growth regulator that is specific to plant-feeding mites and is safe to mite predators. Etoxazol will kill European red mite and two-spotted spider mite eggs and nymphs, and it sterilizes adults. Do not expect quick knockdown activity with this product. It has translaminar activity and should be applied when mite populations are low, generally within one month of bloom. Do not make more than one application per season, and do not apply within 28 days of harvest.

MoA 11 (*Bt*s)

***Bacillus thuringiensis*, Dipel, Xentari, CryMax**
These products contain crystal proteins and spores produced by the bacterium *B. thuringiensis* subsp. *kurstaki* or *aizawa*. When ingested by lepidopterous larvae, the protein crystals dissolve and rupture the gut wall. They do not have contact activity, and larvae may take up to three days to die; however, larvae will stop feeding shortly after ingestion of the product. In apples, they are most effective against leafrollers (tufted apple bud moth, redbanded leafroller, and variegated leafroller). They have relatively short persistence, so thorough coverage is important for effective control. Dipel DF (1 pound per acre), Xentari (1 pound per acre), and CryMax (1 pound per acre) are all registered for use on apples. In larger trees (greater than 350 gallons per acre tree-row volume) the rates should be increased to 1.5 pounds per acre.

MoA 12B (Organotins)

***Hexakis*, Vendex**
Hexakis is formulated as a 50WP. It is registered for use on apples at a rate of 0.25 to 0.5 pound per 100 gallons to control European red mite, two-spotted spider mite, and rust mites. Hexakis is of low toxicity to predaceous mites and can be used at reduced rates to adjust predator-prey ratios. Do not apply more than three times between petal fall and harvest, or within 14 days of harvest.

MoA 15 (Benzoylureas)

***Novaluron*, Rimon**
Novaluron is formulated as Rimon 0.83EC and is recommended at 20 to 40 ounces per acre, with the 20-ounce rate providing excellent control of codling moth, oriental fruit moth, and tufted apple bud moth. Novaluron is a chitin synthesis inhibitor and disrupts the normal development of larvae. Although it is relatively safe to mite predators, it has the potential to flare European red mite populations.

MoA 16 (Chitin Synthesis Inhibitors)

***Buprofezin*, Centaur**
Buprofezin is formulated as Centaur 70WDG and is used at 34.5 ounces per acre for control of scales and leafhoppers. For scales, it should be timed to coincide with peak crawler emergence (petal fall to first cover). Buprofezin is a chitin synthesis inhibitor, is effective against nymphs, suppresses oviposition of adults, and reduces viability of eggs. Do not apply within 14 days of harvest or make more than one application per season.

MoA 18 (Diacylhydrazines)

***Methoxyfenozide*, Intrepid (MoA group 18)**
Methoxyfenozide is formulated as Intrepid 2F and is recommended at 6 to 16 ounces per acre. Intrepid mimics the molting hormone of lepidopteran insects and causes a premature and incomplete molt and death of larvae. It is highly specific to lepidopteran insects and controls codling moth, oriental fruit moth, tufted apple bud moth, and spotted tentiform leafminer. It is very safe to beneficial insects. It has activity against eggs and larvae, and has been shown to adversely affect codling moth egg laying. Intrepid is most active against tufted apple bud moth and can be used at 6 to 10 ounces per acre. It should be used at 16 ounces per acre against codling moth and oriental fruit moth. Do not apply more than 64 ounces per acre per season, or closer than 14 days before harvest.

MoA 20 (Mitochondrial Complex III Electron Transport Inhibitors)

***Acequinocyl*, Kanemite (MoA group 20B)**
Acequinocyl is formulated as Kanemite 15SC and is recommended at 21 to 32 fluid ounces per acre. It is effective against both European red mite and twospotted spider mite but is also safe to predatory mites. Note that is has a similar mode of action to Acramite and should not be used in the same orchard if two miticide applications are necessary. Do not apply within 14 days of harvest.

***Bifenazate*, Acramite (MoA group 20D)**
Bifenazate is a miticide formulated as Acramite 50WS and is used at 0.75 to 1.0 pound per acre. It is effective against European red mite and two-spotted spider mite and has low toxicity to predaceous mites. Bifenazate has excellent knockdown activity and acts as a mite ovicide. Do not make more than one application per season, and do not apply less than seven days before harvest.

MoA 21 (Mitochondrial Complex I Electron Transport Inhibitors)

***Pyridaben*, Nexter (MoA group 21A)**
Pyridaben is sold as Nexter 75WP and should be used at 4.4 to 5.2 ounces per acre. Pyridaben is an excellent miticide and also controls leafhoppers. It is toxic to all motile stages of the European red mite and has residual activity of 14 to 21 days. Pyridaben is of low toxicity to predaceous mites but is toxic to Stethorus punctum. Do not apply within 25 days of harvest.

***Fenpyroximate*, Portal (MoA group 21A)**
Fenpyroximate is formulated as a 0.4EC and is effective against mites, including European red mite, twospotted spider mite, and apple rust mites, in addition to white apple leafhopper and mealybugs. It is used at 1 to 2 pints per acre, with the 1-pint rate recommended on smaller canopy trees (less than 150 GPA tree-row volume). Fenpyroximate acts by contact activity and will immediately result in cessation of mite feeding and egg laying, but mites may take three to seven days to die. Portal has a 14-day preharvest interval, and a maximum of 2 pints per acre per season is allowed.

MoA 22A (Oxadiazines)

***Indoxacarb*, Avaunt (MoA group 22A)**
Indoxacarb is formulated as a 30WG and is recommended at a rate of 5 to 6 ounces per acre. Avaunt will control codling moth, oriental fruit moth, tufted apple bud moth, plum curculio, white apple leafhopper, potato leafhopper, and low densities of apple maggot. Avaunt affects the nervous system of insects, but in a different manner than other insecticides. It has residual activity of eight to 10 days. Do not make more than four applications per season or exceed a total of 24 ounces per acre per season. Do not apply within 28 days of harvest.

MoA 23 (Tetronic Acids)

***Spirodiclofen*, Envidor (MoA group 23)**
Spirodiclofen is formulated as Envidor 2SC and is applied at 16 to 18 ounces per acre. It is toxic to European red mite and two-spotted spider mite eggs, nymphal stages, and adult females upon contact. Its mode of action, inhibition of lipid biosynthesis, is unique and has not shown cross resistance to other miticides. It should be applied either preventively between first or third cover spray or at low threshold levels (one to three mites per leaf). Do not make more than one application per season, and do not apply within 14 days of harvest.

***Spirotetramat*, Movento (MoA group 23)**
Spirotetramate is formulated as a 2SC (Movento) and is applied at 6 to 9 ounces per acre. It has systemic activity in both the phloem and xylem, and therefore moves to both the foliage and roots. Its activity is specific to aphids (including woolly apple aphid), mealybugs, and scales. It does not have rapid knockdown activity and should be applied before pest populations reach high densities. Do not apply before petal fall, do not exceed 25 ounces per acre per season, and do not apply within seven days of harvest. A spray adjuvant having spreading and penetrating properties must be used with Movento. Use of Induce with Movento is prohibited on apples.

MoA 25 (Mitochrondrial Complex II Electron Transport Inhibitors)

***Cyflumetofen*, Nealta (MOA group 25A)**
Cyflumetofen is formulated as Nealta 1.67SC and is labeled at 13.7 fluid ounces per acre. It is a selective miticide that is effective against European red mite and twospotted spider mite but is safe to predatory mites and other beneficials. For resistance management, if a subsequent application is needed after applying Nealta, use a different miticide with a different mode of action.

MoA 28 (Diamides)

***Chlorantraniliprole*, Altacor**
Chlorantraniliprole, also referred to as rynaxypyr, is formulated as a 35WDG and is used at a rate 2.5 to 4.5 ounces per acre. It is highly active against lepidopteran pests, including the codling moth, and is very safe to most beneficial insects and mites. The 3-ounces-per-acre rate has provided excellent results against codling moth and tufted apple bud moth. It has good residual activity and rain fastness. Do not exceed 9 ounces per acre per season or four applications, and do not apply within 14 days of harvest. A maximum of 0.2 pounds active ingredient (chlorantraniliprole) may be applied per season.

***Cyantraniliprole*, Exirel**
Cyantraniliprole is also referred to as cyazypyr, is formulated as a suspoemulsion (oil in water) and contains 0.83 pounds per gallon. It is recommended at 8.5 to 20.5 ounces per acre. It is similar in activity to chlorantraniliprole, but with a wider range of pest activity at higher rates. At lower rates (8.5 to 17 ounces) it is

effective against most key lepidopteran pests, including codling moth, oriental fruit moth, and leafrollers. At higher rates (13.5 to 20.5 rates) it suppresses plum curculio, apple maggot and aphids. Do not apply more than 0.4 pounds active ingredient per acre per season, or less than three days before harvest.

***Cyclaniliprole*, Verdepryn**
Cyclaniliprole is formulated as a 100SL, containing 0.83 pounds active ingredient per gallon. It is recommended at 5.5 to 11 fluid ounces per acre and is effective against lepidopteran pests (codling moth, oriental fruit moth, tufted apple bud moth, leafminers, etc.), as well as plum curculio when applied at higher rates (>8.2 fluid ounces per acre). It has a four-hour re-entry interval and a seven-day preharvest interval.

Viruses

***Cydia pomonella granulovirus*, CYD-X, Cyd-X HP**
This virus is a naturally occurring disease of the codling moth. Larvae must ingest virus particles to be effective, and death will occur within three to five days. It is highly specific to codling moth and is very safe for beneficial insects. CYD-X is recommended at 2 to 3 ounces per acre. A high potency formulation (CYD-X HP) is recommended at a rate of 0.5 to 3 fluid ounces. Under high codling moth densities, fruit may have more stings than when sprayed with other products because larvae are not killed immediately upon ingestion. The virus is broken down by sunlight and has a residual activity of five to seven days, depending on weather conditions. CYD-X works well in combination with mating disruption when applications are timed with egg laying of first and second codling moth flights.

Sulfur

Sulfur will suppress the European red mite and twospotted spider mite when used in cover sprays on a regular basis. However, the use of sulfur after bloom may affect the fruit finish. Also, sulfur is not safe to use above 90°F. Studies in North Carolina have shown that micronized sulfur suppressed mites better than wettable sulfur.

Pre-mixtures

(products containing two or more active ingredients)

***Chlorantraniliprole + Thiamethoxam*, Voliam Flexi (MoA groups 28 and 4)**
Voliam Flexi is formulated as a 40WDG and contains 20% each of chlorantraniliprole and thiamethoxam. It is used at the rate of 4 to 7 ounces per acre. Chlorantraniliprole (see Altacor) controls lepidopteran pests, and the neonicotinoid thiamethoxam (see Actara) exhibits activity against aphids, bugs and plum curculio. Regardless of the product used (Altacor or Voliam Flexi), a maximum of 0.2 pounds per acre per season of chlorantraniliprole may be applied. Voliam Flexi has a 35-day preharvest interval.

***Cyantraniliprole + abamectin*, Minecto Pro (MoA groups 28 and 6)**
Minecto Pro is formulated as a suspension concentration and contains 1.13 pounds of cyantraniliprole and 0.24 pounds of abamectin per gallon. It is recommended at rates of 8 to 12 fluid ounces per acre and is particularly well suited for use at petal fall or first cover. It has excellent activity against lepidopteran pests (codling moth, oriental fruit moth, leafrollers) and European red mite. It also has activity against plum curculio and rosy apple aphid at rates >10 fluid ounces per acre. It has a 21-day preharvest interval and a 12-hour re-entry interval.

***Imidacloprid + cyfluthrin*, Leverage 2.7SE (MOA groups 4 and 3)**
This mixture is formulated as a suspension emulsion and contains 1.6 pounds imidacloprid (see Admire) and 1.1 pounds cyfluthrin per gallon of product. It is recommended at 3.6 to 4.4 fluid ounces per acre and has broad-spectrum activity. It is recommended only for control of stink bugs. It has a preharvest interval of seven days.

***Lamda-cyhalothrin + chlorantraniliprole*, Besiege (MoA groups 3 and 28)**
This is a mixture of 0.835 pounds of lambda-cyhalothrin and 0.417 pounds of chlorantraniliprole per gallon formulated as a ZC (Zeon Concentrate – capsule suspension and soluble concentrate). Besiege is recommended at 6 to 12 fluid ounces per acre and is best used when a lepidopteran pest (such as codling moth, oriental fruit moth, or leafrollers) or stink bugs need to be controlled. It will also control apple maggot, beetles and plum curculio. It has a 21-day preharvest interval and a 24-hour re-entry interval.

***Lambda-cyhalothrin + thiamethoxam*, Endigo (MoA groups 3 and 4)**
This is a mixture of 0.88 pounds of lambda-cyhalothrin and 1.18 pounds of thiamethoxam per gallon of formulated product. It is a broad-spectrum product that is most useful for control of stink bugs, including the brown marmorated stink bug. It contains the same active ingredients as Warrior and Actara, and total season limits of active ingredient that may be applied to the crop need to be followed regardless of the product(s) used. It has a 35-day preharvest interval.

***Novaluron + acetamiprid*, Cormoran (MoA groups 15 and 4)**
Cormoran is a mixture of 0.84 pounds of novaluron and 0.67 pounds of acetamiprid per gallon of product. It is recommended at 20 to 28 fluid ounces per acre and is effective against lepidopteran pests such as oriental fruit moth and tufted apple bud moth, and sucking insects such as aphids, leafhoppers and plant bugs. It has a preharvest interval of 14 days and a re-entry interval of 12 hours.

Oils

Highly Refined Oils

Highly refined oils are those with a molecular weight that exhibit minimal phytotoxicity so that they can be applied after bloom for suppression of mites and scales. There are numerous brands (Ultra-Fine Spray, Biocover), and most are used at concentrations of 0.5% to 2% solution for control of the European red mite. They should not be used in combination with or within 14 days of applying dinitro compounds or fungicides containing sulfur (such as Captan). It is important that these oils be used according to the label to avoid compatibility and phytotoxicity problems. They are most effective when applied at first and second cover sprays or when mites are just beginning.

