RUTGERS
New Jersey Agricultural
Experiment Station

This is a section from the

2023/2024
New Jersey Commercial
Tree Fruit Production Guide

The recommendations are **NOT** for home gardener use.

The **full guide** can be found on the Rutgers New Jersey Agricultural Experiment Station (NJAES) website at: *https://njaes.rutgers.edu/pubs/publication.php?pid=e002*. The guide is revised biennially.

PESTICIDE USE DISCLAIMER

THE LABEL IS THE LAW

A pesticide applicator is legally bound by the labeling found on and with the pesticide container in their possession*.* Before using a pesticide, check and always follow the **labeling distributed with the product at the point of sale for legally enforceable rates and restrictions**.

In addition to the pesticide products listed in this Production Guide, other formulations or brands with the same active ingredient(s) may be commercially available.
ALWAYS CHECK THE LABELING ON THE PRODUCT CONTAINER ITSELF:
a) to ensure a pesticide is labeled for the same use,
b) to ensure the pesticide is labeled for the desired crop,
c) for differences in rates and percent active ingredient, and
d) additional restrictions.

Check the physical product label for the maximum amount of pesticide per application and the maximum number of applications per year.

IMPORTANT: DO NOT RELY ON ELECTRONIC LABELING (unless it is "web labeling" found directly on the product container)**.** *Online pesticide* labels may not be the same as the labeling distributed with the product. Some services include: Proagrica's CDMS *http://www.cdms.net/*; Agworld DBX powered by Greenbook *https://www.greenbook.net*; or Agrian *https://www.agrian.com/labelcenter/results.cfm.*

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See a detailed regulatory discussion of this and other essential information on Pesticide Safety and the Pesticide Label in Chapter 1. Electronic labeling is discussed in section 1.3.1.

If you are having a medical emergency after using pesticides, always call 911 immediately.

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1-800-222-1222

In Case of an Accident

- Remove the person from exposure
- Get away from the treated or contaminated area immediately
- Remove contaminated clothing
- Wash with soap and clean water
- Call a physician and/or the National Poison Control Center (1-800-222-1222).
  Your call will be routed to your State Poison Control Center.
- Have the pesticide label with you!
- Be prepared to give the EPA registration number to the responding center/agency

6 Tree Fruit Diseases, Pests, and Controls

6.1 Diseases and Disorders of Stone Fruit

6.1.1 Diseases of Stone Fruit

Anthracnose

Anthracnose disease on peach, plum, and cherry, also sometimes referred to as ripe rot, only occurs sporadically in New Jersey. The last two significant infections in commercial peach orchards were in 1998 and 2003. In the latter year, orchards consisting of the cultivars White Lady, Klondike, Bounty, PF Lucky 13, and Harrow Beauty had very high levels of fruit infection resulting in considerable yield reduction. Since no information is available on resistance of peach cultivars to anthracnose, all cultivars must be presumed susceptible at this time.

The disease is caused by the plant pathogenic fungi *Colletrotrichum gloeosporioides* and *Colletrotichum acutatum*. These same two pathogens are known to cause bitter rot on apple and anthracnose fruit rot on blueberry. *C. gloeosporioides* also causes ripe rot on grape and anthracnose on pepper. The pathogens are also found on a wide variety of herbaceous plants, including many legumes. On peach fruit, symptoms initially appear as small brown spots, often resembling brown rot. However, unlike brown rot, the circular lesions enlarge more slowly and become characteristically sunken. Older lesions often have concentric rings covered with orange or salmon-colored masses of spores.

Adequate control of anthracnose on peach usually results when Captan 80 WDG at 2.5 lb/A is applied during the cover sprays. The final cover sprays leading up to the first preharvest brown rot spray are particularly critical. Frequent summer rains probably reduce the available residue of this fungicide, thereby decreasing the level of protection; in this case, closer application intervals are required. Also, the practice of switching from captan to sulfur cover sprays most likely increases the risk of infection. Little information is available on the efficacy of sulfur on peach anthracnose. Nevertheless, since sulfur provides poor control of bitter rot on apple, good control of peach anthracnose is not likely.

Fruit susceptibility increases as the fruit ripens and infection is particularly favored by moist, warm (80-90°F) weather. Orchards are at risk if one or more of the following factors are true: (1) the orchard has a past history of anthracnose; (2) the orchard is adjacent to an inoculum source (*e.g.*, apple orchard, woods, previously harvested peach block with anthracnose); (3) weed control has been inadequate, particularly for legumes such as clover; (4) sulfur was used instead of captan for cover sprays; or (5) captan was applied during the cover sprays, but too infrequently relative to frequency of rainfalls (*e.g.*, 14-day or longer interval).

Bacterial Canker

Bacterial canker can be a serious bacterial disease of some stone fruit grown in New Jersey. Apricot is extremely susceptible; cherry and plum are highly susceptible; peaches are only moderately susceptible; and almond and tart cherry are least susceptible. Given this susceptibility scale, control is normally only necessary for apricot, sweet cherry, and plum.

Bacterial canker, or bacterial gummosis, is caused by a *Pseudomonas* bacterium. This pathogen overwinters in canker margins, systemically in the vascular system, and in healthy buds. During cool and wet spring weather, the pathogen multiplies epiphytically and infects buds, blossoms, young leaves, and rarely fruit. Buds or flowers injured by frost are commonly attacked, resulting in a blossom blight appearance. Eventually, however, the pathogen will grow into the woody tissue to form a canker.

Cankers are the most important identifying symptom on sweet cherry trees. The canker is somewhat sunken and darker in color than other areas of the bark. The inner wood of the canker is orange to brown, and gummy amber ooze may be observed. Cankers continue to enlarge in lateral branches and the central leader, sometimes even advancing into two-year wood. The canker may eventually girdle the branch or trunk, causing significant limb loss or tree death, respectively.

Pruning practices and other cultural practices should be modified to prevent canker. During the warmer, drier summer months, the epiphytic pathogen populations tend to be low. Thus, only summer pruning should be performed, preferably after harvest. Prune during dry weather to prevent infection of pruning cuts.

During fall, the return of cool, wet weather allows the epiphytic bacterial pathogen population to once again peak. Autumn rains splash-disperse the bacteria to newly exposed leaf scars, where they infect and begin to form cankers. For susceptible cultivars, successive applications of copper in the fall may help to reduce disease incidence. Bordeaux sprays can begin September 1st if safened with vegetable oil. The sprays are repeated at 14-day intervals for a total of 4-5 sprays. An additional spray should be applied just before bud swell to aid in reducing spring infections. See “Bordeaux Mixture” in section 6.3, Fungicides and Bactericides, for information on how to make Bordeaux mixture.

Although copper applications may help to provide some level of control, results of Michigan studies have shown inconsistent reductions in spring bacterial populations from fall applications. While the fall applications may help to reduce leaf scar infections, the non-systemic copper will not affect bacteria residing in cankers. Thus, fall applications are at best only partially effective in the overall management plan. In some fruit growing areas, particularly the Pacific Northwest, copper is not recommended at all as a control measure. Copper-sprayed trees in these regions have actually been observed to have more bacterial canker than on non-sprayed trees. Furthermore, pathogen resistance to copper is also problematic.

Given that no spray material or timing is highly effective, an integrated approach is currently the best and recommended form of bacterial canker management. Such a program uses a variety of cultural control measures, including use of resistant cultivar/ rootstock combinations, proper tree planting and pruning practices, avoidance of tree injury, modifying irrigation practices, weed and nematode control, etc. An excellent bulletin by the Oregon State University Extension Service describes 12 steps to manage bacterial canker on sweet cherry; it can be found at: ***https://catalog.extension.oregonstate.edu/em9007*** (Bulletin EM 9007, May 2010).

Bacterial Spot

Bacterial spot is caused by the plant pathogenic bacterium *Xanthomonas arboricola pv. pruni*. This bacterium can attack leaves, twigs, and fruit. Foliar infection results in angular, grayish lesions about 0.125 inch in diameter. As lesions age, they become purple and necrotic, and sometimes abscise, leaving a shot-hole appearance. Multiple lesions result in leaf chlorosis (yellowing) and defoliation. Lesions often concentrate along the leaf midribs and tips, the latter resulting in a tip burn appearance.

Cankers are visible in early spring as slightly raised, blister-like areas along the twig. If the terminal bud region becomes infected, the shoot tip becomes a blackened canker that may extend downward along the shoot for about an inch. In this case, the terminal bud is killed. Fruit symptoms are first observable three to five weeks after petal fall. Look for small, depressed, brownish lesions, sometimes accompanied by pits, cracks, or exuding gum. These lesions may eventually coalesce to cover large areas of the fruit surface.

Bacterial spot infections occur anytime from petal fall until after harvest. The two-four week period immediately after petal fall is critical for both early foliage and fruit infection. Thus, to properly control fruit infection, sprays should be applied from petal fall until 15 days before harvest. Mycoshield, FireLine, and fixed-coppers have provided satisfactory disease control.

In addition to the protective sprays mentioned above, there is some evidence that early applications just before bud-swell and prior to bloom can help to reduce the overwintering epiphytic inoculum on tree surfaces. These sprays lower the bacterial population, thereby decreasing the likelihood of infection of newly emerging leaves and fruit. Also, autumn applications during leaf drop may be beneficial in preventing canker formation. Fixed-copper materials can be used at both these times; see section 6.3, Fungicides and Bactericides.

Table 6.1 classifies peach and nectarine cultivars according to their relative susceptibility to infection. Many of the newer cultivars listed are the result of evaluations performed in NJ orchards.

The amount of disease that occurs in any given season is dependent on the weather, spray efficacy and timing, inoculum availability, and cultivar resistance. All cultivars have some susceptibility to the disease, but those less susceptible will have lower levels of fruit infection in years favorable for infection. Thus, the best control measure is to plant only cultivars with the least amount of susceptibility.

Table 6.1 Relative Susceptibility of Peach and Nectarine Cultivars to Bacterial Spot

Determination of bacterial spot susceptibility: Trees of new and standard varieties were grown in mixed cultivar blocks located at commercial orchards in southern NJ. Cultivar plots, which typically consisted of four trees of a single variety, were planted at one location in a block (without replication). Qualitative observations on foliage and fruit were made at harvest over a minimum of four years. Disease levels on foliage, fruit, or both determined susceptibility rating. Bactericides were applied, but usually at rates or frequencies below commercial level.

Low Susceptibility			
Allstar	FlaminFury PF#Lucky12	Harkin	Redstar
Biscoe	FlaminFury PF#Lucky13	Harrow Beauty	Ruby Prince
Blazeprince	FlaminFury PF#14Jersey	Harrow Dawn	Saturn
Blazing Star	FlAminFury PF#15A	Harrow Diamond	Scarlet Pearl
Candor	FlaminFury PF#19-007	Harrow Fair	Scarlet Prince
Coralstar	FlaminFury PF#Lucky24B	Madison	Sentinel
Derby	FlaminFury PF#28-007	Manon	Sentry
Desiree	Glenglo	Messina	Spring Prince
Dixired	Gloria	NJF14	Starfire
Earliglo	Glowingstar	NJF16	Sunbrite
Early-Red-Fre	Harbelle	NJF17	Vinegold
FlaminFury PF#1	Harbinger	NJN100	Vulcan
FlaminFury PF#5B	Harbrite	Redhaven	
FlaminFury PF#7	Harcrest	Redkist	
Medium Susceptibility			
Arcticglo	Easternglo	GaLa	Loring
Autumn Star	Elberta	Galaxy	NJF15
Bellaire	Emeraude	Garnet Beauty	Parade
Blake	Empress	Glohaven	Queencrest
Blushing Star	Encore	Harblaze	Raritan Rose
Bounty	Fantasia	Harflame	Ruston Red
Carogem	Flameprince	Harvester	Salem
Carolina Belle	FlaminFury PF#11	Jade	Spring Snow
Contender	Flamin Fury PF#17	Jefferson	Stark Ovation
Cresthaven	FlaminFury PF#20-007	Jerseydawn	Sugar May
Crimson Snow	Flamin Fury PF#23	Jerseyglo	Summer Beaut
Earlired	Flamin Fury PF#24-007	Jim Dandee	Summer Serenade
Early Loring	Flamin Fury PF#25	John Boy	Triogem
Early Sunhaven	Flamin Fury PF#27A	Late Sunhaven	White Lady
High Susceptibility			
Arctic Belle	Flavor Top	Lady Nancy	Spring Flame
Arctic Blaze	Flavorcrest	Laurol	Sugar Giant
Arctic Gold	Glacier	Maygrand	Sugar Lady
Arctic Jay	Heavenly White	Redgold	Suncrest
Arctic Pride	Honey	Rio Oso Gem	Sunglo
Arctic Star	Honeykist	Snow Beauty	Sunhigh
Arctic Sweet	Honeyroyale	Snow Bride	Sweet Dream
Autumnglo	Jerseyland	Snowfire	Sweet Sue
Autumn Lady	Jerseyqueen	Snow Giant	Topaz
Babygold 5	Johanna Sweet	Snow King	Yukon King
Benedicte	Jolly Red Giant	Snow Prince	Zephyr
Big Red	Karlarose	Snow Queen	
Fayette	Klondike	Springold	

Black Knot

Black knot is a serious disease of commercial plum and is also frequently found on wild cherry and wild plum. The causal agent of black knot, the plant-pathogenic fungus *Apiosporina morbosa*, can infect peach, sweet cherry, and apricot, but its occurrence on these crops is uncommon and not of commercial importance. Although not as common as on plum, losses from black knot have been reported on sour cherry. Characteristic symptoms included elongated black, corky swellings on shoots, branches, and sometimes, even trunks. These outgrowths, which grow lengthwise annually, can be as short as one-half inch to as much as one foot in length. Infected shoots and limbs are stunted and can be eventually killed by a girdling action.

Infection can occur on new shoot growth at any time from bud-break until shoot elongation ceases. However, the period from prebloom through first cover is the most critical time for disease development. During this period, the fungus produces and discharges the greatest number of ascospores on two-year-old knots. These spores are only disseminated when rain periods last at least 6 hours, during which they are splash dispersed to new, healthy tissue. If temperatures during these wetting periods are optimum, at 54 to 75°F, then spores germinate rapidly and infection is most likely. Once infection occurs, some knots may be visible as soon as autumn, while others will become evident the following spring and summer.

Black knot management on plum consists of integrating cultivar resistance, inoculum reduction, and the application of fungicide sprays. Unfortunately, some of the most important plums are highly susceptible: Stanley, Damson, Bluefree, and Shropshire. Moderately susceptible cultivars are Brodshaw, Early Italian, Fellenburg, Methley, and Milton. The cultivars Formosa, Shiro, and Santa Rosa are considered slightly susceptible, while President is the only one reported as highly resistant. Removal of inoculum sources, namely the knots in the orchard as well as on neighboring wild trees, is of great importance for disease control. Knots should be pruned out during the summer when actual canker size is more indicative of the advancing fungal infection; make cuts at least 3-4 inches below the bottom edge of the swelling. Remove or burn prunings before the subsequent spring so that they don‘t act as a potential inoculum source.

Bravo is the best fungicide for control of black knot on plum and should be applied in a series of three sprays at approximately 7-10 day intervals: pink, bloom, and petal fall. At shuck-split and first cover, apply either captan alone or a mixture of captan + Topsin M. Note that although Bravo is labeled for use at shuck-split, fruit injury has been observed, so avoid use at this time. Higher rates of these materials should be used in severe situations when weather is favorable and inoculum is readily available; also, an additional spray at second cover might be beneficial in these situations if shoots are still actively growing. Lower rates would suffice for well-maintained orchards in which black knot has not been a problem. See section 9.4, Plum Disease and Pest Management, for details.

Brown Rot

The plant-pathogenic fungus *Monilinia fructicola* causes brown rot. Infection can occur at bloom or during the preharvest period. Bloom infection results in blossom blight, a necrosis of flowers. Once a flower is infected, the fungus can also proceed into the stem and cause a canker. Spores produced on these flowers and cankers then becomes the inoculum for subsequent infection during the preharvest fruit rot phase.

Normally, two sprays are applied during the bloom period, the first at 5-10% bloom and the second at full bloom. If the weather is very dry, then only one spray may be needed. Conversely, if much rainy weather is encountered, then a third spray at petal fall is desirable.

During bloom, the most susceptible part of the flower is the pistil. With cultivars that possess short petals, the pistils may be exposed for a considerable period before the flower opens; whereas in cultivars with large petals, the pistil is protected until the flower is open. Consequently, the first bloom spray should be timed to coincide with that period when the first pistils have just become exposed.

During the final 21 days prior to harvest, the fruit softens during ripening, becoming more and more susceptible to brown rot. Maintain protection by applying fungicides at regular intervals during this period. For those early cultivars harvested during the first half of the season, when inoculum levels are generally lower, two sprays at 14- and 7-day intervals prior to harvest are usually adequate. However, inoculum levels during the second half of the harvest season are usually much higher; therefore, three sprays are recommended. At this time, sprays at 18-, 9-, and 1-day prior to harvest are recommended. The first two sprays control field infections while the final spray affords coverage during the critical picking and handling period, when fruit are most susceptible. Fungicides differ in spray and preharvest intervals, so follow labels carefully.

Field studies conducted at Rutgers over a seven-year period from 2012 through 2018 demonstrated that late season captan cover sprays can contribute significantly to control of brown rot at harvest, thereby augmenting the efficacy of preharvest fungicide programs. When the final two cover sprays, just prior to initiation of the preharvest program, consist of captan 80WDG at a minimum rate of 3.125 lb/A, the percentage of rot control from just the captan alone ranged from 50 to 69%. The year-to-year consistency of control should also be improved because heavy rainfall during the preharvest period did not reduce control by the captan residue. Furthermore, any reduction of the *M. fructicola* population by the captan cover sprays should reduced selection pressure against the site-specific fungicides commonly used during the subsequent preharvest period. The development of resistance to captan, a multi-site protectant fungicide, is not likely, so this resistance management strategy should be sustainable. Other multi-site protectants, namely sulfur, ziram, and thiram, failed to provide the same enhanced control benefit as captan.

Insect feeding injury increases brown rot infection; therefore, maintain adequate insecticide protection. Also, experiments indicate that brown rot is most difficult to control where peach trees make excessive growth. In such orchards, use nitrogen-containing fertilizers sparingly.

Special attention to brown rot control is required where trees are planted closely or where the orchard is surrounded by woods. Such conditions reduce air drainage, and dew or rain evaporates more slowly from blossoms and fruit than where air drainage is better.

A large variety of fungicides are available for control during both the blossom blight and fruit rot stages of disease development. Refer to section 6.3, Fungicides and Bactericides, and the stone fruit disease and pest management sections for details on materials and resistance management.

Constriction Canker

Constriction canker, previously called Fusicoccom canker, results in the death or necrosis of both vegetative and fruiting shoots. During fall leaf drop, the normal abscission of leaves exposes leaf scars to the environment. Since temperatures are becoming cooler during this period, plant growth is slowing down, and more time is required for leaf scar healing. Consequently, the scars remain susceptible to invasion by pathogens for a longer period of time than under warmer summer conditions.

During rainy periods, the fungal causal agent, *Phomopsis amygdali*, produces spores in fruiting bodies embedded in the cankers. These spores are disseminated by rain-splash and wind-blown rain to fresh leaf scars. After entering the twigs, the pathogen begins to colonize the surrounding tissue. Sometimes, by late fall or early winter, very small slightly sunken reddish-brown cankers can be seen surrounding infected leaf scars. These cankers continue to develop and enlarge during any warm periods in the winter and into the next spring and summer. Eventually, the mature tan to silver colored cankers girdle the twigs, causing classic shoot blight symptoms and direct fruit loss.

In addition to fall infection through leaf scars, the pathogen can also infect shoots through bud scale scars in early spring. As buds break dormancy, the bud scales detach, producing an exposed scar not unlike those produced during fall leaf drop. Infection through these scars results in cankers identical to those produced by fall infections.

