2012 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

North Carolina Cooperative
Extension Service
North Carolina State University

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Agricultural Extension Service
University of Tennessee

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 in running water. If pesticide is inhaled, move to open, clean air. If pesticide is ingested, rinse out the mouth. Follow all label first aid directions. 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 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
Alabama Poison Center
2503 Phoenix Drive
Tuscaloosa, AL 35405

800-222-1222
800-292-6678

ARKANSAS
Poison and Drug Information Center
Univ. of Ark. for Medical Sciences
4301 West Markham – Slot 522
Little Rock, AR 72205

800-222-1222
800-376-4766

GEORGIA
Georgia Poison Center
Education Dept
80 Jesse Hill Jr. Drive, SE
Atlanta, GA 30303

800-222-1222
404-616-9287 (for the deaf)
404-616-9000 (business)

NORTH CAROLINA
Carolinas Poison Center
Carolinas Medical Center
PO Box 32861
Charlotte, NC 28232

800-222-1222
800-848-6946

SOUTH CAROLINA
Palmetto Poison Center
College of Pharmacy
University of South Carolina
Columbia, SC 29208

800-222-1222

TENNESSEE
Tennessee Poison Center
1313 21st Avenue South
Nashville, TN 37232-4632

800-222-1222

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Table of Contents

Pest and Orchard Management Program....2
Tree Row Volume: A Model for Determining Spray Volume....31
IPM Practices for Selected Pests....33
Pesticide Resistance Management....38
Effect of pH on Pesticide Activity....40
Orchard Floor Management....41
Apple Pollination, Honey Bees, and Pesticides....42
Soil and Plant Analysis Guidelines for Southeastern Apple Production....43
Fertility Management Recommendations for Apples....44
Relative Effectiveness of Fungicides....45
Relative Effectiveness of Insecticides and Miticides....48
Toxicity of Pesticides to Beneficial Arthropods....50
Weed Response to Preemergence Herbicides....51
Weed Response to Postemergence Herbicides....52
Fungicides and Bactericides....54
Insecticides and Miticides....57
Herbicides....63
Growth-Regulating Chemicals....67
Vertebrate Management....74
Pesticide Safety....80
EPA Registration Numbers of Various Materials....81

Recommendations for the use of agricultural chemicals are included in this publication as a convenience to the reader. The use of brand names and any mention or listing of chemical products or services in this publication does not imply endorsement by the Cooperative Extension Service nor discrimination against similar products or services not mentioned. Individuals who use agricultural chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage regulations and examine a current product before applying any chemical. For assistance, contact your local Extension Agent.

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Pest and Orchard Management Program

DORMANT

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Cultural Management							
Control tree density, size, and shape for better light and spray penetration.	Conduct annual dormant pruning in central leader trees and appropriate high-density orchards.	*****					The younger the trees, the closer to bud break they should be pruned. Prune older and bearing trees first; prune 1- to 2-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 late winter fertilizer to young, nonbearing trees, and half rate to mature, bearing trees.	*****					See Fertility Management section (page 44) 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 3 to 4 weeks before anticipated dormant bud break.	*****					See Growth-Regulating Chemicals section (page 67) 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/gal) as a "sponge-on" application.		12	0	See Growth-Regulating Chemicals section (page 67) 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 section (page 67) 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.

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management							
Reduce inoculum of apple scab fungus.	Shred leaves with flail mower.	*****					May also help reduce inoculum of fungi that cause Brooks spot, Alternaria blotch, and Glomerella leaf spot.
Reduce inoculum of black, white, and bitter rot fungi.	Prune out dead wood and mummied fruit.	*****					Pruning is extremely important to reduce the likelihood of 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.	****					Will also reduce inoculum of black rot, white rot, and bitter rot.
Reduce inoculum of powdery mildew fungus.	Prune out silver-colored terminals.	***					Particularly useful on young trees of a susceptible cultivar.
Improve control of cedar apple and quince rusts.	Scout orchard, adjacent woods, or borders for red cedar, and remove.	*****					Complete removal of red cedar in areas where cedars are not common may eliminate need for fungicide sprays for these diseases.
Create good conditions for drying fruit and foliage; improve 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 *paraquat* or *Rely* 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 2-3 inches tall, apply a nonselective postemergence herbicide with a preemergence 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.	*2,4-D* amine	++++	1 qt	1.0 lb	48	60	Apply at least 2 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.

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[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

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management							
Control fire blight.	Bactericides *copper hydroxide* *copper oxychloride sulfate* *Bordeaux*	 ++++ ++++ ++++	 See label. See label. See label.		 See label. See label. See label.		This treatment will help control fire blight in blocks of trees of a susceptible cultivar where fire blight has been a problem. It will not eliminate need for streptomycin. Applications later than 0.25- to 0.5-inch green tip may result in injury. Most effective if applied dilute.
Control black rot.	Fungicides Captan 50W or 4L or 80W or 80WDG	 ++++ ++++ ++++ ++++	 — —	 4 lb 2 qt 2.5 lb 2.5 lb	 96 96 24 24	 0 0 0 0	An important spray for black rot control in Georgia. **Warning:** Captan will cause injury when used with or too close to oil applications.
Control crown rot (collar rot).	Fungicides Ridomil Gold EC or WSP	 ++++	 See label.		 12	 1	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 3 to 5 applications of Aliette a year. Make first application of Aliette after leaf emergence. **Note:** Ridomil and Aliette must be applied on a preventive basis. Treatment of trees exhibiting symptoms will not prevent further symptom development.
	Aliette 80WDG or 80 WSP	++++	⅝ to 1½ lb	2 to 5 lb	12	14	
	Phosphite fungicides	++++	See label.				Phosphite fungicides (i.e. Prophyt, Agri-Fos, and others) are registered for crown rot control and have activity similar to Aliette. See labels for use instructions and precautions.

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[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 ½-INCH GREEN

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate Per[2] 100 gal	Rate Per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management							
Control scab. See discussion in Fungicides and Bactericides (page 54) for information on postinfection control program.	<u>Fungicides</u> Syllit 3.4FL	+++++		1.5 to 3 pt	48	7	
	Vangard 75WG	+++++	1.25 oz	5 oz	12	72	Vangard tends to be most active at cool temperatures.
	Vangard 75WG + *mancozeb* 80WP or 75DF or F4 **or** + Polyram 80DF	+++++ +++++ +++++ +++++ +++++	¾ oz ¾ lb ¾ lb 0.6 qt ¾ lb	3 oz 3 lb 3 lb 2.4 qt 3 lb	12 24 24 24 24	72 77 77 77 77	
	Scala SC	+++++	1.75-2.5 oz	7 to 10 oz	12	72	Scala SC is not compatible with captan.
	Scala SC + *mancozeb* 80WP or 75DF or F4 **or** + Polyram 80DF	+++++ +++++ +++++ +++++ +++++	1.25 oz ¾ lb ¾ lb 0.6 qt ¾ lb	5 oz 3 lb 3 lb 2.4 qt 3 lb	12 24 24 24 24	72 77 77 77 77	
	Sovran 50WG	+++++	1 to 1.6 oz	4 to 6.4 oz	12	30	
	Flint 50WG	+++++	—	2 to 2.5 oz	12	14	
	Pristine 38W	+++++	—	14.5 to 18.5 oz	12	0	

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GREEN TIP TO ½-INCH GREEN (continued)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate Per[2] 100 gal	Rate Per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Control scab (continued).	*fenarimol* 1E		3 to 4 oz	8 to 12 oz			Do not use captan within 2 weeks of an oil spray. Although resistance of the apple scab fungus to the EBI fungicides has not been confirmed, some growers have experienced problems in the Southeast in controlling scab when using these fungicides. Growers who have had this problem should use a program that begins with two sprays of Syllit, Vangard, or Scala, followed by two sprays of Flint or Sovran. The fifth spray, which should occur around petal fall, can include an EBI fungicide, but it needs to be combined with a full rate of captan or captan + mancozeb or metiram to ensure scab control. An EBI fungicide at this time will help control powdery mildew, especially on mildew-susceptible varieties, and cedar apple and quince rust if captan is used alone. Do not make more than two sequential applications of an EBI fungicide before rotating to a fungicide with a different mode of action.
	+ *captan* 50WP or	+++++	¾ lb	3 lb	96	30	
	80W or		0.47 lb	1.88 lb	24	0	
	80WDG		0.47 lb	1.88 lb	24	0	
	or						
	+ *mancozeb*						
	80WP or	+++++	¾ lb	3 lb	24	77	
	75DF or	+++++	¾ lb	3 lb	24	77	
	F4	+++++	0.6 qt	2.4 qt	24	77	
	or						
	+ Polyram 80DF	+++++	¾ lb	3 lb	24	77	
	myclobutanil 40W		1¼ to 2 oz	5 to 10 oz			
	+ *captan* 50W or	+++++	¾ lb	3 lb	96	14	
	80W or		0.47 lb	1.88 lb	24	0	
	80WDG		0.47 lb	1.88 lb	24	0	
	or						
	+ *mancozeb*						
	80W or	+++++	¾ lb	3 lb	24	77	
	75DF or	+++++	¾ lb	3 lb	24	77	
	F4	+++++	0.6 qt	2.4 qt	24	77	
	or						
	+ Polyram 80DF	+++++	¾ lb	3 lb	24	77	
	Procure 50WS		1 to 2 oz	4 to 8 oz			
	+ *captan* 50W	+++++	¾ lb	3 lb	96	14	
	80W or		0.47 lb	1.88 lb	24	0	
	80WDG		0.47 lb	1.88 lb	24	0	
	or						
	+ *mancozeb*						
	80W or	+++++	¾ lb	3 lb	24	77	
	75DF or	+++++	¾ lb	3 lb	24	77	
	F4	+++++	0.6 qt	2.4 qt	24	77	
	or						
	+ Polyram 80W	+++++	¾ lb	3 lb	24	77	

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Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate Per[2]		Re-entry Interval (hours)	Preharv. Interval (days)	Comments
			100 gal	Acre			
Control scab (continued).	Indar 75WSP		0.67 oz	2.67 oz			
	+ *captan* 50W	+++++	¾ lb	3 lb	96	14	
	80W or		0.47 lb	1.88 lb	24	14	
	80WDG		0.47 lb	1.88 lb	24	14	
	or						
	+ *mancozeb*						
	80W or	+++++	¾ lb	3 lb	24	77	
	75DF or	+++++	¾ lb	3 lb	24	77	
	F4	+++++	0.6 qt	2.4 qt	24	77	
	or						
	+ Polyram 80W	+++++	¾ lb	3 lb	24	77	
	Tebuzole 45DF	+++++	1 to 2 oz	2 to 8 oz	5	75	
	+ *captan* 50W	+++++	¾ lb	3 lb	96	14	
	80W or		0.47 lb	1.88 lb	24	14	
	80WDG		0.47 lb	1.88 lb	24	14	
	or						
	+ *mancozeb*						
	80W or	+++++	¾ lb	3 lb	24	77	
	75DF or	+++++	¾ lb	3 lb	24	77	
	F4	+++++	0.6 qt	2.4 qt	24	77	
	or						
	+ Polyram 80W	+++++	¾ lb	3 lb	24	77	
	Topguard 1.04SC		3.2 fl oz	13.0 fl oz			
	+ *captan* 50W	+++++	¾ lb	3 lb	96	14	
	80W or		0.47 lb	1.88 lb	24	14	
	80WDG		0.47 lb	1.88 lb	24	14	
	or						
	+ *mancozeb*						
	80W or	+++++	¾ lb	3 lb	24	77	
	75DF or	+++++	¾ lb	3 lb	24	77	
	F4	+++++	0.6 qt	2.4 qt	24	77	
	or						
	+ Polyram 80W	+++++	¾ lb	3 lb	24	77	

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[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 ½-INCH GREEN (continued)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate Per[2] 100 gal	Rate Per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Control scab (continued).	Inspire Super	+++++		8.5 to 12.0 fl oz	12	14	In orchards where EBI resistance is suspected Inspire Super should be combined with a protectant fungicide.
	Adament 50W	+++++	1 to 1.25 fl oz	4 to 5 oz	5	75	Adament is a prepack combination of tebuconazole (an EBI fungicide) + trifolxystrobin (a QoI fungicide). Do not make more than 4 applications per season.
Insect Management							
Control scales and reduce overwintering European red mite and rosy apple aphid eggs.	<u>Insecticides</u> Oil	+++++	2 gal	2 to 3% solution	12	0	Use either a superior-type or highly refined summer oil applied dilute. If the oil application is delayed until tight cluster to pink, use a refined oil or reduce a superior type to ½ to 1 gal/100 gal. **Do not use captan within 2 weeks of an oil application.**
Improve scale control.	Oil + Lorsban 4E or Esteem 35WP or Centaur 70WDG	 ++++ +++++ +++++	2 gal ½ to 1 pt — —	8 gal 2 to 4 pt 4 to 5 oz 9 to 12 oz	12 96 12 12	0 DD 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 petal fall.
Initiate Oriental Fruit Moth (OFM) monitoring program.	Erect pheromone traps.	*****					Erect pheromone traps by green tip to detect first emergence. See section on IPM Practices for Selected Pests (page 33) for monitoring information.
Mating disruption for OFM and codling moth.	<u>Pheromones</u> Isomate CM/OFM TT CideTrak CM/OFM CheckMate Puffer - CM/OFM	 +++++ +++++ +++		*(number of dispensers)* 200/acre 200/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. Hanging of dispensers in trees should be complete by petal fall. See section on "Mating Disruption" in IPM Practices for Selected Pests (page 35).

TIGHT CLUSTER TO PINK

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management							
Control scab.	Fungicides Same as used in green-tip spray.						If two sprays of Sovran, Pristine, or Flint were used, switch to a nonstrobilurin fungicide. Syllit, Scala, and Vangard are most effectively used in the first two sprays of the season.
Control powdery mildew.	Fungicides *myclobutanil* 40W *fenarimol* EC Procure 50WS Indar 75WSP Tebuzole 45 DF Topguard 1.04SC	 ++++ ++++ ++++ ++++ ++++ +++++	 1¼ to 2 oz 3 to 4 oz 1 to 2 oz 0.67 oz 1 to 2 oz 2 to 3 oz	 5 to 10 oz 8 to 12 oz 4 to 8 oz 2.67 oz 2 to 8 oz 8 to 12 oz	 24 12 12 12 5 12	 14 30 14 14 75 14	These are the most important sprays for the control of powdery mildew.
Control cedar apple rust and quince rust.	Fungicides Same as used for powdery mildew, or: *mancozeb* 80W or 75DF or F4 Polyram 80W	 +++++ +++++ +++++ +++++	 ¾ lb ¾ lb 0.6 qt ¾ lb	 3 lb 3 lb 2.4 qt 3 lb	 24 24 24 24	 77 77 77 77	
Control black rot and frogeye leafspot.	Captan 50W or 4L or 80 W or 80WDG	++++ ++++ ++++ ++++	1½ to 2 lb ¾ to 1 qt 0.94 to 1.26 lb 0.94 to 1.26 lb	6 to 8 lb 3 to 4 qt 3.77 to 5 lb 3.77 to 5 lb	96 96 24 24	0 0 0 0	Captan alone will not control powdery mildew or rust diseases.
Insect Management							
Initiate codling moth and leafroller monitoring program.	Erect pheromone traps.	*****					Erect traps now because moths begin to emerge near bloom. See section on IPM Practices for Selected Pests (page 33) for information on monitoring programs.

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TIGHT CLUSTER TO PINK (continued)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2]		Re-entry Interval (hours)	Preharv Interval (days)	Comments
			100 gal	Acre			
Control rosy apple aphid.	Insecticides Actara 25WDG Assail 30SG Calypso 4F Danitol 2.4EC	 +++++ +++++ +++++ ++++	 — — — 2.6 to 4.3 oz	 4.5 oz 2.5 to 4 oz 2 to 4 oz 10.6 to 21.3 oz	 12 12 12 24	 35 7 30 14	Pink stage is the best time to control rosy apple aphid. **Caution:** Rosy apple aphid resistance to Danitol has been observed in some orchards. See Rosy Apple Aphid resistance section (page 39).
Control plant bugs and spotted tentiform leafminer (STLM).	Maintain clean ground-cover. 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. The need for insecticides specifically targeting STLM at this time is questionable because first generation mines rarely exceed threshold levels.

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BLOOM

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate 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 Growth-Regulating Chemicals section (page 67) 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 (can be used only on varieties that have dominant calyx ends).	($BA+GA_{4+7}$) Promalin	+++		1 to 2 pt	12	None	See Growth-Regulating Chemicals section (page 67). Apply as a fine mist application at 40 to 50% of Tree Row Volume (TRV) water rate between king bloom opening and full bloom. Promalin is approved for tank mixing with streptomycin and/or bloom fungicides.
	Perlan	+++	0.5 to 1.0 pt		4		
Increase lateral bud break and lateral shoot growth on 1-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	+++++	125 to 500 ppm (0.5 to 2 pt)/ 10 gal		12	None	Apply to last year's leader growth with a handheld nozzle. See Growth-Regulating Chemicals section (page 67).
	Perlan	+++++	125 to 500 ppm (0.5 to 2 pt)/ 10 gal		4		Make one application when orchard trees have 1 to 3 inches of new growth.

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[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 (continued)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management							
Control scab, rusts, and mildew.	Fungicides Same fungicides as recommended in tight cluster stage.						Avoid sprays in full bloom if possible. Do not overextend application intervals.
Control fire blight.	Bactericides *streptomycin*		4.8 to 8 oz	1½ to 2½ lb	12	50	Begin application at first bloom and continue at 3- to 4-day intervals until petal fall. *Streptomycin* sprays protect only those blossoms open at time of application. It is very important to continue spraying through "rat-tail" bloom, especially on susceptible varieties. See discussion under Pesticide Resistance Management section (page 39) for timing sprays according to conditions favorable for infection.
Insect Management							
Protect pollinators.	Do not apply insecticides during bloom.	*****					Keep orchard floor free of flowering weeds. This will increase pollination activity in the trees and lessen bee activity after apple bloom.
Disrupt mating of codling moth.	Pheromones Isomate CM/OFM TT CideTrak CM/OFM CheckMate Puffer - CM/OFM	 +++++ +++++ +++		*(number of dispensers)* 200/acre 200/acre 1/acre			Do not use mating disruption in blocks of less than 5 acres. Pheromone dispensers should be hung before moths begin to emerge, with hanging completed by petal fall. Also, supplemental sprays with an insecticide will be necessary under moderate to high population densities. See section on IPM Practices for Selected Pests (page 33).