Horticultural Oil

In the green-tip spray, a horticultural oil applied as a 3% solution (3 gallons per 100 gallons) controls overwintering European red mite eggs and San Jose scale. If application is delayed until the tight-cluster to pink stage of tree development, reduce the oil concentration to 1% (1 gallon per 100 gallons). The petroleum oil should be highly refined to eliminate toxicity to leaf tissue. For plant safety and maximum insect control, use a horticultural oil with a minimum viscosity of 68 to 78 seconds (at 100oF), minimum unsulfonated residue of 92%, a minimum pourpoint (oF) of 20, and distillation at 10 mm Hg (oF 50% pourpoint) of 412 + 8.

Oil is an effective miticide if coverage is thorough. Mites have not developed resistance to oil, and this spray is very effective for early season control of the European red mite. It is suggested that you (1) apply oil only in a dilute spray; (2) spray only on days when weather conditions favor good coverage and when temperatures near freezing or frost will not occur within 24 hours; and (3) apply enough liquid to thoroughly wet all surfaces on the tree.

Pheromones for Mating Disruption

Both codling moth and oriental fruit moth pheromones are registered for mating disruption on apples. Sex pheromones are species-specific and usually consist of multiple chemical components. Most products consist of the major components rather than the full blend of chemicals emitted by female moths. Because both codling moth and oriental fruit moth are important pests, dual pheromone dispensers containing both insect pheromones are recommended.

Codling Moth + Oriental Fruit Moth Pheromone Dispensers
Isomate CM/OFM TT: Dispensers contain both codling moth and oriental fruit moth pheromone, so this dispenser can be used to disrupt both insects. Each dispenser contains approximately 320 milligrams of codling moth pheromone and 105 milligrams of oriental fruit moth pheromone. The application rate is 200 dispensers per acre, and they should be placed in the upper third of the tree canopy. A single application should provide season-long disruption of both insects.

CheckMate CM/OFM: These dual pheromone dispensers contain 270 milligrams of codling moth pheromone and 250 milligrams of oriental fruit moth pheromone per dispenser. The application rate is 200 dispensers per acre, and a single application provides season-long disruption of both insects.

CheckMate Puffer CM/OFM: Puffers are aerosol canisters loaded with both codling moth and oriental fruit moth pheromone and placed in orchards at a density of one per acre. Cabinets into which canisters are placed control the release of pheromone, which occurs at 15-minute intervals for a 12-hour period, normally from 5 p.m. to 5 a.m. Each canister contains 24 grams of oriental fruit moth and 55.5 grams of codling moth pheromone that is released over about 160 days. This low-density dispensing system works best in orchards greater than 15 to 20 acres.

CideTrak CM-OFM Combo: Dispensers contain both codling moth and oriental fruit moth pheromones for disruption of both insects. Each dispenser contains 331 milligrams of active ingredient (230 codling moth and 101 OFM) and both are recommended at 200 to 220 dispensers per acre, which should be hung in the upper 14 inches of trees.

CideTrak CMDA+OFM Meso: Dispensers are larger than the CM-OFM Combo formulation and contain a high load of pheromone to allow for fewer dispensers per acre. Recommendations are for 30 to 38 dispensers per acre, with 32 for moderate populations, and 38 per acre along orchard borders. This product also contains pear ester kairomone that affects male and female behavior in codling moths.

Oriental Fruit Moth Pheromone

Isomate OFM TT: Dispensers contain only oriental fruit moth pheromone. Each dispenser contains 479 milligrams of pheromone, and it is labeled at 100 dispensers per acre. However, research in North Carolina has shown that 50 dispensers per acre is just as effective as 100. A single application just before second generation adults emerge in June will provide season-long control of OFM.

CheckMate OFM-F: This product is a sprayable formulation of oriental fruit moth pheromone that is applied with an airblast sprayer. Each ounce of product contains 6.8 grams of oriental fruit moth pheromone, and the application rate is 1.3 to 2.9 ounces per acre. Pheromone will be emitted for about four weeks after application, so the product must be reapplied for extended control. It is particularly useful for later in the season (August and September) when OFM populations often increase to high numbers.

CideTrak OFM-L: Dispensers contain only oriental fruit moth pheromone, with 250 milligrams in each dispenser. They are recommended at 100 to 200 per acre, with 100 dispensers delivering 25 grams of OFM pheromone per acre, which previous research has shown is effective under most circumstances. A single application just before second-generation adults emerge in June will provide season-long control of OFM.

Other Products

***Kaolin*, Surround 95WP**

Surround is finely ground kaolin that forms a white particulate film on sprayed surfaces. In addition to controlling and suppressing certain insect pests, it is also used as a protectant against sunburn and heat stress. Surround is labeled at 25 to 50 pounds per acre, with higher rates recommended on larger trees. Surround is highly susceptible to wash-off by rain.

Herbicides

Before applying herbicides, properly calibrate your sprayer to ensure that materials are applied at the correct rate. Always read the manufacturer's label and follow all instructions. Pre-emergence herbicide rates usually vary according to soil type and should be applied at the rate recommended on the herbicide label.

Pre-emergence Herbicides

***Dichlobenil,* Casoron** (150 pounds per acre), **Casoron CS** (1.4 to 2.8 gallons per acre)

Dichlobenil-containing products are available as a 4% granular (4G) for grass and broadleaf weed control. Products should be applied in late winter while soil temperature is less than 60°F. Best results are observed when soil surface is weed free. **DO NOT** apply Casoron 4G sooner than four weeks after transplanting or three months before or after grafting. The Casoron CS formulation can be used only in orchards established one year ago or longer. It may be tank-mixed with other pre- and post-emergence herbicides. Good agitation is necessary to prevent the herbicide from settling in the tank. Applications should be made when temperatures will not exceed 70°F and rainfall is expected within a few days.

***Diuron*, Karmex 80WDG, Diuron 80WDG** (2 to 4 pounds per acre), **Direx or Diuron 4L** (1.6 to 3.2 quarts per acre)

Diuron will provide PRE control of broadleaf and some grass weeds. Apply in the spring or in the fall after harvest to trees established in the orchard for at least one year. In Georgia diuron may be applied in the spring and again in the fall so long as total use does not exceed 3.2 pounds a.i. per treated acre per year and no more than 2.4 pounds a.i. are applied in a single application. If sequential applications are used allow at least 90 days between applications. Diuron may be tank-mixed with Sinbar and applied to trees established for at least two years for more broad-spectrum pre-emergence weed control. The addition of rimsulfuron or Solicam to diuron has expanded residual control for certain weeds. **DO NOT** treat varieties grafted on full-dwarf root stocks or soils having less than 1% organic matter. **DO NOT** apply more than 4 pounds per acre per year. May be tank-mixed with paraquat and glyphosate.

***Flumioxazin*, Flumi, or Tuscany 51SW** (6 to 12 ounces per acre); **Chateau EZ or Tuscany 4SC** (6 to 12 fluid ounces per acre)

For best results in newly planted orchards, apply flumioxazin once soil settles after transplanting or in the spring, followed by a second application in the summer when control from the initial application deteriorates. Do not use more than 6 ounces per acre if soil has a sand-plus-gravel content that exceeds 80%. Trees established less than one year must be protected with a nonporous wrap or waxed container. Allow at least 30 days between sequential applications. In established bearing orchards, apply after completion of final harvest until silver tip. Tank-mix with paraquat, glufosinate, or glyphosate for postemergence weed control. **When flumioxazin is applied after trees leaf out (non-bearing orchards only), use paraquat or glufosinate only for**

postemergence control. Flumioxazin has a 60-day PHI. Total use cannot exceed 24 ounces per year.

***Indaziflam*, Alion 1.67 SC** (3.5 to 6.5 fluid ounces per acre)
Alion can be used in orchards established three years or more and sequential applications may be used so long as there are at least 90 days between applications and total use rate does not exceed 10.3 ounces per acre per year. The use rate cannot exceed 3.5 fluid ounces per acre (and cannot exceed 7 fluid ounces per acre per year when applying sequential applications) on soils having less than 1% organic matter. Soils containing 1 to 3% organic matter can be treated with 3.5 to 5 fluid ounces per acre (not exceeding 8.5 fluid ounces per acre per year when applying sequentially). As much as 6.5 fluid ounces per acre (not exceeding 10.3 fluid ounces per acre per year when applying sequentially) can be applied to soils containing more than 3% organic matter. Do not use on soils having a 20% or greater gravel content. Soil around trees must be void of depressions, open channels, or cracks in order to prevent herbicide injury. Do not harvest fruit within 14 days of application. See label for details pertaining to replants in established orchards. Alion should be tank-mixed with glyphosate, paraquat, or glufosinate for non-selective POST weed control.

***Indaziflam* + rimsulfuron, Centrus WDG (**3 to 5.6 ounces per acre**)**
Centrus is a premix of Alion and Matrix that will provide PRE and POST control of certain annual broadleaf weeds. Do not use on soils with 20% or more of gravel content. Use on trees established for three or more years. Do not apply within 14 days of harvest. Tank-mix with glyphosate, glufosinate, or paraquat for non-selective POST weed control.

***Isoxaben*, Trellis SC** (16 to 31 fluid ounces per acre)
Trellis provides PRE control of annual broadleaf weeds in newly planted and established orchards. Trellis must be tank mixed with oryzalin or pendimethalin for residual control of annual grass weeds. Activation with at least 0.5 inch of rainfall within 21 days of application is necessary for optimum herbicide performance. Do not apply more than twice per year, and total use rate cannot exceed 31 fluid ounces per acre per crop year. Trellis has a 30-day PHI. Tank mix with glyphosate, paraquat, or glufosinate for non-selective POST weed control.

***Mesotrione*, Motif 4L** (3 to 6 fluid ounces per acre)
Motif has both PRE and POST activity on certain broadleaf weeds like horseweed, dock, Carolina geranium, common groundsel, and dandelion. It can be applied as a directed spray on orchards established for one year or longer. For POST weed control, use ammonium sulfate and a crop oil concentrate or nonionic surfactant. Total use rate cannot exceed 12 fluid ounces per acre per year. Motif has a 30-day PHI and it may be tank-mixed with diuron, glufosinate, glyphosate, Alion, paraquat, pendimethalin, rimsulfuron, or simazine.

***Norflurazon*, Solicam 80DF** (2.5 to 5 pounds per acre)
Solicam will provide PRE control of annual grasses and some broadleaf weeds as well as suppress yellow nutsedge (nutgrass). Application rate is soil-texture dependent. Rainfall is needed within four weeks of application for proper activation. Apply Solicam as a directed under trees once soil has settled around the roots and is free of depressions. Sequential applications of Solicam may be applied so long as cumulative rate does not exceed maximum use rate for soil texture and crop. Solicam may be tank-mixed with Karmex, oxyfluorfen, paraquat, Simazine, Sinbar, or glyphosate.

***Pendimethalin*, Prowl H_2O** (2 to 4 quarts per acre)
Prowl will provide PRE control of annual grass and some broadleaf weeds. Rainfall is needed within 14 days of application to activate herbicide. Apply to newly planted orchards once soil has settled around tree roots and soil is free of cracks. The addition of Prowl H_2O to simazine will expand control spectrum. Prowl H_2O may be applied as sequential applications so long as total use rate does not exceed 4 quarts per acre per year. Allow at least 30 days between applications. Other formulations of pendimethalin may be used in non-bearing orchards ONLY!

***Rimsulfuron*, Matrix, Grapple, Pruvin, Solida** (4 ounces per acre)
Treat only orchards established for one year or more. Rainfall within two to three weeks of application will be necessary for activation and proper herbicide performance. Spray solutions with a pH of less than 4 or greater than 8 will degrade rimsulfuron. Rimsulfuron may be applied as a sequential application so long as total use rate does not exceed 4 ounces per acre on a broadcast basis per year. Application is made in a band on less than 50% of the orchard floor. Allow 30 days between applications. Tank-mix with pendimethalin, Solicam, diuron, or Sinbar for expanded control. Research has shown as little as 2 ounces of product per acre improves the activity of diuron or Sinbar. The addition of glyphosate, paraquat, or glufosinate will be necessary for broad-spectrum POST weed control. Rimsulfuron has a seven-day PHI for apples. Rimsulfuron has POST activity on certain broadleaf weeds (see label for list). Rimsulfuron will control emerged horseweed less than 3 inches tall when applied in combination with a non-ionic surfactant and a spray-grade ammonium sulfate (2 pounds per acre).

***Simazine,* Princep, Simazine 4L** (2 to 4 quarts), **Princep Caliber 90, Simazine 90WDG** (2.2. to 4.4 pounds)
Simazine formulations will provide PRE control of broadleaf and some grass weeds. **DO NOT** apply to trees established less than 12 months or use on gravelly, sandy, or loamy sand soils. May be tank-mixed with paraquat or glyphosate. Combinations of simazine-containing products with pendimethalin or Solicam improve annual grass control. Simazine has a 150-day PHI for apples.

***S-Metolachlor*, Pennant Magnum 7.62DF** (1.3 to 2.6 pints per acre)
Nonbearing orchards ONLY. Rate is soil-texture dependent. Do not apply until soil has settled after transplanting. Pennant Magnum will provide some control of yellow nutsedge. Tank-mix with paraquat or glyphosate for postemergence weed control.

***Penoxsulam + oxyfluorfen*, Pindar GT** (2 to 3 pints per acre)
Pindar GT can only be used in orchards established for four years or longer. Since Pindar GT contains oxyfluorfen, it may be applied only after the completion of final harvest until bud break. DO NOT use on soils that contain less than 20% clay or greater than 70% sand. Pindar GT should be tank-mixed with pendimethalin for expanded pre-emergence control of annual grass weeds. Tank-mix with glufosinate, glyphosate, or paraquat for non-selective POST weed control.

***Sulfrentrazone + carfentrazone*, Zeus Prime XC** (8 to 15 fluid ounces per acre)
Zeus will provide PRE and POST control of annual broadleaf, grass weeds, and yellow nutsedge. Residual control of annual grass weeds improves when Zeus is tank mixed with pendimethalin or Solicam. Tank-mixing with glyphosate, glufosinate, or paraquat is necessary for non-selective POST weed control. DO NOT apply in orchards established less than three years and avoid contact with desirable uncalloused, green bark. Zeus Prime may be applied as a sequential application so long as total use rate does not exceed 15 fluid ounces per acre on a broadcast basis per year and application is made in a band over less than 50% of the orchard floor. Allow at least 60 days between applications. Zeus Prime has a 14-day PHI.