Fungicides should be applied at 14-day intervals during the entire fall leaf drop period to protect scars from infection. In the Mid-Atlantic region, begin sprays in mid-September and continue until all leaves have dropped, generally by late November. Similarly, two to three sprays are applied during the spring bud-break period. This maintains fungicide protection on susceptible scars throughout each period. This program is recommended only for moderate to severely infected orchards, not as a general purpose spray program for all orchards.

A variety of systemic and protectant fungicides were examined for management of constriction canker. The most effective were the protectants Bravo and Captan. Unfortunately, current labels only allow a single fall or post-harvest spray of these materials. However, a 24(c) special local need label was obtained for application of Bravo on peach in New Jersey. Applications are recommended at 3-4 pt/A, preferably at high enough volume to get good coverage of leaf scars.

Although the fungicide programs significantly reduce disease development, they are at best only 50 to 70% effective. To achieve higher levels of control, growers must also reduce inoculum by removing cankers, and the timing of this pruning operation is critical. If pruning is done too early then many of the younger, non-girdling cankers are missed. So, late summer is the best time to prune out cankers since the majority of them have killed the shoots, making them much easier to find. The pruned cankers do not need to be removed from the orchard and can remain on the orchard floor. Inoculum produced by the cankers during rains does not readily move upward.

Peach and nectarine cultivars differ in susceptibility to this disease. In a NJ survey, the cultivars Autumnglo, Jerseyglo, Encore, Cresthaven, Biscoe, Sunqueen, Harbrite, Jerseyland, Redhaven, and Harcrest were all observed with moderate to high levels of canker. In addition, earlier observations have shown Blake, Golden Jubilee, Raritan Rose, Derby, Rio-Oso-Gem, Early-RedFree, Slaybaugh, Jerseyqueen, Triogem, and Redgold to also be quite susceptible. Sunhigh, Dixired, Harken, J.H. Hale, and Coronet are less susceptible. There are no completely resistant cultivars.

Cytospora Canker

Cytospora canker is one of the principal causes of limb loss and tree death. Control of the disease can be achieved using the guidelines listed below. In all cases where a wound occurs or pruning is performed, paint larger cuts with a water-based asphalt emulsion. An interior white latex paint can be substituted for the asphalt paint during periods when the sap is not "running" profusely.

Cytospora Canker guideliness: 1) Delay pruning until growth begins in spring, preferably after bloom and before shuck-split. **Remove cankers from critical areas** as soon as possible after they begin to gum. 2) Control brown rot, scab, borers, and Oriental fruit moth to reduce the number of infection sites. In blocks with a high level of disease, lesser peach tree borer control is often difficult. 3) Do not cultivate so close that bark is injured. Where "hilling" is employed, it is extremely important to cut out any infected area of the lower trunk that will be covered with soil. 4) Paint the trunks with white latex paint before January (see section 7.4, Peach and Nectarine Winter Injury). Do not use acrylic latex paint, for many of these are phytotoxic. 5) Burn all prunings from cankered trees, and burn all trees that are removed from orchards infected with canker. A permit is required for burning.

Leaf Curl

Peach and nectarine leaf curl, caused by the plant pathogenic fungus *Taphrina deformans*, is typically not a difficult disease to control in the eastern United States. However, if inoculum levels are high, environmental conditions favor infection, and/or control methods are sub-par, severe defoliation and stunting can occur. Fruit infection, which results in the formation of irregular raised wrinkled areas on the fruit surface, is generally rare.

Taphrina deformans principally overwinters as spores on the bark surface; the pathogen may also be found in old infected leaves. Initial infection occurs during bud swell in late winter when spores are disseminated by water to buds with loose scales. Additional infection can occur between bud-break and petal fall. Once the pathogen enters leaf tissue, it stimulates rapid cell division and enlargement, resulting in thickened, curled, and puckered leaves. These "tumor-like" areas on the leaves often have a red discoloration. Eventually, the leaves drop or sometimes remain attached, turning brown.

Italian research in 2006 (*https://apsjournals.apsnet.org/doi/pdf/10.1094/PHYTO-96-0155*) described the effects of temperature and moisture on foliar infection. At near optimum temperatures, infection begins after a minimum 12 hours wetness and increases steadily until 48 hours of wetness. Longer durations of wetness do not increase disease levels. In these studies, duration of surface wetness was the primary moisture determinant for infection. If the wetness period was caused by rainfall, the amount of precipitation did not influence the severity of infection. Wetness periods from dew or fog were often too short for infection.

Air temperature during the wetness period needs to be less than 61°F for foliar infection to occur. The amount of infection increases as temperatures decrease to 41°F. In the study, the maximum amount of shoot infection was observed at 41°F. Lower temperatures were not examined, so the minimum temperature at which infection no longer occurs is not known.

A single fungicide spray in fall, after leaf drop, or in late winter just prior to bud-swell, will in most cases provide sufficient control. The recommended fungicides are ziram or chlorothalonil (Bravo, Echo, etc.). Both of these fungicides have provided near 100% control in studies on Redgold nectarine at the Rutgers Agricultural Research and Extension Center (RAREC); non-treated trees had 39% bud infection.

In general, fixed-copper products provide a fair level of control. For example, in the same study at RAREC, Champ Formula 2 at its highest rate (10 pt) provided 68% control. However, it is possible that newer copper formulations, such as Kocide 3000, Nordox, or Badge X2 may be more effective.

Assuming leaf curl has not been problematic in a particular orchard, coppers are the recommended material for bacterial spot susceptible cultivars. In this case, the copper efficacy should be adequate for the lower leaf curl risk while also helping to reduce epiphytic inoculum for bacterial spot.

Peach Decline

Peach trees can die from many causes. The most prevalent loss occurs from winter injury to weakened trees. The problem is most severe where peaches follow peaches, and preplant fumigation for nematode control is not practiced. However, the effect of the preplant treatment lasts only for about 1 year, and a postplant application is needed in the fall following the second growing season. Additional postplant treatments are needed yearly, through the sixth growing season, for maximum control. Other cultural practices required to maintain strong trees are also highly beneficial. One practice which should be avoided, is pruning 1 to 6 year-old trees prior to February. Also, see section 6.6, Nematode Control.

Phytophthora Root and Collar Rot

Phytophthora root and collar rot, caused by various species of the fungal pathogen *Phytophthora*, is a serious problem on peach as well as on apple. It is most troublesome in orchards where the internal soil drainage is poor or where water lays. No cultivar resistance is known for peach rootstocks, and the problem frequently develops from the use of infected nursery stock. However, the pathogen survives well in the soil and newly planted trees could just as easily become infected from resident inoculum.

The most effective control consists of ridging the planting row to ensure that water does not lie in the area of the tree roots and crown. Since the disease can be introduced with infected nursery stock, a careful examination of trees received from the nursery is required.

Ridomil Gold, at 2.0 qt/ treated A, can be used on both nonbearing and bearing trees. Apply in a band corresponding to the weed control strip or apply as an under-the-canopy spray using a handgun to drench the soil. Use enough volume (*e.g.*, 1.0 gal of spray for 1-4 year old trees) to provide good penetration into the root zone or irrigate 0.5” to 1.0” after application. Alternatively, perform the application just prior to a rainfall. Two applications in spring (April and May) and one in September are recommended for sites known to have poor drainage or past problems.

Aliette 80WP can be used on nursery and nonbearing trees within the orchard. It is applied as a series of foliar sprays. Consult label for specific rates and timing schedule.

Fixed-copper-containing fungicides and maneb may also be helpful in preventing infection. They must be applied prior to infection to be of value. Use 4.0 lb/100 gal of either fungicide and add to the borer spray in the fall to reduce costs. When applied with the borer spray, make sure the entire root zone is covered (area under the canopy) and not just the tree trunk. Another application is needed in the spring to increase the effectiveness of these materials.

Powdery Mildew

The fungus *Sphaerotheca pannosa* causes powdery mildew of peach and nectarine. This pathogen overwinters as mycelium in dormant buds, infecting shoots as they emerge during spring. Infection of leaves, shoots, and fruit results in tissues becoming covered by powdery white mycelium and spores; leaves and young fruit can become stunted or malformed. Since the fruit becomes resistant to infection shortly before pit hardening, infections generally occur between pink-bud and third cover sprays. However, once lesions are established, they will continue to expand in size. Sulfur (4 lb) provides reasonably good control, while Rally is extremely effective.

Prunus Necrotic Ring Spot Virus

Prunus necrotic ring spot virus has been present for many years in this region. The disease is pollen transmitted and transmitted through the seed and by grafting with buds from infected trees.

For many years, the virus was considered to be a latent virus, one which was present but producing no symptoms. The strain of the virus present in this region did produce raised blisters on scaffold limbs, a fine net cracking of the bark on older wood, a canker similar to Cytospora Canker, and a slight reduction in size. We now apparently have a more aggressive strain of the virus present. Symptoms consist of the development of black, sunken cankers on the present year's growth in mid-summer. The canker development weakens the terminals and they break-off during periods with heavy winds. The disease generally occurs throughout the tree, with all of the terminals dying. The tree appears to be dying but new shoots eventually develop. The initial symptom is the "Shock Symptom" which develops when the plant first becomes infected. Symptoms rarely appear on the same tree the following year, but other trees in the block may exhibit these symptoms.

Rhizopus Rot

Rhizopus rot, caused by the fungus *Rhizopus stolonifer*, is very rarely seen in the orchard because healthy, uninjured fruit in the tree are not susceptible to infection. However, the fungus often colonizes any injured, fallen fruit. Airborne spores from these diseased fruit contaminate fruit on the tree. Then, once fruit fully ripen, usually after harvest, the inoculum is already present on the fruit, ready to infect and cause disease.

Rotted fruit is identified by a mass of white, threadlike mycelium covered with an abundance of black spore-producing structures, called sporangia. The fungus produces an enzyme that dissolves the tissue which holds the skin to the flesh. Thus, the skin "slips" easily from the flesh when pressure is applied to the skin in the area of the rot. Although preharvest control is usually not necessary, the application of fungicide, such as Botran 75WP, may be necessary in very wet years. For postharvest control, the fungicide Scholar can be used in conjunction with the wax spray. Also, care should be taken to prevent mechanical damage during harvest and packing.

Rusty Spot

Rusty spot of peach is caused by the fungal plant pathogen *Podosphaera leucotricha*. Since this is the same pathogen that causes apple powdery mildew, rusty spot is often observed in peach orchards adjacent to susceptible apple cultivars. Therefore, locating peach orchards upwind of apple orchards makes sense. However, high levels of rusty spot have also been observed in peach blocks not adjacent to apples or anywhere near apple orchards. Thus, additional powdery mildew pathogens may also be acting as causal agents. See Table 6.2 for the relative susceptibility of peach cultivars.

Rusty spot causes direct crop loss through infection of the fruit epidermis. Early symptoms on young peach fruit, which appear 1 to 2 weeks after 100% shuck split, consist of small, circular white lesions that soon turn orange to tan in color. Since the fungal pathogen does not grow well on peach, it rarely sporulates and so lesions do not appear "powdery". As the lesions age, the trichomes or peach hairs detach and the epidermis becomes smooth and russetted. Unlike true powdery mildew of peach, rusty spot does not occur on leaves or shoots.

Rusty spot epidemics are pretty short. They begin at shuck-off and end at 50 days after full bloom. Thus, typical epidemics last only 17 to 30 days. Only very young fruit are susceptible, as fruit become resistant at pit hardening. Given this pattern of disease development, the optimum timing for fungicidal control consists of three to five applications beginning at 90 to 100% petal fall. In most years, four fungicide sprays - applied at petal fall, shuck-split, first cover, and second cover - have provided excellent control.

The DMI fungicides Rally and Rhyme are the standard materials for control, although good control has been achieved with Flint Extra, Inspire Super, and Quadris Top. Sulfur typically provides about 50% control. Higher fungicide rates should be used for very susceptible cultivars, while low to mid-range rates are acceptable for moderately susceptible cultivars. Peach cultivars that have low to very low susceptibility rarely need to be sprayed. Studies have shown that the SDHI fungicides are not that effective.

Finally, for those interested in reducing usage of conventional fungicide, an integrated biorational program has been developed as an alternative. The integrated program consists of alternating a conventional fungicide standard, Rally or Rhyme, with one of two possible biorational fungicides, namely Kaligreen (potassium bicarbonate) or Serenade Optimum. The conventional product is applied at petal fall and first cover, while the biorational is applied at shuck-split and second cover. This integrated program has been shown to provide rusty spot control equivalent to application of Rally or Rhyme alone. Note that although these biorationals significantly reduce rusty spot incidence, their efficacy is not high enough at the labeled rates for them to be used alone in a program. Details on fungicide rates are provided in section 7.8, Peach and Nectarine Disease and Pest Management.

Table 6.2 Relative Susceptibility of Peach Cultivars to Rusty Spot

Very Low	Low	Moderate		High	Very High
Blake	Redhaven	Desiree	Melik Early Topaz	Biscoe	Autumnglo
Gloria	Snow Giant	Encore	Messina	Bounty	Jerseyqueen
Harrow Beauty	White Lady	John Boy	Raritan Rose	Jefferson	Rio-Oso-Gem
Sugar Lady		Jerseyglo	Suncrest	Redskin	
Sugar May		Laurol	Victoria		
Saturn		Loring			

Scab

The fungus *Fusicladosporium carpophilum* causes peach scab. The pathogen overwinters in lesions produced on current season‘s fruiting shoots. In New Jersey, spore production on these lesions begins during bloom and ends early- to mid-July. The spores are not readily released into the air until they become wetted. The period between infection and visual symptoms of the disease on the fruit is very long, from 40 to 70 days. Because of this long period, early maturing cultivars may be harvested before the fruit spots are visible to the naked eye. Infections can occur on the fruit, green twigs, and leaves. Infections occur most readily at temperatures between 65 and 75°F, when rainfall is abundant. Infections can occur at temperatures as low as 40-45°F and as high as 90-95°F.

Lesions formed on current season twigs are light brown, diffuse, and small initially (0.0625 to 0.125 inches in diameter). As they increase in size, they become circular with a darker brown color. A slightly raised bark callus surrounds the margin of the lesion. In the spring, velvety-textured, olive-colored spots appear within the lesion.

On fruit, tiny spots appear around third cover (early July in southern counties) when the fruit are about one-half their final size. The spots develop quickly into very dark, olive-colored, circular spots. Later the spots appear almost black in color. The spots do not “break” the skin as observed on fruit spots caused by bacterial spot. However, the skin frequently cracks open in the areas where numerous infected spots occur, and the Brown Rot or Rhizopus Rot fungus then attacks the flesh of the fruit. The spots are usually more numerous on the stem end of the fruit.

Topsin M (0.5 lb/100 gal), when applied at petal fall, has resulted in “burn out” of many of the overwintering lesions on the twigs. Thus, disease pressure can be measurably reduced as a result of a lower inoculum level. Fruit infections are most common from shuck-split through third cover. Foliar sprays are effective in protecting the fruit from infection, and a single fungicide spray applied around first cover will provide reasonably good control of twig infections in nonbearing blocks.

The disease is troublesome in commercial blocks when the trees did not receive a regular spray program in the preceding year. This occurs when the block was “frozen-out” the previous year and when a new block is first coming into production. The disease can be troublesome during periods of drought, since only 3 hours of 100% RH is necessary for sporulation to occur. Where disease is troublesome, apply Flint Extra, Topsin M + Captan, Bravo, Abound, or Quadris Top; use higher rates and shorter spray intervals if frequent rains occur. In addition to protectant activity, Flint Extra and Abound also act as antisporulants, thereby reducing inoculum production on twig lesions. Sprays should be applied until 40 days before harvest.

Sour Rot

The yeast *Geotrichum candidum* causes sour rot. The disease may occur in the orchard during years when temperatures are abnormally high, but is far more damaging in the postharvest period. Affected fruit exhibit a moderately firm rot on green fruit and the skin does not slip readily. The rot on ripe fruit is very soft and is quite watery in the later stages. A cheese-like scum can be observed within the watery fruit and when the juice dries on the surface. Sulfur provides poor control in the orchard, while captan and maneb provide fair control. The use of chlorine in the hydrocooler water and in dump tanks is the only effective control of the postharvest phase.

Stem Pitting

This virus disease becomes established in a block as a result of planting infected nursery stock or by planting healthy nursery stock in infested soils. Since the virus is transmitted by nematodes, preplant nematicide treatments are mandatory for control. Additional postplant nematicide treatments will probably be needed every 2 years to reduce possible spread. See section 6.6, Nematode Control, for recommendations.

The probability of introducing the virus into new blocks with planting stock has been greatly reduced in the last couple of years since nursery trees from areas known to have the virus are grown in fumigated soil. Growers should select trees that were grown in fumigated soil or from areas not known to have this problem.

Dandelion, dock, and other broadleaf weeds serve as hosts for the stem pitting virus (TomRSV). Thus, to prevent spread within the orchard, a concerted effort to control broadleaf weeds and nematodes is needed.

Trees that are infected prior to planting will begin to decline during the third growing season. Trees that decline during the fourth growing season may have been infected prior to or after planting in the orchard. Those declining in later years were infected after the trees were planted.

6.1.2 Special Nectarine Pest Control Issues

Nectarines are identical to peaches except that they lack pubescence (fuzz). Most management practices are similar for peaches and nectarines, but pest control for nectarines is frequently more difficult than for peaches. Pests, which attack the fruit, are generally the ones causing most concern, but those attacking the foliage may also be more difficult to control. The two diseases that are more troublesome on nectarines than on peaches are brown rot and bacterial spot. For insects, thrips, aphids, and Japanese beetles are frequently more troublesome on nectarines than on peaches.

Russet of the fruit skin is also much more of a problem on nectarines. The smooth skin of the nectarine subjects the fruit to considerable russet in most years. The causes of russet are similar to those that cause russet on Golden Delicious, *i.e.*, cold weather from pink into the early cover sprays when the fruit have a coating of moisture. Russet is related to both weather conditions and the pesticides used during this sensitive period. Most of the russet is superficial and the fruit may still be graded as U.S. Fancy.

A partial explanation of the increased susceptibility of many nectarine cultivars is genetic. Many of the higher quality nectarines were developed in California where brown rot is not a serious problem. Thus, these cultivars were probably not rigorously screened for brown rot tolerance. The smooth nectarine fruit has a much smaller total surface area than hairy peaches. Thus, the nectarine surface cannot retain rates of pesticides, to provide the protection against pest attack, that the peach surface does. This problem can often be corrected through the use of an effective spreader-sticker and improved spray practices to ensure better coverage and retention.

Nectarine fruit, like all smooth-skinned members of the genus Prunus, are subjected to “latent infections,” whereas peach fruit have never been shown to be similarly affected. Latent infections generally occur during the bloom period and remain confined to a tiny number of cells beneath the skin surface for extended periods. As the fruit increases in size, its chemical composition changes, resulting in increased susceptibility to the brown rot fungus. At this time, the fungus starts to grow and soon becomes visible as a brown rot infected fruit. This is generally the time that growers become more concerned about brown rot and initiate a more vigorous spray schedule. Unfortunately, sprays are much less effective, since the infection occurred in the bloom period. A more effective approach would include better timing of highly effective fungicides applications (*i.e.*, from pink through petal fall), together with better spray coverage.

Russet of the fruit also contributes to increased brown rot, since nutrients are exuded through the cracks in the skin. The spores of the brown rot fungus will not germinate without an external supply of nutrients, and the cracks in the skin provide all that is needed for spore germination and infection.

Blossom blight and early fruit infections with the brown rot fungus generally result in extreme difficulty in control of the disease just before and after harvest. In a casual evaluation of the peach and nectarine cultivar block at Cream Ridge NJ during the spring of 1987, several cultivars of nectarines had more than 80 percent of the blossoms infected with blossom blight, while none of the peach cultivars had more than 25 percent blighted blossoms. Further, when examined during the summer, the cankers produced from infected blossoms on nectarine cultivars appeared to be actively sporulating all summer long, whereas those on peaches appeared to become inactivated by mid-summer. These observations suggest that some nectarine cultivars may prove to be a better host for overwintering of the fungus.