[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

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Cultural Management							
Reduce fruit corking.	Solubor	+++	1 lb at first cover				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 Fertility Management section (page 44).
	Borosol	+++		1 pt			
Reduce fruit corking and bitter pit.	calcium nitrate or calcium chloride	+++	3 lb				Repeat calcium sprays in each cover spray all season. Calcium nitrate may contribute to elevated leaf nitrogen levels and vegetative growth. 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 Fertility Management section (page 44).
		+++	2 lb beginning at first cover				
Plant Growth Regulators							
Reduce fruit russetting on susceptible cultivars (esp. Golden Delicious).	(GA_{4+7}) Pro-Vide 10SG	++++	60 to 100 g		4	None	At petal fall, begin the first of four applications at 7- to 10-day intervals. See Growth-Regulating Chemicals section (page 67) for complete recommendations.
	Novagib 10L	++++	20 to 33 fl oz		4		
Thin fruit to reduce crop load and encourage return bloom.	Depends on cultivar, fruit size, and thinning chemical selected. Applications timed from petal fall to about 8 mm would be applied during this time.	+++++	See thinning chart on page 70.		Check label for specific thinning chemical(s) to be used.		See Chemical Fruit Thinning Spray and Apple Thinning recommendations chart in Growth-Regulating Chemicals section.
Initiate vegetative growth control applications.	Apogee	++++	Use at TRV calculated A.I./acre.	12		45	See Apogee table in Growth-Regulating Chemicals section (page 72).

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[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 (continued)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management							
Control scab.	Scout for secondary scab.	*****					If primary scab is controlled by petal fall or first cover, switch to captan. If secondary scab is detected early, dodine or an EBI fungicide can be effectively used in a postsymptom treatment. See discussion under Fungicides and Bactericides (page 54).
Control summer diseases (general).	Fungicides *captan* 50W or 4L or 80W or 80WDG		 2 lb 1 qt 1.25 lb 1.25 lb	 8 lb 4 qt 5 lb 5 lb	 96 96 24 24	 0 0 0 0	If an EBI fungicide is used in this spray, increase the rate of Captan 50W to 6 to 8 lb/acre or Captan 4L to 3 to 4 qt/acre and extend interval to 10-14 days, or follow combination sprays with lower rates of captan or metiram in 5-7 days with full rate of captan or combinations of captan plus mancozeb or metiram. Captan and metiram at petal fall or first cover generally give better fruit finish than mancozeb. If the first cover spray occurs after May 15, include 8 to 12 oz/acre of thiophanate-methyl 85WDG or a phosphite fungicide with captan for sooty blotch or flyspeck control as directed in second and later cover sprays below. Use captan in orchards where black rot is a problem.
	captan 50W or 4L or 80 W or 80 WDG + Polyram 80 W or *mancozeb* 80W 75 DF 4F	+++++ +++++ +++++ +++++ +++++	1¼ lb 0.62 qt 0.79 lb 0.79 lb ¾ lb ¾ lb ¾ lb 0.6 qt	5 lb 2½ qt 3.15 lb 3.15 lb 3 lb 3 lb 3 lb 2.4 qt	96 96 24 24 96 96 96 96	0 0 0 0 77 77 77 77	

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[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.

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Control summer diseases (general) (continued).	Sovran 50WG	+++++	1.0 to 1.6 oz	4.0 to 6.4 oz	12	30	Sovran and Flint will also control apple scab and powdery mildew.
	Flint 50WG	+++++	—	2.5 to 3.0 oz	12	14	
	Pristine 38W	+++++	—	14.5 to 18.0 oz	12	0	
Control Brooks fruit spot.	Fungicides Use fungicides listed for summer diseases or use fungicide combinations listed under green tip.	+++++					Petal fall through third cover sprays are the most important sprays for Brooks spot control. The EBI and QoI fungicides have very little 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 these sprays, a fungicide with activity on powdery mildew or cedar apple rust should be included in this spray.
Insect Management							Preventive control of mites is not recommended unless insecticides known to flare mites are anticipated to be used.
Preventively control European red mite, spotted tentiform leafminer, and white apple leafhopper.	Insecticides Agri-Mek 0.15EC + oil	+++++	2.5 oz	10 oz	12	28	An application of Agri-Mek at petal fall should provide season-long suppression of these pests. A paraffinic spray oil (0.25% or 1 gal/acre) **must** be tank mixed to ensure Agri-Mek's activity. **Do not use captan 2 weeks before or after applying oil with Agri-Mek.**
Preventive control of European red mite.	Apollo SC Savey 50WP Zeal 72WDG Envidor 2SC	++++ ++++ +++++ +++++	— — — —	4 oz 3 oz 2 to 3 oz 16 to 18 oz	12 12 12 12	45 28 28 7	Apply one of these products between petal fall and third cover or when mites reach one adult per leaf. See page 39 for resistance management of European red mite.

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[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 (continued)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Control plum curculio.	Insecticides						Adults begin to enter orchards near bloom, with the majority of adults present by petal fall. An insecticide applied at petal fall is essential to minimize damage. Cool weather during this period may extend adult activity, which may require a second application 10 days later. Read about re-entry intervals for Guthion in the Insecticides and Miticides section (page 57).
	Avaunt 30WG	+++++	—	5 to 6 oz	12	28	
	Actara 25SDG	+++++	—	4.5 oz	12	35	
	Guthion 50WP	+++++	½ lb	2 lb	48h, 14d	21	
	Imidan 70WP	++++	¾ lb	3 lb	24	7	
	Calypso 4F	+++++	—	4 to 8 oz	12	30	
	Clutch 50WDG	++++	—	3 oz	12	14	
	Sevin 50WP	+++	½ lb	1 lb	12	3	
Control Oriental fruit moth.	Insecticides						An insecticide applied between 500 and 600 degree days (DD) after biofix will control the first generation. Read about re-entry intervals for Guthion in Insecticides and Miticides Section (page 57). First generation OFM is easily controlled with all recommended insecticides used at petal fall.
	Guthion 50WP	+++++	½ lb	2 lb	48h, 14d	21	
	Imidan 70WP	+++++	¾ lb	3 lb	24	7	
	Avaunt 30WG	+++++	—	5 to 6 oz	12	28	
	Sevin 50WP	+++++	½ lb	2 lb	12	3	
	Assail 30SG	+++++	—	5 to 8 oz	12	7	
	Calypso 4F	++++	—	4 to 8 oz	12	30	
	Mating Disruption						CheckMate OFM-F is a sprayable formulation that should be considered in early to mid August for control of late-season OFM. Isomate M-100 needs to be hand-applied by later July for late-season control.
	Isomate M-100	+++++		100 disp.	0	0	
	CheckMate OFM-F	+++++		1 to 2 fl oz	0	0	
Control San Jose scale.	Insecticides						Where scales have been a problem the previous year, apply an insecticide for first generation crawlers, which are active from petal fall through third 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	
	Guthion 50WP	+++	½ lb	2 lb	48h, 14d	21	
	Esteem 0.86EC	+++++	—	4 oz	12	45	
	Centaur 70WP	+++++	—	34.5 oz	12	14	
	Movento 2SC	+++++	—	6 to 9 oz	24	7	
	Assail 30SG	+++	—	8 oz	12	7	
	summer oil	+++	—	1 to 2%	12	0	
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 section on Rosy Apple Aphid resistance section (page 39).
	Provado 1.6F	+++++	2 oz	4 to 8 oz	12	7	
	Actara 25WP	+++++	—	4.5 oz	12	35	
	Assail 30SG	+++++	—	2.5 to 4.0 oz	12	7	
	Calypso 4F	+++++	—	2 to 4 oz	12	30	
	Movento 2SC	++++	—	6 to 9 oz	24	7	

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Control white apple leafhopper.	Insecticides						Threshold level for first generation white apple leafhopper is 1 nymph per leaf. Thinning apples with Sevin during this time controls leafhoppers. Leafhoppers may be present from petal fall to second cover spray.
	Sevin 50WP	+++++	½ lb	2 lb	12	1	
	Actara 25WDG	+++++	—	2 to 2¾ oz	12	35	
	Assail 30SG	+++++	—	2.5 to 4.0 oz	12	7	
	Calypso 4F	+++++	—	2 to 4 oz	12	30	
	Provado 1.6F	+++++	1 oz	4 oz	12	7	
	Avaunt 30WG	+++++	—	5 to 6 oz	12	28	
Control spotted tentiform leafminer.	Insecticides						Threshold level for first generation leafminer is one mine per leaf, but rarely do populations reach this level this early in the season.
	Actara 25WDG	++++	—	4.5 oz	12	35	
	Delegate WG	+++++	—	4.5 oz	4	7	
	Provado 1.6F	++++	1 to 2 oz	4 to 8 oz	12	7	
	Assail 30SG	++++	—	1.1 oz	12	7	
Control green fruitworm.	Insecticides See insecticides for codling moth or tufted apple bud moth control.						Green fruitworms are not a common pest: Apply an insecticide at petal fall if larvae are observed.
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 preemergence herbicides until early May extends summer weed control.
Suppress clover bloom to protect bees from insecticide sprays.	*2,4-D*	*****		1 qt	48	60	Apply *2,4-D* 7 to 10 days before spraying insecticides to suppress clover and avoid killing bees.

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[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

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management (Same fungicides as used in Petal Fall Spray)							
Insect Management							
Control codling moth.	Monitor codling moth adult activity.	*****					**See IPM Practices for codling moth (page 33) to determine how to minimize insecticide applications for codling moth control.**
	<u>Insecticides</u>						
	Delegate 25WP	+++++	—	4.5 to 7 oz	4	7	
	Altacor 35WDG	+++++	—	2.5 to 4.5 oz	4	14	Voliam Flexi is recommended only when late emerging plum curculio is a concern, and a minimum of 6.0 oz should be used.
	Voliam Flexi	+++++	—	4 to 7 oz	12	35	
	Belt 4SC	++++	—	3 to 5 fl oz	12	14	
	Guthion 50WP	++++	½ lb	2 lb	48h, 14d	21	
	Imidan 50WP	++++	¾ lb	3 lb	24	7	CYD-X is a virus that controls only codling moth. Frequent applications (7-10 days) at low rates (1 to 2 oz per acre) have worked well in field trials.
	Intrepid 2F	++++	—	10 to 16 oz	4	14	
	Rimon 0.83EC	++++	—	20 to 40 oz	12	14	
	Assail 30SG	++++	—	4 to 8 oz	12	7	
	Calypso 4F	++++	—	4 to 8 oz	12	30	
	CYD-X	++++	—	1 to 3 oz	4	0	Codling moth insecticide-resistant populations exist in some orchards and can affect the performance of certain products.
Control rosy apple aphid, plum curculio, white apple leafhopper, spotted tentiform leafminer, and San Jose scale.	Monitor orchards for these insects. <u>Insecticides</u> (See Petal Fall section, page 13)	*****					Infestations of these insects may occur anytime from petal fall to the second cover spray. Early detection is important for effective control.

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[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

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate 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				See information listed in Petal Fall to First Cover sections (pages 13 through 18) and Fertility Management section (page 44).
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/freeze danger is past (approx. second cover).	++++					See Fertility Management Recommendations section (page 44) for fertilizer use suggestions and complete recommendations.
	Collect leaf samples in July to mid-August for leaf analysis.	+++++					See Fertility Management Recommendations section (page 44) 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 (60-90° for central leader trees and 75-85° 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 growth) every 6 to 8 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 tree 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.	++					

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SECOND COVER AND LATER SPRAYS (continued)

Goals	Options	Relative[1] Effectiveness(+) or Importance (*)	Rate per[2] 100 gal	Rate 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 70.				See Chemical Fruit Thinning Sprays (page 68) and Apple Thinning Recommendations chart (page 70) in Growth-Regulating Chemicals section.
Enhance return bloom.	Fruitone L	+++	2 oz		48	2	Research 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 on page 69.
	Ethrel	+++		16 to 72 fl oz	96		
Control ground suckers around base of trunk.	Tre-Hold A-112 Sprout Inhibitor - Also use herbicides approved for sucker control. See notes in Herbicide section (page 63) for Rely, Gramoxone.	++++	Use 10,000 ppm (10 oz/1 gal) as a low- pressure, large-droplet handgun application.		12	0	See Sucker Control (page 72) for specific recommendation details.
Delay preharvest fruit drop and delay fruit maturity.	ReTain	++++		One 333 g pouch per acre (50 g a.i.)	12	7	**Single Pick Harvest**. Applying one pouch of ReTain per acre 4 weeks prior to the anticipated beginning of the normal harvest period of untreated fruit for the current season will delay the harvest period by 7-10 days. Timing of ReTain application is critical. Apply ReTain closer to harvest in hot years. Use an adjuvant for optimal response. Consult the label. **Multiple Pick Harvest**. Applying one pouch of ReTain per acre 1 to 2 weeks prior to the anticipated beginning of the normal harvest period of untreated fruit for the current season will improve quality and storage potential of later picked apples (2nd and 3rd 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.

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2]		Re-entry Interval (hours)	Preharv. Interval (days)	Comments
			100 gal	Acre			
Delay or reduce preharvest fruit drop or both.	Preload NAA (Fruitone-L)	+++	2 oz		48	2	Apply multiple applications of 5 ppm each week for the 4-week period prior to the normal start of the harvest period for each variety.
	NAA (Fruitone L)	+++	4 to 8 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 7 to 10 days later. See Growth-Regulating Chemicals section (page 67) for details.
	ReTain plus NAA (Fruitone L)	+++++		One 333 g pouch of ReTain plus 8 fl oz Fruitone L per 100 gal per acre	12	7	Apply the ReTain plus Fruitone L combination (plus adjuvant) as a tank-mix 2 weeks prior to the start of the normal harvest. This combination provides improved fruit drop control and firmness retention.
Reduce fruit russetting in susceptible varieties.	Pro-Vide 10SG Novagib 10L (continue applications started at petal fall)	++++ ++++	60 to 100 g	20 oz per acre/appl	12 4	0	See Growth-Regulating Chemicals section (page 67) for recommendation details.
Reduce fruit cracking of susceptible varieties (e.g., Stayman).	Pro-Vide 10SG Novagib 10L	+++ +++	100 to 200 g	2 to 4 pt per acre/appl	12 4	0	Begin applications in early to mid June or as soon as cracking is observed. Repeat at 3-week intervals until harvest. See Growth-Regulating Chemicals section (page 67) for details.
Promote lateral branching of current season's growth.	Promalin	+++	0.8 oz/gal of water (125 ppm)		12	None	See Growth-Regulating Chemicals section (page 67) for recommendation details.

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SECOND COVER AND LATER SPRAYS (continued)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Disease Management							
Control summer diseases (white rot, bitter rot, black rot, sooty blotch, flyspeck, black pox).	Scout orchard. Prune out fire blight strikes.	***** *****					Apply cover sprays at 10- to 14-day intervals. Use a 7- to 10-day interval during wet, rainy periods. If thiophanate-methyl or a phosphite fungicide is not used in cover sprays, it is important to combine captan with sufficient ziram to increase fungicide rate to 8 to 10 lb/acre in order to control sooty blotch and flyspeck. Be sure to observe 77-day preharvest interval when using metiram or mancozeb. When using a combination of captan and ziram, use approximately equal rates of each. Use captan where there is a history of white rot.
	Fungicides *captan* 50W or 4L or 80W or 80WDG	 +++++ +++++	 2 lb 1 qt 1.25 lb 1.25 lb	 8 lb 4 qt 5 lb 5 lb	 96 96 24 24	 0 0 0 0	
	ziram 76DF or 76WDG	++++	2 lb	8 lb	48	14	
	Sovran 50WG	+++++	1.0 to 1.6 oz	4.0 to 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 50WG	+++++	—	2.5 to 3.0 oz	12	14	A maximum of four applications and 11 oz of Flint 50WG can be used per acre per season. It is weak on black pox.
	Pristine 38W	+++++	—	14.5 to 18.0 oz	12	0	A maximum of four applications and 72 oz of Pristine can be used per acre per season. Pristine has activity on strains of the Alternaria blotch fungus that are resistant to Sovran and Flint. It is weak on black pox. If Captan 80W or 80WDG is used then the REI is 48 hours for this and other combinations below.
	captan 50W or 4L or 80W or 80 WDG + *thiophanate-methyl* 85WDG	 +++++	 2 lb 1 qt 1.25 lb 1.25 lb 2 to 4 oz	 8 lb 4 qt 5 lb 5 lb 8 to 16 oz	 96 96 24 24 96	 0 0 0 0 1	
	ziram 76DF or 76WDG + *thiophanate-methyl* 85WDG	 +++++	2 lb 2 to 3 oz	8 lb 8 to 12 oz	48	14	

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Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2]		Re-entry Interval (hours)	Preharv. Interval (days)	Comments
			100 gal	Acre			
Control summer diseases (continued).	*captan* 50W or 4L or 80W or 80 WDG + *metiram* 80DF **or** *mancozeb* 75DF	 +++++	 1.25 lb 1 pt 0.79 lb 0.79 lb ¾ lb ¾ lb	 5 lb 2.5 qt 3.15 lb 3.15 lb 3 lb 3 lb		 77 77	 Metiram and mancozeb cannot be used within 77 days of harvest.
	captan 50 W or 4 L or 50W or 50WDG + *ziram* 76DF, 76WDG + *thiophanate-methyl* 85WDG	 +++++ 	 1 lb ½ qt 0.63 lb 0.63 lb 1 lb 2 to 4 oz	 4 lb 1 qt 2.52 lb 2.52 lb 4 lb 8 to 16 oz	 96	 14	
	captan 50 W or 4 L or 80W or 80WDG + ProPhyt[3]	 +++++	 2 lb 1 qt 1 ¼ lb 1 ¼ lb ½ to ¾ qt	 8 lb 4 lb 5 lb 5 lb 2 to 3 qt	 96	 0	This combination is effective on Glomerella leaf spot. Make the first spray around June 15th or when first leaf spot symptoms appear and continue spraying every 7-10 days until harvest. Use a 7-day interval when it is warm and wet. Use high rate of ProPhyt where Glomerella leaf spot is a problem. Rotations with Pristine or Flint are also effective. The REI is 24 hours if Captan 80W or 80WDG is used.