***Terbacil*, Sinbar 80WG** (2 to 4 pounds per acre)
Sinbar provides PRE control of broadleaf and grass weeds. Trees must be established in the orchard for three years. Application rate is dependent on soil texture and organic matter (see label for details). Sinbar may be applied in the spring or in the fall after harvest. **DO NOT** apply to soils having less than 1% organic matter. Tank mixes of Sinbar with either rimsulfuron or diuron have proven effective in research trials. Refer to product label for details about using Sinbar and diuron as a combination for broad spectrum weed control. A tank mix of Sinbar with Karmex can be applied in orchards established for at least two years. Sinbar may be tank-mixed with glyphosate, paraquat, or glufosinate for non-selective postemergence weed control. **Special use label in NEWLY planted and NONBEARING orchards ONLY:** Sinbar may be applied at 0.5 to 1.0 pound per acre in newly planted and nonbearing orchards. For best results, apply 0.5 pound in the spring followed by another 0.5 pound when control from the initial application deteriorates. Do not use in newly planted orchards until soil has been allowed to settle after transplanting. Do not use on soils coarser than sandy loam with less than 2% organic matter.

Postemergence Herbicides

NOTE: It is important to remember that postemergence herbicides should be applied to actively growing weeds. Weeds under stress from mowing, drought, or cold temperatures may not be adequately controlled by postemergence herbicides. If weeds are stressed from drought, herbicide application should be delayed for one to three days after adequate rainfall when weeds are no longer wilted. If weeds have been mowed, wait several days to allow regrowth before applying postemergence herbicides. Many POST herbicides require the addition of a surfactant. Always check the herbicide label for proper spray additives.

***Bentazon*, Broadloom** (1.5 to 2 pints per acre)
Use in non-bearing apple orchards **ONLY**! Broadloom controls certain broadleaf weeds and yellow nutsedge. For yellow nutsedge control, apply Broadloom at 2 pints per acre with crop oil concentrate at 2 pints per acre to yellow nutsedge that is 6 to 8 inches tall. Application must be repeated seven to 10 days later. **DO NOT** allow spray solution to contact green stems, immature bark, or leaves. **DO NOT** apply more than 4 pints per acre per year.

***Carfentrazone-ethyl*, Aim 2EC** (0.5 to 2 ounces per acre)
Apply in minimum spray volume of 20 gallons per acre. Do not allow Aim to contact desirable foliage, flowers, immature bark, or fruit. Trees two years of age and younger must be protected. Contact with fruit will result in spotting. Sequential applications may be used so long as there are 14 days between applications and total use does not exceed 7.9 fluid ounces per acre per year. Do not apply within three days of harvest. Apply in combination with a nonionic surfactant (1 quart per 100 gallons of spray solution) or crop oil concentrate (1 gallon

per 100 gallons of spray solution). Susceptible broadleaf weeds are controlled best when treated in the two- to three-leaf stage. Aim may be tank mixed with pre-emergence herbicides.

***Clethodim*, Select, Intensity, Arrow 2EC, Volunteer** (6 to 8 ounces per acre), **SelectMax, or Intensity One 1EC** (12 to 16 ounces per acre)
All clethodim products are registered for **NONBEARING** orchards only with the exception of Select Max. Select Max may be applied in bearing orchards and has a 14-day PHI. Clethodim controls annual and perennial grasses but has no activity on broadleaf weeds or sedges. Always add crop oil concentrate at 1% volume per volume (1 gallon per 100 gallons of spray solution) but no less than 1 pint per acre in finished spray volume for the 2EC formulations. When using a 1EC formulation, add non-ionic surfactant at a rate of 1 quart per 100 gallons of spray solution. Refer to product label for information on application timing for optimum control of susceptible grasses. Sequential applications may be necessary for perennial grass control. Select is rainfast 1 hour after application.

***Clopyralid*, Stinger** (.25 to .66 pint per acre)
Stinger will provide POST control of certain broadleaf weeds like white clover, groundsel, horseweed, dandelion, and curly dock. Make no more than two applications per year. Total use rate cannot exceed 0.66 pint per acre per year. Stinger can be used in orchards established for one year or longer. Do not apply during bloom and do not allow direct contact with foliage, fruit or tree trunks. The PHI for Stinger in apple orchards is 30 days. Stinger may be tank-mixed with other herbicides approved for use in apple orchards.

***Fluazifop*, Fusilade DX** (12 to 24 ounces per acre)
Fusilade will provide POST control of annual and perennial grasses in **NONBEARING ORCHARDS ONLY.** It has no activity on broadleaf weeds or sedges (nutgrass). Add 1 gallon of crop oil per 100 gallons of spray solution. Refer to product label to determine optimum grass size at which application will result in maximum control. Sequential applications may be necessary to control perennial grasses. **DO NOT** apply in combination with other herbicides.

***Fluroxypyr*, Starane Ultra** (0.4 to 1.4 pints per acre)
Starane is a postemergence herbicide that controls a variety of broadleaf weeds. Starane should not be applied in orchards established for less than four years. Do not make more than one application per year. Do not apply during bloom. Apply in a minimum spray volume of 10 gallons per acre. Do not apply within 14 days of harvest. This is a supplemental label.

***Glufosinate*, Reckon, Rely 280 SL, Lifeline, Cheetah, Surmise** (48 to 82 ounces per acre)
Glufosinate is a nonselective postemergence herbicide that will control emerged annual and some perennial weeds. Thorough spray coverage is important for optimum control. Make applications in a minimum of 20 gallons of water per acre. Repeat applications may be necessary to control perennial weeds. **DO NOT** allow glufosinate to contact green or uncalloused bark on young trees. **DO NOT** apply to orchards established for less than one year. **DO NOT** apply more than three applications per year and do not exceed a total use rate of 246 fluid ounces per acre per year. Glufosinate may be tank-mixed with Goal, Karmex, simazine, Sinbar, Solicam, and oryzalin. Glufosinate has a 14-day PHI. The addition of a spray-grade ammonium sulfate will enhance herbicide activity on difficult-to-control weed species or weeds under stress. There is no need for additives other than ammonium sulfate. The use of additional surfactants, spreaders, or crop oil may increase the potential for apple tree injury. Glufosinate works best when applied during periods of full sunlight. Applications applied with a few hours of sunrise or sunset can reduce efficacy. The addition of 2,4-D amine or choline will enhance burn down activity on difficult to control broadleaf weed species.

***Glyphosate*, various Roundup and generic formulations. See label for rate.**
Glyphosate is a nonselective herbicide that effectively controls annual and perennial weeds. Glyphosate formulations may or may not require the addition of a surfactant; refer to label for details. Glyphosate can control difficult perennial weeds if applications are appropriately timed. For best results, glyphosate should be applied in a maximum spray volume of 30 gallons per acre. Apple trees two or more years old are tolerant to glyphosate applications made in late winter, spring, and early summer. Trees can be damaged if glyphosate contacts foliage or green bark. The risk of tree injury increases if glyphosate is applied after mid-June. Braeburn variety is very sensitive to glyphosate. See Table 16, Optimum Application Rates and Timing of Glyphosate, on page 80 for information on difficult-to-control perennial weeds. The addition of 2,4-D amine at 1 pint per acre applied with glyphosate will improve control of annual broadleaf weeds, such as morning-glory, dandelion, Carolina geranium, glyphosate resistant horseweed, and dock.

***Halosulfuron*, Sandea or Herbivore 75DF** (0.5 to 1 ounces per acre)
Apply to trees established in the orchard for one year or more. The total use rate in a 12-month period cannot exceed 2 ounces per acre and every effort should be made to avoid herbicide contact with tree foliage. The addition of a nonionic surfactant at 0.25% v/v (1 quart per 100 gallons of spray solution) is necessary for optimum herbicide performance. Sandea is a very effective herbicide for yellow and purple nutsedge control when timely applications are made to actively growing weeds. Sequential applications may be more effective than a single application. Do not use less than 0.75 ounces per acre per application when applying sequentially. Halosulfuron may be tank-mixed with glyphosate for broad-spectrum POST weed control.

***Paraquat*, Firestorm, Parazone, Paraquat Concentrate, or Gramoxone 3SL** (1.75 to 2.7 pints)
Paraquat will control emerged annual weeds (grasses and broadleaves) and suppress perennial weeds. Perennial grasses usually regrow after application. Add 1 quart of a nonionic surfactant to 100 gallons of spray solution for optimum performance. Paraquat is rainfast in 30 minutes. Since paraquat is a restricted-use pesticide, consult the label before handling. Paraquat may be tank-mixed with most PRE herbicides. DO NOT allow paraquat to contact green stems (except suckers), foliage, or fruit. Trees established less than one year must be shielded to prevent injury.

***Saflufenacil*, Treevix** (1 ounces per acre**)**
Treevix is a postemergence herbicide that controls only broadleaf weeds. Apply to trees established one year or longer as a single application or up to three applications sequentially per year with a minimum of 21 days between applications. Tree trunks must be protected until adequate bark has formed to protect trees from the herbicide (usually two to three years). The PHI for Treevix is seven days. In order for Treevix to be effective, it must be applied with methylated seed oil at 1% v/v (1 gallon per 100 gallons of spray solution) and ammonium sulfate at 1 to 2% w/v (8.5 to 17 pounds per 100 gallons of spray solution). In order to have broad-spectrum postemergence weed control, Treevix must be applied in combination with glyphosate or glufosinate. Treevix is compatible with pre-emergence herbicides.

***Sethoxydim*, Poast** (1.5 to 2.5 pints per acre)
Poast will control emerged annual and perennial grasses. It has no activity on broadleaf weeds or sedges (nutgrass). Apply in combination with crop oil (1 gallon per 100 gallons of spray solution). Refer to product label for optimum application timing for control of susceptible grasses. Sequential applications will be necessary for optimum control of perennial grasses. DO NOT apply within 14 days of harvest. Poast may be tank-mixed with 2,4-D amine or choline to control broadleaf and grass weeds.

***2,4-D amine*, various brands** (2 to 3 pints per acre)
2,4-D names and formulations may vary in each state. Some formulations limit use rate to only 2 pints per acre. 2,4-D controls broadleaf weeds and will suppress clover bloom. Apply anytime during the growing season but not within two weeks before or after bloom. Apply no more than two applications per year, and allow at least 75 days between applications. **DO NOT** allow 2,4-D to contact trunk, limbs, or foliage. Application should be made when conditions **DO NOT** favor drift. Some plants are extremely sensitive to 2,4-D and can be seriously injured by 2,4-D drift. 2,4-D may be tank-mixed with Poast to obtain control of both broadleaf and grass weeds. **NOTE:** Apple blossoms are very sensitive to 2,4-D. See label for further instructions.

***2,4-D Choline*, Embed Extra 3.8 SL** (1 to 4 pints per acre)
Embed offers stability and reduced-drift technology not found in traditional amine formulations without compromising weed control. It may be used in orchards established for one year or longer. **DO NOT** apply during bloom or use in orchards having sand soils. Embed has a 14-day PHI for pome fruit. No more than 8 pints or two applications of Embed can be applied within a 12-month period. If making more than one application, allow 75 days between applications. Embed may be tank-mixed with glyphosate, glufosinate, as well as various PRE herbicides.

See Herbicide Mode of Action Table for Herbicide Resistance Management Groups, page 46.

Suggested PRE Tank Mix Options*
Diuron + Sinbar
Diuron + Solicam
Simazine + Solicam
Simazine + Oryzalin or Prowl H_20
Diuron + Rimsulfuron
Sinbar + Rimsulfuron
Zeus Prime + Oryzalin or Prowl H_20
Rimsulfuron + Oryzalin or Prowl H_20

*Include glyphosate, paraquat, or glufosinate for control of emerged weeds.

Table 16. Optimum Application Rates and Timing of Glyphosate

Weed Species	Concentration of Glyphosate Solution to Obtain 90% Control the Following Season	Application Timing for Best Control
perennial grasses (johnsongrass, fescue, quackgrass, etc.)	1%[1]	At time of first flowering
bermudagrass	2%	At time of first flowering
composites (asters, goldenrod, dogfennel)	1%	At time of first flowering
poison ivy/oak	2%	Two weeks on either side of full bloom (early summer)
honeysuckle	1.0 to 2%	Repeat applications may be necessary
kudzu	1.5 to 2%	Full bloom up to one month after (early summer)
blackberry	1.0 to 1.5%	Full bloom up to one month after (midsummer); repeat applications may be necessary
lespedeza	2%	Late summer to fall before frost
Virginia creeper	1 to 2%	Early bud stage just prior to bloom
trumpet creeper	1.5%	Late summer to mid-fall before frost
passionflower (maypop)	1%	Early bloom to fruit
greenbrier	3%	Five fully expanded leaves in spring
clematis vine	1%	After bloom until one week before frost
wisteria	1.5 to 2%	Six to eight weeks after bloom (mid to late summer)
mugwort	1.5 to 2%	Full flower (late summer)
English ivy	2 or 3%	Three to five fully expanded leaves in spring

In general, the above-designated application times have been most efficacious. Following these suggestions should give better control of the target species and reduce the total quantities of chemical used.

[1]1% = 1.25 ounces of glyphosate per gallon of water.

Table 17. Starane Ultra Application Rates for Perennial Weed Control

Weed Species[1]	Starane Ultra Use Rate (pt/A)	Spray Solution Concentration for Spot Treatment with Starane Ultra[2]
blackberry	1.4 pt	0.75%
horsenettle	1.4 pt	0.75%
lespedeza	0.7 pt	0.75%
poison ivy	1.4 pt	0.75%
smilax (suppression only)	1.4 pt	0.75%
Virginia creeper	1.4 pt	0.75%

[1]Weeds that have grown up into the tree should be cut at the soil surface during winter or early spring and allowed to regrow from the base. At that time, they may be treated with fluroxypyr without having to spray herbicide into the tree, potentially contacting leaves or fruit.

[2]A 0.75% solution is made by adding 1.0 fluid ounce of Starane Ultra to a gallon of water.

Growth-Regulating Chemicals

Apply growth-regulating chemicals at a rate determined by tree row volume. Because there is inadequate information on compatibility, apply these chemicals only as a separate spray unless specific compatibility is stated on the label for a particular growth regulator. Growth regulators should not be applied during periods of extremely high or low temperature or moisture stress.

Promalin, Perlan *(benzyladenine, BA; + gibberellin, GA_{4+7})*

If promalin is applied later than full bloom, only late blossoms and fruit that will later drop off or be chemically thinned will respond. Do not apply promalin to runoff. For best results with Promalin or Perlan, the water pH should be below 8.0. See Table 19.