Similar principles and altered control practices for nectarines could be provided for other pests, but to conserve space they will not be listed. To prevent pest problems from developing on nectarines, consider:

- Where possible, select cultivars with high levels of resistance to pests (see Tables 6.1 and 6.2).
- Use the most effective pesticides at the proper rate and proper time from pink through petal fall.
- Employ practices which will improve spray coverage and retention, including the use of spreader stickers. Evaluate and delete pesticides which increase fruit russet.

Many growers are successfully producing high quality nectarines and they are encouraged to continue utilizing those practices that have proven successful.

6.1.3 Postharvest Peach and Nectarine Treatment

FDA regulations specify any food crop to which a nonexempt chemical is added after harvest must be so labeled. The container that goes to the retailer must contain words such as, “These peaches treated with (name of chemical) to prevent rotting.” Postharvest fungicide treatment is important in preventing fruit rot development during storage and in the marketing channel. Good postharvest treatments will ensure the consumer of a highly desirable product.

Hydrocooler Treatment

Fruit in bulk bins should be hydrocooled as quickly as possible before placing in cold storage. The hydrocooler water should contain one of the chlorine-generating products at a minimum of 100-150 ppm at a water pH of 6.5 to 7.0 to kill spores and fungal mycelium on the fruit surface (see Table 6.3 and recommendations below). This treatment will sterilize the fruit surface but provides no residual fungicide protection. A Supplement Label must be in hand to use these materials.

Table 6.3 Materials for Hydrocooler

Material	Rates for 1000 gal
Agclor 310 (12.5%)	0.75 gal
Household bleach (5.25%)	1.8 gal
HTH Chlorine (65%)	1.33 lb

The maintenance of proper chlorine levels will provide postharvest sanitation/disease control, and will reduce the discoloration from ‘inking’ at 120+ ppm when the proper pH is maintained. There are many chlorinating systems available from various packinghouse equipment manufacturers. These include:

a) Gaseous chloride systems that monitor chlorine levels and automatically dispense chlorine gas into the water.
b) Liquid sodium hypochloride systems that also monitor chlorine levels and automatically dispense liquid chlorine into the system.
c) Powdered sodium hypochlorite (Ag Clor 311) for use as a chlorinating agent.
d) There is a supplemental label available from your County Agricultural Agent for the use of HTH swimming pool chlorine as an additional source of chlorine. It is important to remember that the supplemental label must be in the grower’s possession before use.

To keep iron insoluble, maintain the pH of the water between 6.5 and 7.0. If the water is acid, less than pH 6.0, then a buffer should be added to raise the pH to 6.5 to 7.0. Your County Agricultural Agent or Rutgers Extension Specialist can provide specific recommendations based on the pH of your water.

Drain and refill the water in the hydrocooler and dumptank on a regular basis daily, if possible. Be sure to remove all dirt, leaves, and other debris after draining.

Packing Line Treatment for Disease Control

Good postharvest disease control for stone fruit begins with a strong preharvest fungicide program. As indicated in the spray guide, preharvest fungicide applications during the fruit ripening period are absolutely critical for the prevention of brown rot. If late infection by *Monilinia fructicola* occurs, the fruit may appear healthy upon harvest, and perhaps even store well when maintained at cold temperatures. However, once the fruit are warmed, the fungus will continue its rapid growth, causing extensive rot within one or two days. After several years of testing, the reduced-risk fungicide fludioxonil (Scholar 50WP) has been labeled for postharvest disease control on stone fruit crops, including apricots, peaches, nectarines, plums, cherries, plumcots, and prune (fresh). When applied properly to fruit on the packing line, through T-Jets or control droplet-type applicators, fludioxonil has been shown to provide excellent control of brown rot, Rhizopus rot, gray mold, and Gilbertella rot. Since fludioxonil has a different chemistry (phenylpyrrole) than all other fungicides currently being used in the field, development of cross-resistant pathogens is not a concern at this time.

Fludioxonil can be applied on the packing line at a concentration of 8.0-16.0 oz/100 gal or enough to do an aqueous flooding of 200,000 of fruit. The fungicide can be mixed with either water alone or with a wax/oil emulsion. A dip application for peach is also registered for use. See label for further details.

Postharvest Peach Skin Discoloration and Its Control

Skin discoloration (also known as inking, ink spot, black spot, streak, or purple spot) is a disorder of peach which has been observed in New Jersey for more than 20 years. No disease-causing organism can be isolated from affected fruit. The initial symptoms are development of burgundy-colored areas within the red flesh of the peach. These areas eventually turn purplish-black or ink color.

Research conducted at Clemson University, University of California, and Rutgers University has shown that any operation which causes a peach to rub, roll, or physically abrade against another peach can result in discoloration. Inking has also been triggered by iron (in excess of 10 ppm) in the hydrocooler and dumptank water, leachate from latex-rubber drying rollers, excessive brushing or vibration, ammonia, and fungicide sprays. Research to date has resulted in these suggestions for control:

- Avoid any operation that causes excessive vibration, rubbing, or rolling; reduce operations that cause bouncing from the orchard to the packinghouse.
- Keep field bins, held outside the packinghouse prior to hydrocooling, in a shaded area out of sunlight.
- Remove “field heat” as soon as possible. Fruit temperatures, out of the field, can range from 75 to 95° F. Remove field heat with a hydrocooler rather than attempting to remove it with a ventilated cold room.
- Keep hydrocoolers and dumptanks as clean as possible. Excessive iron in treatment water can cause discoloration. Failure to clean hydrocoolers and dumptanks properly can result in high levels of rust in the water, thus increasing discoloration. Drain and refill with fresh water on a regular basis.
- Maintain the pH of water in hydrocoolers and dumptanks between 6.5 and 7.0. Water at a pH of 4.0 and 6.0 has caused problems with discoloration. Proper pH also reduces iron levels.
- Check equipment for a loss of ammonia. Leaks in the refrigeration system can also stimulate inking. Peaches can be affected by ammonia at levels under 1 ppm - below levels that emit an odor.

6.2 Diseases and Disorders of Apples

6.2.1 Early Season Apple Diseases

Apple Scab

This disease, caused by the fungal plant pathogen *Venturia inaequalis*, is the most important apple disease in our area. The fungus overwinters in fallen leaves on the ground. Ascospores (sexual spores) are released from these fallen leaves when they become wet during spring rains. The critical period for spore release is from the time green tissue is first visible through third cover. Any infections which occur during this period result in primary scab, since the ascospores are the initial inoculum for the growing season.

Primary scab infection periods can be predicted by gathering data on wetness period duration and average air temperature during the wetness period. Table 6.4 shows the minimum hours of wetness needed at various temperatures in order for infection to take place. For example, if the average wetness period temperature was 55.4°F and the period duration was 11 hours, then an infection period occurred since only 8 hours of wetness are needed at this temperature.

Research has shown that most ascospores are released only during daylight hours (dawn to dusk). Thus, if a rainfall begins at night, the infection period (duration of wetness) does not begin until sunrise. However, if a rainy period begins late in the day and continues into the night, then the night-time hours of wetting need to be included in the wetness duration, since initial wetting (and spore release) would have occurred during daylight.

Wetness durations and average air temperatures can be determined by visual observations and use of a min/max thermometer. However, a variety of mechanical and electronic devices can be purchased to help automate data gathering. The use of local leaf wetness and weather stations tied to a computer based modeling system can be more efficient. Rutgers University is part of the Network for Environmental and Weather Applications (NEWA), housed at Cornell University. This system models both disease and insect biology and control timing, and can be found here: *https://newa.cornell.edu/*

A variety of fungicides are available for control of scab during the primary period. However, whether or not a fungicide is prone to the development of resistant scab influences how it is used (see section 10.9, Apple Disease and Pest Management. If a fungicide is selected that is not at-risk to resistance, then it can be used alone (*e.g.*, captan or ziram). If a material is selected that is at-risk, then it should be mixed with a fungicide that is not at risk. For example, Rally or Indar should be used in combination with another non-risk fungicide, such as captan. When used in combination, the non-risk fungicide is applied at half the standard rate.

Resistance development is not the only factor which determines use patterns of fungicides. The EBDC fungicides can be applied up to bloom at full rate when used alone. However, they can be used in an extended program, through second cover, when they are applied at half-rate in combination with another non-EBDC fungicide (see Disease Tables in section 10.9, Apple Disease and Pest Management).

In general, if scab is properly controlled with fungicides during the primary scab period, then no further scab disease control is needed for the remainder of the season. However, if field observations at the end of the primary period indicate the presence of primary scab lesions, then additional sprays will be necessary. These lesions produce asexual spores (conidia), which can continue to cause infection throughout the summer. However, unlike the primary ascospores, conidia can be released during any period of the day when rain or heavy dew occurs.

Strains of the apple scab fungus that are resistant to Topsin M and Syllit are present in all areas of New Jersey. Therefore, these fungicides should not be used unless scab isolates from your orchard have been tested for fungicide resistance.

With the heavy dew and cooler nighttime temperatures from mid-August through harvest, scab can become reactivated. Late fruit infections may not be visible to the naked eye, but these infections can develop into tiny fruit infections which develop in storage.

Table 6.4 Minimum Requirements for Apple Scab Leaf Infection[1]

Average Temperature (°F) during wetness	34	36	37	39	41	43	45	46	48	50	52	54	55	57	59	61-75	77	79
Hours of leaf wetness during daylight	41	35	30	28	21	18	15	13	12	11	9	8	8	7	7	6	8	11

[1]Revised Mills

Bitter Rot

The fungus causing this disease, *Colletrotrichum gloeosporioides*, overwinters in cankers on the twigs, branches, and spurs, or in mummified fruit on the tree, or on the ground. The spores are splashed from the infected tissue during periods of rain. Infections occur to uninjured fruit beginning in mid-June. Infections can continue to occur into October. Fruit infections are firm and they appear flattened or sunken.

Control consists of using fungicides with longer residual activity and spraying orchards on a regular schedule. Proper pruning to remove dead wood also assists in control. This pathogen also causes anthracnose on peach.

Black Rot

The fungus *Botryosphaeria obtusa* overwinters in cankers and mummified fruit on the tree. It is responsible for frog-eye leaf spot and black rot on apples. The spores wash and splash from twigs and mummies to foliage and fruit below. Therefore, dead twigs, especially fire blight twigs, should be removed during the pruning operation. Ferbam and captan have shown promise as protectants against black rot infection.

Blister Spot

This disease is caused by the bacterial pathogen *Pseudomona syringae* pv. *Papulans*. It is troublesome on Mutsu and Magnolia cultivars during years when excessive rainfall occurs during the early part of the growing season. It may also occur on other cultivars in lesser quantities. Symptoms consist of purplish-black lesions, 4-5 mm in diameter, that appear at fruit lenticels. Disease is first noticeable at 2-3 months after petal fall, at which time only small, green, raised blisters are visible. These blisters eventually expand and darken with age.

Control consists of using copper containing fungicides (1 lb ai/100 gal) beginning at FIRST COVER. Repeat sprays at SECOND and THIRD COVER. Streptomycin is as effective as copper-containing fungicides but Terramycin is ineffective in control.

Cedar Apple Rust

Rust infections occur between pink and third cover spray. Infections which occur early can occur on the fruit and leaves. Infections which occur after first cover infect only the leaves. Materials which are effective against rust include the protectants mancozeb, polyram, ferbam, and ziram, as well as the DMI fungicides Cevya, Indar, Procure, Rally, Topguard, Vintage, and Inspire Super.

Collar Rot

Collar rot, caused by various species of the *Phytophthora* fungus, can be a serious problem with MM106 and MM104 rootstocks. It also causes some loss of trees on other rootstocks. The disease is most troublesome in orchards with poor internal drainage or in areas where water lays. Control consists of using more tolerant rootstocks and improving drainage. The disease can be brought into the orchard with infected trees, so care should be used when purchasing trees.

Ridomil 2E, Ridomil Gold, and Aliette are labeled for control in bearing and nonbearing blocks, and are effective when used according to label directions (see section 6.3, Fungicides and Bactericides, for details on using these products). Copper-containing fungicides have provided some measure of control when applied as a drenching spray to the trunk. Use 2.0 lb of actual copper in 100 gal of spray, and apply 1.0 gal of spray/tree in late-March to mid-April and again in late-September to mid-October.

Fire Blight The following practices should be employed to reduce loss from this disease:

- Pruning. The most recent theory on control suggests that infected shoots should not be cut out until the terminals harden-off. After terminals harden-off and before leaf fall, prune twigs 4-6 inches below any visible evidence of the disease. If the disease progresses into the main trunk, the trunk should be cut back 4-6 inches below any visible symptoms. Pruning tools should be disinfected by wiping them with a cloth saturated with 70 percent isopropyl (rubbing) alcohol or sodium hypochlorite (household bleach) 1:10 dilution with water. Tools may also be dipped in these solutions. Tools dipped in bleach should be washed in clean water at the end of the day to prevent corrosion of the metal parts.
- Prebloom Sprays. In blocks where fire blight is anticipated, growers may wish to apply a copper spray at HALF-INCH GREEN. This spray will kill the bacteria present on the plant surface and may reduce later infections. It will also help for scab control. For details on early season sprays, see bordeaux mixture and copper (fixed) in section 6.3, Fungicides and Bactericides.
- Blossom Sprays. Make application any time after the first flower opens, the temperature is 65°F or above, and the relative humidity is 60 percent or above. Make subsequent applications on a 3- to 5- to 7-day schedule, depending upon weather conditions.
- Post-bloom Sprays**.** Apply streptomycin sulfate at 10- to 14-day intervals from petal fall until conditions become unfavorable for spread. When hail occurs, apply a spray immediately following the storm, regardless of when last application was applied. Do not use within 50 days before harvest.

(continued on next page)

Use streptomycin sulfate 17% at the rate of 50 ppm (0.25 lb) when used alone and when drying conditions are poor. The addition of Regulaid (1 pt) to streptomycin has increased the level of control. If streptomycin is added to any of the other fungicides, increase the rate of streptomycin to 75 to 100 ppm (0.38 to 0.5 lb). As a resistance management strategy, alternate sprays of streptomycin with oxytetracycline. On pome fruit, this latter antibiotic is available as Mycoshield and FireLine. Applications during poor drying conditions are much more effective. Late evening or night spraying is the preferred method. Do not apply during a rain or when rain is forecast, as the material must be taken up systemically to be effective.

Moldy Core

This disease can become troublesome in some years when the petal fall spray is delayed too long. For control, use Captan 50WP (2 lb) before the calyx closes.

Nectria Canker

This disease, also called European canker, can be a problem on cultivars with enlarged terminal fruiting spurs, such as Rome Beauty and Jerseyred. Infections occur in the fall as leaves are dropping. The symptoms of infection occur in June when the terminals begin to die. The disease can be confused with fire blight except all infections arise from the swollen terminal fruiting spur with European canker.

Powdery Mildew

The powdery mildew fungus, *Podosphaera leucotricha*, overwinters as mycelia in the terminal buds. Although the disease is present every year, it is more prevalent during years when weather is dry and morning dews are heavy. The cultivars Ginger Gold, Suncrisp, Crimson Crisp, Delblush, and Sundance are considered very susceptible to mildew. The mycelium becomes active early in the season. Therefore, control should begin at the prepink stage. Additional sprays are required through the third cover spray.

Rally, Procure, Topguard, and Vintage are the most effective against mildew. Sulfur provides good control, but produces russeting with some cultivars. Cultivars not sensitive to sulfur russet are Rome Beauty, McIntosh, Cortland, and Golden Delicious. Cultivars sensitive to sulfur russet include Starr, Twenty Ounce, Rhode Island Greening, Stayman, and Delicious.

As soon as first noticed (about pink stage), branches or twigs showing systemic or over-wintering mildew should be pruned out to reduce secondary mildew. This is particularly beneficial in young blocks.

White Rot

White rot is caused by the fungal plant pathogen *Botryosphaeria dothidea*. It survives from season to season as mycelium and fruiting structures in cankers, dead bark, and mummified fruit. Current season fire blight strikes are often colonized by the fungus and are also an important source of inoculum.

Effective white rot control requires a combination of good sanitation and preventative sprays. All dead limbs, cankers, and mummies should be removed from the trees. Also, prunings should not be left in the orchard as they can become colonized and serve as an inoculum source during the same growing season. The Rome Beauty, Jerseyred, and Julyred cultivars are most susceptible to this disease.

On apple, application of Captan plus Topsin, from first cover through harvest, provides good control. Sovran and Pristine also provide good control and, unlike captan, are also labeled for use on pear.

6.2.2 Summer Apple Diseases

The summer diseases consist of X-Disease, Black Pox, Brook’s Spot, Sooty Blotch, and Flyspeck. Infections can occur any time from FIRST COVER through harvest, but infections are most common and numerous from early August through September.

Brooks Spot

This disease, caused by *Mycosphaerella pomi*, is most troublesome on Rome and Stayman, but it can also be troublesome on other apple cultivars. Fruit symptoms appear 8 to 12 weeks after the infection occurred as slightly sunken, greenish lesions associated with the lenticels of the fruit. At harvest, the spots are dark purple in color. Foliar lesions appear in August as small, purplish flecks around the leaf stomata. Benlate was highly effective in control, but is no longer available; Topsin M may be an acceptable substitute. Other fungicides with long residual activity may provide good control.

Sooty Blotch and Flyspeck

These diseases almost always occur together and the control measures are the same for both diseases. The fruit infections are superficial on the skin and can be brushed off with vigorous rubbing.

The fungi causing these diseases over-winter on dead twigs and brush within and around the orchard site. Rainfall is needed for spore release, dispersal, and infection. Infections occur most readily when the relative humidity (RH) is 95% or higher and temperatures are between 60-70°F. Temperatures between 50-60°F and 70-80°F are quite favorable for fruit infections. Conditions which increase disease incidence include:

- Frequent showers and high RH with moderate temperature.
- Inadequate pruning, which restricts drying.
- High inoculum levels in dead twigs within the tree, in adjacent hedgerows, or on the ground within the orchard.
- Use of ineffective fungicides or fungicides with short residual activity. Once infection occurs, at least 30-45 days incubation are required before fruit infections become visible to the naked eye. Heavy levels of fruit infections may occur when the last fungicide application is made more than 30 days before harvest.

Captan alone, or combined with Topsin M are effective in control. Sovran, Flint Extra, and Pristine also provide excellent control (for rates, see Covers Disease Tables in sections 10.9, Apple Disease and Pest Management, and 11.4, Pear Disease and Pest Management). Alternation of these materials with captan or ziram during cover sprays has provided excellent control in field tests under high disease pressure.

6.2.3 Physiological Apple Disorders

The incidence of the following physiological disorders may be reduced by the nutrient sprays described in section 10.3, Specific Issues for Apple Orchard Nutrition.

Bitter Pit

Fruit spots vary in size from 0.125 to 0.25 inch in diameter and normally develop after the fruit is harvested. They never approach the size of large cork spots. The spots are initially dark brown and quickly become blackish brown. The affected skin tissue is less firm than adjacent healthy tissue.

The affected tissue beneath the spot on the skin is shallow and spongy in texture. Individual fruits frequently contain 30 or more spots, with most of the spots located around the calyx end of the fruit. The spots are not associated with the fruit lenticels.

Cork

Fruit spots vary in size from 0.25 to 0.5 inch in diameter, with the larger size more common. Spots become visible between the time the fruit is half-grown and harvested. The spots are greenish at first; later they turn blackish-brown. The affected skin tissue is firmer than adjacent healthy tissue at harvest. The spongy, brown tissue that underlies the spots on the skin extends deeply into the flesh. Individual fruits rarely contain more than three to five cork spots. The spots are not associated with the fruit lenticels.

Jonathan Spot

This is often a serious problem in the Jonathan cultivar, and it more closely resembles bitter pit than cork spot. The fruit spots are almost always associated with the lenticels. The flesh adjacent to the lenticels is soft and dark in color, but the fruit spots do not extend deeply into the flesh. Affected tissue frequently becomes infected with one or more fungi, which cause an increase in size of the spots during storage. Several other cultivars show similar spots that are generally classed as Jonathan Spot (*e.g.*, Rome Beauty, Wealthy, Grimes Golden, and Twenty Ounce).

6.2.4 Postharvest Apple Diseases and Disorders

Many factors determine the successful control of postharvest diseases and disorders. Some of the factors are a good spray program during the growing season; proper maturity at harvest; proper handling of fruit; and proper storage, sanitation, and chemical treatment.