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[3]Other phosphite fungicides are also labeled on apples. See the discussion of phosphite fungicides in the Fungicides and Bactericides section (p. 54).

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Control summer diseases (continued).	Inspire Super Rotated with: *captan* 50 W or 4 L or 80W or 80WDG + ProPhyt[3]	 +++++	12 oz 2 lb 1 qt 1 ¼ lb 1 ¼ lb ½ to ¾ qt	 8 lb 4 lb 5 lb 5 lb 2 to 3 qt	*see comments	*see comments	This combination is another option for summer disease control. It has not been evaluated for Glomerella leaf spot control. However it has provided good summer disease control. It is not especially effective on black pox so if you use this program and have a history of black pox in the orchard, begin the cover sprays with an EBDC+ captan combination, or captan+thiophanate methyl, then switch to this program at 3rd cover. Do not make more than 5 applications (60 oz) of Inspire Super per year, used in combination. * If the last spray is Inspire Super, the REI is 12 hours and the PHI 14 days. If the last spray is captan+ProPhyt, then the REI is hours and the PHI 0 days.
Suppress necrotic leaf blotch on Golden Delicious.	*ziram* 76W or WDG zinc oxide 39.8%	+++++ +++++	1 to 2 lb	4 to 8 lb 1 pt	48 0	14 0	Sprays from mid June through early August are most important.
Control powdery mildew.	Scout orchard.	*****					Determine need for additional fungicides based on the number of infections on newly unfolded leaves.
Control Alternaria blotch.	Pristine 38W	+++++		14.5 to 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 4 sprays are allowed by the label. Use in conjunction with a preventive mite management program. Do not make more than 4 applications or apply more than 72 oz of Pristine per season.

[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.
[3]Other phosphite fungicides are also labeled on apples. See the discussion of phosphite fungicides in the Fungicides and Bactericides section (p. 54).

SECOND COVER AND LATER SPRAYS (continued)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. interval (days)	Comments
Insect Management							See IPM practices for codling moth (page 33) and Oriental fruit moth (page 34) 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, late season (August and possibly September) sprays of CheckMate OFM-F or application of Isomate M-100 is recommended for late season control of OFM. OFM populations often increase during August and September in apples.
Control codling moth and Oriental fruit moth.	Monitor pheromone traps weekly for adult activity.	*****					
	<u>Insecticides</u> (See First Cover.)	*****					
	<u>OFM Mating Disruption</u> Isomate-M100 CheckMate OFM-F	 +++++ +++++		 100 1 to 2 oz			
Control tufted apple bud moth.	Monitor pheromone traps weekly for adult activity. Thin fruit to avoid excessive clustering.	***** ****					See IPM Practices for tufted apple bud moth (page 35) to determine the proper timing of insecticide applications. Clustering of fruit is conducive to higher levels of tufted apple bud moth injury.
	<u>Insecticides</u> Intrepid Delegate 25WG Altacor 35WDG Belt 4SCV	 +++++ +++++ +++++ +++++	 — — — —	 6 to 12 oz 4.5 to 7 oz 2.5 to 4.5 oz 3 to 5 fl oz	 4 4 4 12	 14 7 14 14	Insecticide sprays for TABM are recommended only in orchards with a history of damage. See section on IPM practices for TABM (page 35) to properly time sprays. This apray often overlaps with the need for sprays of late-emerging codling moth.
	Bacillus thuringiensis Dipel 2X CryMax XenTari	+++		 1 to 2 lb 1 to 2 lb 1 to 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.**

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Control tufted apple bud moth.	Monitor pheromone traps weekly for adult activity.	*****					See IPM Practices for tufted apple bud moth (page 35) 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.
	<u>Insecticides</u> Intrepid Delegate 25WG Altacor 35WDG Belt 4SCV	 +++++ +++++ +++++ +++++	 — — — —	 6 to 12 oz 4.5 to 7 oz 2.5 to 4.5 oz 3 to 5 fl oz	 4 4 4 12	 14 7 14 14	Insecticide sprays for TABM are recommended only in orchards with a history of damage. See section on IPM practices for TABM (page 35) to properly time sprays. The timing of sthis spray coincides with late-emerging codling moth, so the choice of material should match what was used at first cover for codling moth.
	Bacillus thuringiensis Dipel 2X CryMax XenTari	+++		 1 to 2 lb 1 to 2 lb 1 to 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.**

[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)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Control apple maggot.	Erect red sticky spheres in early June to monitor adults.	****					Erect sticky traps baited with fruit essence lures on outside rows nearest abandoned orchards or other sources of flies. Check weekly. Threshold level is a cumulative of 5 flies per trap. If the threshold is exceeded again 2 weeks after spraying, apply again. Adults can emerge from June through September. Historically, peak emergence generally occurs from mid July to early August.
	Insecticides						Apply Surround at 7- 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.
	Guthion 50WP	+++++	½ lb	2 lb	48h, 14d	21	
	Imidan 70WP	++++	¾ lb	3 lb	24	7	
	Assail 30SG	+++	—	8 oz	12	7	
	Calypso 4F	+++++	—	4 to 8 oz	12	30	
	Provado	++++	—	6 to 8 oz	12	7	
	Surround WP	+++	—	20 to 50 lb	4	—	
Control white apple leafhopper or potato leafhopper.	Insecticides						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. Generally, low rates of insecticides will control leafhoppers.
	Provado 1.6F	+++++	1 oz	4 oz	12	7	
	Actara 25WDG	+++++	—	2 to 2¾ oz	12	14	
	Assail 30SG	+++++	—	2.5 to 4.0 oz	12	7	
	Calypso 4F	+++++	—	2 to 4 oz	12	30	
	Clutch 50WDG	+++++	—	2 oz	12	14	
Control brown stink bugs, including brown marmorated stink bug.	Insecticides						Brown marmorated stink bug is in the early stages of invading NC, and infestations are very sporadic. Check with your extension office for updated information as the 2012 season progresses.
	Actara	++++		4.5 to 5.5 oz	12	35	
	Belay	++++		6 to 12 fl oz	12	7	
	Bifenthrin 2EC	++++		2 to 2.4 fl oz	12	7	
	Endigo ZC	++++		5 to 6 fl oz	24	35	
	Thionex 50WP	+++++		3 to 4 lbs	20 days	21	
	Warrior 1CS	+++		2.56 to 5.2 fl oz	24	21	

[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.

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry interval (hours)	Preharv. interval (days)	Comments
Control spotted tentiform leafminer.	Insecticides						A threshold level of two mines per leaf for second generation larvae (June to July) should be used to dictate the need for STLM control. Control of third generation larvae (August) may be necessary on late-maturing cultivars if populations exceed 4 mines per leaf. Many orchards have high levels of parasites by this time, which usually precludes the need for insecticides.
	Delegate WG	+++++	—	4.5 to 7 oz	4	7	
	Provado 1.6F	+++	2 oz	8 oz	12	7	
	Assail 30SG	++++	—	2.5 oz	12	7	
	Belay	++++	—	6 fl oz	12	7	
	Intrepid 2F	+++++	—	8 to 12 fl oz	12	14	
Control green apple and spirea aphids.	Insecticides						Threshold level for green apple aphid is 50% infested terminals. Control is most important on young trees and in dwarf plantings. On mature trees, a higher threshold is tolerable. Biological control can often preclude the need for chemical control.
	Provado 1.6F	+++++	1 to 2 oz	4 to 8 oz	12	7	
	Actara 25WDG	+++++	—	4.5 oz	12	35	
	Assail 30SG	+++++	—	2.5 to 4.0 oz	12	7	
	Calypso 4F	+++++	—	2 to 4 oz	12	28	
	Belay	+++++	—	4 to 6 fl 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 to 8 oz	12	7	
	Movento 2SC	+++	—	6 to 9 fl oz	24	7	
Control woolly apple aphid	Insecticides						Woolly apple aphid control can be difficult if insecticides are applied after populations reach large densities. Use a threshold of 10% infested shoots. An adjuvant must be used with Movento.
	Movento 2SC	++	—	6 to 9 fl oz	12	7	
	Diazinon 50WP	+++++	1 lb	4 lbs	24	21	
	Thionex 50WP	++++	—	3 to 4 lbs	20 days	21	
Control redbanded leafroller.	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.

[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)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Control lesser apple worm.	Insecticides See insecticides for codling moth.						Lesser apple worm is a sporadic pest of importance in isolated areas. If damage occurs, it is usually by the third generation, which occurs in August.
Control dogwood borer.	Insecticides Lorsban 50W, 4E	 ++++ +++++	 3 lb 1.5 qt	 — —	 96 96	 28 28	Apply insecticides with a handgun sprayer to the trunk, especially to burr knots and graft unions. Moths can lay eggs from mid May through September, so treatment before July is optimal. Lorsban should be applied with a handgun sprayer from no more than 4 ft or with a shielded sprayer to prevent drift onto foliage or fruit.
Control European red mite and two-spotted spider mite.	Monitor trees for mite activity.	*****					**See IPM practices for European red mite (page 36).** European red mite and two-spotted 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 3 to 4 days to determine if biological control reduces mite populations. In orchards with Alternaria blotch, a threshold of 1 mite/leaf (50% infested leaves) should be used to minimize stress to trees.
	Miticides Acramite 50WS Nexter 75WP Portal 0.4EC Apollo SC Savey 50DF Zeal 72WDG Envidor 2SC Kanemite 15SC wettable sulfur summer oil	 +++++ ++++ +++++ ++++ ++++ +++++ +++++ +++++ + ++	 — — — — — — — 1½ to 3½ lb ½ to 1 gal	 ¾ to 1 lb 4.4 oz 1 to 2 pt 4.0 oz 3.0 oz 2 to 3 oz 16 to 18 oz 21 to 21 fl oz 5 to 15 lb ½ to 1% soln.	 12 12 12 12 12 12 12 12 12 12	 7 25 14 45 28 28 14 14 7 0	If Apollo or Savey were 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 2 weeks before or after an oil spray.**

[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)

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Weed Management							
Spot-treat with herbicide to control difficult-to-manage perennial weeds.	*glyphosate*	***** ++++	See Weed Response to Herbicide table (pages 51 to 53).		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.

POSTHARVEST

Goals	Options	Relative[1] Effectiveness (+) or Importance (*)	Rate per[2] 100 gal	Rate per[2] Acre	Re-entry Interval (hours)	Preharv. Interval (days)	Comments
Plant Growth Regulators							
Control fruit storage scald.	*DPA*	++++	2½ pt per one gal of water as a dip or spray to harvested fruit.				See Growth-Regulating Chemicals section (page 67) for complete details.
To maintain apple flesh firmness, fruit acidity and minimize scald.	SmartFresh	++++					See Growth-Regulating Chemicals section (page 67) 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 preemergence 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 (1X) 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: $\dfrac{\text{43,560 sq ft/acre}}{\text{distance between rows (ft)}} = \text{feet of row/acre}$

Step 2: Feet of row/acre (from Step 1) X tree height (ft) X cross-limb spread (ft) = cu ft of foliage/acre.

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

Step 3: Select one of the numbers from Table 1 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:

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

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: $\dfrac{43{,}560 \text{ ft}^2}{25 \text{ ft}} = 1{,}742.4 \text{ ft}$

Step 2: 1,742.4 ft X 20 ft X 17 ft = 592,416 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/acre will apply a dilute application to runoff.

However, general pesticide applications are not applied to runoff. Using 70 percent (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 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 within 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 ⅔ 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 tree row volume (TRV) calculated water rates per acre for various chemicals and types of 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).

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

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

[1]Assume the example orchard was to be sprayed at 3X concentration.
[2]Rate per 100 gal dilute. Example based on 2.0 lb pesticide/100 gal.
[3]This adjustment for concentrate application (5X 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, and then 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.

IPM Practices for Selected Pests

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, but depending on weather conditions, new adults can continue to enter until shortly after petal fall. An insecticide application at petal fall is important to minimize damage when adults are present. Adult plum curculio 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. Eggs hatch within a few days after being laid and feed in the fruit. The mature larva is ¼-inch long, white, slightly curved, and legless. Damage on apples is usually observed as feeding or oviposition scars and is cosmetic. There are two generations per year in most areas of the Southeast, but one generation occurs in higher elevations of the southern Appalachians.

Scouting and Control: After bloom, check twice weekly for plum curculio adults or feeding and egg-laying scars. Typically, an insecticide at petal fall is sufficient for control, but occasionally emergence may be protracted and a second application at first cover may further suppress damage. A model developed in NY that predicts damage to apple 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.

Apple Maggot

The apple maggot usually completes one generation per season at elevations above 2,000 feet and two generations at less than 1,200 feet. However, depending upon the year, fly activity can extend from June through September. Adult fly emergence from overwintering pupae in the soil is unpredictable and can occur from late May to August, but the peak emergence is usually between mid July and early August. About 7 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. 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 2 to 4 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 nonsprayed 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 apple maggot adults 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., abandoned orchard). Hang spheres in trees with fruit, and remove fruit within 18" 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 14-day intervals if captures again reach 5 flies. Because the timing of emergence is difficult to predict, insecticide sprays should not be based on population trends of the previous year.

Codling Moth

Codling moths begin to emerge and mate during April or early May, depending on location, and complete two generations per season. Depending on location and the year, a partial or complete third generation may occur. Eggs generally begin to hatch near the first cover spray, and soon larvae 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 OFM, codling moth larvae do not have an anal comb**.**

In recent years the codling moth has become a serious problem in orchards throughout the Southeast. Factors associated with problem orchards are (1) bin piles stored near orchards and/or (2) 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. Recent research suggests that orchards within 100 to 150 yards of bin piles 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 codling moth degree-day 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 it has worked well throughout the US. However, the model may not be entirely accurate where insecticide-resistant populations occur or where bin piles are a source of codling moths, because these moths emerge later than predicted by the model.

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 degree-day model predicts percent 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 degree days when male flight begins in the spring, which is referred to as 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, degree days are calculated daily. It is only necessary to check traps once per week after biofix is determined. Use the table on page 37 to determine the number of degree days occurring at various maximum and minimum daily temperatures.

First Generation: Recommendations are provided for low- and moderate-to-high population densities. Low-density orchards are those with less than 0.5 percent of the fruit damaged the previous year and pheromone trap catches that do not exceed 10 moths per trap per week anytime during the first generation (to about 850 DD after biofix).

In low-density orchards, make a single insecticide application at 350 DD after biofix. *In moderate-to high-density* orchards, apply two insecticide applications at 14 to 21 days apart, the first at 150 to 250 DD after biofix: 100 to 150 if using a product which depends primarily on ovicidal activity for control (i.e., Intrepid or Rimon), and 250 if using an insecticide that targets early stage larvae. Additional applications may be necessary if trap captures remain high (greater than 7 moths per trap).

A second emergence of overwintering adults sometimes occurs between 500 and 800 degree days 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: 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 2,000 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 3 to 7 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.

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

Exceptions to the Model: Where codling moth 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 an abandoned orchard, where bins are placed near an orchard, or in problem orchards with high populations.

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

Cumulative Degree Days	% Adult Emergence	% Egg Hatch	Cumulative Degree Days	% Adult Emergence	% Egg Hatch
0 (biofix)	1	0	1,300	43	10
50	5	0	1,350	52	15
100	15	0	1,400	60	21
150	27	0	1,450	68	28
200	40	0	1,500	77	36
250	52	3	1,550	80	45
300	63	9	1,600	85	63
350	72	18	1,650	89	62
400	80	30	1,700	92	69
450	87	42	1,750	95	75
500	91	54	1,800	97	81
550	95	64	1,850	99	85
600	97	73	1,900	0	89
650	98	81	1,950	2	92
700	99	87	2,000	4	95
750	99	92	2,050	7	94
800	100	95	2,100	10	99
850	0	97	2,150	15	100
900	1	98	2,200	20	3
950	2	99	2,250	25	5
1,000	5	100	2,300	31	8
1,050	8	0	2,350	38	12
1,100	13	1	2,400	45	16
1,150	18	2	2,450	52	21
1,200	26	3	2,500	59	27
1,250	35	6	2,550	65	31

Oriental Fruit Moth

Oriental fruit moths 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 Oriental fruit moth 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 degree-day model predicts adult emergence and egg hatch for the first three

generations of the four or five generations that occur in the Southeast. However, generations overlap in the late season, which makes the degree-day model less useful later in the season. The table on page 37 uses daily maximum and minimum temperatures to determine daily DDs for Oriental fruit moth (base 45°F). 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 1 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 3 moths per trap per week between 800 to 1,600 DD after biofix). In *low-density* orchards (3 to 5 moths per trap per week caught 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 pheromone trap catches, or both, and may need two insecticide applications 14 days apart starting at 1,100 DD.

Third-Generation OFM: An insecticide is recommended at 2,200 DD after biofix if pheromone trap catches exceed 5 moths per trap per week at 1,900 DD after biofix and if there is fruit damage caused by the second generation.

Fourth-Generation OFM: Because of overlapping generations late in the season, it is difficult to predict when egg hatch of the fourth generation begins. However, continuous egg laying can occur from August through October, and pheromone traps are the best method to determine the potential for late-season damage. Apply an insecticide within 7 to 10 days of a pheromone trap threshold of 7 moths per trap per week.

Tufted Apple Bud Moth

The tufted apple bud moth (TABM) is the most common leafroller occurring on apple in the Southeast. In the 1990s it was the most destructive insect pest of apples, 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 degree-day model similar to that of the Oriental fruit moth and codling moth was developed specifically for populations in the Southeast. For calculating degree days from maximum and minimum daily temperatures, use the Oriental fruit moth table on page 37 (45°F). Place TABM pheromone traps at the *tight cluster to pink stage of bud development* at a density of 1 trap per 20 acres of orchard. Biofix is the first date on which a sustained catch occurs and may vary from 2 to 5 moths per trap over a one-week period. The cumulative number of degree days from the point of biofix is used to predict 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 percent 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 percent 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. Not unless pheromone trap captures exceed about 15 moths per trap by 2,600 DD after biofix (time of 10% egg hatch of the second generation) is an insecticide application recommended. Control is most important on later maturing apples that are harvested after mid September.