ProVide, Novagib *(gibberellin, GA_{4+7})*

Timing of the application is important. Apply GA_{4+7} as a fine mist in no less than 100 gallons of water per acre or approximately 40 to 50% of TRV. Limited data are available on the use of Pro-Vide 10SG with other pesticides. Do not tank mix Pro-Vide 10SG with other pesticides unless you have personal experience with the mixture. See Table 21.

Chemical Blossom Thinning Sprays

A specific formulation of liquid lime sulfur (LS) is labeled for blossom thinning in North Carolina [NovaSource™ Lime-Sulfur Solution (Tessenderlo-Kerley, Inc.)], but is not available in other southeastern states. Spray oil should be added to LS to enhance its penetration and boost its efficacy. When mixed with oil, use LS at 1.5 to 2% (v/v). Oil options include fish oil at 2% (v/v), dormant petroleum oil at 1%, or summer oil at 1 to 1.5% v/v. Two LS applications during bloom are suggested if possible.

For well-pruned dwarf and semi-dwarf trees, a spray volume of 80 to 100 gallons per acre via air-blast is typically used but may need to be adjusted based on tree size. Avoid excessive spray volume to minimize leaf damage and fruit russeting. Do not concentrate the chemicals when spraying at lower volume. When mixed with oil, use LS at 1.5 to 2% (v/v).

Application timing can occur using a visual estimate of the number of open blossoms or by use of variety-specific pollen tube growth models (see Pollen Tube Growth Model at **newa.cornell.edu**). If using visual estimates, use two sprays: one at 20 to 30% bloom followed by a second spray at 80 to 100% bloom. LS can cause apple leaf burn and fruit russet. Avoid use of LS when temperature will exceed 85°F within 24 hours. The potential for injury is greater under slow drying conditions (low light, high humidity). Do not tank-mix other spray materials. Additional applications of either oil or LS immediately after LS thinning sprays is very likely to increase thinning response. To allow oil residues to weather, leave a two- to three-week interval between the last spray containing oil and the first captan spray. If there is high risk of severe frost or freeze damage during the bloom period, consider delaying or avoiding application of LS as a bloom thinner.

Chemical Fruit Thinning Sprays

Due to variability of chemical thinner response, it is recommended that growers use all thinners on a trial basis until they become experienced. If seed numbers are low due to poor pollination or fertilization, weak trees, weak or damaged spur leaves , or cloudy weather, then lower concentrations of thinning chemicals should be considered. In addition, young trees are generally easier to thin than mature trees. Base the timing of thinner applications on factors such as average fruit diameter, initial fruit set, weather forecasts for the following three to four days, and estimated tree-carbon balance. Determine average fruit diameter by measuring all growing fruitlets per cluster. Sample randomly selected clusters throughout the tree canopy and orchard. At least 100 fruitlets should be measured to calculate average diameter. Sunny days and cool nights following application of chemical thinners will make the fruit harder to thin. Cloudy days and warm nights following thinner application will make the fruit easier to thin.

The Apple Carbon Balance Model, developed by researchers at Cornell University, uses light and temperature data to help predict the daily carbon balance of a model apple tree and can be used to help inform apple-thinning decisions. If proximal to a NEWA weather station, a daily carbon balance can be estimated (**newa.cornell.edu**). The following inputs are required to run the model: (1) green tip date; (2) full bloom date; and (3) estimate of the percentage of flowering spurs. The carbon balance model was not developed to account for all factors that influence the efficacy of a thinner application, and uses forecasted weather data to predict carbon balance. This model is a useful decision-making aid, but users should be aware of model limitations.

NOTE: The use of spray oils required with certain other pesticides (such as Agri-Mek) applied in some unknown

proximity to thinner applications will interact and increase thinner activity.

Fruitone L, PoMaxa, ReFine 3.5WSG, etc. *(naphthalene-acetic acid, NAA)*
The time of application for optimum thinning with NAA plus carbaryl is 7 to 9 millimeters average fruitlet diameter for Red Delicious cultivars and up to 12 millimeters with Golden Delicious. Under optimum growing conditions NAA thinner applications usually occur approximately 14 to 21 days after full bloom. NAA must be applied at the proper fruit size; otherwise, thinning may be reduced, stunted fruit (nubbins) may remain on the tree, or both. Using NAA at rates above 5 parts per million on Red Delicious may cause excessive nubbining and half-grown fruit to stick on the tree to harvest. The Fruitone-L, PoMaxa, and ReFine formulations of NAA provides 2½ parts per million per 100 gallons for each ounce of product used.

Carbaryl
All formulations of carbaryl have equal chemical-thinning activity on an active ingredient basis. Where carbaryl is used for chemical thinning at petal fall, only a liquid formulation should be used because it is safer around bees than the WP formulations. Carbaryl has thinning activity on Golden Delicious; however, occasional fruit russeting may result. The Sevin XLR and Carbaryl 4L formulations each have 4 pounds of active ingredient per gallon. Late use of carbaryl for thinning purposes may be detrimental to an integrated mite management program and should be avoided, especially on Red Delicious.

Ethephon and Carbaryl
Combinations are not suggested for standard or non-spur Red Delicious cultivars because excessive thinning is likely to occur. For thinning spur Red Delicious, note that the thinning effect of ethephon and carbaryl is not translocated from non-fruiting spur and leaves to the fruiting spurs; thus, for applications to be effective, the fruit and leaves of fruiting spurs must be completely covered. An ethephon and carbaryl tank mix for chemical thinning is recommended only as a dilute application (1x) using a water volume accurately calculated with the "tree-row volume" formula (see page 35). Concentrate applications are generally stronger and very erratic in thinning response. To obtain uniform thinning throughout the tree, the spray delivery pattern must be adjusted on an airblast sprayer to deliver 80% to 90% of the spray volume to the top third of the tree canopy. This nozzling adjustment ensures adequate coverage of fruiting spurs in the top portion of trees and helps avoid overthinning in the lower and internally shaded portions of trees. Ethephon and carbaryl thinning applications may be used between 12 and 18 millimeters average fruit diameter; however, applications should be made early in the size range (12 to 15 millimeters) unless adverse weather delays application. Because rainfall and cloudy weather can have an effect on thinner activity, ethephon and carbaryl applications should not be made less than 48 hours before an imminent cloud and rain event, or closer than 12 hours after a significant rainfall (0.5 inch or more). Persistent cloudiness, light mist, rain, or all three after application may increase thinning activity; a hard rain within 8 to 10 hours may reduce thinner activity by wash-off.

MaxCel or Exilis (6BA) and Carbaryl
MaxCel and Exilis (Plus or 9.5SC) are post-bloom thinners that can be applied when fruits range from 5 to 15 millimeters in diameter. 6BA can be applied in concentrations ranging from 75 ppm to 200 ppm. Best results are obtained when BA at a concentration of 75 to 100 ppm is tank-mixed with carbaryl at 0.5 to 1.5 pounds active ingredient (a.i.) per 100 gallons. 6BA should be applied when maximum daily temperature will be 65°F or greater for two or three days after application. Expect a stronger response when daily temperatures exceed 86°F. MaxCel performs best at water pH between 5 and 7; do not exceed pH of 8.5. Apply with an airblast sprayer in a sufficient amount of water to ensure thorough coverage without excessive runoff; do not apply in less than 75% of tree row volume.

Combinations of BA (MaxCel or Exilis) and NAA (Fruitone L, PoMaxa, ReFine 3.5WSG, etc.)
Combinations of BA and NAA have proven to be as effective as combinations of BA and carbaryl. The combination of BA and NAA provides an alternative to BA plus carbaryl when there are concerns about the impact of carbaryl on beneficial insects. Do not use the BA-plus-NAA combination on cultivars that are normally sensitive to NAA thinning sprays such as Red Delicious.

Table 18. Improving Fruit Shape

Goal	Chemical	Rate and Time of Application
To improve shape and increase fruit weight of Delicious and Gala apples.	Promalin, Perlan [benzyladenine (BA) +gibberellin (GA4+7)]	Single application: Apply Promalin or Perlan at 1 to 2 pt/acre between king bloom opening and full-bloom stage as a fine mist at 40% to 50% of TRV-calculated dilute water volume. Split applications: Make first application of 0.5 to 1 pt/acre between early king bloom and early petal fall of king blooms. Make the second application three to seven days later. Do not apply more than 2 pt/acre per year.

Table 19. Increasing Lateral Branching

Goal	Chemical	Rate and Time of Application
To increase lateral branching on one-year-old wood *before* bud break.	MaxCel	Make targeted applications to buds and bark on one-year-old wood where branching is desired at 4.0 fl oz/pint of latex paint (5,000 ppm). Apply at terminal bud swell but prior to visible lateral bud development. Use a narrow paint roller or paint brush for application. For best results use interior latex paint as the solution carrier. Do not use exterior latex paint or paint that includes anti-fungal additives. Do not apply this rate of MaxCel or this application method after bud break, as late applications have been known to cause injury to tender shoot tips and fail to promote bud break. Apply at temperatures greater than 50°F.
	Perlan/Promalin ± nonionic surfactant	May also be applied as a latex paint mixture with a brush or sponge at 3.8 to 6.3 fl oz per pint of latex paint (5,000 to 7,500 ppm). Do not apply the latex paint mixture after bud break.
To increase lateral bud break and shoot growth and improve branch angle on one-year-old wood on nonbearing trees.	Promalin + nonionic surfactant	0.5 to 2 pt/10 gal (125 to 500 ppm) and surfactant at 2.5 oz/10 gal. Apply to previous season's leader growth with thorough coverage when new growth is 1 to 3 inches long.
	Perlan	0.5 to 2 pt/10 gal when orchard trees have 1 to 3 inches of new growth.
	Bagging + Promalin without surfactant	Bag previous season's unbranched central leader growth three to four weeks before anticipated bud break with a bag or sleeve of 2- to 4-mil clear polyethylene to promote greater branching. Fold around the leader and fasten tightly with a clothespin at the bottom and the top; leave on until the growth in the bag is 1 to 2 inches long (usually at bloom). Daytime temperatures should be monitored carefully to prevent overheating of the foliage inside the bag. However, some leaf scorch is acceptable. Lower bag closure should be loosened for two to four days before bag is removed. Upon bag's removal, the leader should be sprayed with a 250-ppm application of promalin as described above.
To promote lateral branching on current season's terminal growth.	Promalin without surfactant	Use 8 oz/10 gal (125 ppm). Apply after every 8 to 10 inches of terminal growth in conjunction with removal of at least one-half of each immature terminal leaf without damaging the growing point or bud (i.e., summer nipping).
	MaxCel	Use 16 to 32 fl oz in 10 gallons (250 to 500 ppm). Apply the first of three to four applications to the three to four leaves at the tip of the new shoot at the height where new lateral branches are desired. Continue on a 5- to 10-day schedule. Do not tank-mix with streptomycin or apply streptomycin on the same day.
To minimize blind wood by forcing break of paradormant buds on older wood (2+ years old) of apple trees	MaxCel	Make a notch immediately above dormant buds with a sharp instrument (box cutter, double-bladed hacksaw, etc.) and apply up to 1,500 ppm of MaxCel directly into the notch using a squirt bottle or paint brush. For best results, the notch must penetrate through the cambium layer. Notching and application should be done in the spring when temperatures are warm. Optimal timing is between tight cluster and early bloom. Adding 500 ppm Promalin or Perlan has also been beneficial. If applications are made after bud break, use caution to prevent contact of the MaxCel solution with green tissue to avoid injury to tender shoot tips. Be aware of the associated risks of bacterial infection from *Erwinia* and *Pseudomonas* in open wounds, and implement appropriate risk-mitigation measures, including avoiding notching when conditions are favorable for infection.

Table 20. Increasing Apple Fruit Set

Goal	Chemical	Rate and Time of Application
To increase fruit set after a frost or freeze.	Promalin/Perlan	Apply within 24 hours of a frost event when the majority of the crop is between early bloom and full bloom. Apply 1 to 2 pints in 75 to 150 gallons of water per acre. ****Note** This is a rescue treatment and should be used only if significant crop loss is anticipated. Parthenocarpic fruit have reduced storage potential and may be misshapen. Your specific situation (site, temperatures observed, market, and crop insurance) should be considered.**
To increase the duration of floral receptivity and fruit set if pollination conditions are poor during bloom.	ReTain	Apply one pouch of ReTain per acre as a single application from pink to full bloom. Applications made prior to pink or after full bloom will significantly reduce efficacy of the treatment. Do not apply after petal fall.
To decrease June drop on trees with light bloom.	Apogee, Kudos	Apply 10 to 12 oz per 100 gallons when shoots are 1 to 3 inches long (i.e., during bloom).

Table 21. ProVide and Novagib Recommendations

Goal	Chemical	Rate and Time of Application
To reduce russet formation caused by weather conditions on susceptible cultivars (esp. Golden Delicious).	ProVide 10SG	Make four applications at 7- to 10-day intervals at a rate of 60 to 100 g (2.1 to 3.5 oz) per 100 gal of water for optimal response. Make first application at petal fall. Do not exceed 400 g per acre per year for russet control. Apply as a fine mist. Seven-day intervals between applications will give better russet control than 10-day intervals.
	Novagib 10L	Apply Novagib 10L in three to six consecutive applications. Make the first application of 20 to 33 fl oz in 100 gallons of water per acre at the beginning of petal fall. Repeat this at 7- to 10-day intervals. Do not apply more than 80 fl oz per acre per season.
To reduce fruit cracking (esp. Stayman).	ProVide 10SG	Make three to six consecutive applications of 3.5 to 7.0 oz (100 to 200 g) of ProVide 10SG in 100 gallons of water per acre (25 to 50 ppm). Make the first application at least two to three weeks before fruit cracking is likely to be observed in the orchard. Continue application at 14- to 21-day intervals. Use of a nonionic surfactant will improve coverage and enhance penetration. **NOTE:** Do not treat for cracking suppression on apples that have received ProVide 10SG applications to suppress russet.
	Novagib 10L	Apply 2 to 4 pts of Novagib 10L per acre in sufficient water to achieve good coverage of the fruit. Make the first of three to six consecutive applications two to three weeks before cracking is expected to occur. Repeat application at 14- to 21-day intervals. Apply under slow drying conditions. The efficacy of Novagib 10L may be reduced by compounds causing a high pH in the spray tank. Use a nonionic surfactant to improve coverage and enhance penetration.