Blue Mold and Storage Scab

Use one of the following water dips prior to placing fruit in storage. All of these materials are compatible with DPA and Stop Scald.

- Captan 50WP (2.5 lb)/100 gal
- Mertect 340-F (1.0 pt) plus Captan 50WP (1.0 lb)/100 gal

Since all of these materials will settle-out on standing, the solution must be constantly agitated. Further, all of the above can be removed from the solution with the settling of dirt particles. Thus, the solution should be recharged with fresh fungicide on a regular basis. Recharging should be accomplished after every 30 bins/100 gal of capacity, *i.e.*, after 300 bins in a 1000 gal tank. Add about 1/5 the initial fungicide rate when recharging the tank.

Storage facilities, packing houses, and orchard boxes should be treated with a 1:34 bleach solution (1.0 gal of 5.25% bleach in 34 gal water). Permit complete drying of the exposed surfaces before exposing fruit.

Scald

Either Stop Scald (ethoxyquin) or DPA will provide control of scald if properly used. Each can be used as a dip or spray treatment. The rates that provide adequate control, except on Rome Beauty are:

- Stop Scald 3 pt/100 gal water (2,700 ppm) OR;
- DPA (liquid or dry) 2 qt of 31% (2,000 ppm)

With the Rome Beauty cultivar, adequate control is obtained with the following rates:

- Stop Scald 2 pt/100 gal water (1,800 ppm), OR;
- DPA (liquid or dry) 1 qt of 31% (1,000 ppm)

Both of these materials are more effective on warm than on cold fruit. DPA is more apt to injure fruit than Stop Scald. Injury is minimized if the treated apples are dried before storage. DPA is the preferred choice on Delicious, Stayman, Winesap, and Cortland. The risk of injury with DPA is greater if used on Rome Beauty, Baldwin, or Golden Delicious. Stop Scald is preferred on these three cultivars, and it can be used successfully on Delicious and Stayman.

<u>Additional factors to consider:</u>

- Liquid formulations are preferred. Keep solution well agitated if DPA is used.
- The 100 gal Stop Scald mixture or the 120 gal DPA mixture should be sufficient to dip or rollerspray 1,000 bushels. If the solution gets dirty, change it. Replace solution at least every other day.
- If dipping, submerge for no more than 30 seconds; remove, and tilt box to drain solution that has collected in the stem or blossom end of the fruit.
- These materials are most effective if applied within 1 day after harvest. Apples stored 1 to 2 weeks can still be treated, but fruit temperature must rise to 60°F or above to obtain proper coverage and control. This is especially true for Delicious, which is difficult to cover at lower temperatures.
- Solution temperatures must be 50 to 80°F to obtain the most effective results.
- To prevent possible reduced control and fruit injury, do not allow fruit to set in the sun after treatment.
- Do not apply Stop Scald to fruit that has been sitting in the sun. Fruit staining and reduced control can result.
- Scald inhibitors can be irritating to the skin of some individuals. Plastic or rubber gloves should be worn by these persons.
- Postharvest treatments must be labeled on the shipping container. For Stop Scald, the stamp should read: “Treated with Ethoxyquin to Retard Spoilage.” For DPA, it should read: “Treated with Diphenylamine to Retard Spoilage.”The lettering must be as large as other information on the container. For polyethylene bags, stamp the master carton only.

6.3 Fungicides and Bactericides

The following alphabetical listing of fungicides and bactericides is meant to provide additional information on the capabilities and limitations of registered tree fruit fungicides and bactericides. These descriptions are not intended to be complete compilations of all the properties of the materials listed, but rather provide additional insight on chemical usage. **For specific information on rates, consult individual product labels.**

Abound 2.08F (azoxystrobin) is a derivative of naturally occurring fungicides, which can be found in edible, wood-decay mushrooms. Because of its low toxicity, Abound has been classified by the EPA as a reduced risk fungicide. It belongs to the QoI class of fungicides. Abound is registered for control of blossom blight, scab, brown rot, and powdery mildew on peach, nectarine, cherry (sweet and tart), plum, and apricot. Abound provides good to excellent control of brown rot and scab. Because of its different chemistry, Abound makes a good partner for alternation with the DMI fungicides Indar, Propiconazole, or Elite. However, Abound should not be alternated with Flint Extra or Pristine since these materials are also QoIs. Abound has also been labeled for several diseases on grapes.

Azoxystrobin has been found to be highly phytotoxic to certain apple cultivars. Thus, users should be careful to avoid spray drift and not use the same sprayer for apples. Also, growers spraying Quadris on vegetables should avoid drift on apples, as this product also contains azoxystrobin as its active ingredient. Furthermore, spray tanks cannot be adequately rinsed with water to allow safe usage on apple.

In tests conducted during 1999-2000, 41% of approximately 100 apple cultivars were sensitive; insensitive varieties showed no adverse effect. If you have mostly stone fruit and only a few apple cultivars, a simple test can be conducted to determine their sensitivity. Contact your agricultural agent for details on performing this test.

Agri-mycin 17WP (streptomycin) is an antibiotic with activity against a broad range of bacterial plant pathogens causing spots, blights, wilts, rots, etc. On tree fruit, it is registered for use in controlling fire blight on apples and pears. Firewall 17WP and Streptrol 17WP are other available formulations of streptomycin.

Sprays should be applied two-three times during bloom, or timed according to a disease forecasting system. Routine sprays during the summer are not cost-effective, but applications should be performed immediately after hailstorms if the orchard has a history of blight. Dilute volumes are best, as getting complete spray coverage is critical.

The fire blight pathogen can become resistant to streptomycin. Consequently, other bactericides, such as copper materials and oxytetracycline (pear only) should be incorporated into the spray program.

Aliette 80WDG (fosetyl-Al) is registered on both pome and stone fruit for control of crown and root rot caused by Phytophthora species. On apple, it is labeled for both bearing and nonbearing trees, while on stone fruit, it can only be used for nonbearing trees.

On pome fruit, Aliette can be applied as a root dip prior to planting a new orchard. Mix 3.0 lb/100 gal and soak roots for 30 to 60 minutes. Aliete is not registered for use as a dip for stone fruit.

On bearing pome and stone fruit orchards, Aliette is applied as a series of foliar sprays during the spring and early summer when conditions favor high soil moisture. Make three or four applications on a 60-day spray interval at 5 lb/100 gal; or alternatively, apply six to eight applications at 2.5 lb/100 gal.

Aprovia fungicide is registered for use on many pome fruit crops, including apple, pear, Asian pear, crabapple, and quince. It is not registered for use on stone fruit crops. Aprovia has a 12 hour REI, a 30-day PHI, a rate range of 5.5-7.0 fl oz/A, and a maximum rate of 27.6 fl oz/A per year. **Note**: the application at the lower rate would technically allow five applications per year, but the label limits the number of applications to four per year.

The active ingredient in Aprovia, benzovindiflupyr, is a succinate-dehydrogenase inhibitor (SDHI) belonging to FRAC group 7. The fungicide's formulation is a 0.83EC, or 0.83 lb of benzovindiflupyr per gallon of emulsifiable concentrate. For resistance management, do not apply more than two consecutive applications of Aprovia before switching to a non-group 7 fungicide.

The Aprovia label lists control of nine pome fruit diseases: apple scab, pear scab, Alternaria blotch, Alternaria rot, cedar apple rust, quince rust, powdery mildew, sooty blotch and flyspeck. The major fruit rot diseases (bitter rot, black rot, white rot, and brooks fruit spot) are only listed as suppressed on the product's label. Field studies have shown excellent control of scab, sooty blotch, and flyspeck.

The addition of spreading / penetrating type adjuvant is recommended. See the label for details.

Bordeaux Mixture (copper sulfate + calcium hydroxide), which was discovered in 1882 in a grape vineyard in Bordeaux, France, controls many fungus and bacterial leaf spots, blights, downy mildews, and cankers. However, it is also phytotoxic to plants and often has compatibility problems with other materials. For these reasons, Bordeaux has largely been replaced by fixed or insoluble copper fungicides (see Copper, fixed).

Although Bordeaux displays foliar phytotoxicity, it can still be useful as a dormant spray for control of peach leaf curl and fire blight on apple and pear. For leaf curl, a common formula is 4-6-100, while for blight, a good mix is 8-8-100 plus 1 percent of 60- or 70-second emulsifiable spray oil. In both cases, the first number is pounds of copper sulfate, the second number is pounds of hydrated spray lime, and the third is gallons of water.

For bacterial canker on sweet cherry and plum, a 4-6-100 formula can be applied during the fall leaf drop period and as a dormant spray in spring. During the first few fall sprays, add canola or cottonseed oil, at 2.8 qt/100 gal, as a safener to lessen the mixture's phytotoxicity.

Botran 75WP (dicloran) is extremely effective against Rhizopus rot on stone fruit. At higher rates it will also control brown rot, but efficacy is still less than many other preharvest materials. It is registered for applications during the blossom blight and preharvest fruit rot periods on peach, nectarine, plum, prune, and sweet cherry.

Bravo WeatherStik 6F, Bravo Ultrex 82.5WDG, (chlorothalonil) will provide fair control of brown rot blossom blight and good control of scab on stone fruit. Blossom blight applications should be made from popcorn through petal fall. Bravo can be applied as late as shuck-split for peach scab control. Bravo is also effective against leaf curl, coryneum blight, and cherry leaf spot.

Bumper 41.8EC (propiconazole) - see Propiconazole.

Cabrio 20EG (pyraclostrobin) is a QoI fungicide labeled for use in controlling blossom blight and powdery mildew on sweet and tart cherry. Cabrio is applied at 9.5 oz/A, and should be alternated with other non-QoI fungicides. Cabrio is <u>not</u> labeled for use on peach (see Pristine).

Captan 50WP, 80WDG (captan) is an excellent protective fungicide for control of scab, frog-eye leaf spot, black rot, white rot, Brook's spot, bitter rot, sooty blotch, flyspeck, and calyx-end rot on pome fruit. Captan can be used for post-infection control of apple scab, but must be applied within 18 hours from the beginning of an infection period. This fungicide will not control cedar apple rust and powdery mildew.

On stone fruit, captan provides very good control of brown rot and scab when applied in the summer cover spray program. The final two cover sprays prior to the preharvest program should consist of captan 80WDG at 3.125 lb/A. These two sprays will provide residual activity throughout the preharvest period, providing resistance management for the QoI, SDHI, and DMI fungicides commonly at the end of the season.

Captan is ineffective for powdery mildew and peach rusty spot. Mite problems in captan-treated blocks are generally more severe than where other fungicides are used. Captan is not compatible with oil or lime.

Carb-O-Nator 85SP (potassium bicarbonate) - see **Kaligreen**

Cevya fungicide is registered for use on many pome fruit crops, including apple, pear, Asian pear, crabapple, and quince. The fungicide can also be used on a wide variety of stone fruit crops, including peach, nectarine, plum, cherry, and apricot. For both crop groups, Cevya has a 12-hour restricted-entry interval (REI); a 0 day pre-harvest interval (PHI); a rate range of 3.0 – 5.0 fl oz/A; and a maximum rate of 15 fl oz/A per year. Thus, only three to five applications can be made per year at the maximum to minimum rates, respectively.

The active ingredient in Cevya, mefentrifluconazole, is a demethylation inhibitor (DMI) which disrupts cell membrane synthesis in susceptible plant pathogenic fungi. Thus, Cevya is classified as a Group 3 fungicide by the Fungicide Resistance Action Committee, or FRAC. Cevya contains 3.34 lb of this active ingredient per gallon of the suspension concentrate; hence, the formulation is a 3.34 SC. For resistance management, alternate or mix Cevya with other non-group 3 fungicides.

Cevya is labeled for control of eight diseases on each crop group. On pome fruit, Cevya has efficacy against alternaria blotch, scab, black rot / frogeye leaf spot, cedar apple rust, flyspeck, sooty blotch, white rot, and pear scab. Powdery mildew and quince rust are suppressed. On stone fruit, Cevya is listed as controlling alternaria leaf spot, brown rot blossom blight, brown rot fruit rot, leaf spot, Rhizopus rot, rust, scab, and shothole. Powdery mildew on peach is suppressed.

In four field studies conducted on apple at universities in the Mid-Atlantic and Northeast regions, Cevya provided excellent control of apple scab on fruit, providing 92 to 100% control. Management of foliar scab was very good to excellent, with an average 90% control and a range of 78 to 98% control. Results from a single study indicated excellent control of cedar-apple rust, sooty blotch, flyspeck, and white rot; however, more data are needed to confirm these findings. Also, white rot disease pressure was low in this study. Powdery mildew control from a single study was rated as fair, which agrees with the label statement of "suppression only". Finally, poor control of bitter rot was observed in two studies, which explains the absence of this disease on the label.

On peach, when Cevya was applied during the preharvest fruit ripening period, results from four assessments conducted in the Mid-Atlantic region demonstrated very good to excellent control of brown rot at harvest. Percent brown rot control was 74, 94, 96, and 94% for these four assessments, with an average 90% control. In a single study, Cevya provided good control of brown rot blossom blight and rusty spot, yielding 78 and 80% control, respectively; additional data are needed to confirm.

Champ Formula 2.79F (copper hydroxide) - see **copper (fixed).**

Chlorothalonil 720 (chlorothalonil) - see **Bravo.**

Copper (fixed) is a form of copper compound in which the copper ion is fixed securely to the molecule, thereby making it relatively insoluble in water. Thus, when a fixed copper compound is applied in a spray, a coating of copper compound crystals is deposited on the plant surfaces. During wet conditions, these crystals slowly solubilize and release copper ions, which are the active ingredient that kill the pathogenic bacteria or fungi. Unfortunately, the copper ions are not discriminatory and can also injure sensitive plant cells, such as peach leaves or apple fruit surfaces. Cool, humid conditions tend to slow drying after an application, resulting in greater uptake by the plant and more injury, while warm dry conditions (*e.g.*, spraying during mid-day) tend to reduce phytotoxicity.

Although all fixed copper compounds provide the same active ingredient, copper ions, they do differ in the type of molecule used to deliver the copper. These molecules can release the ions at different rates, and can be formulated in different ways, particularly with respect to particle size. These differences, along with the rate of application, ultimately determine the efficacy and phytotoxicity of any given copper compound.

Six types of fixed copper compounds are available based upon the type of molecule used to deliver the copper: (1) copper hydroxide (Kocide, Champ, Nu-Cop); (2) copper sulfate (Cuprofix, Bordeaux mixture); (3) copper oxychloride (C-O-C); (4) cuprous oxide (Nordox); (5) copper ammonium carbonate (Copper-Count-N); and (6) organometallic copper (Cueva). Some copper products are mixtures of these types, such as Badge X2 (copper oxychloride + copper hydroxide) or C-O-C-S (copper oxychloride + copper sulfate). Copper products using other copper compounds are available, but less commonly used. Cueva, Nordox, and Badge X2 are OMRI listed for use on organically grown crops.

On apple, an early spray of copper can be applied, from green-tip to 0.25 inch green, for control of fire blight. Spray 2.0-4.0 lb of copper hydroxide (Champ, Kocide, Nu-Cop)/100 gal, plus 1% 60- or 70-second emulsifiable spray oil. Use high volumes so that runoff occurs, thus ensuring complete coverage. Do not apply later than 0.25 green, as copper is severely phytotoxic.

Repeated use of coppers for bacterial leaf spot and bacterial canker control can result in the development of copper-tolerant strains of the bacterium.

Double Nickel. This biofungicide, which has the bacterium *Bacillus amyloliquefaciens* strain D747 as its active ingredient, is available as a water dispersible granular formulation (25WDG) and as an aqueous suspension (LC) formulation. Each product can be applied up to and including the day of harvest and has an REI of 4 hours. They are OMRI listed for use in organic production.

Both formulations are registered for use on a wide variety of stone fruits, including peach, nectarine, cherry, plum, and apricot, and a wide variety of pome fruits, including apple, pear, crabapple, and quince. Most research has examined Double Nickel in combination with and/or in alternation with other active ingredients and conventional standards. Thus, efficacy of the product alone against most pathogens needs to be determined.

Stargus is a similar material with a slightly different active ingredient (*Bacillus amyloliquefaciens* strain F727).

Decco No Scald DPA. (diphenylamine) is registered as a post harvest anti-scald material for apples. It is delivered either in an aerosol or fogger operation in an enclosed operation.

Elevate 50WDG (fenhexamid) is registered for use on stone fruit, grapes, and strawberries. On peach and nectarine, Elevate is labeled for control of blossom blight and brown rot. A zero PHI (postharvest interval) allows the fungicide to be applied up to and including the day of harvest.

Fenhexamid has a different chemistry than all other fungicides labeled on stone fruit, thus making it a good candidate for fungicide resistance management. However, Elevate has never been tested under NJ conditions and results from other sites indicate sporadic efficacy against brown rot, achieving only moderate levels of control.

Ferbam 76WDG (carbamate) is a protectant-type fungicide with good efficacy against cedar-apple rust and as a fall or spring dormant spray for peach leaf curl. It is also effective for black knot on cherries and plums, and for leaf and fruit spot on pears. Ferbam will russet sensitive apple cultivars such as Golden Delicious, but is safe on Delicious and Rome Beauty. This fungicide has only moderate activity for control of apple scab, sooty blotch, cherry leaf spot, and brown rot of stone fruit.

FireLine 17WP (oxytetracycline) - see **Mycoshield.**

FireWall 17WP (streptomycin) - see **Agri-mycin.**

Flint Extra 4.05SC (trifloxystrobin) is a QoI fungicide registered for use on apple, pear, crabapple, loquat, mayhaw, and quince. Flint Extra is also registered for use on stone fruit, specifically apricots, cherries, nectarines, peaches, plums, plumcots, and prunes. Like other QoI fungicides, Flint Extra exhibits broad-spectrum activity against a variety of fungal diseases.

On apple, Flint Extra provides excellent control of scab; good control of powdery mildew, sooty blotch, and flyspeck; and fair control or suppression of white rot and bitter rot when used at higher rates. The level of black rot control has yet to be determined; a limited number of studies indicate poor control of rust. Flint Extra is also registered for use on grapes, although it should not be applied to Concord grapes or crop injury may occur.

Preventative applications of Flint Extra should be applied at 7-14 day intervals, depending on target pathogen and level of disease pressure. Excellent control of scab, sooty blotch, and flyspeck can be achieved at 2.5 fl oz/A, while a 2.9 fl oz/A rate will be needed for cultivars that are very susceptible to powdery mildew. A higher 2.9 fl oz rate is needed for bitter and white rot suppression. Up to 100 hours curative capability is possible when applying Flint Extra for post-infection scab control. In this case, use the higher 2.9 fl oz/A rate, followed by a second application at 7-10 days later.

For best apple scab resistance, alternate sprays with another fungicide having a different chemistry, such as Rally, Procure, or Vangard. Or apply sprays in a block program, where no more than two consecutive sprays of Flint Extra are used. For summer apple disease control, Flint Extra alternating with Captan or Ziram provides good control.

On stone fruit, Flint Extra is labeled for control of cherry leaf spot, powdery mildew (rusty spot), and scab. Good to excellent control of peach rusty spot has been achieved at 3.0 fl oz/A on highly-susceptible cultivars. Flint Extra also has good to excellent activity against peach scab. Application at petal fall and/or shuck split at the maximum 3.8 fl oz/A rate can significangtly reduced sporulation on scab lesions, as well as provided protectant activity.

During the preharvest period for management of brown rot, the Flint Extra label allows applications up to 1 day before harvest. Studies in NJ have shown that when applied at high rates, Flint Extra provides good control of the fruit rot phase. Since Flint Extra is a QoI fungicide, it is a good choice for alternation with DMI fungicides (Indar, Cevya, and Propiconazole) or SDHI fungicides (Fontelis or Miravis) during the preharvest period.

Fontelis 1.67SC (penthiopyrad) is labeled for use on most stone fruits (apricot, sweet and tart cherry, nectarine, peach, plum, plumcot, and prune) as well as apple and pear. On these crops, Fontelis has a rate range of 14.0-20.0

fl oz/A and a REI of 12 hours. The PHI for stone fruit crops is 0 days while the PHI for apple and pear is 28 days.