Mating Disruption

Mating disruption programs consist of emitting relatively large amounts of 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. Oriental fruit moth is much easier to control with mating disruption compared with codling moth; use both mating disruption and insecticides against moderate to high codling moth populations. 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: A number of companies market pheromone dispensers for mating disruption, including hand-applied dispensers that emit pheromones for a relatively long period and sprayable products that last for shorter periods and need to be reapplied. Companies are now marketing pheromone dispensers that contain both codling moth and oriental fruit moth 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: For the codling moth, place pheromone dispensers in the orchard before adults begin to fly in the spring. First emergence of adults usually begins during late bloom or petal fall of Delicious cultivars. Hence, dispenser application should be completed by petal fall. Best results are obtained when dispensers are hung in the upper third of the canopy, because this is where mating occurs.

The Oriental fruit moth begins to emerge near green tip of Delicious cultivars, so for season-long control, dispensers should be in the orchard by this time. However, insecticides applied at petal fall for other insects usually controls this first generation, so if using Oriental fruit moth dispensers only, application can be delayed until just before emergence of the second- or third-generation adults (950 and 1850 DD after biofix, respectively). If using sprayable pheromones for mating disruption, make the initial application when hand-applied dispensers are applied. If mating disruption is not used against this insect and pheromone trap captures remain low during the season, a single late-season application in mid to late August will help to suppress late-season populations.

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 at periodic intervals. When properly used, pheromone trapping can be useful to determine the need for insecticides under mating disruption orchards. Traps should be hung in the upper one-third of the canopy, because 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 preferably one per three acres, and checked at weekly intervals. Trap captures should be added each week, and when the cumulative number exceeds an average of three moths per trap, an insecticide may be necessary. Threshold levels are based on using large delta-style traps and Trece CM L2 lures, which should be replaced at 12-week intervals.

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 5 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 5 to 10 mites per leaf (80 to 90 percent 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 5 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 1-2 mites.

Relationship between European red mite density per leaf and % infested leaves.

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

Codling moth degree days (50°F lower base, 88°F upper base) at various daily maximum and minimum temperatures.

Max / Min	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96
20	0	1	1	2	2	3	3	4	5	5	6	7	8	9	9	10	11	12	13	14	15	15
22	0	1	1	2	2	3	3	4	6	6	6	7	8	9	10	10	11	12	13	14	15	15
24	0	1	1	2	2	3	4	4	6	6	7	7	8	9	10	11	11	12	13	14	15	16
26	0	1	1	2	2	3	4	4	6	6	7	7	8	9	10	11	12	12	13	14	15	16
28	0	1	1	2	2	3	4	4	6	6	7	8	8	9	10	11	12	13	14	15	15	16
30	0	1	1	2	2	3	4	5	6	6	7	8	9	10	10	11	12	13	14	15	16	16
32	0	1	1	2	3	3	4	5	6	6	7	8	9	10	11	11	12	13	14	15	16	17
34	0	1	1	2	3	3	4	5	6	7	7	8	9	10	11	12	13	14	14	15	16	17
36	0	1	1	2	3	4	4	5	6	7	8	8	9	10	11	12	13	14	15	16	17	17
38	0	1	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	14	15	16	17	18
40	0	1	2	2	3	4	5	6	6	7	8	9	10	11	12	13	14	15	16	17	17	18
42	0	1	2	2	3	4	5	6	7	7	8	9	10	11	12	13	14	15	16	17	18	19
44	0	1	2	3	3	4	5	6	7	8	9	10	11	12	13	14	15	15	16	17	18	19
46	0	1	2	3	4	5	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
48	1	2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	20
50	1	2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
52	2	3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
54	-	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
56	-	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
58	-	-	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
60	-	-	-	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
62	-	-	-	-	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
64	-	-	-	-	-	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
66	-	-	-	-	-	-	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
68	-	-	-	-	-	-	-	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
70	-	-	-	-	-	-	-	-	18	19	20	21	22	23	24	25	26	27	28	29	30	31
72	-	-	-	-	-	-	-	-	-	20	21	22	23	24	25	26	27	28	29	30	31	32
74	-	-	-	-	-	-	-	-	-	-	22	23	24	25	26	27	28	29	30	31	32	33
76	-	-	-	-	-	-	-	-	-	-	-	24	25	26	27	28	29	30	31	32	33	34
80	-	-	-	-	-	-	-	-	-	-	-	-	26	27	28	29	30	31	32	33	34	35

Oriental fruit moth degree days (45°F lower base, 91°F upper base) at various daily maximum and minimum temperatures.

Max / Min	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96
20	1	1	2	2	3	4	4	5	6	7	8	9	9	10	12	12	13	14	15	16	17	17	18	19
22	1	1	2	2	3	4	4	6	7	7	8	9	10	11	12	12	13	14	15	16	17	18	18	19
24	1	2	2	2	4	4	5	6	7	7	8	10	10	11	12	12	14	15	15	16	18	18	19	20
26	1	2	2	3	4	5	5	6	7	7	8	10	10	11	12	13	14	15	16	16	18	18	19	20
28	1	2	3	3	4	5	5	6	7	8	9	10	10	11	13	13	14	15	16	17	18	19	20	20
30	1	2	3	3	4	5	5	6	7	8	9	10	10	12	13	13	15	16	16	17	19	19	20	21
32	1	2	3	3	4	5	6	6	8	8	9	10	11	12	13	14	15	16	17	18	19	19	20	21
34	1	2	3	3	4	6	6	7	8	8	10	11	11	12	14	14	15	17	17	18	19	20	21	21
36	1	2	3	3	5	6	6	7	8	9	10	11	11	13	14	14	16	17	18	19	19	20	21	22
38	1	2	3	4	5	6	6	7	9	9	10	11	12	13	14	15	16	17	18	19	20	21	21	22
40	1	2	3	4	5	6	6	8	9	9	10	11	12	13	15	15	16	18	18	19	20	21	22	23
42	1	3	4	4	6	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
44	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
46	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
48	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
50	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
52	-	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
54	-	-	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
56	-	-	-	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
58	-	-	-	-	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
60	-	-	-	-	-	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
62	-	-	-	-	-	-	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
64	-	-	-	-	-	-	-	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
66	-	-	-	-	-	-	-	-	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	35
68	-	-	-	-	-	-	-	-	-	23	24	25	26	27	28	29	30	31	32	33	34	35	36	36
70	-	-	-	-	-	-	-	-	-	-	25	26	27	28	29	30	31	32	33	34	35	36	37	37
72	-	-	-	-	-	-	-	-	-	-	-	27	28	29	30	31	32	33	34	35	36	37	38	38
74	-	-	-	-	-	-	-	-	-	-	-	-	29	30	31	32	33	34	35	36	37	38	39	39
78	-	-	-	-	-	-	-	-	-	-	-	-	-	31	32	33	34	35	36	37	38	39	40	40
80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33	34	35	36	37	38	39	40	41	41

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 EBDC fungicides). **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, 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. Collecting baseline susceptibilities, defining probable resistance problems beforehand, and proposing pesticide-use strategies to forestall 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.

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 southeastern United States, pesticide resistance has been documented in the tufted apple bud moth, codling moth, rosy apple aphid, and European red mite. Currently, codling moth resistance is most important, but good resistance management strategies are required to prevent other pests from developing resistance.

Codling Moth

Insecticide-resistant codling moth populations became prevelant throughout the Southeast in the early 2000s. Resistance to one or more registered insecticides, including Guthion, 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 (7 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, make an attempt 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.

Rosy Apple Aphid

The rosy apple aphid has developed widespread resistance to Lorsban, and control failures with Asana, Ambush, Danitol and Diazinon have become more common in recent years. Consequently, neonicotinoid insecticides are now most commonly used for control. It is important to remember that all neonicotinoids (Actara, Assail, Calypso, Belay, and Provado) have a similar mode of action and should be considered the same material for rotation 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 30 years as site-specific (systemic) chemicals have been developed and used on many crops and against many pathogens. The broad spectrum protectants (such as captan and mancozeb) that were used previously had multiple sites of activity in the target pathogens, greatly reducing the likelihood of resistance development.

Resistance has become a problem in the U.S. in only three pathogens that affect apples during the growing season: *Venturia inaequalis*, cause of apple scab; *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 U.S., including the Southeast, in the mid-1970s. As a consequence they are no longer recommended for apple scab control in the Southeast. The ergosterol biosynthesis inhibiting fungicides (EBI) were first introduced in the late 1980s, and reduced sensitivity of *V. inaequalis* has been reported or suspected in a number of orchards in the Northeast and Midwest. Some growers in NC have also had problems controlling scab with EBI fungicides, suggesting that resistance may be a problem here as well. Resistance of the fire blight bacterium, *E. amylovora*, to streptomycin (Agri-mycin 17, Streptrol) is widespread in several states but has not been reported in the Southeast. Resistance of *P. syringae* pv. *papulans* has been confirmed in an orchard in Tennessee.

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 to three 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. 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 ergosterol biosynthesis inhibiting 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 EBI 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. Most recently glyphosate resistant weeds have been found across the Southeast and Midwest. Glyphosate resistant weed populations have been verified in Delaware, North Carolina, South Carolina, Georgia, and Tennessee. The two most notable species developing resistance to glyphosate are horseweed and Palmer amaranth. Glyphosate resistant ragweed is suspected and being investigated as well. Growers should be aware that these 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 county agent with the Cooperative Extension Service.

In order 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 below). 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.

4. Use herbicides only as needed.

Herbicide Mode of Action Table

MOA Group	Herbicide Members
1	Clethodim (Select, etc.), Fluazifop (Fusilade), Sethoxydim (Poast)
2	Rimsulfuron (Matrix, Pruvin, Solida) and Halosulfuron (Sandea)
3	Oryzalin (Surflan) and Pendimethalin (Prowl)
4	2,4-D amine and fluroxypyr (Starane or Comet)
5	Simazine and Terbacil (Sinbar)
7	Diruon (Karmex, Direx)
9	Glyphosate (Roundup, etc.)
10	Glufosinate (Rely)
12	Norflurazone (Solicam)
14	Flumioxazin (Chateau) and Carfentrazone (Aim)
20	Dichlobenil (Casoron)
22	Paraquat (Gramoxone, Firestorm, Parazone)
29	Indaziflam (Alion)

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 label on dimethoate, phosmet, malathion, azinphosmethyl, formetanate, ethephon, NAA, and possibly others warns 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 and 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. This is also true for chlorothalonil. 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 residues 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 the southeastern growing region are mildly acidic (6.7 plus or minus 0.2) there are exceptions; therefore, 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 CO_2 is weakly buffered and readily changed by acidifying agents.

Although not pH-related, some pesticides can be affected by other contaminants in the water. For example, fenbuconazole, not labeled on apples, is greatly reduced in effectiveness by suspended particulates. Still other compounds like 2,4-D and azoxystrobilurin 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. Herbicides are directed at the soil and weeds underneath the tree.

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. Another option is the use of organic mulches in the tree row. 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.

Herbicide Considerations

To ensure proper herbicide use, always read 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 county's Cooperative Extension agent.

Remember that herbicides are applied as a directed spray along each side of the tree row. Flat fan nozzles are most widely used 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 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.

Several herbicides are registered for use in apple orchards. Some are preemergence herbicides that control weeds that have not emerged, and others are postemergence herbicides that control emerged weeds. Preemergence herbicides control germinating weed seeds but usually do not give acceptable control of emerged weeds. Rainfall is needed to properly activate preemergence herbicides. Rainfall within 7 to 14 days after application activates most herbicides; however, best control occurs when activation (rain or irrigation) occurs within a few days of application. The desired amount of time for rainfall after application varies by herbicide. 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 may not be adequately controlled by postemergence herbicides. If weeds are stressed from drought, delay herbicide application until after adequate rainfall when weeds are no longer wilted. 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, sethoxydim, clethodim, or fluazifop (Roundup, Poast, Select, or Fusilade DX, respectively). Effects of glufosinate, paraquat, fluroxypyr, and 2,4-D (Rely, Gramoxone Max, Starane Ultra, and Orchard Master, respectively) are noticeable in 1 to 3 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.

Herbicide Application Timing

The goal of an effective weed management program is to eliminate weed competition the first 6 to 8 weeks after bud swell and keep the area under the trees weed-free through harvest. Timing of preemergence (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 (glyphosate or paraquat) in the fall after harvest (November). The fall application will generally provide PRE control into the early summer. When fall PRE treatment breaks and emerging weeds get 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 Preemergence.** This approach requires a burndown herbicide 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 Split.** (Due to changes in the Chateau label, this option is available for non-bearing orchards only.) The registration of Chateau allows for a spring/summer split application time. However, Chateau is the only herbicide with label flexibility to allow this sequential application program. Chateau at 6 to 8 ounces per acre with a nonselective postemergence 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 application of Chateau at 6 to 8 ounces per acre with either paraquat or Rely for nonselective postemergence weed control should be applied. The Sinbar label for non-bearing orchards allows the same use pattern as well. 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.

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 build up of subleathel 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 glyphostate should not be applied later than June. If possible a single application of glyphosate would be best. As an alternative Rely 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 label 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 percent. 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, preemergence herbicides registered for use after transplanting provide effective preemergence 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, Honey Bees, and Pesticides

Most apple varieties are self-incompatible and require cross-pollination with a suitable pollinizer variety to obtain good fruit set. Honey bees and other native bees are the primary pollinators for apples. All bees are susceptible to insecticides and need to be protected during bloom and at other times.

Most insecticide labels include a warning: “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.” Any apiary within 2½ miles of the 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 herbicide.

The following recommendations will help to minimize bee kills:

- Read and obey warning statements on pesticide labels regarding honey bees.
- 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

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 by using 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.

A soil analysis estimates the soil's ability to supply a particular nutrient. Plant tissue analysis measures the current nutrient status of the tree. Potential nutritional problems can often be detected before visual deficiency symptoms appear. By using both soil and plant analysis together, a fertility program can be custom designed for your orchard. The general idea is to give each block of trees what is needed for growth and apple production, but not to apply nutrients that can be supplied by the soil in adequate amounts.

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. Trees in the block should be of the same age, rootstock, and variety. A good sample consists of up to 20 sub-samples (cores). These should be throughly mixed in a clean bucket before filling the soil sample box. Samples should be divided into two depths: 0 to 6 inches and 6 to 12 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 should be the same age, variety, and rootstock. To make full use of published critical nutrient levels, and thus obtain the best information, routine plant samples should be taken mid June to mid July, with earlier sampling at lower elevations. Sample mid-shoot of this season's growth from the upper third of the tree. Collect a total of 40 leaves taken from at least ten 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.

Interpretation of Soil and Tissue Analysis

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 and large-fruited varieties. 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.

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.

For Assistance

Your county 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*, AGW-439-47, is available. It is part of the SoilFacts series and can be downloaded from the university's Soil Science Web page (www.soil.ncsu.edu).

This fact sheet contains detailed instructions for setting up a routine soil and plant leaf analysis program for an orchard. In North Carolina, soil and tissue analysis are both services of the N.C. Department of Agriculture and Consumer Services Agronomic Division. Additional information can be obtained directly from the Agronomic Division at www.ncagr.com/agronomic.

Fertility Management Recommendations for Apples

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

Purpose	Material	Amount	Comments
Apply preplant fertilizers.	Lime and phosphorus fertilizer	Depends on soil test.	Prepare soil as deeply as possible before planting. Take soil samples 12 inches deep for lime and phosphorus recommendations. Apply half, adjusted for the depth of incorporation, and plow down; apply other half, and work in well.
Improve and/or maintain growth of young trees.	10-10-10 or its equivalent	1 lb for each year of age until tree begins bearing, then as recommended from leaf analysis.	Apply before rainfall, or irrigate after application before buds swell in the spring.
Raise boron level of tree.	Solubor	1 lb/100 gal of spray at 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.
Maintain vegetative growth and fruit development.	Nitrogen	1.25 lb of actual N for trees producing 10 to 15 bu 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 nonspurs on bearing trees. Determine the actual yearly application through observations of growth plus crop size and fruit condition plus the leaf analysis.
Increase foliar level.	Potassium	Apply according to leaf analysis. Rate depends on soil analysis.	Leaf analysis is a good way to tell need for a ground application.
Increase tree's calcium level.	Gypsum ($CaSO_4$)	15 to 50 lb/tree with a 6- to 10-ft radius.	Apply only as needed by low soil or tissue calcium. One application usually lasts 3 to 5 years.
	Calcium nitrate	Apply in late fall or early spring at rate to supply recommended nitrogen.	Make soil applications to increase calcium supply and reduce bitter pit.
Reduce incidence of bitter pit.	Calcium nitrate	3 lb/100 gal for sprays 2 weeks apart and ending 2 to 3 weeks before harvest.	Apply to reduce the incidence of bitter pit. Higher rates of calcium nitrate can cause an excess nitrogen effect that is undesirable and contributes to bitter pit.
	Calcium chloride	2 lb/100 gal of water at same time as calcium nitrate.	Apply to reduce the incidence of bitter pit. DO NOT apply when temperature is 85°F or above.