Table 22. Return Bloom Sprays

Goal	Chemical	Rate and Time of Application
To increase return bloom for the following season, especially on heavily cropped trees.[1]	NAA (Fruitone L, PoMaxa, or ReFine 3.5WSG)	5 ppm (2 oz/100 gal), or 2.5 ppm + surfactant After the chemical fruit-thinning window has passed (typically six weeks past petal fall), use biweekly applications of NAA in the next three to four cover sprays. This can generally be accomplished with two applications in June and two in July for apple-growing areas in the Southeast. NAA applications may be tank-mixed with pesticide cover sprays. **If captan is included in cover sprays, do not add a surfactant.**
	Ethephon (Ethrel, Ethephon 2, Motivate, etc.)	16 to 72 fl oz per acre depending on cultivar, crop load and history of biennial bearing. Use 16 to 24 fl oz per acre on Gala, Rome, Red Delicious; 24 to 48 fl oz acre on Golden Delicious; 48 to 72 oz/acre on Fuji, Cameo. Make a single application five to six weeks after bloom. Consider a second application two to three weeks later if the crop load is excessive. **Do not use Ethephon for increasing return bloom on Honeycrisp.**

[1]This response is effective on slightly to moderately overcropped trees (125% to 200% of full crop) but will not be effective on excessively overcropped trees.

Table 23. Defruiting Young Trees

Goal	Chemical	Rate and Time of Application
To defruit trees too young or too small to begin bearing (all varieties).	NAA + Carbaryl + Ethephon	2 oz Fruitone L or PoMaxa + 1 lb a.i. carbaryl + 2 pt Ethrel per 100 gal applied at 8 to 10 mm fruit diameter. **Caution: Application can suppress vegetative growth for three to six weeks.**
	6-BA + carbaryl + non-ionic surfactant	150 ppm 6-BA (MaxCel; Exilis Plus; Exilis 9.5 SC) + 1 quart carbaryl + 1 quart non-ionic surfactant per 100 gallons. While some fruit may persist after treatment, this combination will not retard vegetative growth. Daytime highs must be greater than 70°F for this treatment to be effective.

Apple Thinning Recommendations for the Southeast

Thinner Activity	Chemicals/Combinations rate per 100 gal	Fruit Size avg-mm	Gala, Goldrush, Jonagold, etc.	Red Delicious		Golden Delicious	Rome		Fuji
				Std	Spur		Std	Spur	
least	Sevin XLR or Carbaryl 4L 1 pt (0.5 lb a.i.)	petal fall	X	X	X	X May cause russet	X	X	X
	Carbaryl 0.5 to 1.0 lb a.i.[1]	7 to 9	X	X	—	—	X	—	—
	Carbaryl + surfactant 0.5 to 1.0 lb a.i. + 0.5 to 1.0 pt	7 to 9	X	X	—	—	X	—	—
	Liquid lime sulfur + oil 1.5 to 2.0 gal + 1.0 to 2. gal	bloom	X	X	X	X	X	X	X
	MaxCel/Exilis + Carbaryl 75 to 100 ppm + 0.5 to 1.5 lb a.i.	8 to 12	X	X	X	X	X	X	X
	Carbaryl + NAA 0.5 to 1.0 lb a.i. + 2.5 to 5 ppm	7 to 9	X	X	X nubbin possible		X	X	Do not use NAA on Fuji
	NAA 5 to 25 ppm	9 to 12	—	—	X nubbin possible	X	—	—	
	NAA + surfactant 5 to 15 ppm + 0.5 to 1.0 pt	9 to 12	—	—	X nubbin possible	X	—	—	
	Carbaryl + spray oil 0.5 to 1.0 lb a.i. + 0.5 to 1.0 pt	6 to 9	—	—	X	—	—	X	—
	Carbaryl + Ethrel + NAA 1 lb a.i. + 0.5 to 0.75 pt + 2.5 ppm	9 to 11 18 to 30 for rethinning easy-to-thin varieties			X	—	—	X	X
	Carbaryl + Ethrel 1 lb a.i. + 1.5 pt	12 to 18	—	—	X	—	—	X	X
most	Carbaryl + Ethrel + NAA 1 lb a.i. + 1.5 pt + 5 to 10 ppm	18 to 30	X	—	—	—	—	X	X

WARNING: Use of spray oils as required with certain pesticides (such as Agri-Mek) applied in proximity to thinner applications will interact and increase chemical thinner activity.

[1]a.i. = active ingredient

Apple Re-Thinning Recommendations for the Southeast

Thinner Activity	Chemicals/Combinations (rates per 100 gallons)	Timing of application	Rethinning (all varieties)
least	Carbaryl 0.5 to 1.0 lb a.i.	7 to 10 days after first thinner application.	To push off weak or stunted fruit off, esp. on Golden Delicious.
↓	Carbaryl + surfactant 0.5 to 1.0 lb a.i. + 0.5 to 1.0 pt	14+ days after first thinner application.	Rome, Standard Red Delicious, Mutsu, GoldRush, Jonagold, etc.
↓	Carbaryl + Ethrel ± NAA 1 lb a.i. + 0.5 to 0.75 pt ± 2.5 ppm	18 to 30 mm and at least 14 days after first application.	On moderately overcropped trees (150 to 200% crop load), esp. on easy-to-thin varieties.
most	Carbaryl + Ethrel ± NAA 1.0 lb a.i. + 1.5 pt + 5 to 10 ppm	18 to 30 mm and at least 14 days after first application.	Heavy to excessively overcropped trees (250%+), esp. spur-type varieties.

Note: When re-thinning, reconfigure nozzles to direct spray to areas in the canopy where crop load is excessive, and avoid spraying areas where crop load has already been reduced to an acceptable level. Ethephon can cause excessive thinning if temperatures are high. If maximum temperatures are between 75°F and 80°F, reduce the rate of ethephon by one-third. If maximum temperatures are >80°F, reduce the rate of ethephon by two-thirds. Don't apply ethephon if temperatures are >90°F.

Apogee, Kudos *(prohexadione calcium)*

Prohexadione calcium reduces terminal growth by inhibiting synthesis of gibberellins, which regulate shoot growth in apples. Once applied, it requires 10 to 14 days to slow growth. Prohexadione calcium degrades within the trees in a few weeks, so repeat applications will be necessary to maintain growth control throughout the entire growing season. **Continue applications as long as the potential for shoot growth is present**, but remember that the preharvest interval is 45 days.

Amount to Apply: The label suggests rates of application between 3 and 12 ounces **per 100 gallons** of dilute spray (62.5 to 250 ppm). The **amount applied per acre** depends on your tree row volume (TRV). While it is frequently suggested that plant growth regulators should be diluted when applied, prohexadione calcium has been used very effectively when applied in water volumes less than TRV, as long as the a.i. per acre is maintained based on TRV and uniform coverage is achieved. Water volume below 50 gallons per acre is not recommended. Do not apply more than a total of 99 ounces of prohexadione calcium per acre per season.

Time of Application: It is essential to make the first application when terminal shoots are no longer than 1 to 2 inches. This usually coincides with late bloom or petal fall. Earlier applications (pink bud stage) can result in enhanced vegetative growth control when used as part of a season-long growth management program. Successful use of prohexadione calcium will depend on making the first application on time. There is no detrimental effect on bees, so the first application can be made even before bees are removed from the orchard.

Surfactants: To assure good wetting and coverage, use a nonionic surfactant. Follow the manufacturer's rate recommendations. **It is recommended that a water conditioner, such as AMS, be added to the spray mix when the water source for the mix contains high levels of calcium (hard water).** See product label for rates.

Using Prohexadione Calcium on Trees Sprayed with Promalin, Pro-Vide, Perlan, or Novagib: Promalin, Pro-Vide, Perlan, and Novagib are gibberellin-containing products that are applied in the bloom or postbloom period to improve fruit shape and reduce fruit russeting, respectively. Prohexadione calcium inhibits gibberellin production in apple trees. Data indicate that prohexadione calcium may directly reduce russet and that it may enhance the efficacy of a GA4+7 program for russet control. However, prohexadione calcium may reduce the efficacy of preharvest GA4+7 sprays for control of cracking on Stayman. This has not been proven, but the possibility exists.

Using Prohexadione Calcium to Control Fire Blight: Prohexadione calcium will cause shoot growth to harden off, thereby reducing susceptibility of shoots to fire blight. The growth retardation response must have occurred **before** fire blight infection for it to be effective. Generally, this will require a minimum of 10 to 12 days before infection. Prohexadione calcium does not have any direct effect on the fire blight bacteria and is not effective on blossom blight, so traditional control measures using streptomycin are necessary. Apply prohexadione calcium to suppress fire blight with applications that are made to control growth (when shoots are 1 to 2 inches in length, or at petal fall of king bloom). Whether the 3-to-

6-ounce-per-100-gallons rate used for growth control is as effective for fire blight control as a 12-ounce-per-100-gallons rate has not been determined for southeastern orchard conditions.

Early application timings (pink bud stage) at 6 to 12 ounces have been effective in managing blossom and shoot blight in some growing regions. Earlier timings may be considered on a trial basis.

Cracking: On apple varieties known to be prone to cracking (such as Empire and Stayman), prohexadione calcium has been associated with an increase in fruit cracking.

Vegetative Growth Control Recommendations

Goal	Chemical	Rate and Time of Application
To reduce vegetative growth, and to reduce later season tree canopy volume and density to improve pesticide efficiency. To suppress fire blight shoot blight.	Prohexadione calcium (Apogee or Kudos)	3 to 12 oz + 1 pt nonionic surfactant per 100 gal. Use of a water conditioner is recommended with hard water. Do not apply later than 45 days before harvest.[1] With early maturing cultivars such as Gala, a postharvest application may be necessary for season-long growth control. Apply as a sequential biweekly application beginning at 1- to 2-inch shoot growth using 6 oz/100 gal, or apply as sequential monthly applications beginning at 1 to 2 inches of shoot growth using 6 to 10 oz/100 gal. (See below table for application options.) Do NOT tank-mix with calcium chloride, calcium nitrate, or boron. Apogee can be tank-mixed with pesticide cover sprays.

[1]Maximum allowable use rate per season is a total of 99 ounces per acre.

Application Options for Prohexadione Calcium in the Southeast

Tree Vigor (relative to crop load, rootstock, and cultivar vigor)	Weeks after 1" to 2" of terminal growth (approx. PF)[1]						
	0	2	4	6	8	10	12
Moderate vigor	3 oz[2]	3 oz	3 oz	3 oz			
	or 6 oz	Ca3	6 oz	Ca			
High vigor	3 oz	3 oz	3 oz	3 oz	3 oz	3 oz	
	or 6 oz	Ca	6 oz	Ca	6 oz	Ca	
Excessive vigor	3 oz	3 oz	3 oz	3 oz	3 oz	3 oz	3 oz
	or 6 oz	Ca	6 oz	Ca	6 oz	Ca	6 oz
Crop loss	3 oz	3 oz	3 oz	3 oz	3 oz	3 oz	3 oz
	or 6 oz		6 oz		6 oz		6 oz

[1]Application sequences must start at 1 to 2 inches of new growth extension for effective response.

[2]3 or 6 oz/100 gal rates must be adjusted to rate per acre based on TRV of each orchard being treated.

[3]Ca: Calcium nitrate, calcium chloride, or boron sprays cannot be tank-mixed with prohexadione calcium. Sysstem-CAL can be tank-mixed with Apogee.

Sucker Control

Apply Tree-Hold A-112 as a low-pressure, large-droplet (to prevent drift up into the tree), directed-spray application at the base of the tree with handheld equipment. A thorough application that gives complete wetting and coverage is necessary for good results. Do not allow spray to drift onto tree foliage or fruiting spurs. For best results, cut woody sucker growth at ground level during the dormant season and apply Tre-Hold are A-112 when new suckers 4 to 12 inches long. Do not apply during the period from bloom to four weeks after bloom.

Sucker Control Recommendations

Goal	Chemical	Rate and Time of Application
To control suckers from the ground around the trunk of apple trees.	Tre-Hold A-112 (NAA, ethyl ester)	Use 10,000 ppm (10 fl oz/gal). Apply after dormant removal of suckers and when new suckers are 4 to 12 inches long.

Water Sprout Control

Do not spray Tre-Hold A-112 up into the trees. Tre-Hold A-112 should not contact buds or fruiting spurs. Tre-Hold A-112 is not recommended when green growth is present. One to 4 pints of light-colored latex (water-based) paint may be included per gallon to mark where application has been completed. Thorough coverage with complete wetting is necessary for good results.

Water Sprout Control Recommendations

Goal	Chemical	Rate and Time of Application
To control water sprout regrowth around pruning cuts and to control water sprout growth on top of large scaffold limbs where old trees are opened up.	Tre-Hold Sprout Inhibitor A-112	Use 10,000 ppm concentration (10 oz/gal); apply with sponge or brush as a localized application to the pruning cut and before growth starts in the spring (can be mixed with latex-based paint as a marker to show which cuts have been treated).

Stop-Drop Sprays

ReTain (*aminoethoxyvinylglycine*) is at least as strong and generally a stronger fruit drop control material than preload NAA, but it has the added benefit of delaying fruit maturity. This maturity delay allows additional time on the tree for fruit to increase in size and develop natural coloration (for red varieties) without excessive loosening and without fruit becoming overly mature. In a normal year, ReTain should be applied four weeks before the beginning of the harvest period of untreated fruit for the current season for a single-pick variety and one to two weeks before the beginning of the harvest period of untreated fruit for the current season for multiple-pick varieties. Up to two pouches of ReTain can be applied per acre. When applied under optimal conditions, a single pouch can provide a 7- to 10-day delay in maturity and subsequent drop control. The two-pouch rate can further delay maturity and fruit drop. In a hot year, ReTain should be applied two weeks before harvest. ReTain has a seven-day preharvest interval (PHI) for apples.

A single NAA application of 10 to 20 ppm applied at the onset of drop may delay fruit drop for seven to 10 days. An additional application may be made if fruit is left for longer than seven to 10 days or if the application fails to give satisfactory control. If a second application is made, apply six to seven days after the first application. It is necessary to wet the foliage thoroughly for maximum effectiveness of stop-drop sprays. Applications of higher-than-recommended concentrations of NAA may accelerate fruit maturity and reduce storage life. Applications of NAA after the onset of fruit drop will give ineffective control.

The tank-mix combination of ReTain plus a 100% organosilicone surfactant plus 20 ppm NAA applied two weeks prior to normal harvest provides superior control of fruit drop and firmness retention compared to ReTain or NAA alone.