Fontelis has a single active ingredient, penthiopyrad, which belongs to the SDHI (FRAC code 7) chemical group. Consequently, for resistance management reasons, a maximum of two sequential Fontelis applications are allowed before switching to a fungicide with a different chemistry. A total of 61.0 fl oz/A/season can be applied to an orchard, which results in 3-4 applications/year.

Fontelis has been extensively field tested for peach disease control at the Rutgers Agricultural Research and Extension Center, Bridgeton. Over a six-year period, Fontelis provided excellent blossom blight control and good to excellent brown rot control. In contrast, Fontelis' control of rusty spot and peach scab were only rated as fair and poor, respectively. However, it should be noted that scab pressure in the test blocks was extremely high; better scab control was achieved in other states under more typical disease levels.

Given the above peach disease control profile, the recommended use for Fontelis is for management of brown rot during the preharvest period. At this timing, Fontelis can be rotated with other fungicides of different chemistries, such as the DMIs (Indar, Meteor, Bumper, and Quash), the QoIs (Flint Extra and Abound), or DMI-QoI premixes (Quadris Top). Although Fontelis performed very well for blossom blight control, use of other chemistries such as the anilinopyrimidines (Vangard), dicarboximides (Rovral), and protectants is preferred during bloom for resistance management.

On apple, Fontelis is rated as good for scab control, but only fair for powdery mildew and rust control. Consequently, Fontelis is best deployed during the early season for primary scab control; a powdery mildew fungicide may be added if this disease is problematic. When Fontelis is applied as a mixture with a protectant, such as mancozeb (*e.g.*, Manzate 75DF at 3.0 lb/A), the combination provides excellent control of scab and good control of rust. A lower 10.0-12.0 fl oz rate of Fontelis is labeled for use in these mixtures; however, 14.0 fl oz is the recommended minimum, even for mixtures.

Indar 2F (fenbuconazole) is a highly effective fungicide for control of brown rot, blossom blight and fruit rot on peach, nectarine, cherry, and apricot. It also provides control of peach scab and cherry leaf spot, and there is some evidence of rust and shot-hole suppression. As with any DMI fungicide, Indar should be mixed or rotated with other non-DMI fungicides to avoid the development of resistant pathogens.

In New Jersey, an EPA 24C Special Local Need registration allows use of Indar 2F at a maximum 12.0 fl oz/A rate on peach and nectarine, or twice the standard rate. This higher rate is normally not required, but may be necessary if DMI resistance becomes widespread in NJ orchards.

Although Indar has been used as a stone fruit fungicide for years, the newer **Indar 2F** formulation was first registered for use on apple in 2007. The active ingredient fenbuconazole is a group 3 DMI fungicide, and so a maximum of two consecutive Indar or group 3 fungicides sprays is recommended before alternating to a non-DMI fungicide. Like Inspire Super MP, Indar 2F has better scab activity than the older DMIs Rally (Nova) and Procure. However, Indar's mildew activity is somewhat less than these three products. On apple, Indar is labeled for use at 6.0-8.0 fl oz/A with a PHI of 14 days and a REI of 12 hours. Indar 2F is recommended for primary scab control and rust control through second cover. As with Inspire Super MP, summer cover spray applications of Indar 2F are not recommended.

Inspire Super 2.82EW (difenoconazole + cyprodinil) fungicide is labeled for use on most stone fruits, including apricot, tart cherry, nectarine, peach, plum, plumcot, and prune and on many pome fruits, including apple, crabapple, loquat, mayhaw, pear, Asian pear, and quince. Inspire Super should not be applied to sweet cherries. Application rates are 16.0-20.0 fl oz/A on stone fruit and 12.0 fl oz/A on pome fruit.

The two active ingredients in Inspire Super consist of the DMI fungicide difenoconazole, found in Inspire 250EC, and the AP fungicide cyprodinil, found in Vangard 75WG. Since these two active ingredients belong to different FRAC groups, 3 and 9 respectively, use of the mixture is a resistance management strategy. However, both active compounds are rated as having a "medium risk" for resistance development. Thus, a maximum of two consecutive applications is recommended before rotating to another chemistry not belonging to groups 3 or 9.

In peach field studies at the Rutgers Agricultural Research and Extension Center, Inspire Super has provided excellent control of blossom blight canker development and good control of brown rot fruit rot, scab, and rusty spot. The recommended use for Inspire Super is for brown rot fruit rot control when disease pressure is low to moderate. Given a PHI of 2 days, preharvest applications of Inspire Super could be rotated with QoI (group 11) or

SDHI (group 7) fungicides. As a resistance management strategy, application during bloom should be avoided since the goal is to limit use of "at-risk" fungicides during this time, especially DMIs.

On pome fruit, efficacy of Inspire Super is excellent against scab and rust and good against powdery mildew, sooty blotch, and fly speck. Recommended usage is for primary scab control and for powdery mildew and rust control from petal fall through second cover. Although the 14-day PHI would allow some summer applications for sooty blotch and fly speck control, use beyond second cover is not recommended because of potential continued selection pressure for scab resistance, particularly on any secondary scab that resulted from less than perfect primary scab control.

Iprodione 4L - see **Rovral.**

Kaligreen 82SP (potassium bicarbonate) is a broad-spectrum contact biorational fungicide registered for control of diseases on a wide variety of crops, including most major stone and pome fruit species. In particular, potassium bicarbonate has been shown to be effective against many powdery mildew pathogens. In peach studies in NJ, potassium bicarbonate (Kaligreen) has been shown to significantly reduce incidence of peach rusty spot. However, since control is only partial, the recommended program integrates potassium bicarbonate with one of the conventional fungicides myclobutanil (Rally) or flutriafol (Rhyme). For further details on this program, see Rusty Spot in section 6.1.1, Diseases of Stone Fruit. Kaligreen has a REI of 4 hours and a PHI of 1 day. Ideally, the spray solution should have a neutral pH, as acidity can reduce efficacy.

Kocide 3000 30DF (copper hydroxide) - see **copper (fixed).**

Kumulus 80DF (wettable sulfur) - see **Sulfur.**

Luna Sensation 4.2SC (fluopyram + trifloxystrobin) is labeled for apple, sweet cherry, and tart cherry. On apple, the recommended rates range from 4.0 to 5.8 fl oz/A, depending on the target disease, with a PHI of 14 days. On sweet and tart cherry, Luna Sensation is applied at 5.0 to 5.6 fl oz/A with a PHI of one day.

The two active ingredients in Luna Sensation, fluopyram and trifloxystrobin, belong to the SDHI (group 7) and QoI (group 11) chemical classes, respectively. These compounds are rated as having medium to high risk of resistance development. Thus, a maximum of two consecutive applications are allowed before rotating to a different fungicide class. Furthermore, the label limits the total number of applications/season to four for apple and only two for cherry.

On apple, Luna Sensation provides excellent control of scab and powdery mildew, and good control of rusts. This profile makes the fungicide a good choice for use during the primary scab season, but as indicated above the fungicide should be rotated and/ or mixed with other fungicide chemistries.

On cherry, Luna Sensation delivers excellent control of brown rot blossom blight and leaf spot and good control of brown rot fruit rot. Since only two applications are available, the recommended use is for fruit rot management in conjunction with other chemistries, such as the DMIs (group 3). As a resistance management strategy, other chemistries (AP or dicarboximide) or protectant fungicides should be considered for blossom blight control.

Luna Tranquility 4.16SC (fluopyram + pyrimethanil). The current label only allows use on apple. The fungicide is applied at a rate range of 11.2 to 16.0 fl oz/A and has a PHI of 72 days. The two active ingredients, fluopyram and pyrimethanil, are classified as SDHI (group 7) and AP (group 9) fungicides, respectively. SDHI fungicides have a medium-to-high risk of resistance development, while AP fungicides are rated as medium risk compounds.

On a poor to excellent rating scale, Luna Tranquility provides good control of both apple scab and apple powdery mildew, but poor control of rusts. Given this efficacy and its high PHI, the fungicide is recommended for early season primary scab and powdery mildew control in orchards having low to moderate disease pressure. If rust diseases are problematic, an additional fungicide, such as an EBDC protectant (*e.g.*, Manzate), can be added to provide rust control as well as scab resistance management.

Since both active ingredients in Luna Tranquility are at risk for resistance development, the label requires users to make no more than two consecutive applications before rotating to a fungicide of a different group. Furthermore, a maximum of 54.7 fl oz can be applied/A/season, which results in only three to four applications, depending on the rate chosen. DMI (group 3), QoI (group 11), and protectant fungicides, as well as combinations of these materials, are acceptable partners for rotation in a program with Luna Tranquility.

Mancozeb (coordination product of zinc ion + manganese EBDC) is a broad-spectrum fungicide registered for use in controlling scab, rusts, sooty blotch, flyspeck, and Fabraea leaf spot on pome fruit. Available Mancozeb products are Dithane, Manzate, and Penncozeb. No mancozeb materials are labeled for use on stone fruit.

Mancozeb can be applied in one of two ways. When used at full rate, the fungicide is applied from half-inch green-tip through bloom. When used at half rate in combination with another fungicide, sprays can be applied through second cover. This latter approach is called "extended application". The mancozeb materials have maximum application limits in terms of amount of fungicide that can be applied/A each year; see labels for product-specific amounts. Also, EBDC fungicides cannot be applied within 77 days of harvest.

Manzate 75DG - see **mancozeb.**

MeloCon WG - see **Nonfumigant Nematicides** in section 6.6, Nematode Control.

Merivon 4.18SC (fluxapyroxad + pyraclostrobin) is currently registered for use on stone fruits (apricot, sweet and tart cherry, nectarine, peach, all plum types, and prune) and pome fruits (apple, crabapple, Asian pear, and pear).

The two active ingredients in Merivon, fluxapyroxad and pyraclostrobin, belong to the SDHI (group 7) and QoI (group 11) chemical classes, respectively. Since these compounds have medium to high risk of resistance development, a maximum of two consecutive applications are allowed before rotating to a fungicide that does not belong to either group 7 or 11. In addition, the maximum number of applications that are permitted/season is three for stone fruits and four for pome fruits. As with all high-risk fungicides, proper integration with other chemistries and protectant fungicides is an important strategy for preventing resistance development.

On stone fruit crops, Merivon is labeled at rates of 4.0 to 6.7 fl oz/A and has a PHI of 0 days. Results of several years of research on peach at the RAREC demonstrated that Merivon at 5.0 to 6.5 fl oz/A provides excellent control of brown rot blossom blight and fruit rot, good control of Rhizopus fruit rot, and fair control of peach scab and rusty spot. Given this profile, the recommended usage for Merivon is for preharvest brown rot control, where it could be used in rotation with DMI (group 3) and protectant fungicides. Although Merivon provided excellent control of blossom blight, the fungicide is not recommended for use at this time. As a resistance management strategy, other chemistries (such as AP, dicarboximide, and protectants) are best used during bloom.

On apple, Merivon provides excellent control of scab and powdery mildew and good control of rusts. Although this efficacy profile indicates that Merivon could be deployed alone during the primary scab season, rotation with other chemistries and/or mixing with protectants, such as mancozeb (*e.g.*, Manzate 75DF at 3.0 lb/A), is the recommended approach for resistance management. Even so, the labeled rate range of 4.0 to 5.5 fl oz/A only allows four applications/season.

On all crops, Merivon should not be applied with EC or solvent based formulations or with crop oil concentrate (COC) or methylated seed oil (MSO) adjuvants. On pears, to avoid damage to foliage and/or fruit, do not apply Merivon with horticultural mineral oil.

Meteor 4F - see **Rovral.**

Micro Sulf 80DF (wettable sulfur) - see **Sulfur.**

Microthiol Disperss 80DF (wettable sulfur) - see **Sulfur.**

Miravis fungicide is registered for use on many pome fruit crops, including apple, pear, and quince, and many stone fruit crops, including apricot, cherry, nectarine, peach, and plum. The active ingredient in Miravis is pydiflumetofen, a succinate-dehydrogenase inhibitor (SDHI) belonging to FRAC group 7. The fungicide's formulation is a 1.67SC, or 1.67 lb of pydiflumetofen per gallon of suspension concentrate.

On pome fruit, Miravis is registered for application at only one rate, 3.4 fl oz/A, while on stone fruit Miravis can be applied within the rate range of 3.4 to 5.1 fl oz/A. For both crop groups, do not make more than two consecutive applications and no more than four applications at maximum rate per year. The maximum annual rate on pome and stone fruit is 13.6 fl oz/A/year and 20.4 fl oz/A/year, respectively; see label for further use restrictions, including guidelines for resistance management. Although the restricted-entry interval (REI) for both crop groups is the same (4 hours), the pre-harvest interval (PHI) for pome fruits is 30 days while the PHI for stone fruits is 0 days.

The Miravis label lists control of nine pome fruit diseases and eight stone fruit diseases. On pome fruits, Miravis has activity against alternaria blotch, alternaria rot, apple scab, cedar apple rust, quince rust, flyspeck, sooty blotch, powdery mildew, and pear scab. The fungicide only provides suppression of bitter rot, white rot, black rot, and brooks fruit spot. On stone fruits, Miravis has activity against Alternaria spot and fruit rot, anthracnose, brown rot blossom blight, brown rot fruit rot, leaf rust, powdery mildew, scab, and shot hole.

In two separate studies on apple, Miravis provided excellent control of both fruit and foliar scab. The fungicide yielded 96 to 97% control of fruit scab, and 91 to 98% control of scab on leaves. However, powdery mildew control was only fair; in two separate studies, only 50 and 63% control was obtained. In a single study, under heavy bitter rot disease pressure, Miravis yielded only 22% control, which is too low for even a “suppression” rating. However, additional data are needed to confirm this finding.

When applied on peach during the pre-harvest fruit ripening period, Miravis provided very good to excellent control of brown rot at harvest and post-harvest. In results from two separate studies, brown rot control averaged 88%, with a range of 74 to 98%. In contrast, Miravis only provided 67% control of brown rot blossom blight in results from a single study. Under light disease pressure, the fungicide yielded 100% control of peach scab. However, for both these latter two diseases, additional data are needed to confirm the findings.

Mycoshield 17WP (oxytetracycline) is an antibiotic extremely effective against bacterial spot of stone fruit. It is a brand of agricultural terramycin. The desired concentration for control is 150 ppm, or 12.0 oz of material/100 gal water applied. FireLine 17WP is another available formulation of oxytetracycline.

Since it has a short residual of only five to seven days, terramycin must be applied on a weekly schedule beginning at shuck-split. Furthermore, this bactericide is most effective when it gets inside the plant tissue. Thus, applications are best made when conditions allow slow drying, such as during the evening when relative humidity tends to be higher. This approach greatly improves tissue penetration and subsequent control.

For effective control of bacterial spot using this antibiotic, complete spray coverage is also critical. It is important to use a spray volume that thoroughly wets the foliage and fruit to the point of runoff. Typical volumes are 3.0 gal/tree for planting densities of 80 trees/A, which translates into 240 gal of spray/A. For trees of different sizes and/or densities, adjust the volume to maintain good wetting, but maintain the concentration at 150 ppm.

Since bacterial plant pathogens can become resistant to antibiotics, alternation of Mycoshield with other materials, such as fixed-coppers, should be considered. This strategy is particularly important for highly susceptible cultivars, which have a higher rate of development of disease.

Mycoshield is also registered for use in controlling fire blight on pear. Some pear cultivars, especially the Asian pears, are sensitive to this antibiotic and may show injury.

Mycoshield and FireLine are now also registered for use on apple against fire blight. Their labels for apple are very similar, except that Mycoshield can only be applied five times/season, while the FireLine label allows up to six applications. The oxytetracycline active ingredient is a tetracycline (group 41) antibiotic, while the bactericide most commonly used for fire blight on apple, streptomycin, is a glucopyranosyl antibiotic (group 25). Thus, alternating use of these oxytetracycline products with streptomycin products (Agri-mycin, FireWall) allows for an “all-antibiotic” resistance management strategy. Note that although Mycoshield, FlameOut, and FireLine are applied at 150 ppm (12.0 oz/100 gal) for bacterial spot control on stone fruit, the proper concentration for fire blight control on apple and pear is 200 ppm, equivalent to 16.0 oz in 100 gal water. Since coverage is critical for bacterial disease control, use of higher volumes of spray/A is recommended. Both products have a PHI of 60 days and REI of 12 hours.

Nordox 75WG - see **copper (fixed).**

Nu-Cop 50DF (copper hydroxide) - see **copper (fixed).**

Orius 45DF, Orius 20AQ (tebuconazole) is a DMI fungicide registered for control of brown rot, blossom blight and fruit rot on peach, nectarine, and cherry. It is also effective for use on leaf spot and powdery mildew of cherry. Since Orius also has good activity against Rhizopus rot, it would be an excellent choice for preharvest application when wet weather results in “in-field” development of this disease. As with other DMIs, the potential for resistance development exists. Thus, Orius should be applied as a mix or in alternation with fungicides of a different chemistry.

Oso 5%SC. This fungicide is registered for use a wide variety of stone fruit crops, including apricot, cherry, nectarine, peach, plum, plumcot, and prune. On pome fruits, Oso is labeled for apple, crabapple, loquat, mayhaw, pear, and quince. The active ingredient is a zinc salt of polyoxin D, which belongs to FRAC code 19 (cell wall biosynthesis inhibitors). Polyoxin D has a medium risk of resistance development. Although a type of antibiotic, polyoxin D does not control bacteria. The product has an REI of 4 hours and a PHI of 0 days.

Oso is labeled for control of botrytis blossom blight and powdery mildew on peach, and for alternaria leaf spot, leaf blotch, powdery mildew, and scab on pome fruit. Control of rusty spot on peach in field studies at Rutgers has been variable. Very good control (88%) was observed in 2014, while an insignificant level of control (42%) was obtained in 2015; in both years disease pressure was low. Management of brown rot at harvest was somewhat more consistent, yielding 72% control under heavy disease pressure and 95% control under light disease pressure. Blossom blight control under very heavy disease pressure in 2015 was very good to excellent, yielding 87% control in incidence with a 92% reduction in canker formation; however, a second year of data are needed to confirm these efficacy results. Addition of a sticker/spreader is suggested.

Oxidate (hydrogen dioxide) is an OMRI approved broad-spectrum bactericide / fungicide registered for use on many crops, including both stone and pome fruit. When applied, it acts as a surface sterilant. Effective control of diseases in the field needs to be demonstrated. Given the active ingredient, also known as hydrogen peroxide, residual activity against pathogens is considered unlikely. Oxidate is also labeled, and perhaps more useful, for sterilization of equipment and cutting tool surfaces. Rendition is a similar material.

Penncozeb 75DF - see **mancozeb.**

Polyram 80DF (metiram) is an EBDC fungicide mixture, the main component being ammoniates of zinc EBDC. On apple, it is effective as protectant sprays for control of scab, cedar-apple rust, sooty blotch, and flyspeck. This fungicide has no activity against powdery mildew. As with the mancozeb fungicides, Polyram can be used at full rate prior to bloom or at half this rate for an extended application program through second cover.

Pristine 38WG (pyraclostrobin + boscalid) consists of a mixture of QoI and SDHI fungicides labeled for use on apricot, cherry (sweet and sour), nectarine, peach, plum, plumcot, prune, apple, pear, and Oriental pear. The resulting product provides broad- spectrum disease control. Stone fruit diseases listed on the label are alternaria leaf spot, anthracnose, blossom blight, brown rot, leaf spot, powdery mildew, rusty spot, scab, and shothole. Pome fruit diseases listed on the label are alternaria blotch, apple scab, pear scab, bitter rot, black rot, white rot, powdery mildew, brooks spot, flyspeck, and sooty blotch. Cedar-apple rust and quince rust are only suppressed by Pristine.