Relative Effectiveness of Fungicides

(— = ineffective; 1 = slightly effective; 6 = very effective or very safe on fruit finish)

Fungicide and Rate of Usage Per 100 Gal of Dilute Spray	Preharvest interval (days)	Relative Control Rating							Safety Rating	
		Scab	Rusts	Brooks Spot	Black Rot/ White Rot	Bitter Rot	Sooty Blotch and Flyspeck	Powdery Mildew	Golden Del.	Red Del.
captan (Captan 50W) 1.5 lb[1]	0	4	2	3	3	3	3	—	6	5
captan (Captan 50W) 2 lb[1]	0	5	2	4	4	4	4	—	6	6
captan (Captan 50W) 1 lb + *ziram* (Ziram 76W or Ziram Granuflo) 1 lb or *thiophanate-methyl* (85WDG) 2 oz	14	4	4	5	5	4	5	2	4	5
captan (Captan 50W) 2 lb + ProPhyt 2 qt	0	4	2	3	4	4	4	—	6	6
captan (Captan 50W) 2 lb + ProPhyt 2 qt rotated with *difenoconazole+cyprodinil* (Inspire Super) 12 oz	14[2]	6	6	3	5	5	6	4	6	6
cyprodinil (Vangard 75 W) 1.25 oz	72	5	—	—	—	—	—	1	6	6
dodine (Syllit 3.4FL) 0.75 pt	7	5	—	?	—	—	2	1	3	4
fenarimol (1E) 3 oz + *captan* (Captan 50 W) 0.75 lb	30	6	5	2	2	1	1	5	6	6
or *mancozeb* 75 DF 0.75 lb or F4 0.6 qt	77	6	6	3	1	2	3	5	6	6
or *metiram* (Polyram 80 DF) 0.75 lb	77	6	6	3	1	2	3	5	6	6
fenbuconazole (Indar 75WSP) 2.67 oz + *captan* (Captan 50 W) 0.75 lb	14	6	5	2	2	1	3	5	6	6
or *mancozeb* 75 DF 0.75 lb or F4 0.6 qt	77	6	6	3	1	2	4	5	6	6
or *metiram* (Polyram 80 DF) 0.75 lb	77	6	6	3	1	2	3	5	6	6

[1]Equivalent rates of Captan 4L are 0.75 qt and 1 qt/100 gal for 1.5 and 2 lb rates of Captan 50W. Equivalent rates of Captan 80W or 80WDG are 0.47, 0.63, 0.94, and 1.26 lb for 0.75, 1.0, 1.5, and 2.0 lb rates of captan 50W.

[2]If the last spray is *captan*+ProPhyt then the PHI is 0 days, if it is Inspre Super then the PHI is 14 days.

Relative Effectiveness of Fungicides (continued)

(— = ineffective; 1 = slightly effective; 6 = very effective or very safe on fruit finish)

Fungicide and Rate of Usage Per 100 Gal of Dilute Spray	Preharvest interval (days)	Relative Control Rating							Safety Rating	
		Scab	Rusts	Brooks Spot	Black Rot/ White Rot	Bitter Rot	Sooty Blotch and Flyspeck	Powdery Mildew	Golden Del.	Red Del.
kresoxim-methyl (Sovran 50 WG) 1.0-1.6 oz[3]	30	6	4	5	4	3	5	4	6	6
mancozeb 75DF or 80W 1.5 lb or F4 1.2 qt	Petal Fall	4	5	3	2	3	3	1	4	5
metiram (Polyram 80W) 1.5 lb	Petal Fall	4	5	3	2	3	3	1	5	5
myclobutanil 40W 1.25 to 2.0 oz[3] + *captan* (Captan 50W) 0.75 lb	14	6	5	4	2	1	1	5	6	6
or *mancozeb* 75DF or 80W 0.75 lb, or F4 0.6 qt	77	6	5	4	1	2	3	5	6	6
or *metiram* (Polyram 80DF) 0.75 lb	77	6	6	1	1	2	3	5	6	6
pyraclostrobin + boscalid (Pristine) 3.6 to 4.6 oz[3]	0	6	4	5	4	4	5	4	6	6
pyrimethanil (Scala SC) 1.75 to 2.5 oz[3]	72	5	—	—	—	—	—	1	6	6
sulfur (wettable) 3 lb	0	1	1	—	—	—	—	4	4	4
tebuconazole + trifloxystrobin (Adament 50WG) 4 to 5 oz[3]	75	6	6	3?	?	?	3	5	6	6
tebuconazole (Tebuzol 45DF) 4 to 8 oz[3] or *captan* (Captan 50W) 3 lb	75	5	5	2	5	1	1	6	6	6
or *mancozeb* 75DF 3 lb or F4 2.4 qt	77	5	6	3	5	2	3	6	6	6
or *metiram* (Polyram 80DF) 3 lb	77	5	6	3	5	2	3	6	6	6
thiophanate-methyl (85WDG) 2 to 3 oz[3]	0	—[4]	—	4	4	—	5	4	5	6
thiophanate-methyl (85WDG) 2 to 3 oz[3] + *captan* (Captan 50W) 1.5 lb	1	4	2	5	4	3	4	2	5	5
or *captan* (Captan 50W) 2 lb		5	2	5	5	4	5	2	6	5

[3]When variable rates are given, use higher rate when the likelihood of disease is high.
[4]Thiophanate-methyl should not be used for scab control in North Carolina because of widespread resistance of the apple scab fungus to benzimidazole fungicides.

Relative Effectiveness of Fungicides (continued)

(— = ineffective; 1 = slightly effective; 6 = very effective or very safe on fruit finish)

Fungicide and Rate of Usage Per 100 Gal of Dilute Spray	Preharvest interval (days)	Relative Control Rating							Safety Rating	
		Scab	Rusts	Brooks Spot	Black Rot/ White Rot	Bitter Rot	Sooty Blotch and Flyspeck	Powdery Mildew	Golden Del.	Red Del.
trifloxystrobin (Flint 50 WG) 0.5 to 0.625 oz[3]	14	6	4	5	4	4	5	4	5	5
triflumizole (Procure 50WS) 1 to 2 oz[3] + *captan* (Captan 50 W) 0.75 lb	14	6	5	4	2	1	1	5	6	6
or *mancozeb* 75 DF or 80 W 0.75 lb or F4 0.6 qt	77	6	5	4	1	2	3	5	6	6
or *metiram* (Polyram) 80 DF 0.75 lb	77	6	5	4	1	2	3	5	6	6
ziram (Ziram F4)[5] 3 pt or (Ziram 76 W or Ziram Granuflo)[5] 2 lb	14	3	4	4	3	4	5	1	4	5

[3]When variable rates are given, use higher rate when the likelihood of disease is high.
[5]Combine ziram with thiophanate-methyl 85WDG at 2 to 3 oz/100 gal to improve white rot, black rot, sooty blotch, and flyspeck control.

Relative Effectiveness of Insecticides and Miticides[1]

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

Material	Insects and Mites																		Fruit finish
	SJS	RAA	AA/ SA	WLH	PB	PC	CM	OFM	TABM	VLR/ RBL	STLM	CMB	AM	JB	WAA	BMSB	ERM	TSM	
Acramite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	5
Actara	4	5	5	5	4	5	2	2	1	1	3	3	1	4	2	4	—	—	5
Agri-Mek	—	—	—	5	—	—	—	—	—	—	5	—	—	—	—	—	5	5	4
Altacor	—	—	—	—	—	1	5	5	5	5	5	—	1	—	—	—	—	—	5
Ambush	—	3	4	5	3	3	—	—	—	—	4	—	—	—	1	2	—	—	4
Apollo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	5
Asana	—	3	4	5	3	3	4	5	4	5	4	—	3	4	—	2	—	—	4
Assail	3	5	5	5	3	3	4	4	2	2	4	5	3	4	2	2	—	—	5
Avaunt	—	—	—	5	2	5	3	3	4	4	—	—	1	3	—	—	—	—	5
Belt	—	—	—	—	—	—	4	4	4	5	4	—	—	—	—	—	—	—	5
B. thuringiensis	—	—	—	—	—	—	1	1	3	3	—	—	—	—	—	—	—	—	5
Calypso	3	5	5	5	4	4	4	4	2	2	4	4	5	4	2	3	—	—	5
Centaur	5	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
Clutch	—	5	5	5	—	4	3	3	1	1	3	—	3	4	—	3	—	—	5
CYD-X	—	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	5
Danitol	—	4	4	5	5	3	4	5	4	5	3	3	3	5	—	3	3	3	5
Delegate	—	—	—	1	—	2	5	5	5	5	5	—	2	—	—	—	—	—	5
Diazinon	5	5	1	1	4	3	4	4	3	3	2	5	2	3	5	2	—	—	3
Endigo	2	5	5	5	5	5	3	4	5	5	4	3	3	5	2	4	—	—	4
Envidor	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	4	5
Esteem	5	2	2	—	—	—	3	4	2	2	4	—	—	—	—	—	—	—	5
Guthion	4	1	1	1	4	5	4	5	2	4	1	1	5	5	1	2	—	—	5

[1]Relative effectiveness ratings for specific insecticides reflect their efficacy as labeled. For instance, if a product is effective against an insect but it cannot be used because the preharvest interval prevents its application when the insect is present, it would be rated as no activity.

Pest Key:
SJS = San Jose scale
RAA = Rosy apple aphid
AA/SA = Apple aphid/spirea aphid
WLH = White apple leafhopper
PB = Plant bugs
PC = Plum curculio
CM = Codling moth
OFM = Oriental fruit moth
TABM = Tufted apple bud moth
VLR/RBL = Variegated/redbanded leafroller
STLM = Spotted tentiform leafminer
CMB = Comstock mealybug
AM = Apple maggot
JB = Japanese beetle
WAA = Woolly apple aphid
BMSB = Brown marmorated stink bug
ERM = European red mite
TSM = Two-spotted spider mite

Relative Effectiveness of Insecticides and Miticides[1] (continued)

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

Material	Insects and Mites																		Fruit finish
	SJS	RAA	AA/ SA	WLH	PB	PC	CM	OFM	TABM	VLR/ RBL	STLM	CMB	AM	JB	WAA	BMSB	ERM	TSM	
Imidan	2	1	1	1	4	4	3	3	2	4	1	1	4	4	1	2	—	—	5
Intrepid	—	—	—	—	—	—	4	3	5	5	4	—	—	—	—	—	—	—	5
Lannate	3	3	3	5	4	3	3	3	3	4	4	2	2	2	1	4	—	—	4
Lorsban	5	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
Movento	5	4	4	—	—	—	—	—	—	—	—	4	—	—	3	—	—	—	5
Oil	4	2	—	—	—	—	1	—	1	—	—	—	—	—	—	—	4	2	3
Oil + Lorsban	5	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	3
Nexter	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	4	3	4
Portal	—	—	—	5	—	—	—	—	—	—	—	3	—	—	—	—	5	5	4
Provado	2	5	5	5	2	2	2	2	1	2	4	4	4	4	3	2	—	—	5
Rimon	—	—	—	—	—	—	4	4	4	5	—	—	—	—	—	2	—	—	4
Savey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	5
Sevin	2	—	—	5	3	3	4	3	2	2	2	—	3	5	—	1	—	—	4
Surround	—	—	—	—	—	4	2	2	2	2	1	—	4	2	—	—	—	—	5
Thionex	—	4	4	4	5	3	2	2	2	2	4	—	2	4	4	5	—	—	4
Vendex	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	4	4
Voliam Flexi	4	5	5	5	4	4	5	5	5	5	5	3	2	3	2	2	—	—	5
Vydate	3	4	3	5	3	1	1	1	1	1	4	2	—	2	2	2	2	3	4
Warrior	—	4	5	5	4	3	4	5	4	5	4	—	3	5	—	3	—	—	4
Zeal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	5	5

[1]Relative effectiveness ratings for specific insecticides reflect their efficacy as labeled. For instance, if a product is effective against an insect but it cannot be used because the preharvest interval prevents its application when the insect is present, it would be rated as no activity.

Pest Key:
SJS = San Jose scale
RAA = Rosy apple aphid
AA/SA = Apple aphid/spirea aphid
WLH = White apple leafhopper
PB = Plant bugs
PC = Plum curculio
CM = Codling moth
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VLR/RBL = Variegated/redbanded leafroller
STLM = Spotted tentiform leafminer
CMB = Comstock mealybug
AM = Apple maggot
JB = Japanese beetle
WAA = Woolly apple aphid
BMSB = Brown marmorated stink bug
ERM = European red mite
TSM = Two-spotted spider mite

Toxicity of Pesticides to Beneficial Arthropods

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

Material	Mite Predators			Aphid Predator	Generalist predators (lady beetles, lacewings, syrphids, *Orius*)	Parasitic Wasp
	Stethorus punctum	*Amblyseius fallacis*	*Zetzellia mali*	*A. aphidomyza*		*Trichogramma*
Actara	2	1	1	—	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	—
Belt	1	0	0	0	1	0
Bacillus thuringiensis	0	0	0	0	2	0
Calypso	3	1	1	—	2	—
Centaur	2	—	—	—	1	—
Clutch	3	1	1	—	2	—
CYD-X	0	0	0	0	0	0
Danitol	3	3	3	3	3	—
Diazinon	2	2	—	3	2	—
Endigo	3	3	3	3	3	2
Envidor	1	—	—	—	1	—
Esteem	2	0	0	1	2	—
Guthion	1	2	1	3	2	2
Imidan	1	2	1	1	1	1
Intrepid	0	0	0	0	0	1
Lannate	3	3	2	3	3	3
Lorsban	1	1	2	2	2	3
Movento	0	0	0	1	1	0
Oil	1	1	2	1	1	1
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
SpinTor	0	1	0	0	0	—
Vendex	1	1	1	1	1	—
Voliam Flexi	2	1	1	—	2	—
Vydate	2	3	3	2	3	—
Zeal	0	1	1	—	1	—

Weed Response to Preemergence Herbicides

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

HERBICIDES	Chateau	Diuron	Alion	Solicam	Prowl	Oryzalin	Simazine	Sinbar	Oxyfluorfen	Pennant Magnum	Rimsulfuron
BIENNIAL AND PERENNIAL WEEDS											
Bermudagrass	0	0	0	0	0	0	0	2	0	0	0
briars	0	1	—	0	0	0	0	—	0	0	—
dallisgrass	2	2	0	2	1	1	1	—	2	0	—
dogfennel	2	3	0	5	2	2	3	4	3	0	—
horsenettle	2	1	—	0	0	0	1	3	0	0	—
Johnsongrass (rhizome)	0	0	0	0	2	2	2	—	0	0	—
musk thistle	—	4	—	4	0	4	5	2	2	0	—
plantains	4	0	1	4	2	2	4	4	2	0	—
wild garlic	—	2	0	4	0	0	—	4	1	0	—
yellow nutsedge	0	0	0	3	0	0	1	3	0	4	3
ANNUAL GRASSES											
barnyardgrass	4	4	5	4	4	4	3	4	3	5	3
crabgrass	4	4	5	4	5	5	3	4	5	5	3
fall panicum	4	3	4	4	4	4	3	5	3	5	—
goosegrass	4	4	5	4	5	5	4	4	4	5	—
Johnsongrass (seedling)	4	2	—	3	4	3	2	5	3	3	—
signalgrass (broadleaf)	4	3	5	3	5	3	2	4	2	4	—
BROADLEAF WEEDS											
chickweed	5	4	5	5	5	3	4	5	5	—	—
cocklebur	4	3	—	2	0	0	3	3	1	0	3
evening primrose	4	3	4	—	2	2	4	5	5	—	—
galinsoga	—	4	—	4	0	2	4	4	4	5	—
horseweed	5	3	4	4	0	1	4	5	2	—	4
jimsonweed	5	3	—	2	1	1	3	2	—	—	—

Weed Response to Preemergence Herbicides (continued)

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

HERBICIDES	Chateau	Diuron	Alion	Solicam	Prowl	Oryzalin	Simazine	Sinbar	Oxyfluorfen	Pennant Magnum	Rimsulfuron
BROADLEAF WEEDS (continued)											
lambsquarters	5	4	5	4	2	2	4	5	3	—	3
morningglories	5	4	4	1	2	2	4	5	0	0	4
nightshades	5	3	—	4	1	1	3	5	3	5	3
pigweeds	5	4	5	4	4	4	5	5	4	5	5
prickly sida	4	2	1	4	1	1	4	5	2	0	3
ragweed	5	5	4	4	1	2	5	5	5	—	3
spotted spurge	5	0	5	3	3	3	2	5	—	—	5
wild radish, mustards	5	4	4	4	2	2	5	5	4	0	—

Weed Response to Postemergence Herbicides

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

HERBICIDES	Rely	Glyphosate	Paraquat	2, 4-D	Basagran	Fusilade	Poast	Clethodim	Aim	Treevix	Fluroxypyr
BIENNIAL AND PERENNIAL WEEDS											
Bermudagrass	2	3	1	0	0	5	4	5	0	0	0
briars	3	4	1	3	0	0	0	0	0	0	3
dallisgrass	4	4	4	0	0	3	3	3	0	0	—
dogfennel	—	5	0	3	0	0	0	0	0	—	—
horsenettle	2	3	2	1	0	0	0	0	0	1	4
Johnsongrass (rhizome)	4	4	1	0	0	4	4	4	0	0	—
musk thistle	4	5	2	5	4	0	0	0	0	3	—
plantains	—	5	2	4	—	0	0	0	0	0	4
wild garlic	4	3	1	3	0	0	0	0	0	0	—
yellow nutsedge	2	4	1	0	4	0	0	0	0	0	—

Weed Response to Postemergence Herbicides (continued)

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

HERBICIDES	Rely	Glyphosate	Paraquat	2, 4-D	Basagran	Fusilade	Poast	Clethodim	Aim	Treevix	Fluroxypyr
ANNUAL GRASSES											
barnyardgrass	4	5	3	0	0	4	4	4	0	0	—
crabgrass	5	5	4	0	0	5	5	5	0	0	—
fall panicum	5	5	4	0	0	5	5	5	0	0	—
goosegrass	5	5	4	0	0	4	4	4	0	0	—
Johnsongrass (seedling)	5	5	4	0	0	5	5	5	0	0	—
signalgrass (broadleaf)	4	5	4	0	0	4	4	4	0	0	—
BROADLEAF WEEDS											
chickweed	5	5	5	2	0	0	0	0	1	0	5
cocklebur	5	5	5	5	5	0	0	0	4	5	5
evening primrose	4	2	3	5	1	0	0	0	2	3	5
galinsoga	5	5	5	3	5	0	0	0	0	—	—
horseweed	3	5	2	3	1	0	0	0	0	5	5
jimsonweed	4	5	5	5	5	0	0	0	4	—	—
lambsquarters	4	5	5	5	4	0	0	0	5	5	—
morningglories	5	4	4	4	1	0	0	0	4	5	5
nightshades	5	5	5	5	1	0	0	0	4	5	3
pigweeds	5	5	5	4	1	0	0	0	5	5	3
prickly sida	5	5	4	4	4	0	0	0	0	5	—
ragweed	5	5	5	5	5	0	0	0	0	5	4
spotted spurge	5	5	5	5	—	0	0	0	1	—	—
wild radish, mustards	5	4	3	5	5	0	0	0	3	4	—

Fungicides and Bactericides

***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 nonsprayed trees. Captan results in excellent fruit finish. Captan is NOT safe with oil or within 2 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 (Cuprofix Ultra 40 Disperss), 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 relatively weak on powdery mildew and cedar apple rust and has little summer disease activity. Use Vangard 75WG on a 7-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 7-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 EBI fungicides will control rust diseases. Use a minimum of 100 gallons water per acre to ensure complete coverage. Do not apply more than 22 ounces of Vangard 75WG per acre per season. Do not apply within 72 days of harvest. See discussion under pyrimethanil Scala SC for resistance management strategies.