Stop-Drop Spray Recommendations

Goal	Chemical	Rate and Time of Application
To delay preharvest fruit drop; delay fruit maturity; and allow time for added fruit-size increase and natural coloration of red varieties.	ReTain	Ingredient (one pouch) per acre plus a 100% organosilicone surfactant at 0.05 to 0.1% (v/v) four weeks before anticipated normal start of harvesting using 100 gal/acre or 50% of TRV. To enhance the duration of preharvest drop control or delayed maturity, up to two pouches per acre can be used. Some varieties such as Gala are more sensitive to ReTain and only require application at half-rates for efficacy.
Preload NAA	NAA	Apply NAA at weekly intervals beginning four weeks before date of normal anticipated harvest at the rate of 5 ppm/week. Application can be included with preharvest cover sprays. This program has also been shown to increase return bloom in the following year.
To reduce preharvest fruit drop at or after the onset of fruit loosening or drop.	NAA	Apply at 8 to 32 fl oz/acre at first sign of preharvest fruit drop on most cultivars. Use full coverage, 80 to 100% TRV. Higher application rates (>10 ppm NAA) may cause fruit softening at temperatures above 85°F.
To delay fruit drop and maintain firmness in late harvested fruit. Provides the most consistent control of fruit drop and softening.	ReTain plus NAA	Apply one pouch of ReTain per acre plus 10 to 20 ppm NAA as a tank-mix combination two weeks before normal harvest. Include nonionic surfactant normally combined with ReTain in the tank mix. Higher application rates (>10 ppm NAA) may cause fruit softening at temperatures above 85°F.

Fruit Scald Control

Fruit should be dipped or drenched in Diphenylamine (DPA) in crates or bins. Treat fruit before it cools, as soon after harvest as possible and not more than one week after harvest. The longer treatment is delayed, the less effective it will be. Do not wash or brush fruit immediately after treatment. Thorough coverage of fruit with inhibitor is important for satisfactory control. The inhibitor solution must be kept clean, well agitated, and aerated. Fruit should not be dipped more than 30 seconds to prevent excessive residue. Do not treat fruit more than once with the same inhibitor. Fruit wraps and waxes are available that contain scald inhibitors. There are reports of DPA causing skin browning in Golden Delicious.

Fruit Scald Control Recommendations

Goal	Chemical	Rate and Time of Application
To reduce incidence of scald on stored apples.	DPA Concentrate (Diphenyl-amine[1])	2.5 pt/gal water (1,000 ppm). Apply as a dip or spray to harvested fruit.

[1]10 ppm residue tolerance.

SmartFresh *(1-methylcyclopropene [1-MCP])*

SmartFresh (1-MCP) is a postharvest treatment that maintains fruit flesh firmness and acidity for a longer time, even under less-than-ideal storage conditions. SmartFresh will also reduce the incidence of scald. To have the greatest effect from SmartFresh, apples must be harvested at optimal maturity, and guidelines for firmness and starch levels have been developed for different cultivars by the producer (AgroFresh). SmartFresh is introduced into the atmosphere of an airtight facility or container in which fruit is held for 24 hours. After the 24-hour period, fruit is returned to normal refrigerated storage. The amount of product used depends on the volume (cubic feet) of the treatment facility; therefore, loading the facility with apples to capacity is necessary to reduce treatment cost. Treat as soon as possible after harvest (within three to seven days) for best effect.

SmartFresh must be ordered directly from AgroFresh Inc. by calling their toll-free customer service number (1-866-206-1001). It is highly encouraged that the treatment facility be tested for leaks before initial treatment and annually thereafter. Contact your local Extension agent for further information.

Vertebrate Management

White-tailed Deer *(Odocoileus virginianus)*

Deer are attracted to nearly all species of fruit trees. Deer are selective browsers and grazers and move slowly through the orchard feeding on leaves, twigs, and fruit from different trees or on ground covers. They may also browse heavily on one tree and ignore others close by. They are frequently seen browsing orchards in early summer, late summer, and fall, when food is most scarce. The most common damage occurs when emerging leaves and shoots are eaten in spring and summer. In late summer to early winter, fruits and nuts make up a large part of their diet. Deer have no upper incisor teeth. They pinch their food with their lower incisors against a tough pad in their upper jaw and leave ragged edges at the point of detachment. This type of damage is most devastating in young plantings. During September to November (after antler growth is complete), bucks may damage trunks and scaffolds by rubbing their antlers to leave their sign. (They do not use the trunks to rub off the velvet on their antlers, as is commonly believed; this falls off naturally.)

Deer are creatures of habit and will not return to a predominantly forest-based diet once more nutritious plants have been found. While damage from deer browsing is most severe on young trees, significant economic losses can also occur in mature orchards. Damage varies from slight to extreme, depending on population, weather, alternate food sources, and tree size. Damage generally varies season to season and year to year.

The home range of deer tends to be quite limited, often as little as 1 square mile. Heavy hunting pressure, dogs, and seasonal changes in food supply can cause deer to shift foraging areas within their home range. Bucks increase their movements slightly during the fall mating season.

Management

Effective management begins by anticipating the extent of possible damage and then responding with appropriate control measures. Consider the severity of deer damage during the previous year and reports of deer density in your area as indicators of potential problems. Compare the cost of control versus the cost of damage. In new plantings, browsing damage may set back the development and subsequent fruiting of the orchard for several years. In extreme situations, damage may prevent

an orchard from ever reaching its potential. Several methods for limiting deer damage might be considered. Each of them, or combinations of them, may prove to be effective:

Habitat modification. Deer prefer early successional forests that are in the shrub-tree sapling stage. They are abundant in agricultural areas where field crops and orchards are interspersed with forest habitat. Converting forest areas adjacent to orchards into cropland or pasture may help limit movement of deer into orchards.

Hunting. Encourage hunting on the farm. Non-hunted areas may serve as refuges during hunting season. Hunters should be encouraged to harvest doe deer to keep the population in check.

Shooting. Check with area wildlife officers regarding permission to shoot deer out of season if they become a problem. Lethal control methods often have only a temporary effect on general deer population.

Repellents. Repellents vary in their effectiveness. They are affected by population, feeding habits, and environmental conditions. They may be effective if damage is light to moderate, if small acreages are involved, if alternative food sources exist in the area, and if only a few applications will be needed for adequate control. **Repellents will not work satisfactorily when deer populations are high**.

Two types of repellents are available. The first is an **area repellent**, which includes elements such as tankage (putrefied meat scraps), ammonium soaps, bone tar oil, blood meal, human hair, and bar soap. These repellents should be applied close to or on the plants needing protection. In some cases, putting them on the side of the orchard where the deer enter is effective. However, it may be necessary to disperse repellents throughout the planting.

The other general type is a **contact repellent** that works by taste. Apply it directly to plants during the dormant season and on dry days when temperatures are above freezing. Expect some feeding damage when taste repellents are used. Repellents in this category include putrescent egg solids, thiram, and hot pepper sauce. Reapplication is often necessary as rainfall will wash the repellents off. When using commercial repellents, always follow label directions. Below are commercial repellents used to repel deer in orchards.

White-tailed Deer Management Recommendations

Common Name	Product Name	EPA Reg. #
13.8% ammonium soap[1]	Hinder	4-15
37% egg solids	Rockland Deer Guard	4866-10
20% thiram	Chew-Not	358-105
11% thiram, 11% acrylic polymers	Bonide Rabbit-Deer Repellent	4-136
2.5% capsaicin	Hot Sauce Animal Repellent	72-574
dried blood meal	Plantskydd Repellent	exempt

[1]Application to apples under hot, humid conditions may result in fruit-finish problems such as spray burn rings.

Soap bars also have been used in orchards to repel deer. Drill a quarter-inch hole through the center of each small soap bar. Leave the wrapper on to prevent excessive weathering. Hang the bars away from the trunk on a wire or string and about 30 inches above ground. Putting soap bars in nylon mesh bags tied onto trees instead of using wire or string may keep the soap on the trees for a longer period of time. Bar soap has no EPA registration. The cost of materials plus the substantial amount of labor involved in putting the soap bars on trees may render this treatment economically impractical.

Fencing. In areas having a high deer population, fencing may well be the only viable control method. Electric fences offer an effective, less expensive option than conventional fences. A single strand of high-tensile wire 30 inches above ground can be quite effective; if it is visible, the deer will investigate. Treat the wire with a 50/50 mixture of peanut butter and vegetable oil or drape aluminum foil strips coated with peanut butter to attract deer. Decorating the wire with flagging will further increase effectiveness. Highly visible fences with very conspicuous wire or wire-impregnated tape are visible to deer and are effective without an attractant. Once deer get shocked from the fence, they tend to avoid the area unless they are being chased.

In extreme pressure situations, the Pennsylvania five-wire fence might be justified. It is constructed with five high-tensile strength wires stretched to 250 pounds tension and charged using a high voltage/low impedance "New Zealand-type" energizer. Wires are charged so as to shock deer from wire to wire. Put the lowest wire 10 inches above ground and space the others 12 inches apart. Baiting the middle wire with peanut butter may increase the effectiveness of the fence. Control weeds along fences to avoid shorting them out. A 6- to 8-foot mowed strip around the fence should be maintained to discourage deer from jumping and to lessen the weed

load on the fence. Fences need to be checked regularly to be certain that the shocking wires' power is sufficient to turn deer. Fencing will also keep bucks from rubbing their antlers against the trunks and damaging them. To protect individual trees, set three fence posts 1 to 2 feet apart in an equilateral triangle around each tree. Nonelectrified fences for deer exclusion need to be at least 8 feet high to be effective. They are much more costly than electric fences.

Cottontail Rabbit *(Sylvilagus floridanus)*

Rabbits feed on a wide variety of green vegetation. From spring through fall, clover, grass, and broadleaf weeds are the mainstay of their diet when other green vegetation is not available. During winter they shift to twigs, buds, and bark of woody plants. This is when damage occurs to young fruit trees. Favorable habitats for rabbits include thickets, brush piles, fencerows, grassy fields, and perimeters of cultivated fields. Rabbit populations are directly related to the amount of favorable habitat available and can increase if predation is light or lacking. Several methods for controlling rabbit damage exist. A combination of techniques will provide the most satisfactory results:

Habitat modification. Remove brushy, thick habitats in the vicinity of orchards.

Exclusion. Guards around young trees can prevent rabbits from feeding on the bark of the trunk. The best guard is probably a piece of ¼-inch mesh hardware cloth. It should extend from 2 inches in the soil (for stability) to between 18 and 24 inches above ground. The guard should be big enough that it can be left for several years without the risk of it girdling the trunk of the tree. Solid guards that prevent good sunlight or spray contact with the trunk, restrict air circulation, or fit closely around the trunk should be installed in late fall and removed in spring to prevent pests from building up under the guard or girdling the trunk. A 3-foot-high fence made of small-mesh chicken wire will keep rabbits out. Bury the lower part of the wire a few inches to prevent rabbits from going under it. Keep weeds and grasses from growing up along the fence.

Repellents. Certain taste repellents are effective in preventing most feeding damage by rabbits when sprayed on tree trunks at the appropriate times or when mixed with white latex paint and applied to tree trunks for prevention of southwest trunk injury. These repellents include the following:

Cottontail Rabbit Management Recommendations

Common Name	Product Name	EPA Reg. #
13.8% ammonium soap[1]	Hinder	4-15
37% egg solids	Rockland Deer Guard	4866-10
20% thiram	Chew-Not	358-105
11% thiram, 11% acrylic polymers	Bonide Rabbit-Deer Repellent	4-136
2.5% capsaicin	Hot Sauce Animal Repellent	72-574
dried blood meal	Plantskydd Repellent	exempt

[1]Application under hot, humid conditions may result in fruit-finish problems such as spray burn rings.

Voles

Pine vole (*Microtus pinetorum*)
Prairie vole (*Microtus ochrogaster*)
Meadow vole (*Microtus pennsylvanicus*)

Voles are compact rodents with stocky bodies, short legs and tails, small eyes, ears that are partially hidden, and dense underfur covered with thicker, longer guard hairs. Voles are usually brown or gray, but many color variations exist.

Orchardists in the Southeast need to be concerned with pine voles, meadow voles, and prairie voles. The table below indicates the geographic area in which each of these animals may be found.

Monitor to determine if voles exist in the orchard and what types of voles are present. Some differences exist between types of voles regarding control practices.

Pine voles, also called woodland voles, average 4 to 6 inches in length (including the tail, which is about the same length as the hind foot). Their brown fur is soft and dense. Some underparts are gray mixed with some yellow to cinnamon. The tail is barely bicolored or unicolored. They have small, indistinct eyes as compared to the meadow vole. Meadow voles average 5 to 7 inches total length (including the tail, which is about twice the length of the hind foot), and have gray to yellow-brown fur obscured by black-tipped hairs. Their underparts are gray (sometimes washed with silver or buff). The tail is bicolored.

Prairie voles average 5 to 7 inches in length from the nose to the tip of the tail, which is about twice as long as the hind foot. Their fur is gray to dark brown and mixed with gray, yellow, or hazel-tipped hairs, giving it a peppery appearance. The underparts are gray to yellow-gray.

Vole Range in the Southeastern U.S.

Animal	Range
Pine vole[1]	Found from central Texas to Wisconsin and east to the Atlantic coast with a few exceptions such as southern Alabama and the southeastern corner of North Carolina
Meadow vole[1]	North Carolina, South Carolina, north part of Georgia and Tennessee (northeastern part)
Prairie vole[2]	Arkansas, Missouri, Alabama (northern third of the state), Tennessee (all except extreme east Tennessee)

[1]Johnson, M.L., and S. Johnson. 1982. Voles. Pages 326-354 in *Wild Mammals of North America: Biology, Management and Economics*. J.A. Chapman and G.A. Feldhammer, eds. The John Hopkins University Press, Baltimore, Md.

[2]Schwartz, C. W., and E. R. Schwartz. 1981. *The Wild Mammals of Missouri*, rev. ed. University of Missouri Press, Columbia. 356 pp.

Habitat

Voles occupy a wide variety of habitats. They prefer areas having a heavy groundcover of grasses, grasslike plants, or litter. When two species are found together in an area, they usually occupy different habitats. Orchards, windbreaks, overgrown fencerows and ditch banks, and cultivated fields (especially no-till fields) are favorable habitats, although different types of voles have varying or additional habitat preferences.