Field studies in New Jersey showed excellent control of brown rot on peach when applied in preharvest sprays at 10.5 oz/A. On peach cultivars highly susceptible to rusty spot, Pristine provided adequate control only when applied at its highest rate of 14.5 oz/A. Under heavy disease pressure, Pristine was not effective in controlling peach scab when applied via airblast at 100 gpa; however, good control was obtained when applied dilute via handgun, indicating the importance of complete coverage when disease pressure is high. Although data are limited, Pristine also showed excellent control of blossom blight and anthracnose.

Field tests on apple examined application of Pristine (14.5 oz/A) in alternation with Ziram 76DF during cover sprays. Four applications of Ziram and three applications of Pristine provided excellent control of sooty blotch, flyspeck, and bitter rot; good control was obtained for white and black rots. Pristine should be rotated with fungicides of different chemistry to lessen the risk of resistance development. The DMI fungicides are good candidates for this purpose when managing brown rot or blossom blight.

Procure 50WS (triflumizole) is a DMI fungicide with activity against powdery mildew, scab, and rust on apple and powdery mildew and scab on pear. This fungicide is readily absorbed, locally systemic, and can act as an anti-sporulant when applied to lesions already present. In addition to being a protectant, Procure can be applied up to 72 hours post-infection when used at its higher 4.0 oz/100 gal rate.

Propiconazole (Bumper 3.6EC, PropiMax 3.6EC, Tilt 3.6EC)provides excellent control of brown rot on most stone fruit crops, including apricot, cherry (sweet and sour), nectarine, peach, plum, plumcot, prune, and other hybrids of these crops. It also provides control of blossom blight, powdery mildew, and cherry leaf spot.

In recent years, resistant strains of *Monilinia fructicola*, causal agent of brown rot, have been detected in a number of peach growing regions in the eastern United States, including New Jersey. Since propiconazole and related DMI fungicides Indar and Elite are important tools for brown rot management, alternation of these materials with other fungicide chemistries is highly recommended. This action is necessary to prevent or delay the widespread occurrence of pathogen resistance to the DMI's.

PropiMax 3.6EC (propiconazole) - see Propiconazole.

Quadris Top 2.72SC is labeled for apricots, sweet and tart cherries, peach, nectarines, plums, plumcots, and prunes. It is also labeled for use on grapes and strawberries. The fungicide is a premix of two active ingredients, the second generation DMI difenoconazole and the Qol azoxystrobin. Difenoconazole is the active ingredient in the fungicide Inspire, while azoxystrobin is the active ingredient found in Abound.

In several years of field testing on peaches at Rutgers, Quadris Top applied at the labeled 12.0 to 14.0 oz/A rate provided excellent control of brown rot blossom blight, scab, and brown rot fruit rot. Management of peach rusty spot was considered good, while control of Rhizopus rot was only fair in postharvest evaluations. Quadris Top was the first and currently the only fungicide rated as excellent for management of peach scab. This high level of control, even under very heavy disease pressure was most likely due to the fact that both active ingredients in the product are active against *Fusicladium carpophilum*, the scab pathogen. Several other stone fruit diseases are also listed on the label, including anthracnose and shot hole; however, no data are currently available to indicate the efficacy of this fungicide against these diseases.

In peach disease management programs, Quadris Top fits best as a preharvest brown rot fungicide given its 0-day PHI; a maximum of two consecutive sprays are allowed at this time. The fungicide can also play an important role, along with Flint Extra and Bravo, in controlling peach scab when inoculum levels are high and environmental conditions are very favorable (many wetting periods following shuck-split). Although Quadris Top provided excellent blossom blight control, management of the brown rot pathogen at this time is best performed with other fungicide chemistries (not DMI or Qol) as a resistance management strategy. Possible alternatives for blossom blight control include protectant fungicides (*e.g.*, Bravo or Captan), Topsin M, Rovral, Vangard, or Elevate.

Quash 50WDG (metconazole) is a DMI fungicide labeled for use on stone fruits. It is labeled for and provides good control of brown rot blossom blight on apricot, nectarine, peach, cherry (sweet and sour), and plum. It also labeled for brown rot and scab on peach, nectarine and apricot, as well as for powdery mildew control on cherry and plum.

In two years of testing on peach in New Jersey, Quash has shown outstanding control of brown rot during the preharvest fruit ripening period. However, the current (2009) label only allows Quash to be used up to 14 days before harvest. Thus, for brown rot management on peach and nectarine, Quash can only be used for the first preharvest application, typically applied between 21- and 14-days preharvest. Scab control has only been fair under heavy disease pressure in NJ tests; better scab control has been observed under less pressure in other states. Several use restrictions apply, including a maximum of 3 applications/season.

Quintec 2.08F (quinoxyfen) is a protectant fungicide for control of powdery mildew on sweet and tart cherry. Generally, powdery mildew is not problematic on cherry in New Jersey. However, if this disease has occurred in the prior year, apply Quintec beginning at shuck-fall following label directions. Quinoxyfen is also labeled for grape powdery mildew control. Currently, a supplemental label allows use on peach, but control of rusty spot was only rated as fair.

Rally 40WSP (myclobutanil), formally called Nova, is a DMI fungicide that is effective against blossom blight and brown rot, has some activity against powdery mildew, but is weak against peach scab. It is labeled for use during bloom, cover sprays, and preharvest period. At 4.0-5.0 oz/A, Rally is the best material for control of peach rusty spot. On apples, Rally is registered for control of scab, powdery mildew, and cedar apple rust. When used in a protectant schedule, the postbloom sprays should include a non-related protectant fungicide to guard against resistance development. For post-infection scab control, Rally should be applied within 96 hours from the start of the infection period. As a curative spray, Rally can suppress sporulation of lesions, but this approach requires several applications.

Rendition (peroxyacetic acid and hydrogen peroxide) is a broad spectrum surface sterilant with 5.2% peracetic acid as its active ingredient. It is active on fungi, bacteria, viruses, and algae. Rendition can be applied to foliage, soil, surfaces, post-harvest in line sprays and water treatment. It can be applied to all fruit crops. Rendition has a 1 hour REI and 0 day PHI. Oxidate is a similar material.

Ridomil Gold EC (mefenoxam) provides excellent control of root and collar rot caused by *Phytophthora* species on both pome and stone fruit. Up to three applications, each at 2.0 qt/treated A, are allowed/season. A treated acre is defined as the actual surface area contacted with an application, *i.e.*, the tree row. Typically, two sprays are applied in spring, the first being in early April, followed by one in fall, usually October. Optimum timing is during periods of wet weather when soil moisture is high.

Ridomil can be applied in a band application using an herbicide sprayer. In this case, the material should then be irrigated with one-half to one-inch of water to move it into the root zone. Band applications make sense for mature orchards since most of the tree row soil contains tree roots. However, for younger orchards, the fungicide can be more economically applied as a soil drench only to the area beneath the canopy. Instructions for a soil drench application for apples are given in the product label. These same instructions can be followed for stone fruit, as long as the labeled 2.0 qt/treated acre rate is not exceeded.

Rovral 4F (iprodione) is a dicarboximide fungicide registered for control of blossom blight on stone fruit. A maximum of two applications/season at 1.0-2.0 pt/A is allowed. Rovral and similar products (Meteor, Iprodione) are not labeled for use after petal fall.

Scala 5SC (pyrimethanil) is an anilinopyrimidine fungicide registered for management of scab on pome fruits, including apple, pear and Oriental pear. Scala's unique chemistry, similar to that of Vangard, makes it useful for resistance management by alternating with DMI or QoI fungicides.

Scala is also registered on stone fruit (peach, nectarine, plum) for control of brown rot, blossom blight, shot hole, and gray mold. In a 2015 study under heavy blossom blight disease pressure, Scala 5SC at 14 fl oz/A provided very good control of blossom blight canker and was equivalent to the iprodione (Rovral, Meteor) standard. Scala reduced cankers per shoot by 89% while Rovral provided a 91% reduction. However, before Scala can be recommended, at least one additional year of data are needed to show that it can consistently control blossom blight. Based on much earlier studies, Scala is not recommended for preharvest brown rot control. Scala is not effective for rusty spot control.

Scholar 50WP (fludioxonil) - see section 6.1.3, Postharvest Peach and Nectarine Treatment.

Sercadis fungicide is registered for application on just one tree fruit crop, apple. Currently, there are no plans for addition of other pome or stone fruit crops to the label. The formulation is a suspension concentrate that contains 2.47 lb of the active ingredient fluxapyroxad per gallon, or a 2.47SC. This active ingredient is a succinate-dehydrogenase inhibitor (SDHI) or FRAC group 7. Fluxapyroxad is one of the two active ingredients in Merivon fungicide.

On apple, Sercadis can be applied within the rate range of 3.5 to 4.5 fl oz/A, with a maximum of four applications or 18 fl oz/A per year. For resistance management, mix or alternate with other non-SDHI fungicides, and do not apply more than two sequential applications. It has a restricted-entry level interval (REI) of 12 hours and a pre-harvest interval (PHI) of 0 days. The Sercadis label lists control of apple scab, powdery mildew, alternaria blotch, black rot / frogeye leaf spot, and flyspeck; rust diseases, namely cedar apple rust and quince rust, are only suppressed.

In two apple studies conducted in the Mid-Atlantic region, Sercadis provided only fair to good control of foliar scab (63 and 71% control), but very good control of fruit scab (83 and 86% control). Powdery mildew control was fair under heavy disease pressure in two studies, ranging from 54 to 60% control, while very good management (80% control) was observed under light disease pressure in a third study. In a single study, Sercadis provided excellent management of cedar-apple rust (94% control) under moderate disease pressure. Given that the label only lists suppression for cedar-apple rust, additional data are needed to confirm this finding.

A variety of studies examined Sercadis for summer disease control. In three separate studies conducted in the Mid-Atlantic and Northeast apple growing regions, Sercadis consistently had better control of flyspeck than sooty blotch. In these studies, flyspeck control was 97, 85, and 95%, while control levels for sooty blotch were 81, 71, and 46%, respectively. Results from a single study showed poor management of bitter rot; only 28% control was achieved. This finding explains why bitter rot is not listed on the label.

Performance of Sercadis can be improved with use of adjuvants or additives. However, mixture with some oils and emulsifiable concentrates (EC) can cause phytotoxicity. See label for details.

Serenade Optimum 26.2WP (QST 713 strain of *Bacillus subtilis*) is a broad-spectrum biological/biorational fungicide registered for use on a wide variety of crops, including both stone and pome fruits. On both types of crops, Serenade Optimum has an REI of 4 hours and a 0 day PHI. The product is also listed for use in organic production.

In New Jersey, Serenade has been examined extensively for use in managing peach rusty spot, where it has been shown to significantly reduce disease incidence. However, since control is only partial, the recommended program integrates Serenade with the conventional fungicide myclobutanil (Rally). For further details on this integrated program, see Rusty Spot in section 6.1.1, Diseases of Stone Fruit.

On pome fruit, Serenade Optimum is listed as providing suppression of fire blight and scab; rotation with conventional fungicides/ bactericides is recommended.

Sovran 50WG (kresoxim-methyl) is a QoI fungicide registered for use on apple, pear, quince, crabapple, loquat, mayhaw, and Oriental pear. This broad-spectrum fungicide provides excellent control of scab, sooty blotch, and flyspeck; good control of powdery mildew, white rot, and black rot/frogeye leaf spot; fair control of cedar apple rust; and no efficacy against bitter rot. In addition, limited tests have shown good control of brooks spot. No results are yet available on activity against fabraea leaf spot on pear. Sovran is also registered for use on grapes. Labeled rates for Sovran are 4.0 to 6.4 oz/A at 10-14 day intervals. Results of efficacy studies in NJ indicated excellent control of sooty blotch and flyspeck at the lower 4.0 oz/A rate and 100 gpa volume. For scab control, Sovran also exhibits up to 96 hours of curative capability. However, when used for post-infection control, the higher rate should be applied, followed by a second application, 10 days later. Antisporulant activity also occurs against scab and powdery mildews.

For resistance management, limit the number of consecutive sprays of Sovran to three before switching to a fungicide of different chemistry; or use an alternate spray strategy. Thus, Sovran makes an excellent partner in spray programs that have relied heavily on the DMI fungicides Rally or Procure. Furthermore, Sovran provides an additional management tool for summer diseases.

Stargus (*Bacillus amyloliquefaciens* strain F727) **-** see **Double Nickel**

Streptrol 17WP (streptomycin) is registered for bacterial disease control on apples and pears. See Agri-mycin 17WP for details on usage.

Sulfur is available as dry wettable powders, dry flowables, and as liquid lime sulfur. The lime sulfur form is best used for dormant applications, as it can be injurious to both foliage and fruit. The wettable sulfurs are much less injurious, but can still cause some leaf burning and fruit russeting on apple if used during hot weather (above 85°F). Newer sulfur formulations, such as Kumulus, Micro Sulf, Microthiol Disperss, or That Flowable Sulfur, cause less injury. The labeled rate range for these materials on stone and pome fruit is 8.0-24.0 lb of actual sulfur/A. Typically, application at 10-12 lb actual sulfur/A provides a good compromise between getting adequate disease control and minimizing injury.As a fungicide, sulfur is quite effective against powdery mildews on pome and stone fruit. It also has good efficacy against scab on peaches and nectarines. However, it has little activity for control of cedar-apple rust, the fruit rots, summer diseases, and only partial control of peach rusty spot. Do not use sulfur within seven days after an oil application.

Sulfur is not recommended for control of apple scab, as it is only moderately effective. Many other superior fungicides are available for this use. Similarly, on stone fruit, sulfur should not be used for brown rot control during the critical bloom or preharvest period, particularly if the weather is favorable for disease development. However, sulfur can be used during the cover sprays when fruit are less susceptible to brown rot infection. During this period, sulfur provides good control of scab on peach and nectarine.

Syllit 3.4FL (dodine) is available for use on both pome and stone fruit. On apple, this fungicide gives excellent control of scab, but does not control powdery mildew, rust, rots, or most summer diseases. Dodine can be used for post-infection scab control, but must be applied at the highest rate and within 36 hours from the start of the infection period.

Although registered for application on peach and nectarine, label restrictions limit usage, particularly for orchards east of the Mississippi River. On cherry, Syllit is excellent against leaf spot.

That Flowable Sulfur 6F (sulfur) - see **sulfur.**

Thiram Granuflo 75WDG (thiram) provides fair protection against brown rot and peach scab. This fungicide is not recommended when conditions are extremely favorable for disease. Thiram is also used as a deer repellent.

Tilt 3.6EC (propriconazole) - see **Propiconazole.**

Top Cop with sulfur (basic copper sulfate, sulfur) - see **copper (fixed), sulfur.**

Topguard 1SC (flutriafol) is a DMI fungicide registered on stone fruit for control of brown rot blossom blight and fruit rot, powdery mildew, and cherry leaf spot. Stone fruit crops listed on the label include apricot, peach, nectarine, sweet cherry, tart cherry, plum, Japanese plum, Damson plum, chicksaw plum, plumcot, and prune. On pome fruit Topguard is registered for for control of scab, powdery mildew, quince rust, and cedar-apple rust. Labeled pome fruit crops are apple, crabapple, loquat, mayhaw, and quince. Topguard is not registered for use on pear.

Topguard has not been tested in New Jersey. Results of two years of testing on peach in Georgia and South Carolina indicated only fair control of brown rot fruit rot. No data are currently available for efficacy against brown rot blossom blight or peach rusty spot. On cherry in Michigan trials, Topguard has similarly provided only fair control of brown rot. Results from Michigan on control of cherry leaf spot were inconclusive because leaf-spot resistant strains were believed to be present in the test orchard. However, a single year of cherry leaf spot data from Oregon, albeit under light disease pressure, indicated good control.

As with other DMI and at-risk fungicides, Topguard should be rotated with fungicides of a different chemistry as a resistance management strategy. The REI on stone and pome fruit is 12 hours, while the PHI is 7 and 14 days, respectively.

Topsin M 70WDG, Topsin M 70WP, Topsin M 70WSB (thiophanate-methyl) is registered for control of brown rot, peach scab, powdery mildew, black knot, and cherry leaf spot on a variety of stone fruit crops. On apple, Topsin M is effective for scab, powdery mildew, black rot, sooty blotch, and flyspeck control. The 70WDG formulation has an REI of 12 hours, while the other formulations have an REI of 2 days.

Thiophanate-methyl is an MBC fungicide, which has a high risk of resistance development. Consequently, extended use of Topsin M without other non-MBC fungicides can result in the development of resistant plant-pathogenic fungi.

Vangard 75WG (cyprodinil) is an anilinopyrimidine fungicide registered for use on both stone and pome fruits. It is currently registered for apricot, tart cherry, nectarine, peach, plum, prune, apple, and pear. Cyprodinil has low toxicity and has been classified by the EPA as a reduced risk compound. It has a medium risk of resistance development.

On apple and pear, Vangard provides 48 hours postinfection capability for scab control, with six days residue for forward, preventative activity. It also exhibits good suppression of apple powdery mildew. On stone fruit, Vangard is registered only for use in controlling brown rot blossom blight. In NJ field studies conducted during 2009 and 2010, Vangard applied at 5.0 oz/A during bloom provided 83 to 100% control of blossom blight canker formation.

Vintage 1SC (fenarimol) is highly effective against scab, powdery mildew, and rust on pome fruit. It will provide up to 96 hours of post-infection control against scab. However, since it has a residual activity of only 3 days, it must be combined with a protectant-type fungicide if spray intervals are longer than 7 days. Vintage replaces the older EC formulation of fenarimol.

Ziram 76DF (ziram) is a zinc salt derivative of dithiocarbamic acid, the precursor to a wide variety of organic sulfur fungicides, such as the EBDC's. On apple, it can be applied from pre-bloom through cover sprays for use in controlling scab, both cedar-apple and quince rusts, sooty blotch, flyspeck, bitter rot, and necrotic leaf blotch. On pear, it also has activity against Fabraea leaf spot. On both of these pome fruits, ziram can be used as a mixing partner along with a MBC or DMI fungicide.

On peach and nectarine, ziram can be used for both peach scab and brown rot control. On cherry, ziram is also effective against leaf spot as well as brown rot. However, for all these stone fruits, it cannot be applied within 14-days of harvest and so has limited use for late season fruit rot control.

Ziram is one of the best fungicides for leaf curl control on stone fruit. Dormant applications, either in fall after leaf drop or in spring prior to bud-swell, can be applied for controlling this disease. In a 2008-2009 NJ study, a fall application of Ziram 76DF at 6.0 lb/A reduced leaf curl incidence by 99% (non-treated trees had 62% bud infection).

6.4 Insect and Mite Pests of Fruit Trees

Apple Maggot

Adult flies usually begin to emerge in mid-June and continue to emerge for about 3 months. Female flies lay eggs in fruit. Upon hatching, the maggot feeds and tunnels within the fruit. Abandoned, unsprayed apple and pear trees plus hawthorn and pyracantha are all major sources of infestation. Control should be applied within 1 week of when the first adult flies are trapped. Consider removing wild/abandoned host trees surrounding your orchard.

Black Peach Aphid

The black peach aphid establishes colonies and feeds belowground on peach roots and large populations can severely debilitate young trees. In spring, many of these overwintering root feeders emerge to establish colonies on the buds. Their color is dark brown to black and when full grown, are nearly 0.1 inch long. Populations can increase rapidly as the winged forms spread the infestation throughout the orchard. In mid-summer, aphids migrate downward through soil cracks to peach roots where they spend the winter. Once aphids become established on the roots, control is difficult. The most effective control of the black peach aphid is to prevent its introduction into the orchard on the roots of nursery stock. Natural levels of biological control may suppress populations from establishing.

Brown Marmorated Stink Bug (BMSB)

Brown marmorated stink bug is an invasive species whose populations have become damaging in New Jersey since its introduction. For identification and to distinguish from native stink bug species, visit: *http://www.stopbmsb.org/stink-bug-basics/life-stages/ or http://njaes.rutgers.edu/stinkbug/similar.asp.*

BMSB is a highly mobile pest that feeds on many agricultural crops including tree fruit as well as landscape plants found in the wood borders of farms. Unlike some orchard pests, BMSB can cause damage throughout its life cycle and is present for much of the growing season. There are a large number of effective compounds against BMSB, however, many have short residual activity against this pest and require multiple applications. Insecticide effectiveness against BMSB is listed in Table 6.5.