***Difenoconazole+cyprodinil,* Inspire Super**
Inspire Super is a premix of the EBI 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 EBI fungicides on powdery mildew. It has been shown to provide good control of apple scab in orchards where low levels of the apple scab fungus are resistant to other EBI fungicides. For improved scab control where resistance to EBDC fungicides is suspected, combine Inspire Super with and EBDC fungicide or captan. When used in rotation with captan + a phosphite fungicide it provides good summer disease control (see SECOND COVER AND LATER SPRAYS, page 24). Use the 12 fl oz/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 EBI fungicides. Do not apply more than 60 fl oz of Inspire Super per year.

***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 7-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 compatible with oil and 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 80W. 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 an EBI 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 + an EBI fungicide for scab control if resistance is suspected. Mancozeb and metiram are weak on white rot and black rot. Fruit finish with metiram is generally better than with mancozeb.

***Fenarimol,* various trade names**
Fenarimol, formulated as 1EC, is effective against scab, powdery mildew, and cedar-apple rust. For dilute applications (greater than 200 gallons per acre), apply fenarimol EC at 3 ounces plus mancozeb 80W (0.75 pounds) or 75DF (0.75 pounds) or 4F (0.6 quart) or metiram 80W (0.75 pounds) or Captan 50W (0.75 pounds) per 100 gallons on a 7- to 10-day protectant schedule, beginning at green tip. For concentrate applications (less than 200 gallons per acre), use 8 to 12 ounces of fenarimol EC per acre combined with captan or mancozeb. Do not use less than 8 ounces of fenarimol EC per acre. If powdery mildew or rusts are a problem, use 8 to 12 ounces per acre. Fenarimol EC can be applied in an after-infection program for apple scab. The first application should be applied within 96 hours from the beginning of an infection period at 8 to 12 ounces per acre. A second application should be made 7 days later at 8 to 12 ounces per acre. See label for details of use in an after-infection program for

apple scab. These same rates can be used to eradicate existing visible lesions; however, eradicant applications should be avoided. It is very important to use two applications 5 to 7 days apart for effective eradication. Include a full rate of a protectant in the first spray of the eradicant program. *In orchards where EBI resistance is present, fenarimol + 3.0 pounds per acre of mancozeb, or captan, or metiram will not satisfactorily control scab.* Do not apply more than 12 ounces per acre per application or more than 84 ounces per acre per season. Do not use fenarimol EC within 30 days of harvest.

***Fenbuconazole,* Indar**
Indar 75WSP is an EBI fungicide and has activity similar to other EBI fungicides (fenarimol, myclobutanil, triflumizole, fenbuconazole, and tebuconazole) on apple scab, powdery mildew, and the rust diseases. It 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 N.C. (given the pressure typically present during the summer). Use Indar 75WSP at 2.67 oz/acre. Do not make more than 4 applications of Indar per season, and do not apply more than 10.67 oz/acre/season. Because it is in the same chemical class as the other EBI fungicides, it will not control strains of the apple scab fungus resistant to them. 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.

***Flutriafol,* Topguard**
Topguard 1.04SC is an EBI fungicide with activity on scab, powdery mildew, cedar apple rust and quince rust. It is somewhat weaker on apple scab than the other new EBI fungicides but has very good powdery mildew activity. For scab control combine 13.0 fl oz with 3.0 lb 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 fl oz per acre. Use the higher rate on susceptible cultivars where powdery mildew has been a problem. Do not use more than 52 fl oz per acre or make more than 4 applications of Topguard per season. Do not add adjuvants to the spray solution or make an application within 14 days of harvest.

***Fosetyl-Al,* Aliette**
Aliette WDG is registered for crown (collar) rot control on apple trees in the orchard or in 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.

***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 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 nonstrobilurin 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**
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 2 weeks after planting. See the label for correct use rates.

***Myclobutanil,* various trade names**
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 7- 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 5 to 7 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, or captan, or metiram will not satisfactorily control scab. Myclobutanil 40W, when used alone, has very little activity on any summer diseases.

Phosphite fungicides (phosphonate fungicides)
Phosphite fungicides are fungicides that 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 broadspectrum 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 broadspectrum control of diseases including Glomerella leaf spot and Alternaria leaf spot (rotation with Pristine). There are several different phosphite fungicides in the market including ProPhyt, K-Phyt, 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 percent of the strobilurin fungicide pyraclostrobin plus 25.2 percent 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 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*, 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 4 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.

***Pyrimethanil,* Scala**
Scala SC, an anilinopyrimidine (AP) fungicide, contains 45.4 percent 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 fl oz/acre alone or 5 fl oz/acre in combination with 3 lb/acre of mancozeb or metiram on a 5- to 7-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 4 sprays of either product alone or 5 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 oz 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 4- or 5-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. Streptomycin is registered for use at 50 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 7-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. Sulfur is not safe to use above 90°F. Many formulations of sulfur are available; check label for rates.

***Tebuconazole,* Tebuzol**
Tebuconazole (Tebuzol 45DF) is an EBI fungicide with a similar activity to the other EBI fungicides. At 4.0 to 8.0 oz per acre it controls scab, cedar apple rust, quince rust, and powdery mildew. It should be combined with 3.0 pounds per acre of mancozeb, metiram, or captan to reduce the possibility of resistance developing. *In orchards where EBI resistance is present, Tebuzole or Tebuzole + 3.0 pounds per acre of mancozeb, or captan, or metiram will not satisfactorily control scab.* Tebuzole has 72 hours of eradicant activity from the beginning of a scab infection period. Do not use over 3 pounds per acre per season. Tebuzol has a 75 day phi.

***Thiophanate-methyl,* various trade names**
Thiophanate-methyl, formulated as 85WDG, was originally sold as Topsin M but is now available under several other trade names. Thiophanate-methyl 85WDG is NOT recommended for apple scab control in North Carolina because of widespread resistance to it, but it is very useful for summer disease control. For broad spectrum summer disease control, combine thiophanate-methyl 85WDG at 2 to 4 ounces per 100 gallons with Captan 50W at 1.5 pounds to 2.0 pounds or Captec 4 L at 0.75 to 1.0 quart per 100 gallons; or ziram 76 W at 2.0 pounds or ziram 4 F at 3 pints per 100 gallons. Thiophanate-methyl 85WDG applied alone at 4 to 6 ounces per 100 gallons will provide good control of sooty blotch, flyspeck, Brooks spot, black pox, white rot, and black rot. It is **ineffective** against bitter rot and Glomerella leaf spot.

***Trifloxystrobin,* Flint**
Flint 50WG is a strobilurin fungicide (QoI) with protectant and eradicant properties. It has very good activity on apple scab. Although it has 48-hour eradicant activity, it is most effective when used in a protectant program. It is also active on powdery mildew, but powdery mildew control is improved if Flint is alternated with a sterol inhibitor fungicide. Use 2.0 to 2.5 ounces per acre for apple scab and powdery mildew control. Use the higher rate where conditions are favorable for disease development. Flint 50WG provides very good control of sooty blotch and flyspeck when applied at 2.0 to 2.5 ounces per acre in the last two sprays of the season. Flint 50WG will suppress bitter rot when applied at 3.0 ounces per acre on a 10- to 14-day interval. In orchards where white rot is a problem, mix 1.5 ounces of Flint 50WG per acre with 2.4 pounds Captan 40W per acre. Resistant strains of *Alternaria mali* are widespread and Flint should not be relied on to control Alternaria blotch. It is weak on black pox. Do not apply more than 11 ounces of Flint 50WG per acre per season. Do not apply Flint 50WG within 14 days of harvest. Do not exceed more than four applications of Flint 50WG per season. To avoid resistance, do not apply more than two consecutive applications of Flint 50WG without using a nonstrobilurin fungicide.

***Trifloxystrobin + tebuconazole,* Adament**
Adament is a combination of the QoI fungicide trifloxystrobin (Flint) and the EBI fungicide tebuconazole. It has good activity on scab IF there is not resistance in the orchard to either or both groups of chemistry (i.e., EBI or QoI). It also has activity on cedar apple rust and powdery mildew. Although it has activity on summer diseases, the 75-day PHI precludes its use for most of the summer season. Both QoI and EBI fungicides tend to be weak on Brooks spot and black pox, so if Adament is used in the petal fall, first, and second cover sprays, it should be combined with an EBDC fungicide. Do not make more than 4 applications of Adament per season or more than two sequential applications of it or other QoI or EBI fungicides.

***Triflumizole,* Procure**
Procure is an EBI fungicide with activity similar to that of other EBI fungicides. It is registered at 2 to 4 ounces per 100 gallons for the control of scab, powdery mildew, and cedar apple rust. It should be applied 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 7- to 10-day schedule beginning at green tip. Use the higher rate of Procure 50WS if scab or mildew has been a problem in the orchard or if the weather is very favorable for scab infection. Higher rates of Procure 50WS will effectively eradicate scab up to 72 hours after the beginning of a scab infection period. *In orchards where EBI resistance is present, triflumizole + 3.0 pounds per acre of mancozeb, or captan, or metiram will not satisfactorily control scab.* Procure 50WS does not have much useful activity for control of the summer diseases. Do not use more than 64 ounces of Procure 50WS per acre per season.

***Ziram,* Ziram**
Ziram, formulated as 76W, 76WDG (Granuflo), or 4F, is a dithiocarbamate fungicide in the same group as thiram and ferbam. It is registered for apple scab control but is most useful for summer disease control. 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 rot or black rot. The 76W and 76WDG formulations should be used at 2 pounds per 100 gallons, the 4F at 3 pints 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 56 pounds per acre per season.

Insecticides and Miticides

Adjacent to each pesticide is the IRAC mode of action (MoA) classification number. Pesticides within the same MoA group have the same mode of action.

Organophosphate Compounds

***Azinphos-methyl*, Guthion (MoA group 1B)**
Azinphos-methyl is formulated as a 50WP (0.5 to 0.75 pounds per 100 gallons). It is a broad-spectrum insecticide that is effective against many direct pests of apples, particularly non-resistant codling moth, Oriental fruit moth, plum curculio, and apple maggot, with residual activity of 10 to 14 days. Azinphos-methyl is highly toxic and should be used with extreme care. Azinphos-methyl will not be allowed for use on apples after 2012, and the total allowable use rate per acre per season (formulated product) is 3 pounds. The re-entry interval is 14 days for rates of 1 pound AI/acre or less, and 21 days for rates greater than 1 pound AI/acre. The preharvest interval is 14 days when applied at 1 pound AI/acre or less, and 21 days for rates greater than 2 pounds AI/acre. For pick-your-own operations, allow a preharvest interval of 33 days for rates of 0.6 pound AI/acre or less, 39 days for rates of 0.6 to 1.0 pound AI/acre, and 44 days for rates greater than 1.0 pound AI/acre. A 60-foot vegetation buffer area must be maintained around permanent bodies of water, and azinphos-methyl should not be applied within 60 feet of occupied dwellings, which do not include farm buildings and barns.

***Chlorpyrifos,* Lorsban (MoA group 1B)**
Chlorpyrifos is formulated as a 4EC, 50W and 75WG. All formulations can be applied to the canopy of trees only during the prebloom period and will control San Jose scale, climbing cutworms, and nonresistant rosy apple aphids, and the 75WG formulation can be applied through petal fall. The 4EC can be used once per season as a dormant or delayed dormant application at 0.5 to 1.0 pint per 100 gallons. When mixed with 2 gallons oil per 100 gallons water and applied as a delayed dormant spray, it is effective against San Jose scale and cutworms. Use the 50WP at a rate of 0.5 to 0.75 pounds per 100 gallons, and the 75WG formulation at 0.5 to 0.67 pounds per 100 gallons. Do not use the 50W formulation with oil. Do not enter treated orchards for 4 days after application. A supplemental label exists for Lorsban 4EC to control borers in apples after bloom. Under the supplemental label, applications must be directed at the trunk from a distance of no more than 4 feet using a low-pressure handgun or shielded sprayer, and spray should not contact foliage or fruit. For borer control, use the 4E formulation at 1 to 2 quarts per 100 gallons and the 50W at 3 pounds per 100 gallons. NOTE: Only one application of Lorsban can be applied per season, regardless of whether the application is made to the canopy before bloom, or to the trunk for borer control after bloom.

***Diazinon,* Diazinon (MoA group 1B)**
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, San Jose scale, and Comstock mealybugs. The 50WP formulation may be applied up to 21 days before

harvest. 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 russetting.

***Methidathion*, Supracide (MoA group 1B)**
Methidathion is formulated as Supracide 2E. Used at a rate of 1 to 2 pints per 100 gallons and tank-mixed with an oil as a delayed dormant application, it will control San Jose scale and rosy apple aphids. Do not apply after any blossoms have opened.

***Phosmet*, Imidan (MoA group 1B)**
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 the tufted apple bud moth or San Jose scale. It is one of the safest organophosphates to beneficial arthropods. It has a re-entry interval following application of 3 days, and a preharvest interval of 7 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.

Carbamate Compounds

***Carbaryl*, Sevin (MoA group 1A)**
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, codling moth, Oriental fruit moth, and Japanese beetle and good control of cicada and redbanded leafroller. Carbaryl is also used as a fruit thinner on several apple varieties. Carbaryl may be applied within 3 days of harvest. Carbaryl may roughen the lenticles of fruit.

***Methomyl*, Lannate (MoA group 1A)**
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). Methomyl 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 re-entry interval of 3 days. Do not apply within 14 days of harvest.

***Oxamyl*, Vydate (MoA group 1A)**
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.

***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 larval stages and will not directly affect mite predator populations. It is most effective when applied when mite populations are low, or at petal fall or first cover. To minimize the potential for resistance development, do not use Savey or Apollo in the same or successive years.

Carbazate Compounds

***Bifenazate*, Acramite (MoA group UN – unknown)**
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 7 days before harvest.

Diamide Compounds

***Chlorantraniliprole*, Altacor (MoA group 28)**
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 oz 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 lb active ingredient (chlorantraniliprole) may be applied per season.

***Flubendiamide*, Belt 4SC (MoA group 28)**
Flubendiamide is formulated as a 4SC and is used at 3 to 5 ounces per acre. It is active against lepidopteran pests, including codling moth, and is safe to most beneficial insects and mites. Do not exceed 15 ounces per acre per season, and do not apply within 14 days of harvest. For resistance management rotation schemes, remember that flubendiamide and chlorantraniliprole have the same mode of action.

Neonicotinoid Compounds

***Acetamiprid*, Assail (MoA group 4A)**
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 7 days before harvest.

***Clothianidin,* Belay (MoA group 4A)**
Clothianidin is formulated as Belay 2.13SC. It is recommended at 4 to 6 ounces per acre for control of aphids and leafhoppers, and 6 to 12 ounces per acre for plum curculio, apple maggot, and stink bugs. It is toxic to coccinelid predators (lady beetles) upon contact, and to honey bees for up to 5 days after application. Do not apply closer than 14 days before harvest or more than 12 ounces per acre per year.

***Imidacloprid*, Provado, Admire, various generics (MoA group 4A)**
Imidacloprid is formulated as Provado 1.6F and Admire 4.6SC. It is a systemic insecticide that affects the nervous system of insects and is recommended at rates of 4 to 8 ounces 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 7 days of harvest.

***Thiacloprid,* Calypso (MoA group 4A)**
Thiacloprid is formulated as Calypso 4F. It has systemic activity and is recommended at 0.5 to 1.0 ounce per 100 gallons for control of aphids, leafminers, leafhoppers, and mirid bugs. For control of apple maggot, codling moth, oriental fruit moth, and plum curculio, it should be used at 4 to 8 ounces per acre. It is toxic to coccinelid predators (lady beetles) upon contact. Do not apply closer than 30 days before harvest or more than 16 ounces per acre per year.

***Thiomethoxam,* Actara (MoA group 4A)**
Thiomethoxam 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 rates greater than 2.75 ounces per acre.

Organotin Compounds

***Hexakis*, Vendex (MoA group 12B)**
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.

Oxadiazine Compounds

***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 8 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.

Phenoxypyrazol Compounds

***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. It is used at 1 to 2 pts per acre, with the 1 pt 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 require 3 to 7 days to die. Portal has a 14-day preharvest interval, and a maximum of 2 pts per acre per season is allowed.

Pyridazinone Compounds

***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. Pyridaben 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 predacious mites, but is toxic to *Stethorus punctum*. Do not make applications closer than 30 days apart, and do not apply within 25 days of harvest.

Sulfur

Sulfur will suppress the European red mite and two-spotted spider mite when used in cover sprays on a regular basis. However, the use of sulfur after bloom may affect the fruit finish on Golden Delicious, Red Delicious, and Stayman. Also, sulfur is not safe to use above 90^{o}F. Studies in North Carolina have shown that micronized sulfur suppressed mites better than wettable sulfur.

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.** If these materials must be used, limit their use to a single application before bloom, preferably with an oil as a delayed dormant application.

***Esfenvalerate,* Asana (MoA group 3)**
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 apple 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 (MoA group 3)**
Fenpropathrin is formulated as a 2.4EC (Danitol 2.4EC) and is used at a rate of 10⅔ to 21⅓ 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 pyrethriod 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 42⅔ ounces per acre per season.

***Lambda-cyhalothrin,* Warrior (MoA group 3)**
Lambda-cyhalothrin is formulated as Warrior and contains 1 pound 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 2.56 to 5.12 ounces per acre. Do not apply closer than 21 days before harvest.

***Permethrin,* Ambush, Pounce (MoA group 3)**
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.

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 (1 to 3 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 7 days of harvest. A spray adjuvant having spreading and penetrating properties must be used with Movento. Use of Induce with Movento is prohibited on apple.

Tetrazine Compounds

***Clofentezine,* Apollo (MoA group 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 larval stages and will not directly affect mite predator populations. To minimize the potential for resistance development, do not use Apollo or Savey in successive years.

Biologically Based Insecticides

***Abamectin,* Agri-Mek (MoA group 6)**
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 percent 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 2 weeks before or after applying Agri-Mek and oil.