Pine voles may be found in deciduous and pine forests, abandoned fields, shrubby areas, orchards, and other areas having heavy groundcover. They are particularly prevalent where the soil texture permits easy tunneling.

Meadow voles prefer wet meadows and grassland habitats, particularly unmowed or infrequently mowed tall fescue fields.

Prairie voles may be found in old fields and marshlands. (When associated with cotton rats, they favor the drier areas.)

Population Development and Fluctuations

Voles may breed throughout the year in a mild winter, but litters are most common in the spring and summer. They have one to five litters per year with an average of three to six young per litter. The gestation period is about 21 days, and voles become sexually active at the age of one month. Young are weaned by the time they are 21 days old. Females mature in 35 to 40 days. Their peak breeding period is between March and October, but in mild winters they may breed all year. A single female meadow vole could potentially produce more than 70 young in a year. The average lifespan of a vole is short, probably in the range of 2 to 16 months.

Large population fluctuations are common. Population levels generally peak every four years, but the cycles are not predictable. Dispersal, food quality and quantity, climate, predation, physiological stress, and genetics all affect population levels. Other factors are probably involved.

Behavior

Voles are active day and night throughout the year. Their range is usually ¼ acre or less but varies with season, population density, habitat, food supply, and other factors.

Voles construct many tunnels or surface runways (depending on the type of vole) with numerous burrow entrances. A single burrow system may contain several adults and young. Meadow voles and prairie voles build surface runways in grass and litter. Their runways are 1 to 2 inches wide. Vegetation near well-traveled runways may be clipped close to the ground. Feces and small pieces of vegetation will be found in the runways. Nests built of dry grasses and leaves are large, globular, and may be found close to tree trunks in clumps of grass.

Pine voles do not use surface runways. Instead, they construct an extensive system of subterranean tunnels in loose, crumbly soil. As they tunnel, they push out dirt, producing small, conical piles of soil on the surface of the ground. Their nests are large and globular and are built of dry grasses and leaves. They may be found near tree trunks, clumps of grass, and at the end of tunnels.

Damage and Damage Identification

Meadow voles and prairie voles may cause extensive damage to orchards by feeding on and girdling the base of trunks or roots at or near the soil line. This damage is most likely to occur in late fall and winter when more preferred food sources of grasses, tubers, and seeds become limited. The presence of snow cover often encourages severe injury. Pine voles may cause damage beneath the surface of the soil, generally to a depth of about 6 inches. Frequently, injury to trees is not evident until trees are in decline, often past the point of salvation. Wounds created by voles and cotton rats may also serve as entry points for insects and diseases, which may further enhance tree decline and death.

Voles make nonuniform gnawing marks that occur at various angles and in irregular patches. These marks will be about $^{3}/_{8}$ inch wide, $^{1}/_{16}$ inch long, and $^{1}/_{16}$ inch deep.

Damage Prevention and Control Methods

Vole control is a year-round project. Many practices are directed toward discouraging the presence of voles in the

orchard. In some years, these practices may need to be supplemented by the use of rodenticides.

Several different concepts may be used in preventing vole and cotton rat damage in orchards. These include nonchemical techniques involving certain cultural practices in the orchard, exclusion, and habitat modification. Rodenticides may be used for vole control. A combination of several methods will provide the best protection.

Biological Controls
Voles are prey for many predators including coyotes, snakes, owls, hawks, weasels, dogs, and cats. Predators do not normally control vole populations due to the tremendous reproductive capability of voles. Predation can be enhanced by not discouraging the presence of predators and by following some of the practices detailed below.

Exclusion involves the use of tree guards. As described in the section on rabbits, quarter-inch mesh hardware cloth probably makes the most desirable tree guard. Guards should be installed at planting and be left in place for several years; the first five years of tree life are when most damage is apt to occur. Therefore, the guard should be large enough that it will not girdle the tree during this period. If other types of guards are used, they should be white to limit trunk heating during the winter months. Solid guards should not be used. Guards having few vent holes should be put on in the fall and removed in spring to prevent pest problems from developing on the tree trunk under the guard. Monitor spiral guards to be sure that shoots do not grow through vent holes, which can lock the guard so that it cannot expand as trunk diameter increases. Guards should extend from about 2 inches below ground (for stability and to deter meadow voles, prairie voles, and cotton rats) to about 18 to 24 inches above ground. Guards are not effective deterrents for pine voles as they work primarily underground. The cost of purchasing and installing guards is substantial. Compared to the potential loss from damage, however, they can be a good investment.

Certain **cultural practices and habitat modifications** in and around the orchard can reduce vole presence. The major food source for voles is not apple trees but the roots and stems of grasses and other groundcover. Elimination of weeds, groundcover, and litter under and around trees will reduce the capacity of these areas to support voles and cotton rats, increase their exposure to predators, and lessen the availability of nesting materials. The use of herbicides to maintain clean areas extending at least 3 feet out from tree trunks, plus close, frequent mowing of the orchard floor and the area around it, will restrict vole movement into the orchard. Tillage, where possible, also removes cover, destroys existing runways and burrow systems, and kills a fair number of voles outright. Keep in mind, however, that tilling too deeply will cause root damage to trees. Tillage should be avoided in sites having a severe erosion potential. These practices are much more effective in controlling the surface-feeding voles than pine voles.

Voles can live in dense populations in ditch banks, rights-of-way, unmowed waterways, and adjacent fields. Cleaning up and mowing these areas can discourage vole movement into orchards.

After harvest, remove or shred dropped fruit and leaves to speed up decomposition. Raking fruit and leaves from under trees and into wind-rows between rows and then shredding this material removes a preferred food source. It also eliminates potential cover and destroys runways and shallow tunnels.

Pelleted formulations of baits are preferred to grain baits as they tend to weather better, are more effective against voles, and pose less of a threat to other wildlife.

Toxicants (rodenticides) may be needed to supplement the control achieved by use of the nonchemical control methods outlined above. *The use of toxicants should* ***not*** *be considered as the primary method of vole control.* The following materials are labeled for use in southern states.

The best type of rodenticide to use depends on the vole species found in your orchard. The rodenticides mentioned above will provide some control of both meadow voles and pine voles. However, zinc phosphide baits tend to be more effective against meadow voles while anticoagulant baits provide better control of pine voles.

Rodenticide	Labeled for Use In
zinc phosphide ZP Rodent Bait-Ag	All states
diphacinone Ramik Brown	All states

Zinc phosphide is an acute toxicant. A single feeding usually provides a lethal dose. Chronic rodenticides (anticoagulants) require multiple feedings over several days before a lethal dose will be obtained.

Zinc Phosphide 2% bait should only be used during the dormant season. It may be applied in any of the following ways:

(1) Broadcast: Apply at a rate of 10 pounds per acre using mechanical spreaders into vegetative cover to reduce the potential for non-target poisoning and to focus on areas in which voles are found.

(2) Spot or trail baiting: Place 1 teaspoon of pellets in surface trails or at the mouths of holes leading to underground burrows. Two to four bait spots should be made near the base of each infested tree. Do not disturb the runway system, and cover pellets by pulling overhanging grass back in place. Use 2 to 3 pounds of bait per acre.

(3) Bait placement stations: Place 2.5 ounces of bait under at least two established stations per tree. These stations should be established two to three months before baiting by placing rectangular (at least 15 inches by 15 inches) asphalt shingles or fiberboard trays, wood, or metal at the tree dripline. Split car tires horizontally and place with the hollow side down. Distribute one tire per tree every 10 trees for a good place to set the bait. For pine vole control, place bait directly in tunnels or under stations.

Zinc phosphide is an acute dosage rodenticide and has an R (restricted) safety code. When used improperly, it presents a serious non-target risk — including to the applicator. It is highly toxic to all birds and mammals. Bait shyness may occur if voles receive a sublethal dose. They will then tend to avoid the bait. If rebaiting is necessary, use an anticoagulant bait instead of a second application of zinc phosphide.

Ramik Brown is formulated as a 0.005% bait and is placed by hand in vole runs at 10 pounds per acre or broadcast with a mechanical spreader to vegetation under and around trees at 20 pounds per acre. Ramik Brown is a continuous feed anticoagulant and should be reapplied in 21 to 30 days to ensure that voles in the nest at the first treatment are exposed. It has a safety code of C (caution).

Refer to the label for information on use, including states where certain rodenticides are labeled for use, rate, and timing.

Vole Monitoring

The number of voles that can be tolerated represents a trade-off between the cost of control and the cost of damage, which will vary with growers. Most damage occurs at high populations. Monitoring helps to determine when populations start to increase and when controls should begin.

After harvest is the best time to check for the presence of voles. Runways free of growing vegetation and with bits of freshly cut vegetation and brown or green droppings shaped like rice grains constitute positive evidence of surface-feeding voles. Since pine voles do not use surface runways, they are harder to detect. Look for mounds of loose soil at push-up holes. Also, look for tiny, elongated tooth marks on apples laying on the ground.

Bait placement stations (or concentration stations) installed two to three months before baiting may be checked for the presence of tunnels. Bait may be seeded directly into the tunnels and the station replaced. Check to see if the bait has been consumed after two weeks. If the bait is gone, assume that there is still an active population in that area and put down additional bait. If some bait remains, assume that voles using those tunnels have been controlled, and do not use additional bait under that station.

The apple sign test is a good indicator of vole activity. Select 40 to 50 trees scattered throughout the orchard but especially near the edges of areas with other kinds of vegetation. Check for the presence of holes and runs and place a piece of asphalt roofing over one of the holes. After one week, check the shingle and place a piece of apple about the size of a quarter in the run or hole under the shingle. Check the next day and record whether the apple is missing, which is a positive sign for voles. Keep records on all the selected trees and record these same trees for a full year. It is not usually necessary to know the exact number of voles present, but it is good to know if the population is increasing or decreasing and whether a given treatment has had an effect on population size. To estimate the vole population, weigh the apple piece at the time it is put out and again 24 hours later. One pine vole consumes approximately 13 grams of apple in 24 hours. One meadow vole will consume about 20 grams of apple in this same time period. This is also an effective way to check the results of a rodenticide application.

Trapping, while not an effective means of controlling large vole populations, can be used to check for their presence and to aid in identifying the type of voles in the orchard. Mousetraps with expanded triggers may be placed perpendicular to runways, at the level of the runway using a piece of apple or a dab of peanut butter as bait. Fall through late winter is when voles should be easiest to trap. Select about 10 trees and place four traps

per tree. Record the number of voles caught over a three- to five-day period. If the control program is successful, no more than two or three voles should be caught.

For surface-feeding voles, place traps in runways perpendicular to the direction of travel, even with the bottom of the runway and with the trigger in the runway. For pine voles, excavate a portion of a tunnel and set the trap perpendicular to the direction of travel and even with the bottom of the tunnel. Be sure to provide enough room for the trap to function properly. Cover the trap with something like a pot or bucket to prevent light from reaching the trap without affecting its operation.

Set traps in the afternoon and check them the following morning to lessen chances of other animals robbing or getting caught in the traps.

Tips to Increase the Effectiveness of Rodenticides

1. Apply baits only in late fall and winter.
2. Do not apply baits to bare ground. Maintain a clean area extending out from tree trunks at least 3 feet.
3. Apply baits when no rain is expected for the following three days as wet weather may decrease the effectiveness of the bait.
4. Apply rodenticides by midafternoon as voles are most active at dawn and dusk.
5. Continually monitor to determine the types of voles present and to evaluate the effectiveness of the control program. This will allow for correct bait placement and for repeat bait applications if needed.
6. Where more than one type of rodenticide is labeled for use in the state, do not rely on repeat applications of zinc phosphide in a given season; voles will develop "bait shyness" to it, and it is a very toxic material.
7. Consider the use of rodenticides as only one part of a vole management program. Depending on rodenticides only will result in poor control.

Voles probably account for more fruit tree decline and death than any other factor in U.S. orchards. Frequently, by the time vole damage is noticed, it is too late to save the trees. Even where damage has not led to tree death, several years of reduced yields and quality may pass before damaged trees completely recover. Vole control should be a preventive program and should be an integral part of orchard management programs.

More detailed information on vole control may be found in the appropriate fact sheet listed below:

Wildlife Damage Management Fact Sheet AG-472-1, *Voles in Commercial Orchards and Ornamental Nurseries*, available online at: **content.ces.ncsu.edu/voles-in-commercial-orchard-and-ornamental-nurseries**.

Beavers *(Castor canadensis)*

Beavers can damage orchards by cutting down trees or by flooding portions of orchards. Access to orchards may be blocked if beaver activity floods roadways. Regulations regarding beaver control may vary from state to state. Therefore, before initiating a control program, be sure to check with the local wildlife resources agency to determine which options are available.

Relocation, repellents, and fumigation of dens are not recommended control practices. Relocation is costly, affected beavers may not survive, and moving beavers to another area only transfers the problem to others. Also, it is illegal to relocate beavers in North Carolina. Repellents are ineffective, and fumigation of dens is not an approved practice.

Effective control options include fencing beavers out of the area, using water-level control structures that beavers are not as apt to bother, and removing the beaver population. Removal of the population may be accomplished by shooting, trapping, or a combination of the two. Trapping is the desired method of removing an entire colony in small watersheds and farm ponds. Regardless of the method used, it is easier to take care of beaver problems when they first occur.

Pesticide Safety

PESTICIDE SIGNAL WORDS — In order from most dangerous to least, LD means lethal dose and LD 50 means lethal dose that will kill 50% of a population. Similarly, LC means lethal concentration and LC 50 means the concentration will kill 50% of a population. Oral means a single dose taken by mouth and dermal means a single dose applied to the skin. **Danger/Poison** accompanied by skull and crossbones means the oral LD 50 is 0 to 50 mg/kg of body weight; inhalation LC 50 is 0 to 0.2 mg/l of air; dermal LD 50 is 0 to 200 mg/kg of body weight; eye effects, corrosive; skin effects, corrosive. *In essence, a few drops to a teaspoon can kill*. **Warning** — oral LD 50, 50 to 500 mg/kg; inhalation 0.2 to 2 mg/l; dermal LD 50, 200 to 2000 mg/kg; eye effects, corneal opacity and irritation reversible within seven days; skin effects, severe irritation at 72 hours. *In essence, 1 teaspoon to 2 tablespoons can kill*. **Caution III** — oral LD 50 500 to 5,000 mg/kg; inhalation LC 50 is 2 to 20 mg/l; eye effects, no corneal opacity and irritation reversible within seven days; dermal LD 50, 2,000 to 20,000 mg/kg; skin effects, moderate irritation at 72 hours. *In essence, it takes 1 ounce to 1 pint to kill*. Occasionally you will see **Caution IV**. The LD 50 is in excess of 5,000 mg/kg; the inhalation LC 50 is more than 20 mg/l; the dermal LD 50 is more than 20,000; no eye effects; and skin effects are mild or slight. *In essence, it takes more than a pint to kill*. The designation III or IV may not be present on some containers labeled **Caution**.