In peaches, weekly border sprays have been as good at reducing damage as full block or alternate row middle sprays, while only spraying ~25% of the orchard. Be cautious about the overuse of pyrethroid insecticides, which have been shown to cause secondary pest outbreaks (scale, mites, and aphids).

Monitoring: Unlike native stink bug species, BMSB is not found in the ground cover. Monitoring to detect populations is best made with aggregation pheromone traps to indicate activity, supplemented with visual observations on plants. BMSB moves into orchards from either the wood edge or other crops and initial monitoring on host plants can be done on the orchard perimeter. Additional inspections of fruit will help to determine damage, as this pest can be difficult to detect. In peach, we currently do not have economic or treatment thresholds but can use 1-2% fruit injury as guidelines. In apples, a trap-based threshold of 4 cumulative adults to initiate alternate row middle sprays is recommended. Based on phenology, management is not necessary until 1st cover.

Phenology: Rutgers has developed and is testing a phenological model to predict populations in the field. BMSB requires 538 DD (base 14˚C) to complete development. Females require an additional period of 40-200 DD (dependent on host resources and photoperiod) for reproductive development. Adults disperse to the orchard, especially peach, at ~80-100 DD (accumulations starting April 22), generally the second to third week of May. Termination of overwintering state requires a lengthening of photoperiod and thus, early warming periods will not speed up activity. The adults dispersing into the orchard are reproductively mature and egg masses can be found in about 1 week. The first adults appearing in the orchard are generally found in peach, which is a highly suitable host plant. Adults will move in and out of peach orchards and eventually into apple throughout the season. Nymphs can complete their development in peach. In New Jersey, we have two generations of BMSB.

Catfacing Insects

The tarnished plant bug and the dusky, green, and brown stink bugs collectively form the group called catfacing insects. Their feeding on peaches during the pink and petal fall through shuck-split periods generally results in dimpled, fuzz-free areas, and aborted fruit. Feeding during the shuck-fall to second and third covers results in unsightly, slightly sunken, callused, black blemishes on the skin surface generally 0.0625 to 0.25 inch in diameter. Damage closer to harvest appears as water soaked lesions. These insects overwinter as adults and move into peach orchards about the time buds begin to swell. Because these bugs are strong fliers, their presence may be widespread, and depending upon availability of other host plants, injury can vary considerably from block to block. Other hosts include vetch, alfalfa, clover, goldenrod, fleabane, dog fennel, pigweed, ragweed, lambsquarter, and dozens of different kinds of flowers and commercial vegetables. Where catfacing has been a problem, insecticide applications are essential at petal fall and shuck-split. Additional bug controls are needed during the shuck-split to shuck-fall period through third covers, depending upon the extent of the bug populations. Early season orchard cultivation is risky because it forces the bugs up into the trees. Eliminating alternate weed hosts in the orchard should reduce damage caused by this pest complex.

Codling Moth

Codling moth attacks fruit of apples and pears and is not tolerated in commercial fruit. The earliest fruit entries by codling moth larvae usually occur about the time the second cover is applied. We have three generations in New Jersey. Control should be timed with trap catches and a degree-day model. Mating disruption reduces or prevents mating and egg laying within the orchard and provides insurance for weather events that may reduce the reliability of the degree-day model or insecticide efficacy (see section 10.7.1, Mating Disruption Technology for Key Apple Insect Pests). Effective insecticides include diamides, spinosyns, insect growth regulators, and granulovirus (Madex HP) and should be applied at the proper development stage. Biological products, including Madex HP may need to be reapplied every 5-7 days during the active egg laying period. Many codling moth populations in NJ have evolved resistance to pyrethroid insecticides.

Dogwood Borer/Apple Bark Borer

These insects are attracted to apple burr knots or partially developed root initials that form a mass of soft tissue on the trunk of size-controlling rootstocks. Eggs are laid on the burr, and upon hatching, larvae then burrow into it. Feeding disrupts sap flow and girdling can occur and kill the tree. The borer problem can be aggravated by mesh, screen rabbit guards that collect and hold leaves about the trunk, thus providing a more favorable environment for development. Mating disruption options are available (see section 10.7.1, Mating Disruption Technology for Key Apple Insect Pests).

European Apple Sawfly

European apple sawfly adults are small, dark brown, clear-winged, fly-like wasps. Larvae overwinter in the soil, and pupate in the early spring. Adults emerge and lay eggs between pink and petal fall. Eggs are laid near the calyx end of the fruit. As the larvae feed, they form a winding borrow just under the skin, leaving a russetted scar at harvest. Uncontrolled larvae can enter a second fruit and borrow into the core. A petal fall spray usually provides adequate control, but in problem blocks both pink and petal fall sprays may be needed.

European Red Mite

The European red mite overwinters in the egg stage on twigs and in bark cracks and crevices. On apples, eggs normally hatch during the prepink to early bloom bud stages, whereupon the mite larvae crawl to the unfolding leaves and commence feeding. European red mites can build up to the point where leaf bronzing is visible by mid- to late July. If leaf damage is both heavy and early enough (second to fourth covers), next year's crop can even be affected. Superior Oil applications on apple, from delayed dormant through tight cluster, provide good control as do prebloom Apollo and Savey applications. In recent years, a number of orchards were found to have strains of mites with various degrees of resistance to Kelthane, Carzol, and Vendex. Early control measures often increase the likelihood of good predator-to-prey ratios by allowing mite predators to keep mites below treatment levels.

Green Peach Aphid

Large numbers of green peach aphids suck the plant juice from the leaves causing them to become stunted, curled, and discolored (yellow) by June. Aphids normally disperse to other host plants by mid-June. For best results, make applications before leaves become curled and discolored.

Leafrollers

There are several species of leafrollers in NJ orchards. Tufted apple bud moth and variegated leafroller (see TABM and VL below) are two that are somewhat resistant to Imidan. The red-banded leafroller with three generations/year and the fruit tree leafroller with one generation/year are still susceptible to most insecticides. The most important times to control these latter two pests are in the petal fall and first cover sprays.

Lesser Peach Tree Borer

Lesser peach tree borer (LPTB) attacks weak and injured trees, winter-damaged orchards, and diseased trees. Adult borers (moths) are attracted to injured trees and deposit eggs in wounds from May through early July and again in September. Insecticide protection is recommended primarily for the control of the second brood in early September, and slightly later in northern counties. Applications should be made with a hand gun to the point of run off, making sure to cover all cankers. Asana, or Pounce should be applied postharvest with a handgun. See labels for dosage rates. Mating disruption has proven very effective for LPTB and PTB, even on plots as small as 2 acres (see section 7.6.1, Mating Disruption Technology for Key Peach and Nectarine Insect Pests). Mating disruption is not a curative treatment and will not kill larvae already inside of the tree. Young trees should be protected immediately after planting, options are available.

Oriental Fruit Moth

Oriental fruit moth (OFM) attacks both stone and pome fruit. There are four generations of this insect each year, but a fifth generation may occur in the southern two-thirds of the state during a warm year. First generation larvae bore into succulent twigs usually about the time when shucks split. This damage is visible as “flagging” which resembles dead leaves on the end of the terminal. Later generations also attack developing fruit, often boring into the fruit as tiny larvae, close to the stem. Control is timed to degree day accumulations and usually commences about the time shucks split. Mating disruption is very effective for OFM and has been rigorously evaluated in commercial New Jersey farms. See section 7.6.1 for peaches and nectarines, and 10.7.1 for apples.

Peach Silver Mite

This is a very tiny mite that feeds on leaf surfaces causing them to become silvery. In orchards where sulfur is used, they are not a problem. This mite is unlikely to cause injury.

Peach Tree Borer

Peach tree borers (PTB) usually fly from mid-June on, but most of the larvae are present in the trees by early September. Control can be achieved by drenching the tree trunk and scaffold limbs with Asana XL at 5.8 oz/100 gal rate. Trees should be treated for peach tree borers the same time that the scaffold limbs are treated for lesser peach tree borers. Airblast sprayers are not suited for borer control because not enough spray reaches the target area. Mating disruption has proven very effective for LPTB and PTB, even on plots as small as 2 acres (see section 7.6.1). Mating disruption is not a curative treatment and will not kill larvae already inside of the tree. Young trees should be protected immediately after planting, options are available.

Pear Leaf Blister Mite

Pear leaf blister mite causes brownish blisters beneath the leaves. By late summer, blisters may nearly cover the entire under leaf. In spring as buds develop, tiny (0.008 inch long) mites commence feeding on leaves, forming blisters.

Pear Psylla

This tiny insect has developed resistance to practically all insecticides used for its control since the 1960s. Psylla adults become active and start laying eggs in spring as outdoor temperatures reach 45°F. Yellowish-white eggs are laid on bud scales, bark cracks, and crevices of fruiting spurs. Nymphs soon hatch and commence sucking sap from tender young leaves. For best results, commence control early in the growing season. Thorough spray coverage is absolutely essential for control. A dilute spray application invariably results in better, more lasting control than a concentrate application. Pre-bloom Superior Oil, plus a pyrethroid insecticide (Asana, Ambush, or Pounce) applied dilute during the dormant period when eggs are first laid, is still one of the most effective means of delaying psylla buildup. In problem blocks, a second oil application plus a pyrethroid is advised during the green cluster bud stage. Be sure to read the labels for restrictions when using pyrethroids before bloom.

Post-bloom use of any pyrethroid insecticide is discouraged. Pyrethroids are toxic to various predator insects. See section 11.4, Pear Disease and Pest Management, for materials effective after bloom.

Pear Rust Mite

Pear rust mite feeding results in a russeting on the fruit. If rust mites were troublesome the previous season, start controls at green cluster bud and repeat at petal fall. Thorough spray coverage is essential for satisfactory control of mites. Concentrate or alternate row sprays generally result in inadequate control due to minimal spray deposit.

Plum Curculio

Generally, overwintering Plum Curculio (PC) adults (weevils) make their first appearance in orchards during bloom. There is a strong ede effect, particularly in blocks with wood edges. Cool weather slows down their emergence from overwintering sites while warm spells (70°F and above) can produce large numbers of weevils suddenly in trees. There are two generations/year in North Jersey. In peaches this could result in live larvae in the fruit at harvest and external damage by the second generation is difficult to see as the fruit may look intact. There has been an increase in the amount of feeding injury and larval contamination in peaches in recent years due to the second generation. A degree day model for peaches has been evaluated by Rutgers. Using January 1 as the start date, PC adults begin moving into the orchard around 200 DD_{50} with peak activity at 295 DD. In blocks with a history of PC damage, management should begin at 295 DD through the end of oviposition activity. In apples, the second generation is generally not problematic as the fruit is too hard for development of the larvae. The petal fall, shuck-split, shuck-fall, first, and second cover sprays are most critical for control.

Rosy Apple Aphid (RAA) and Apple/Spirea Aphids

Overwintered rosy apple aphid eggs commence hatching in early spring, and the peak hatch occurs during the green-tip period. Hatch is generally completed by 0.5 inch green. Superior Oil has little effect on aphid nymphs but will suffocate embryos in unhatched eggs. Most insecticides that are listed in the apple spray tables under Delayed Dormant and Tight Cluster are more effective when combined with oil for aphid control. For best RAA control, start the control program early. Don‘t wait until petal-fall. Control of apple/spirea aphids is suggested only when 50 percent or more of the terminals are infested with visible colonies. Removal of sucker growth aids control.

San Jose Scale

San Jose scale seems to be more troublesome every year and difficult to control once the immature stages (crawlers) and, particularly adult scales, are noted on twigs and limbs during the growing season. Dormant application of Superior Oil or Centaur is still the best way to control this pest and is recommended in problem blocks. Best results are obtained when oil is applied in at least 200 gal of spray/mature A. Applications should be made as full block sprays to ensure complete coverage. A growth regulator such as Esteem or Centaur or Venerate can be applied during the crawler stage and is recommended in problem blocks.

Spotted Tentiform Leafminer

Spotted tentiform leafminer has developed resistance to Imidan and Sevin. In problem orchards, control before bloom is most important. If necessary, the best time to control the second brood is in late-June to mid-July, when there is an average of 0.5 to 1 sap-feeding mines/leaf. Sapfeeding mines are made by the young sap-feeding larvae and are only seen from the bottom side of the leaf, and tissue feeder mines can be seen from the tops of leaves. The third brood should be treated if there is an average of 2 to 3 or more total mines/leaf. The fourth brood should only be treated as an emergency when previous generations have not been controlled. Premature fruit drop can occur when there is an average of 10 or more mines/leaf, or leafminer feeding has been accompanied by heavy mite pressure or leafhopper activity.

Thrips

Several species of thrips can damage tree fruit. The Western flowers thrips and flower thrips can damage apples during bloom and cause scarring or dimpling of the fruit. On nectarine and peach, early season feeding damage can result in russetted fruit while late season damage takes on a silvering appearance. Cold, wet springs are not favorable for this pest because it delays development, and heavy rains can actually kill these frail insects. Mowing ground cover during bloom and harvest should be avoided to prevent thrips from leaving the ground cover for the fruit. Also, eliminating flowering weeds in the orchard should prevent thrips populations from increasing and subsequent movement to the crop.

Tufted Apple Bud Moth and Variegated Leafroller

These insects have similar life histories, habits, and damage. In NJ, tufted apple bud moth usually outnumbers variegated leafroller but both may be found in the same orchard. There are two generations/year. Adults generally begin flying and laying eggs from about mid-June to mid-July and from about mid-August through mid-September. In recent years, most damage has come from the second generation of moths because either spraying has stopped, fruit is tightly clustered, insufficient spray volume was used, or because of resistance development. Damage appears as a “shotgun” type of scarring on the upper and side surfaces of the fruit. Heavier crops are most likely to sustain damage. For best results, increase spray volume/A and thin to remove fruit clusters.

Two-spotted Spider Mite

Two-spotted spider mite overwinters as an adult on perennial plants (weeds) and orchard trees. Dormant oil sprays are not effective for controlling this species however, most other miticides are satisfactory. In spring, two-spots serve as food for the predator mite, *Amblyseius fallacis* and *Stethorus punctum* (lady bird beetles) before they climb trees in search of European red mites.

White Apple Leafhopper

The white apple leafhopper has become resistant to commonly used cover spray insecticides such as Imidan. Overwintered eggs begin hatching at pink, and hatching is usually over by petal fall. Whitish nymphs and adults feed on the lower leaf surface, which causes the leaves to appear a mottled yellow to white. Sticky honeydew secretions from leafhopper feeding frequently cover lower fruits. In orchards where leafhoppers have become troublesome, it is important to include an effective leafhopper control in the petal fall to first cover period.

Table 6.5 Efficacy and Use of Insecticides to Control Brown Marmorated Stink Bug

	PEACH & NECTARINES					POME FRUIT					
Product Name	**BMSB Rating**	**Rate**	**Seasonal No. apps or material**	**PHI**	**Interval (days)**	**Rate**	**Seasonal No. apps or material**	**PHI**	**Interval (days)**	**IRAC**	**Class**
Actara [1]	+++	5.5oz	11.0 oz	14	7	5.5oz	16.5 oz	35 [1]	10	4A	Neonicotinoid
Perm-up [2]	+++	10.0 oz	3	14	10	N/A	N/A	N/A	N/A	3A	Pyrethroid
Asana	++	14.5 oz	5	14	N/A	14.5 oz	7	21	N/A	3A	Pyrethroid
Assail 30 SG	+++	8 oz	4	7	10	8 oz	4	7	12	4A	Neonicotinoid
Azera	++	16.0-56.0 oz	10	0	3	16.0-56.0 oz	10	0	3		Pyrethrin + Neem extract
Baythroid XL	+++	2.4 fl oz	5.6 fl oz	7	14	2.4 fl oz	2.8 fl oz	7	14	3A	Pyrethroid
Belay[4]	++++	6.0 fl oz	2	21	10	6.0 fl oz	12.0 fl oz	7	14	4A	Neonicotinoid
Besiege	+++	12.0 oz	31.0 oz	14	7	12.0 oz	31.0 oz	21	10	3A +28	Pyrethroid + Diamide
Bifenture Brigade Capture *(SECTION 18 required)*	++++	12.8 oz	28.8 oz after PF, season total 32.0 oz	14	30	12.8 oz	28.8 oz after PF, season total 32.0 oz	14	30	3A	*Pyrethroid*
Danitol	+++	21.3 oz	2	3	10	21.3 oz	2	14	10	3A	Pyrethroid
Dimate	+++	1.0 lb	1	28	N/A	1.0 lb	1	28	N/A	1B	Organophosphate
Endigo ZC	++++	5.5 oz	19.0 oz	14	7	6.0 oz	28.0 oz	35	10	3A	Pyrethroid
Lambda-Cy	++	5.12 oz	25.6 oz 20.48 oz postbloom	14	5	5.12 oz	25.6 oz 20.48 oz postbloom	21	5	3A	Pyrethroid
Lannate SP	++	1.0 lb	6	4 [3]	7	1.0 lb	5	14	7	1A	Carbamate
Leverage 360	+++	4.4	10.2 oz	7	14	4.4 oz	5.1 oz	7	14	4A +3A	Neonicotinoid + Pyrethroid
M-Pede	++	2% v/v	3 sequen-tial apps		7	2% v/v	3 sequen-tial apps		7		Potassium salt
Mustang Max	+++	4.0 oz	24.0 oz	14	7	4.0 oz	24.0 oz	14	7	3A	Pyrethroid
Pyganic 1.4 EC	++	16.0 oz	N/A	0.5	N/A	16.0 oz	N/A	0.5	N/A		Pyrethrin
Scorpion	+++	7.0 oz	10.5 oz	3	7	N/A	N/A	N/A	N/A	4A	Neonicotinoid
Surround	++	25.0-50.0 lb	N/A	1	7	25.0-50.0 lb	N/A	1	7		Particle film
Venom	+++	4.0 oz	8.0 oz	3	7	N/A	N/A	N/A	N/A	4A	Neonicotinoid
Voliam Flexi	+++	7.0 oz	14.0 oz	14	10	7.0 oz	16.0 oz	35	10	4A +28	Neonicotinoid + Diamide
Warrior II	+++	2.56 oz	12.8 oz, 10.24 oz postbloom	14	5	2.56 oz	12.8 oz, 10.24 oz postbloom	21	5	3A	Pyrethroid

[1] If used at ≤2.75 oz, PHI is 14 days in pome fruit. [2] Not allowable after petal-fall in pome fruit. We do not recommend applications for BMSB prior to petal-fall in apples. [3] PHI in nectarines is 1 day. [4] Belay is not labeled for nectarines.

Note: The amount allowable in premixed products holds true for the single compound as well. For example, Actara (thiamethoxam) is limited to 11.0 oz (0.172 lb a.i.) per season. If using another product, such as Voliam Flexi or Endigo that also contains thiamethoxam, the seasonal limit applies to the use of this material as well.

6.5 Resistance Management, Insecticides, and Miticides

6.5.1 Resistance Management

Many fruit growers have experience with pest resistance to pesticides. Whether it was mite resistance to Plictran or other miticides in the early '80s, tufted apple budmoth resistance to organophosphates (Imidan) in the early '90s, or more recently, codling moth and Oriental fruit moth resistance to organophosphates. **Resistance is defined by the Insecticide Resistance Action Committee (IRAC) as "a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for the pest species**". Pest resistance to an active ingredient usually results from the repeated use or over-use of that product against a pest, leading to resistant gene forms surviving and reproducing in that environment, resulting in the evolution of a pesticide resistant population. As pest resistance to pesticides became more common, the pesticide industry formed its own working group to help coordinate resistance management efforts. Much of what follows is also available at: *https://irac-online.org/*.

IRAC was formed in 1984 and works as a specialist technical group of the industry association CropLife providing a coordinated industry response to prevent or delay the development of resistance in insect and mite pests. There are IRAC country group committees in many parts of the world researching and responding to local resistance issues as well as IRAC International which operates at a global level. The IRAC Mission is: 1. Facilitate communication and education on insecticide resistance. 2. Promote the development of insecticide resistance management strategies to maintain efficacy and support sustainable agriculture and improved public health.