***Bacillus thuringiensis,* Dipel, Xentari, CryMax (MoA group 11)**
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 require up to 3 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 gal/acre tree row volume) the rates should be increased to 1.5 pounds per acre.

***Cydia pomonella granulovirus,* CYD-X, Carpovirusine**
This virus is a naturally occurring disease of the codling moth. Larvae must ingest virus particles to be effective, and death will occur within 3 to 5 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, and Carpovirusine is recommended at 1 to 2 pints per acre. 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 5 to 7 days, depending on weather conditions.

***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 oz per acre. When targeting codling moth, the initial application should be made at first egg hatch, which begins at 225 to 250 degree days after biofix. It will suppress apple maggot populations residing in a treated orchard when applied at 6 to 7 oz 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 7 days before harvest.

Insect Growth Regulators

***Buprofezin*, Centaur (MoA group 16)**
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, also 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.

***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 with 28 within days of harvest.

***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 lepidoteran 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 also 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.

***Novaluron*, Rimon (MoA group 15)**
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.

***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 ½ 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.

Pre-mixtures of Active Ingredients

***Chlorantraniliprole* + *Thiamethoxam*, Voliam Flexi (MoA group 28 and 4)**
This product contains two different active ingredients (in a 1:1 ratio) with different modes of action. It is formulated as a 40WDG and used at the rate of 4 to 7 ounces per acre. Chlorantraniliprole (the same active ingredient in Altacor) controls lepidopteran pests, and the neonicotinoid thiamethoxam exhibits activity against aphids, bugs and plum curculio. Thiamethoxam is the same active ingredient in Actara (see description under neonicotinoid section). Regardless of the product used (Altacor or Voliam Flexi) a maximum of 0.2 lbs per acre per season of chlorantraniliprole may be applied. Voliam Flexi has a 35 day preharvest interval.

***Lambda-cyhalothrin* + *Thiamethoxam*, Endigo (MoA group 3 and 4).** This is a mixture of 0.88 lbs of lambda-cyhalothrin and 1.18 lbs of thiamethoxam per gallon of formulated product. It is a broad spectrum product that is most useful for control of stink bugs. 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.

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 percent 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.

Superior Oil

In the green-tip spray, a superior-type oil applied as a 2 percent solution (2 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 ½ to 1 percent (0.5 to 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 superior-type oil with a minimum viscosity of 68 to 78 seconds (at 100^{o}F), minimum unsulfonated residue of 92 percent, a minimum pourpoint (^{o}F) of 20, and distillation at 10 mm Hg (^{o}F 50% point) of 412 + 8.

A superior-type spray 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 for mating disruption 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 Pheromone

CheckMate CM/OFM Pheromone dispensers are similar to CheckMate CM-XL 1000, but contain pheromone of both codling moth and Oriental fruit moth. Each dispenser contains 270 mg of codling moth pheromone and 250 mg of Oriental fruit moth pheromone. Dispensers are applied at 150 to 200 per acre. Pheromone will be released for approximately 160 days.

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 mg of codling moth pheromone and 105 mg 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.

CideTrak CM/OFM Dispensers contain both codling moth and oriental fruit moth pheromone for mating disruption of both pests. Each dispenser contains a total of 240 mg of codling moth pheromone and 250 mg of Oriental fruit moth pheromone. Dispensers should be attached to a limb in the upper third of the canopy at a density of 200 dispensers per acre.

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 180 days.

Oriental Fruit Moth Pheromone

CheckMate OFM Pheromone is dispensed through a membrane system, and dispensers are attached to the limbs of trees by a bread clip. Each dispenser contains 250 mg of Oriental fruit moth pheromone and should be applied at 100 to 200 dispensers per acre. Dispensers will release pheromone for a minimum of 90 days.

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 4 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.

Isomate-M 100 Dispensers consist of a reddish-colored polymer filled with Oriental fruit moth pheromone. They are twisted around the limbs of trees. Each dispenser contains 232.1 mg of Oriental fruit moth pheromone. It is recommended that they be applied at 100 dispensers per acre, and they will emit pheromone for about 100 days.

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 used 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. Preemergence herbicide rates usually vary according to soil type and should be applied at the rate recommended on the herbicide label.

Preemergence 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 percent 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 4 weeks after transplanting or 3 months before or after grafting. The Casoron CS formulation can be used only in orchards established 1 year or more. 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 are not expected to exceed 70°F and rainfall is expected within a few days.

Diuron, **Karmex 80WDG, Karmex XP, 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 at least 1 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 lb ai per treated acre per year and no more than 2.4 lb ai is 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 at least 2 years for more broad-spectrum preemergence weed control. The additions 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 percent organic matter. **DO NOT** apply more than 4 pounds per acre per year. May be tank mixed with paraquat and glyphosate.

Flumioxazin, **Chateau 51WDG** (6 to 12 ounces per acre)
For best results in newly planted orchards, apply Chateau 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 percent. Trees established less than 1 year must be protected with a nonporous wrap or waxed container. Allow at least 30 days between sequential applications. In established orchards, apply after completion of final harvest until pink bud. Tank mix with paraquat, Rely, or glyphosate for postemergence weed control. **When Chateau is applied after trees leaf out, use paraquat or Rely only for postemergence weed control.** Chateau has a 60-day PHI. Total use cannot exceed 24 oz in a year.

Indaziflam, **Alion 1.67 SC** (5 to 6.5 fl. oz per acre)
Alion can be used in orchards established 3 years or more and sequential applications may be used so long as there are at least 30 days between applications and total use rate does not exceed 10.3 oz per acre per year. 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. Alion should be tank mixed with glyphosate, paraquat, or Rely for non-selective POST weed control.

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 4 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. Sequnetial 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.

Oryzalin, **Surflan 4AS** (2 to 4 quarts per acre), **Oryzalin** (2 to 4 quarts per acre)
Oryzalin will provide PRE control of annual grasses and some broadleaf weeds. It may be applied to newly planted orchards once soil has settled around the tree roots. Oryzalin is most effective if rain is received within 14 days of application. Oryzalin may be tank mixed with oxyfluorfen, paraquat, rimsulfuron, simazine, or glyphosate.

Oxyfluorfen, **Goal 2XL, Galligan** (2 to 8 pints per acre) **GoalTender 4EC** (1 to 4 pints per acre)**, Galigan H_2O** (1 to 3 pints per acre)
Oxyfluorfen will provide PRE control of broadleaf weeds, especially nightshade, groundcherry, and pigweed. **DO NOT** apply oxyfluorfen from the period after buds start to swell until completion of final harvest. Avoid any activity that may disturb the soil surface once oxyfluorfen has been applied. Rainfall is needed within 3 to 4 weeks to activate the herbicide. Oxyfluorfen may be tank mixed with Devrinol, paraquat, Kerb, glyphosate, simazine, Solicam, and Surflan.

Prowl H_20 (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_20 to simazine will expand control spectrum. Prowl H_20 may be applied as sequential applications so long as total use rate does not exceed 4 qts per acre per year. Allow at least 30 days between applications.

Rimsulfuron, **Matrix, Pruvin, or Solida** (4 oz per acre)
Treat only orchards established for one year or more. Rainfall within 2 to 3 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 oz per acre per year and application is made in a band on less than 50% of the orchard floor. Allow 30 days between applications. Tank mix with Oryzalin, Solicam, Karmex, or Sinbar for expanded control. Research has shown as little as 2 oz of product per acre improves the activity of diuron or Sinbar. The addition of glyphosate, paraquat, or Rely will be necessary for broadspectrum POST weed control. Rimsulfuron has a 7 day PHI for apples.

***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 Oryzalin or Solicam improve annual grass control. Simazine has a 150 day PHI for apple.

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 paraquat or glyphosate for postemergence weed control.

***Terbacil*, Sinbar 80WP or 80WG** (2 to 4 pounds per acre)
Sinbar provides PRE control of broadleaf and grass weeds. Trees must be established in the orchard for 3 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 percent 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. Sinbar may be tank mixed with glyphosate, paraquat, or Rely 280 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 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 1 to 3 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*, Basagran** (1.5 to 2 pints per acre)
Basagran may used in non-bearing apple orchards **ONLY**! Basagran controls certain broadleaf weeds and yellow nutsedge. For yellow nutsedge control, apply Basagran 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 7 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. Contact with fruit will result in spotting. Do not apply within 3 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 2 to 3 leaf stage. Aim may be tank mixed with preemergence herbicides.

***Clethodim*, Select, Intensity, Arrow 2EC, Volunteer** (6 to 8 oz per acre), **SelectMax,** or **Intensity One 1EC** (12 to 16 oz per acre)
Clethodim is registered for **NONBEARING** orchards. It controls annual and perennial grasses but has no activity on broadleaf weeds or sedges. Always add crop oil concentrate at 1 percent 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.

***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), **Comet 1.5** (0.66 to 2.66 pints per acre)
Starane is a postemergence herbicide that controls a variety of broadleaf weeds. Starane should not be applied in orchards established less than 4 years. Do not make more than one application per year. Do not apply during bloom. Apply in a minimum spray volume of 10 gpa. Do not apply within 14 days of harvest.

***Glufosinate*, Rely 280** (48 to 82 ounces per acre)
Rely 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 Rely to contact green or uncalloused bark on young trees. **DO NOT** apply it to orchards established less than 1 year. Rely may be tank mixed with Devrinol, Goal, Karmex, simazine, Sinbar, Solicam, and Surflan. Rely 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 ammonimum sulfate. The use of additional of surfactants, spreaders, or crop oil may increase the potential for apple tree injury.

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 2 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 the chart on page 66 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 morningglory, dandelion, Carolina geranium, glyphosate resistant horseweed, and dock).

***Glyphosate + carfentrazone,* Rage** (20 to 99 fl oz per acre)
Apply as directed spray for non-selective POST weed control. Do not apply to tree suckers or allow contact with desirable plant parts. Use hooded application equipment. The addition of a non-ionic surfactant at 0.25% v/v (1 quart per 100 gallons of spray solution) with 2 to 3 lbs of ammonium sulfate per acre will result in optimum herbicide performance. Rage has a 3 day PHI.

***Halosulfuron,* Sandea 75DF** (0.5 to 1 oz per acre)
Apply to trees established in the orchard for 1 year or more. The total use rate in a 12 month period cannot exceed 2 oz/A 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 qt per 100 gal of spray solution) is necessary for optimum herbicide performance. Sandea is a very effective herbicide for yellow and purple nutsedge control when applied timely to actively growing weeds. Sequential applications may be more effective than a single application. Halosulfuron may be tank mixed with glyphosate for broad spectrum POST weed control.

***Paraquat,* Firestorm, Parazone, Paraquat Concentrate** (1.75 to 2.7 pints), **Gramoxone 2SL** (2.5 to 4.0 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 1 year must be shielded to prevent injury.

***Saflufenacil,* Treevix** (1 oz 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 sequentially up to 3 applications 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 2 to 3 years). The PHI for Treevix is 7 days. In order for Treevix to be effective it must be applied with methylated seed oil at 1% v/v (1 gal per 100 gal of spray solution) and ammonium sulfate at 1 to 2% w/v (8.5 to 17 lb per 100 gal of spray solution). In order to have broadspecturm postemergence weed control Treevix must be applied in combination with glyphosate or Rely 280. Treevix is compatible with preemergence 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 to control broadleaf and grass weeds.

***2,4-D amine*,** various generic formulations (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. Apply any time during the growing season but not within 2 weeks before or after bloom. Apply no more than 2 applications per year. Allow at least 75 days between applications. 2,4-D will suppress clover bloom. **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.

Suggested Tank Mix Options*
Diuron + Sinbar
Diuron + Solicam
Simazine + Solicam
Simazine + Surflan
Diuron + Rimsulfuron
Sinbar + Rimsulfuron
*Include glyphosate, paraquat, or Rely for control of emerged weeds.

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%	2 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 1 month after (early summer)
blackberry	1.0 to 1.5%	Full bloom up to 1 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
greenbriar	3%	5 fully expanded leaves in spring
clematisvine	1%	After bloom until 1 week before frost
wisteria	1.5 to 2%	6 to 8 weeks after bloom (mid to late summer)
mugwort	1.5 to 2%	Full flower (late summer)
English ivy	2 or 3%	3 to 5 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.

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 compatability 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.

Goal	Chemical	Rate and Time of Application
To improve shape and increase fruit weight of Delicious apples.	Promalin, Perlan [*benzyladenine* (BA) +*gibberellin* (GA_{4+7})]	Apply Promalin (1-2 pt / 100 gal) or Perlan (0.5-1 pt / 100 gal) between king bloom opening and full-bloom stage as a fine mist at 40 to 50% of TRV calculated dilute water volume.
To increase lateral bud break and shoot growth and improve branch angle on 1-year-old wood on nonbearing trees.	Promalin + 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 3 to 4 weeks before anticipated bud break to promote greater branching with a bag or sleeve of 2- to 4-mil clear polyethylene. 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 about bloom time). 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 2-4 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).

Pro-Vide, 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 percent 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.

Goal	Chemical	Rate and Time of Application
To reduce russet formation caused by weather conditions on susceptible cultivars (esp. Golden Delicious).	Pro-Vide 10SG	Four applications at 7-10 day intervals at a rate of 60-100 g (2.1 to 3.5 oz) per 100 gal of water are necessary for optimal response. Make first application at petal fall. Do not exceed 400 g/acre/year for russet control. Apply as a fine mist.
	Novagib 10L	Apply Novagib in 2 to 4 consecutive applications. Make the first application of 20 to 33 oz in 100 gallons of water per acre at the beginning of petal fall. Repeat this at 7-10 day intervals. Do not apply more than 80 oz per acre per season.

Goal	Chemical	Rate and Time of Application
To reduce fruit cracking (esp. Stayman).	Pro-Vide 10SG	Make 3 to 6 consecutive applications of 50-100 g of Pro-Vide 10SG in 50 gallons of water per half acre (25-50 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 14-21 day intervals. Use of a nonionic surfactant will improve coverage and enhance penetration. **NOTE:** Do not treat for cracking suppression apples that have received Pro-Vide 10SG applications to suppress russet or Apogee sprays to reduce shoot growth during the same growing season.
	Novagib	Apply 2 to 4 pts of Novagib per acre in sufficient water to achieve good coverage of the fruit. Make the first of 3 to 6 consecutive applications two to three weeks before cracking is expected to occur. Repeat application at 14-21 day intervals. Apply under slow drying conditions. The efficacy of Novagib may be reduced by compounds causing a high pH in the spray tank. Use a nonionic surfactant to improve coverage and enhance penetration.

Chemical Fruit Thinning Sprays

Because of 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, trees are weak, or the weather is cool and cloudy, use lower concentrations of thinning chemicals. Also remember that young trees are generally easier to thin than mature trees. **Base the timing of thinner applications on average fruit diameter. 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.** All hand-gun applications should be made to the point of runoff at a rate of chemical use that is one-third to one-half the rate recommended for an airblast application. **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 (*naphthalene-acetic acid, NAA*)

The time of application for optimum thinning with NAA (Fruitone-L) or NAA plus carbaryl (Sevin) 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 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 formulation of NAA provides 2½ parts per million per 100 gallons for each ounce of Fruitone-L product used.

Sevin (*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 the "XLR Sevin" 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 russetting may result. The XLR formulation has 4 pounds 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.

Ethrel and Sevin *(ethephon and carbaryl)*

Combinations are not suggested for standard or nonspur Red Delicious cultivars because excessive thinning is likely to occur. For thinning spur Red Delicious, note that the thinning effect of ethephon and carbaryl (Ethrel and Sevin) is not translocated from nonfruiting 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 Ethrel-Sevin 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. 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 percent 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. Ethrel-Sevin 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, Ethrel-Sevin 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 washoff.

MaxCel and Sevin *(6-BA and carbaryl)*

MaxCel is a post-bloom thinner that can be applied when fruits range from 5 to 15 millimeters in diameter. MaxCel can be applied in concentrations ranging from 75 ppm to 150 ppm. Best results are obtained when MaxCel at a concentration of 75 to 100 ppm is tank mixed with Sevin at 0.5 to 1.5 pounds active ingredient (a.i.) per 100 gallons. MaxCel should be applied when maximum daily temperature will be 65°F or above for 2 or 3 days after application. Expect more thinning 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 percent of tree row volume.

Goal	Chemical	Rate and Time of Application
To defruit trees too young or too small to begin bearing (all varieties).	Fruitone L + Sevin + Ethrel	2 oz Fruitone L + 1 lb a.i. Sevin + 2 pt Ethrel per 100 gal applied at 8 to 10 mm fruit diameter. **Caution**: Application will temporarily suppress vegetative growth (3 to 4 wks).
To chemically reduce fruit load on bearing trees for improved fruit size and return bloom.	See fruit thinning chart on following page.	
To increase return bloom for the following season, especially on heavily cropped trees.[1]	Fruitone L	5 ppm (2 fl oz/100 gal), or 2.5 ppm + surfactant. After the chemical fruit-thinning window has passed (typically 6 weeks past petal fall), use biweekly applications of NAA in the next 3 to 4 cover sprays. (Typically 2 in June and 2 in July for apple-growing areas in the Southeast). These NAA applications may be tank mixed in pesticide cover sprays.
	Ethrel	16-72 oz/acre depending on cultivar, crop load and history of biennial bearing. Use 16-24 oz/acre on Gala, Romes, Red Delicious; 24-48 oz/acre on Golden Delicious; 48-72 oz/acre on Fuji, Cameo. Make a single application 5-6 weeks after bloom. Consider a second application 2-3 weeks later if the crop load is excessive. Do not use Ethrel on Honeycrisp.