CLASSIFICATION OF PESTICIDES: The Environmental Protection Agency (EPA) is directed by federal law to classify pesticides for **Restricted Use**. Pesticides classified as Restricted Use may be purchased and applied only by certified licensed applicators or under their direct supervision. All other pesticides are unclassified as **General Use**. Unclassified General Use pesticides may be purchased by the general public.

PERSONAL PROTECTIVE EQUIPMENT: Personal protective equipment must be used as noted on each product's label. The applicator must read the label. Maintain a wardrobe of protective equipment for pesticide applicators and handlers. It is strongly advised to reread labels before each use, even if you have read them before. Protective equipment labels are regularly updated with new information, requirements, and revised or deleted uses. Changes are common as a result of EPA review and reregistration.

ENDANGERED SPECIES ACT (ESA): The EPA enforces some aspects of this statute. This act prohibits the use of certain pesticides in certain locations. The labels of restricted pesticides will specify the specific counties or areas within the counties where these pesticides are restricted. In order to use the pesticide, the user must obtain an EPA-use bulletin for the specific pesticide for protection of endangered species. The bulletins are available from a variety of sources, including pesticide dealers, the Farm Service Agency, and local Extension centers.

WORKER PROTECTION STANDARD (WPS): The WPS applies to agricultural workers performing tasks related to the cultivation and harvest of agricultural plants, including fruit. The law pertains to employees who mix, load, or apply pesticides, or repair application equipment. The WPS mandates specific restricted-entry intervals, personal protective equipment, emergency assistance, employee pesticide safety education, and worker access to displayed information. A specific product's WPS mandates will be found in the **Agricultural Use** section of a product's **Direction for Use**. The WPS requires agricultural employers to display certain information on individual pesticide applications at a central location during the Restricted Entry Interval (REI) and for 30 days following.

RECORD KEEPING: Most states have their own pesticide record-keeping requirements in addition to USDA federal pesticide record-keeping requirements. The federal requirement covers restricted-use products only. Check with your local Extension agent for your state's restrictions.

LICENSING OF APPLICATORS: All states have licensing or certification requirements. **Restricted-use products** (RUP) may be purchased and applied only by licensed or certified applicators. Generally, there are categories of applicators, and a test must be passed to become a certified licensed applicator in the appropriate category. Once the test is passed, the applicator must be recertified periodically, generally through a system of continuing education credits or hours. Check with your local Extension agent or your state contact for information on obtaining a license and programs that will provide the necessary continuing education hours.

PESTICIDE FIRE PLAN: Plan for a fire emergency. A good plan will provide clear instructions on what to do during the critical, confusing early minutes of a fire; provide fire officials with a quick summary of the chemicals stored, information on hazards, and special firefighting techniques; and provide EPA, state, and local governments with evidence of your concern,

should charges of negligence or lawsuits follow. Crop Life America provides planning guidelines for handling pesticide chemical fires. Write to Dept. 0527, Washington, DC 20073-0527, or call 202-296-1585.

PESTICIDE STORAGE: Safe pesticide storage significantly increases farm safety. You should consider the costs and difficulty of clean-up; liability in the event of a spill or fire; liability if a person or animal is injured or killed; the costs of EPA, state, and OSHA fines; your cost and time to correct violations; and, finally, the cost of the pesticides. Your local Extension agent can give you publications that offer thoughtful guidance in preparing a pesticide storage site. There are no federal regulatory guidelines available, and most states have no regulatory statutes.

EPA Registration Numbers of Materials Discussed in This Guide

Category	Pesticide	Registration Number
FUNGICIDES	Actigard 50WG	135158-54-2
	Agri-Fos	71962-1-54705
	Agri-mycin17	55146-96
	Aliette WDG	264-516
	Aprovia	1072957-71-1
	Blossom Protect	86174-4
	Buffer Protect	86174-4
	Captan 4L	1812-260
	Captan 50WP	10182-145-51036
	Captan 80WDG (Drexel)	66222-58-19713
	Captan 80WDG (Arysta)	66222-58-66330
	Captec 4L	66330-239
	Cevya	7969-407
	C-O-C-S WDG	34704-326
	Cueva	67702-2-70051
	Cuprofix Ultra 40 Disperss	70506-201
	Excalia	59639-230
	Fireline 17WP	80990-1
	Firewall	80990-4
	Flint	264-777
	Flint Extra	264-826
	Fontelis	352-834
	Harbour	66222-121
	Indar 2F	62719-416
	Inspire Super 2.82EW	100-1317
	Kasumin 2L	66330-404
	Kocide 101	1812-288
	Koverall	67760-110
	K-Phite	73806-1
	LifeGard WG	70051-119
	lime sulfur	various
	Luna Sensation	264-1090
FUNGICIDES (continued)	Luna Tranquility	264-1085
	Manzate Flowable (DuPont)	352-706
	Manzate Flowable (UPI)	70506-236
	Manzate Pro-Stick (DuPont)	352-704
	Manzate Pro-Stick (UPI)	70506-234
	Merivon	7969-310
	Miravis	100-1601
	Nu-Cop 50WP	45002-7
	Omega 500F	71512-1-100
	Penncozeb 75DF	70506-185
	phosphite fungicides	various
	Polyram 80DF	7969-105-34704
	Pristine	7969-199
	Procure 480SC	400-518
	ProPhyt	42519-22-5905
	Phostrol	55146-83
	Rally	62719-410
	Ridomil Gold	100-1202
	Scala SC	264-788
	Sercadis	7969-309
	Sovran 50WG	7969-154
	Streptrol	55146-80
	sulfur	various
	Syllit FL	55260-6
	thiophanate-methyl	various
	Topguard	67760-75
	Vangard 75WG	100-828
	Ziram 76W	34704-471
	Ziram 76WDG	45728-12
INSECTICIDES and MITICIDES	Acramite 50WS	400-503
	Actara 25WDG	100-938

Category	Pesticide	Registration Number
INSECTICIDES and MITICIDES (continued)	Admire Pro	264-827
	Agri-Flex	100-1350
	Agri-Mek	100-898
	Altacor 35WDG	352-730
	Ambush 2E	5481-549
	Apollo SC	66222-47
	Asana XL (0.66EC)	352-515
	Assail 30 SG	8033-36-70506
	Avaunt 30WG	352-597
	Baythroid XL	264-840
	Belay	59639-150
	Besiege	100-1402
	Carpovirusine	66330-55
	Centaur	71711-21
	Closer	62719-623
	Cormoran	66222-264
	CryMax	70051-86
	Cyd-X	70051-44
	Cyd-X HP	70051-112
	Danitol 2.4EC	59639-35
	Delegate WG	62719-541
	Diazinon 50WP	34704-435
	Dipel DF	73049-39
	Endigo	100-1276
	Endosulfan 3EC	19713-399
	Envidor 2SC	264-831
	Esteem 35WP	59639-115
	horticultural oils	various
	Imidan 70WP	10163-169
	Intrepid 2F	62719-442
	Karate	100-1086
	Lannate LV	352-384
	Lannate SP	352-342
	Leverage	264-770
	Minecto Pro	100-1592
	Movento 2SC	264-1050
	Mustang Maxx	79-3426
	Nealta 1.67SC	7969-336
	Nexter 75WP	81880-4-10163
	oils	various 2.7SE
	Portal 0.4EC	71711-19
	Pounce 3.2EC	279-3014

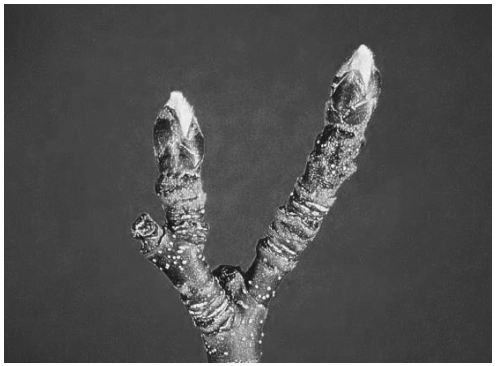
Category	Pesticide	Registration Number
INSECTICIDES and MITICIDES (continued)	Proaxis	74921-3-34704
	Rimon 0.83EC	66222-35-400
	Savey 50WP	10163-208
	Sevin 50WP	769-972
	Sevin XLR	264-333
	Sivanto Prime 200SL	264-1141
	sulfur	various
	Surround 95WP	61842-18
	Tombstone	34704-912
	Vendex 50WP	70506-211
	Verdepryn 100SL	71512-34-88783
	Voliam Flexi	100-1319
	Xentari	73049-40
	Zeal 72WDG	59639-123
MATING DISRUPTION	CheckMate CM/OFM	56336-49
	CheckMate OFM-F	56336-24
	CheckMate Puffer	73479-11
	Isomate OFM TT	53575-29
HERBICIDES	2,4-D	various
	Aim 2EC	279-3241
	Alion 1.67	264-1106
	Arrow 2EC	66222-60
	Broadloom	70506-306
	Casoron 4G	400-168
	Casoron CS	400-451
	Chateau EZ	9639-221
	Chateau SW	59639-99
	Comet 1.5	71368-87
	Direx 4L (DuPont)	352-678
	Direx 4L (MANA)	66222-54
	Diuron 80WDG	34704-648
	Firestorm	82557-1-400
	Flumi	89442-UT
	Fusilade DX	100-1070
	Galigan 2E	66222-28
	Galigan H_20	66222-140
	glyphosate	various
	Goal 2XL	62719-424
	GoalTender 4EC	62719-447
	Gramoxone SL	100-1217
	Herbivore	2749-528-1381
	Intensity	34704-864

Category	Pesticide	Registration Number
HERBICIDES (continued)	Intensity One 1EC	34704-976
	Karmex XP	352-692
	Lifeline	70506-310
	Matrix	352-556
	Motif	70506-331
	Oryzalin	66222-138
	Panther D	71368-115
	Paraquat Concentrate	82542-3
	Parazone 3SL	66222-130
	Pennant Magnum	100-950
	Pindar	62719-611
	Poast	7969-58
	Princep 4L	100-526
	Princep Caliber 90	100-603
	Prowl H_2O	241-418
	Pruvin	66222-184
	Rage	279-3307
	Reckon	88685-2-84237
	Rely 280	264-829
	Roundup	various
	Sandea	10163-254
	Select	59639-3
	SelectMax	59639-132
	Simazine 4L (Drexel)	19713-60
	Simazine 4L (Loveland)	34704-687
	Simazine 4L (Un. Supp.)	100-526-33270
	Simazine 4L (Winfield)	9779-296
	Sinbar 80WDG	61842-27
	Sinbar 80WP	61842-13
	Solicam 80DF	100-849
	Solida	67760-105
	Starane Ultra	62719-577
	Stinger	62719-73
	Surflan 4AS	70506-43
	Surmise	42750-258
	Treevix	7969-276
	Trellis	62719-659
	Tuscany	71368-102
	Volunteer	59639-3-55467
	Zeus Prime	279-3337

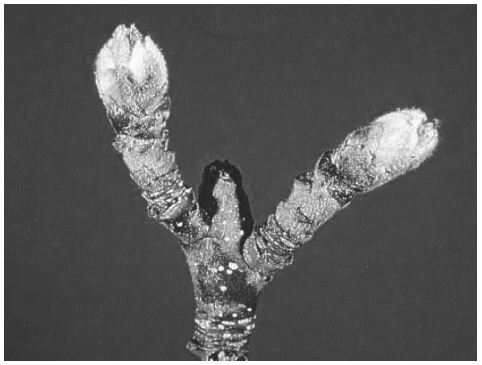
Category	Pesticide	Registration Number
VERTEBRATE MANAGEMENT	Bonide Rabbit-Deer Repellent	4-136
	Chew-Not	358-105
	Hinder	4-15
	Hot Sauce Animal Repellent	72-574
	Plantskydd Repellent	exempt
	Ramik Brown	61282-45
	Ramik Green	61282-46
	Rockland Deer Guard	4866-10
	Zinc Phosphide Pellets	61282-49
	ZP Rodent Bait-Ag	12455-17
PLANT GROWTH REGULATORS	Apogee	7969-188
	Ethephon	66330-262
	Ethrel	264-267
	Fruitone L	5481-541
	Maxcel	73049-407
	Novagib	62097-7-82917
	Perlan	62097-6-82917
	Promalin	73049-41
	ProVide 10SG	73049-409
	ReTain	73049-45
	Sevin XLR	264-333
	SmartFresh	71297-3
	Tre-Hold	5481-429

Apple Growth Stages

1 – Dormant

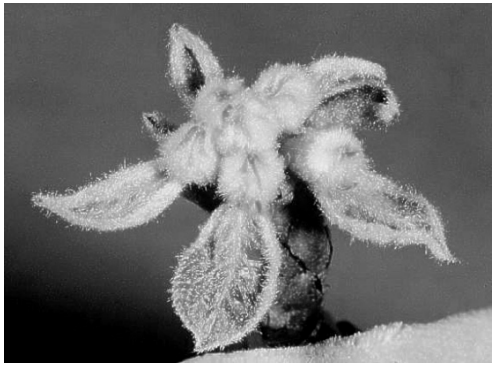


2 – Silver Tip



3 – Green Tip

4 – Half-Inch Green



5 – Tight Cluster

6 – Pink

7 – Bloom

8 – Petal Fall

9 – Fruit Set

Printing of this publication was supported, in part,
by contributions from the following organizations:

BASF Corp
Bayer Crop Science
CBC (America)
Coastal AgroBusiness
Corteva Agriscience
FMC Corporation
Gowan Company
Helena Chemical Company
Nichino America
Nutrien Ag Solutions
Syngenta
Valent USA

Published by

NC State Extension

NC STATE

EXTENSION

02/23—GM

AG-472

content.ces.ncsu.edu/integrated-orchard-management-guide-for-commercial-apples-in-the-southeast

650 copies of this publication were printed at a cost of $9.29 per copy.