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

Apple Thinning Recommendations for the Southeast

Thinner Activity	Chemicals/Combinations rate per 100 gal	Fruit Size avg-mm	Gala, Goldrush, Jonagold, etc.	Red Del.		Gold Del.	Rome		Fuji
				Std	Spur		Std	Spur	
least	Sevin XLR 1 pt	petal fall	X		X			X	
	Sevin 0.5-1 lb a.i.	7 to 9	X	X			X		
	Sevin + surfactant 0.5 - 1 lb a.i. + 0.5 - 1 pt	7 to 9	X	X			X		
	MaxCel + Sevin 75-100 ppm + 0.5 - 1.5 lb a.i.	8 to 12	X	X	X	X	X	X	X
	Sevin + Fruitone L 0.5 - 1 lb a.i. + 2.5 - 5 ppm	7 to 9	X	X	X nubbin possible		X	X	Do not use Fruitone L on Fuji
	Fruitone L 5 - 25 ppm	9 to 12				X			
	Fruitone L + surfactant 5 - 15 ppm + 0.5 - 1 pt	9 to 12				X			
	Sevin + spray oil 0.5 - 1 lb a.i. + 0.5 - 1 pt	6 to 9			X			X	
	Sevin + Ethrel + Fruitone L 1 lb a.i. + 0.5 - 0.75 pt + 2.5 ppm	9 to 11 18 to 30 for rethinning easy-to-thin varieties			X			X	
	Sevin + Ethrel 1 lb a.i. + 1.5 pt	12 to 18			X			X	X
most	Sevin + Ethrel + Fruitone L 1 lb a.i. + 1.5 pt +/- 5-10 ppm	18 to 30	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.
a.i. = active ingredient

Apple Re-Thinning Recommendations for the Southeast

Thinner Activity	Chemicals/Combinations (rates per 100 galons)	Timing of application	Rethinning (all varieties)
least	Sevin 0.5 - 1 lb a.i.	7 to 10 days after first thinner application	If needed to push weak/stunted fruit off, esp. on Golden Delicious
	Sevin + surfactant 0.5 - 1 lb a.i. + 0.5 - 1 pt	14+ days after first thinner application	Rome, Std. Reds, Mutsu, GoldRush, Jonagold, etc.
	Sevin + Ethrel ± Fruitone L 1 lb a.i. + 0.5 - 0.75 pt ± 2.5 ppm	18 to 30 mm and at least 14 days after first application	On moderately overcropped trees (150-200% crop load), esp. on easy-to-thin varieties
most	Sevin + Ethrel ± Fruitone L 1 lb a.i. + 1.5 pt ± 5 - 10 ppm	18 to 30 mm and at least 14 days after first application	Heavy to excessively over-cropped 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.

Apogee (*prohexadione calcium)*

Apogee (prohexidione calcium) reduces terminal growth by inhibiting synthesis of gibberellins, which regulate shoot growth in apples. Once applied, it requires between 10 and 14 days for Apogee to slow growth. Apogee degrades within the trees in a few weeks, so repeat applications will be necessary to maintain growth control throughout the entire growing season. **Applications must be continued 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 you apply per acre** depends on your tree row volume (TRV). While it is frequently suggested that plant growth regulators should be applied dilute, Apogee 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 oz. of Apogee per acre per season.

Time of Application: It is essential to make the first application when terminal shoots are no longer than 1 to 3 inches. This usually coincides with late bloom or petal fall. Successful use of Apogee 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.

Use of Apogee 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 russetting, respectively. Apogee inhibits gibberellin production in apple trees. Data indicate that Apogee may directly reduce russet and that it may enhance the efficacy of a GA4+7 program for russet control. However, Apogee may reduce the efficacy of preharvest GA4+7 sprays for control of cracking on Stayman. This has not been proven, but the possibility exists.

Use of Apogee to Control Fire Blight: Apogee will control fire blight on shoots by inducing resistance in the tree. 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 to be effective. The active ingredient in Apogee does not have any direct effect on the fire blight bacteria and it is not effective on blossom blight, so traditional control measures using streptomycin are necessary. Apply Apogee to control fire blight with applications that are made to control growth (when shoots are 1 to 2 inches in length) or no later than petal fall. Whether the 3- to 6-ounces-per-100-gallons rate used for growth control is as effective for fire blight control as a 12-ounces-per-100-gallons rate has not been determined for southeastern orchard conditions.

Cracking: On apple varieties known to be prone to cracking (such as Empire and Stay-man), Apogee has been associated with an increase in fruit cracking.

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.	Apogee	3 to 12 oz + 1 pt surfactant per 100 gal. 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 6-10 oz/100 gal. (See below table for application options.) Do NOT tank mix with calcium chloride or calcium nitrate or boron sprays. Apogee can be tank mixed with Sysstem-CAL calcium and pesticide cover sprays.

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

Application Options for Apogee 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	Ca[3]	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" 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 Apogee. Sysstem-CAL can be tank-mixed with Apogee.

Sucker Control

Apply as a low-pressure, large-droplet (to prevent drift up into the tree), directed-spray application at base of tree with handheld equipment. A thorough application, giving 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 when new sucker growth is 4 to 12 inches long. (Do not apply during the period from bloom to 4 weeks after bloom.)

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 concentration (10 oz/gal). Apply after dormant removal of suckers and when new sucker growth is 4 to 12 inches long.

Water Sprout Control

Do not **spray** Tre-Hold up into the trees. Tre-Hold should not contact buds or fruiting spurs. Tre-Hold use 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 giving complete wetting is necessary for good results.

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 colorization (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 1 to 2 weeks before the beginning of the harvest period of untreated fruit for the current season for multiple pick varieties. In a hot year, ReTain should be applied two weeks before harvest. ReTain has a 7-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 7 to 10 days. An additional application may be made if fruit is left for longer than 7 to 10 days or if the application fails to give satisfactory control. If a second application is made, apply it 6 to 7 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 adjuvant plus 20 ppm NAA applied 2 weeks prior to normal harvest provides superior control of fruit drop and firmness retention compared to ReTain or NAA alone.

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 (1 pouch) per acre plus Silwet L-77 or Sylgard surfactant at 0.1% (13 oz/100 gal) 4 weeks before anticipated normal start of harvesting using 100 gal/acre or 50% of TRV.
Preload NAA	Fruitone-L (*NAA*)	Apply Fruitone-L at weekly intervals beginning 4 weeks before date of normal anticipated harvest at the rate of 5 ppm/week. Application can be included with preharvest cover sprays.
To reduce preharvest fruit drop at or after the onset of fruit loosening or drop.	Fruitone-L	Apply at 8-32 fl oz/acre at first sign of preharvest fruit drop on most cultivars; 15 to 20 ppm may be required on late varieties such as Rome, Stayman, Fuji, and Granny Smith. Use full coverage, 80 to 100% TRV.
To delay fruit drop and maintain firmness in late harvested fruit. Provides the most consistent control of fruit drop and fruit softening.	ReTain plus NAA	Apply 1 pouch of ReTain per acrea plus 20 ppm NAA (Fruitone L) as a tank-mix combination 2 weeks before normal harvest. Include surfactant normally combined with ReTain in the tank mix.

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 1 week after harvest. The longer treatment is delayed, the less effective it is. Do not wash or brush fruit immediately after treatment. Thorough coverage of the fruit with the 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.

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 will maintain fruit flesh firmness and acidity for a longer period of time, even under less than ideal storage conditions. SmartFresh will also minimize the incidence of scald. In order 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 Inc.). SmartFresh is introduced into the atmosphere of an airtight facility or container in which the fruit is held for 24 hours. After the 24-hour treatment period, the fruit is returned to normal refrigerated storage. The amount of product used depends on the volume (cubic feet) of the treatment facility; therefore, loading of the facility with apples to its capacity is necessary to reduce treatment cost. Treat as soon as possible after harvest (within three to seven days) to maximize the effect of SmartFresh.

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 leak tested before initial treatment and annually thereafter. Contact your County 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 or 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 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 areas within their home range. Bucks increase their movements slightly in 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. Nonhunted 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 are often temporary in nature.

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, and if few applications will be needed for adequate control. **Repellents will not work satisfactorily in high-pressure situations.**

Two types of repellents are available. The first is an area repellent, which includes things such as tankage (putrified 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.

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 ¼-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 so 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 (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 power is sufficient to turn deer. Fencing will also keep bucks from damaging young tree trunks by rubbing their antlers against the trunks. To protect individual trees, set three fence posts 1 to 2 feet apart in an equilateral triangle around each tree. Unelectrified 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. During 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 and can become high 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) up to 18 to 24 inches above ground. The guard should be big enough so 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 put on 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 in with white latex paint being applied to tree trunks for prevention of southwest trunk injury. These repellents include the following:

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 short 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.

Southeastern orchardists 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 or cotton rats 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). They 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 and cotton rat ranges in the Southeastern U.S.

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. In addition to these, the different types of voles have some other 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 in association 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 also 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/or 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 ⅛ inch wide, ⅜ 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 following practices.

Exclusion involves the use of tree guards. As described in the section on rabbits, ¼-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, because the first 5 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 exclude 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. However, compared to the potential loss from damage, they can be a good investment.

Certain **cultural practices and habitat modification** in and around the orchard can reduce vole presence. The major food source for voles is not apple trees, but 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 windrows between rows and then shredding this material removes a preferred food source as well as 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 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:

Rodenticide	**Labelled for Use In**
zinc phosphide ZP Rodent Bait-Ag Zinc Phosphide Pellets	All states
diphacinone Ramik Brown Ramik Green	All 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.

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 percent 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 nontarget 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 2½ ounces of bait under at least two established stations per tree. These stations should be established 2 to 3 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. Car tires split horizontally and placed with the hollow side down and distributed one per tree every 10 trees provide 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 nontarget 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 percent 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 tradeoff between the cost of control and the cost of damage. It 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 (concentration stations) put down 2 to 3 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 2 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. Place a piece of asphalt roofing over a hole or run. After 1 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 use 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 3- to 5-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 that will prevent light from reaching the trap without interfering with the operation of the trap.

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 3 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) 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 only on rodenticides 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.

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. 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.

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

Wildlife Damage Management Fact Sheet AG-472-4, *Beavers,* available on the Internet at www.ces.ncsu.edu/nreos/wild/wildlife/wdc/beaver.html

Wildlife Damage Management Fact Sheet AG-472-1, *Voles in Commercial Orchards and Ornamental Nurseries,* www.ces.ncsu.edu/nreos/wild/wildlife/wdc/voles.html

Printed copies of the above references may be obtained by contacting: Communication Services, Box 7603, NC State University, Raleigh, NC 27695-7603.

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 percent of a population. Similarly LC means lethal concentration and LC 50 means the concentration will kill 50 percent 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 0-50 mg/kg of body weight; inhalation LC 50 is 0 -0.2 mg/l of air; dermal LD 50 is 0-200 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, 50-500 mg/kg; inhalation 0.2-2 mg/l; dermal LD 50, 200-2000 mg/kg; eye effects, corneal opacity and irritation reversible within 7 days; skin effects, severe irritation at 72 hours. *In essence, 1 teaspoon to 2 tablespoons can kill.* **Caution III** - oral LD 50 500-5,000 mg/kg; inhalation LC 50 is 2-20 mg/l; eye effects, no corneal opacity and irritation reversible within 7 days; dermal LD 50, 2,000-20,000 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**. All other pesticides are unclassified as "**General Use.**" Unclassified General Use pesticides may be purchased by the general public. Pesticides classified as Restricted Use may be purchased and applied only by certified licensed applicators or under their direct supervision.

PERSONAL PROTECTIVE EQUIPMENT — Personal protective equipment must be used as noted on each label. The applicator must read the label. Maintain a wardrobe of protective equipment for pesticide applicators and handlers. Even if you have read the label before, always refresh your memory by readingit again before each use. The label is dynamic and is constantly changed as new information is discovered or required or uses are deleted and added. Changes are common as a result of EPA review and reregistration.

ENDANGERED SPECIES ACT (ESA) — The EPA enforces some aspects of this statute. The promulgation of this act prohibits the use of certain pesticides in certain locations. The labels of these pesticides, so restricted, will state that the pesticide is restricted in specific counties or areas within the counties. 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 county Extension centers. The ESA has not been enacted in all states.

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 includes employees who handle pesticides (mix, load, apply, and repair application equipment). 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 30 days following the REI.

RECORD KEEPING — Most states have a pesticide record-keeping requirement. If they do not, there is a USDA federal pesticide record-keeping requirement. The federal requirement covers restricted-use products only. Check with your county Extension agent for your state's situation.

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 county Extension agent or your state contact for information on getting a license and on 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 chemical stored and information on hazards and special fire fighting techniques; and provide EPA, state, and local governments with evidence of your concern, should charges of negligence or lawsuits follow. Crop Life Amercia (formerly the American Crop Protection Association) has a planning and guidelines packet for handling pesticide chemical fires. Write to Dept. 0527, Washington DC 20073-0527, or call 202-296-1585.

PESTICIDE STORAGE — Safe pesticide storage can significantly increase farm safety. You should consider the following: costs and difficulty of cleanup; 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

FUNGICIDES	
Adament	264-1052
Agri-Fos	71962-1-54705
Agri-mycin 17	55146-96
Aliette WDG	264-516
Captan 4L	1812-260
Captan 50WP	10182-145-51036
Captan 80WDG (Drexel)	66222-58-19713
Captan 80WDG (Arysta)	66222-58-66330
Captan 80WP	10182-164
Captec 4L	66330-239
C-O-C-S WDG	34704-326
C-O-C-S 15 Sulfur 25 Dust	34704-393
C-O-C-S Copodust	34704-320
Cuprofix Ultra 40 Disperss	70506-201
Dithane DF 75 DF	62719-402
Dithane F-45 4F	62719-396
Dithane M-45 80WP	62719-387
fenarimol	various
Firewall	80990-4
Flint	264-777
Indar 75WSP	62719-421
Inspire Super	100-1317
Kocide 101	1812-288
lime sulfur	various
Manzate Flowable (DuPont)	352-706
Manzate Flowable (UPI)	70506-236
Manzate Pro-Stick (DuPont)	352-704
Manzate Pro-Stick (UPI)	70506-234
myclobutanil	various
Penncozeb 80WP	70506-183
Penncozeb 75DF	70506-185
Penncozeb 4F	70506-194
phosphite fungicides	various
Polyram 80DF	7969-105-34704
Pristine	7969-199
Procure 50WS	400-431
ProPhyt	42519-22-5905
Phostrol	55146-83
Ridomil Gold	100-1202
Scala SC	264-788
Sovran 50WG	7969-154
sulfur	various
Syllit FL	55260-6
Tebuzol 45DF	70506-113
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
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
Belt 4SC	264-1025
Calypso 4F	264-806
Carpovirusine	66330-55
Centaur	71711-21
Clutch 50WDG	69639-152
CryMax	70051-86
Cyd-X	70051-44
Danitol 2.4EC	59639-35
Delegate WG	62719-541
Diazinon 50WP	34704-435
Dipel DF	73049-39
Envidor 2SC	264-831
Esteem 35WP	59639-115
Guthion 50WP	264-733
Imidan 70WP	10163-169
Intrepid 2F	62719-442
Lannate 90SP	352-342
Lorsban 4EC	62719-220
Lorsban 50W	62719-221-10163
Lorsban 75WG	62719-301-10163
Movento 2SC	264-1050
Nexter 75WP	81880-4-10163
oils	various
Portal 0.4EC	71711-19
Pounce 3.2EC	279-3014
Provado 1.6F	264-763
Rimon 0.83EC	66222-35-400
Savey 50WP	10163-208
Sevin 50WP	769-972
Sevin XLR	264-333
sulfur	various
superior oils	various
Supracide 2E	10163-236
Surround 95WP	61842-18
Vendex 50WP	70506-211
Voliam Flexi	100-1319
Vydate 2L	352-372
Warrior	100-1112
Xentari	73049-40
Zeal 72WDG	59639-123

EPA Registration Numbers (continued)

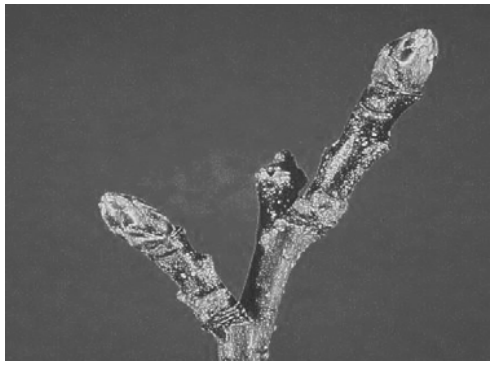
Mating Disruption	
CheckMate CM/OFM	56336-49
CheckMate OFM	56336-36
CheckMate OFM-F	56336-24
CheckMate Puffer	73479-11
CideTrak CM/OFM	51934-11
Isomate CM/OFM TT	53575-30
Isomate M100	53575-19

HERBICIDES	
2,4-D	various
Aim 2EC	279-3241
Alion 1.67	264-1106
Arrow 2EC	66222-60
Casoron CS	400-451
Basagran (Winfield)	7969-45-1381
Basagran (Arysta)	7969-45-66330
Casoron 4G	400-168
Chateau 51WDG	59639-119
Comet 1.5	71368-87
Direx 4L (DuPont)	352-678
Direx 4L (MANA)	66222-54
Diuron 80WDG	34704-648
Firestorm	82557-1-400
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
Intensity	34704-864
Intensity One 1EC	34704-976
Karmex 80WDG	1812-362
Karmex XP	352-692
Matrix	352-556
Oryzalin	66222-138
Paraquat Concentrate	82542-3
Parazone 3SL	66222-130
Pennant Magnum	100-950
Poast	7969-58
Princep 4L	100-526
Princep Caliber 90	100-603
Prowl H_2O	241-418
Pruvin	66222-184
Rage	279-3307
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 (United 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
Surflan 4AS	70506-43
Treevix	7969-276
Volunteer	59639-3-55467

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

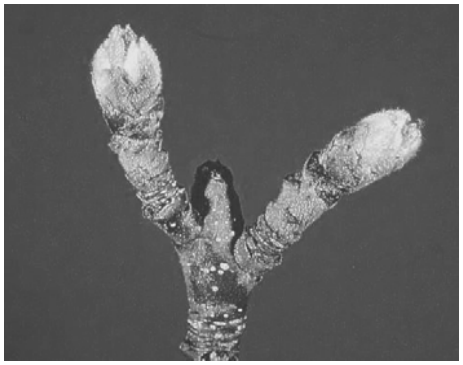
PLANT GROWTH REGULATORS	
Apogee	7969-188
Ethrel	264-267
Fruitone L	5481-541
Maxcel	73049-407
Novagib	62097-7-82917
Perlan	62097-6-82917
Promalin	73049-41
ProVide 10SG	73049-409
ReTain	73049-45
Sevin XLR	264-333
SmartFresh	71297-3
Tre-Hold	5481-429

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

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