MoA, Target-site resistance and Cross-resistance

In the majority of cases, not only does resistance render the selecting compound ineffective but it also confers cross-resistance to other chemically related compounds. This is because compounds within a specific chemical group usually share a common target site within the pest, and thus share a common **mode of action (MoA)**. It is common for resistance to develop that is based on a genetic modification that affects this target site. When this happens, the interaction of the selecting compound with its target-site is impaired and the compound loses its pesticidal efficacy. Because all compounds within the chemical sub-group share a common MoA, there is a high risk that the resistance that has developed will automatically confer cross-resistance to all the compounds in the same sub-group. **It is this concept of cross-resistance within chemically related insecticides or miticides (acaricides) that is the basis of the IRAC mode of action classification**.

Managing Resistance

Successful resistance management programs should delay or prevent the occurrence of resistance to insecticides or miticides. Effective programs will maintain the efficacy of existing pesticide products. An active program which prevents resistance is always easier than trying to regain susceptibility. Growers should seek a program that alternates, or uses a sequence of rotations of compounds from different MoA groups, while minimizing materials from any one MoA group. The IRAC companies have developed a classification system that includes 28 categories and sub-groups, plus a category for materials with unknown modes of action, and has been internationally recognized. For a complete list by active ingredients and more information go to: *https://irac-online.org/*.

6.5.2 IRAC Classification for Tree Fruit Insecticides and Miticides

The IRAC class is now published at the beginning of most pesticide labels. The classification system avoids the end user trying to figure out if an active ingredient is the same or similar, or has the same MoA as another product. The user simply refers to the **IRAC class on the label**, and integrates various classes into a pest management program. In the event that the IRAC class is not published on the label, and for ease of grower use, Tables 6.6 and 6.7 summarize the IRAC classes as defined for tree fruit insecticides and miticides. As examples of similar chemistries, note that all pyrethroids are in class 3A, and that all neonicotinoids are in class 4A.

Table 6.6 IRAC Classification for Tree Fruit Insecticides

Product	Active Ingredient	Chemical Group/Sub-group	IRAC Class
Actara	Thiamethoxam	Neonicotinoids	4A
Admire Pro	Imidacloprid	Neonicotinoids	4A
Agri-Flex	abamectin + thiamethoxam	Avermectin + Neonicotinoid	6, 4A
Altacor	Chlorantraniliprole	Ryanodine receptor modulators, Diamides	28
Ambush25W	Permethrin	Pyrethroids, Pyrethrins	3A
Apta/Bexar	Tolfenpyrad	mitochondrial complex I electron transport inhibitors (METI)	21A
Asana	Esfenvalerate	Pyrethroids, Pyrethrins	3A
Assail	Acetamiprid	Neonicotinoids	4A
Avaunt	Indoxacarb	Sodium channel blockers, Indoxacarb	22
Battalion	Deltamethrin	Pyrethroids, Pyrethrins	3A
Baythroid	beta-cyfluthrin	Pyrethroids, Pyrethrins	3A
Belay	Clothianidin	Neonicotinoids	4A
Beleaf	Flonicamid	Feeding blockers, Flonicamid	9C
Besiege	lambda-cyhalothrin chlorantraniliprole	Pyrethroids Diamides	3A 28
Brigade/Bifenture	Bifenthrin	Pyrethroids, Pyrethrins	3A
B.t.s	Bacillus thuringiensis	Microbial disrupters of midgut, B.t.s and assc. proteins	11
Closer SC	Sulfloxaflor	Neonicotinoid-like	4C
Centaur	Buprofezin	Chitin biosynthesis inhibitors Type 1	16
Cormoran	novaluran + acetamiprid	Benzoylurea IGR + Neonicotinoid	15,4A
Danitol	Fenpropathrin	Pyrethroids, Pyrethrins	3A
Decis	Deltamethrin	Pyrethroids, Pyrethrins	3A
Delegate	Spinetoram	Spinosyns	5
Diazinon	Diazinon	Organophosphates	1B
Esteem	Pyriproxifen	Juvenile hormone mimics, Pyriproxyfen	7C
Exirel	Cyantraniliprole	Diamide	28
Imidan	Phosmet	Organophosphates	1B
Intrepid	Methoxyfenozide	Ecdysone receptor agonists, Diacylhydrazines	18
Lannate	Methomyl	Carbamates	1A
Leverage	Imidacloprid cyfluthrin	Neonicotinoids Pyrethroids, Pyrethrins	4A 3A
Movento	Spirotetramat	tetramic acid	23
Mustang MAXX	zeta-cypermethrin	Pyrethroid	3A
Proaxis/Declare	gamma-cyhalothrin	Pyrethroid	3A
Proclaim	emamectin benzoate	Chloride channel activators, Avermectins	6
Renounce/Tombstone	Cyfluthrin	Pyrethroid	3A
Rimon	Novaluron	Chitin biosynthesis inhibitors, Benzoylureas (IGR)	15
Scorpion 35SL/Venom	Dinotefuran	Neonicotinoid	4A
Senstar	spirotetramat + pyriproxyfen	Tetramic acid + Juvenile hormone mimic	23, 7C
Sevin	Carbaryl	Carbamates	1A
Vydate	Oxamyl	Carbamates	1A
Voliam-Flexi	thiamethoxam, chlorantraniliprole	Neonicotinoids Diamides	4A 28
Warrior II	lambda-cyhalothrin	Pyrethroids, Pyrethrins	3A
Versys	Afidopyropen	Feeding blocker	9D
Verdepryn 100SL	Cyclaniliprole	Diamides	28

Table 6.7 IRAC Classification for Tree Fruit Miticides

Product	Active Ingredient	Chemical Group/Sub-group	IRAC Class
Acramite	bifenazate	Unknown	Un
Agrimek	abamectin	Chloride channel activators, Avermectins	6
Apollo	clofentazine	Mite growth inhibitor, Clofentezine/Hexythiazox	10A
Carzol	formetanate hydrochloride	Carbamates	1A
Envidor	spirodiclofen	Lipid synthesis inhibitors, Tetronic & Tetramic acids	23
Kanemite	acequinocyl	Mitochondrial electron transport inhibitors 3, Acequinocyl	20B
Kelthane	dicofol	Unknown	Un
Nealta	cyflometofen	Mitochondrial complex II electron transport inhibitor	25
Nexter	chloropyridazin	Mitochondrial electron transport inhibitors 1 (METI acaricides)	21
Portal XLO	fenpyroximate	Mitochondrial electron transport inhibitors 1 (METI acaricides)	21A
Savey	hexythiazox	Mite growth inhibitor, Clofentezine/Hexythiazox	10A
Vendex	fenbutatin-oxide	Mitchondrial ATP inhibitors, Organotins	12B
Zeal	etoxazole	Mite growth inhibitor, Etoxazole	10B

6.5.3 Insecticides and Miticides

Acramite (bifenazate) (50WS) is a miticide in the carbazate class that has a novel mode-of-action. It is effective against ERM and TSM. It is affected by hard water and should have a conditioner added to the spray tank.

Actara (thiamethoxam) (25WG) is a foliar-applied insecticide containing the active ingredient thiamethoxam. Thiamethoxam is a second-generation neonicotinoid insecticide, belonging to the thianicotinyl subclass of chemistry and possessing unique chemical properties that result in excellent control of many sucking and chewing pests.

Admire Pro (imidacloprid) (1.6) (Pasada 1.6F) is a systemic and contact insecticide for post-bloom use on apples and pear. It is effective against leafhoppers, leafminers, aphids, and San Jose scale crawlers. It is toxic to bees so do not allow it to drift onto blooming weeds. Allow 7 days between last application and harvest.

Agrimek (abamectin) (0.15 EC) (ABBA 0.15EC) is a miticide/insecticide labeled for control of mites, tentiform leafminer, and first-generation white apple leafhoppers on apple, and mites and pear psylla on pears. It is very effective when timed properly. Agrimek penetrates quickly into leaves to form a reservoir of active material. Agrimek must be applied with a minimum 1% or 1.0 gal of oil/A before leaves harden-off.

Altacor (Rynaxypyr®/chlorantraniliprole) (WDG) is one of two anthranilic diamide classes of insecticides registered in tree fruit. The material is most effective on Lepidopteran larvae such as codling moth and Oriental fruit moth. While there is some contact activity, Altacor is most effective when treated plant material is consumed. Exposed insects quickly stop feeding, become paralyzed and die within 1-3 days. Applications should be timed at or just prior to egg laying. Depending on the insect species, Altacor has both ovicidal and ovi-larvicidal (killing neonate larvae before they completely hatch) properties, as well as larvicidal properties from ingestion. Altacor is rain fast and has long residual activity.

Ambush – see **permethrin.**

Apollo (clofentizine) (42SC). Apollo is a tetrazine compound for mite control on apples, pears, peaches, nectarines, cherries, and apricots. It is primarily an ovicide, but also controls young motile stages. It has no direct effect on adult pest mites but is safe against natural enemies. Best results are achieved in spring, when red mite eggs are hatching, and before adults are present. If many adult mites are present, Apollo can be combined with other adulticides. Thorough coverage is essential for control. Apply only once/year. Do not rotate Apollo and Savey with each other.

Apta/Bexar (tolfenpyrad) is a group 21A insecticide with fungicidal properties. This is the same class as some miticides. It labeled on both pome and stone fruits. In apples and pears it is effective against leafhoppers, aphids (but not woolly apple aphids), apple maggot, leafrollers, plum curculio and rust mites. In stone fruit it is also effective against mealybugs and aphids found in stone fruit. This product is highly toxic to aquatic organisms and bees. Do not apply where there are blooming weeds.

Asana (esfenvalerate) (XL-0.66EC) (Adjourn) is a pyrethroid insecticide labeled for control of many insects on pome and stone fruit. On pears, it is frequently used prebloom against pear psylla. It can also be used against several stone fruit pests including Oriental fruit moth, plum curculio, periodical cicada, plant bugs, and as a trunk spray for controlling peach tree and lesser peach tree borers. It is also effective against pests of apple including oblique banded leafroller, codling moth, variegated leafroller, white apple leafhopper, tentiform leafminer, apple aphid (green), tufted apple bud moth, plum curculio (suppression), apple maggot, red-banded leafroller, green fruitworm, rosy apple aphid, and plant bugs. Asana, like other pyrethroids, is toxic to mite predators and its use probably will encourage mite build up. Therefore, Asana is not generally recommended for post-bloom application. Do not apply Asana closer than 21 days before harvest for apples, 28 days for pears, and 14 days for peaches. See the label for other restrictions.

Assail (acetamiprid) (30SG) is the first neonicotinyl registered on apples and pears that provides codling moth and Oriental fruit moth control. It has a 12 hour REI and a 7 day PHI. Practical resistance management would suggest that growers should limit the number of neonicotinyl applications in a season, so care must be taken when adding Assail to a program that is already using Provado or Actara.

Avaunt (indoxacarb) has a unique mode of action. It affects insects from direct exposure to spray droplets and through ingestion of treated foliage/fruit. Indoxacarb is not systemic but does have translaminar movement into the mesophyll. After application, it may be transported into the waxy leaf surface where it is protected from weathering. Once absorbed or ingested, nerve function is impaired, resulting in feeding cessation, paralysis, and death. Feeding cessation occurs almost immediately even though it may take several days for insects to die. It is effective on a wide range of insects, including Lepidopteran larvae such as codling moth and Oriental fruit moth, in addition to leafhoppers (suppression) sawfly, and plum curculio.

Bacillus thuringensis (B.t.) (Biobit, Dipel, Javelin, MVP, SOK, Thuricide, and Xentari) (wettable powder) are safe, biological insecticides labeled for control of cankerworms, gypsy moth, variegated and redbanded leafrollers, tufted apple bud moth, and tent caterpillars at the rate of 0.5 to 1.0 lb/A. These materials are nontoxic to bees and mite predators and may be applied up to harvest.

Baythroid (cyfluthrin) (2EC) is a pyrethroid that is effective against many fruit pests. It is recommended for use during the prebloom period on pome fruits, and through petal fall on stone fruits. Use after petal fall is more likely to cause outbreaks of mites and other secondary pests such as woolly apple aphids and scale.

Belay 2.13SC (clothianidin) is a neonicotinoid insecticide registered for use on pome and stone fruit (note: Belay is not labeled for nectarines). It has activity against aphids, leaf-hoppers, leafminers, plum curculio, apple maggot, pear psylla, BMSB, and Oriental fruit moth. Like other neonicotinoid insecticides, it is highly systemic, but should only be used in limited amounts when other neonicotinoid materials are used.

Beleaf (Flonicadmid) is a selective Homopteran feeding inhibitor, and is a unique MOA with its own subgroup and is a good solution for resistance management and natural enemy protection. Beleaf at labeled rates provides excellent control of both wooly apple aphid and rosy apple aphid. In pome and stone fruit, Beleaf has a blanket label covering all aphids and plant bugs.

Besiege (lambda-cyhalothrin and chlorantraniliprole) is a premix consisting of 4.63% lambda-cyhalothrin and 9.26% chlorantraniliprole, the same active ingredients in Warrior II and Altacor. Because it has both a synthetic pyrethroid and a diamide, it is very effective on a wide range of pests. Since the diamide component is slightly less than 1/3 of that in Altacor, you will need about 3 times the Altacor rate for similar control. This material should not be rotated with repeated use of pyrethroids or other diamide compounds (Altacor, Voliam Flexi, Exirel and Verdepryn).

TREE FRUIT DISEASES, PESTS, AND CONTROLS

Brigade/Bifenture (bifenthrin) (WSB, 10DF or 2EC) is a pyrethroid insecticide that is labeled on pears, but not apples and stone fruit. It can only be used on those crops under section 18 labeling. Like other pyrethroids it has a wide spectrum of pest activity, but is especially effective on plant bugs and stink bugs.

Carzol (formetanate hydrochloride) (92SP) is a carbamate insecticide/miticide registered for control of mites, plum curculio, and plant bugs on peaches; mites and thrips on nectarines; and mites, leafhoppers, leafminers, and thrips on apple. Carzol is recommended at 12.0 to 20.0 oz/A. This material is most effective on European red mite and least damaging to predator mites when applied during pink and petal fall. Carzol cannot be applied after petal fall.

Centaur (buprofezin) is an insect growth regulator (IGR) with a unique mode of action that acts on nymphal stages of insects by inhibiting chitin biosynthesis. It also suppresses egg laying of adults and reduces egg viability. Centaur is labeled on pome and stone fruits for control of Scale Insects, Mealybugs, Leafhoppers and Pear Psylla. It is not disruptive to beneficial insects and mites.

Closer (sulfoxaflor)(SC) is related to the neonicotinoid group of insecticides but is in a different IRAC class (4C). It is labeled for pome fruits and stone fruits. In apples it is effective for aphids and leafhoppers at the low rate and will control plant bugs and wooly apple aphids at the high rate, and will suppress San Jose Scale (crawler stage). For peaches it can be used to target aphids only, but will suppress San Jose Scale (crawler stage) and thrips.

Codling Moth granulosis virus (Madex HP) is a naturally occurring virus of the codling moth that has been formulated for agricultural applications. It has no effect on other insects or animals. It must be ingested by codling moth larvae, and will kill larvae in 3-5 days. Because of its mode of action, it must be applied early as larvae are starting to hatch. Carpovirusine is used at the rate of 7.0-13.5 oz/A, while Madex HP is used at 0.5-3.0 oz/A. Make at least two applications of Madex HP per generation, reapplication may be needed after 6-8 sunny days during the active egg hatch period. A rate of 1.5 oz/A is typically recommended in New Jersey. Blocks under mating disruption for codling moth may use 0.5 oz/A. Some stings may still be visible. In New Jersey, the virus has been used as a resistance management tool in combination with insecticides and/or mating disruption. Madex will control both codling moth and Oriental fruit moth.

Confirm (tebufenozide) (2F) controls codling moth and many leafrollers on apples and pears. It works best against tufted apple budmoth and codling moth when applied according to degree-day models starting at early egg hatch.

Cormoran (novaluron + acetamiprid) is a new premix containing an insect growth regulator (novaluron group 15) and a neonicotinoid, acetamiprid (group 4A). These are the same ingredients as in Rimon and Assail. Therefore it has a wide spectrum of pest activity that includes aphids, apple maggot, internal worms, leafhoppers and Japanese beetle. Plum curculio is listed on the label, but while it controls this pest it is not a quick knockdown material. This product can be toxic to bee larvae, so do not use where there are flowering weeds.

Danitol (fenpropathrin) (2.4EC) is a broad-spectrum pyrethroid that controls many pests and suppresses European red mite on apple. It fits into the spray program prebloom, at petal fall - first cover, and again as harvest approaches.

Decis (deltamethrin) (Battalion 0.2EC) is a broad-spectrum insecticide registered for use on pome fruit but not stone fruit. It is toxic to fish and bees and should be used primarily prebloom to minimize impacts to integrated mite management programs.

Delegate (spinetoram) (25WG) is a more persistent and effective product than Entrust, and has a wider pest spectrum. It is useful against internal feeders, leafrollers, pear psylla, and thrips.

Diazinon (50WP) is an organophosphate insecticide with broad-spectrum insecticidal activity labeled for pests of stone and pome fruit. Do not apply within 21 days of harvest. Diazinon is moderately toxic to *Stethorus punctum* larvae and adults.

Entrust (Spinosad) is derived from *Saccharopolyspora spinosa* bacteria. The naturally occurring active ingredients are fermentation products *spinosyn A* and *spinosyn D*. Originally trade named Spintor, Entrust is effective on leafminers, leafrollers, Oriental fruit moth, codling moth, cherry fruit fly, thrips (with a spreader sticker), and suppression of apple maggot.

Envidor (spirodiclofen) (2SC) is a miticide registered on apple, pear and stone fruits for the control of European red mite, two- spotted spider mite, apple and pear rust mites, and peach silver mite. Acting as an insect growth regulator by inhibiting lipid biosynthesis, Envidor has activity against mite eggs, immature stages and adult females, but not adult males. Adult males that survive will continue to feed; therefore Envidor should be applied before populations begin to build.

Esteem (pyriproxyfen) (35WP) is an insect growth regulator. It effectively controls San Jose scale when combined with oil in the delayed dormant spray. It can be used in season to control codling moth and San Jose scale. On apple, it suppresses leafrollers, and controls leafminers and apple aphids. On pear, it is an effective delayed dormant through pink spray for pear psylla.

Exirel (cyantraniliprole/Cyaxypyr) (EC) is a second generation diamide insecticide (IRAC 28) that is effective for internal worms, leafrollers, leafminers, leafhoppers and plum curculio when combined with a spreader sticker. In stone fruit it can also be used to control Japanese beetle, cherry fruit fly and spotted wing drosophila. This material is extremely toxic to bees, and can only be used when bees are not present in the orchard. Therefore maintain a weed free groundcover and clean weed free strips under the trees.

Grandevo DF (biopesticide) is a dry flowable insecticide/miticide containing metabolites produced during fermentation of *Chromobacterium subtsugae* strain PRAA4-1^{T}. Grandevo contains no viable bacteria, has a 4 hour REI and a 0 day PHI and is OMRI approved. Grandevo may be useful in both organic and conventional fruit production for insecticide resistance management and residue management.

Imidan (phosmet) (70WP) is an organophosphate insecticide recommended in several cover sprays for control of codling moth, plum curculio, apple maggot, red-banded leafroller, and Oriental fruit moth. It is not effective against mites, aphids, or leafhoppers. White apple leafhopper becomes numerous wherever Imidan is used regularly. Imidan is not highly toxic to mite predators when applied according to schedule.

Intrepid (methoxyfenozide) (2F) is labeled for use on apple, pear, and other pome fruit to control codling moth, Oriental fruit moth, leafrollers, and leafminers.

Kanemite (acequinocyl) (15SC) is a miticide labeled for the control of European red mite and two-spotted spider mite in pome fruit. The miticide works by contact activity only but is active on all spider mite life stages, including eggs. It kills spider mites quickly and provides up to 28-days of residual activity. It is (group 20B) in a different chemical grouping than Nexter and Portal XLO (group 21), so it can be rotated on a limited basis with those materials, as well as other miticides.

Kelthane (dicofol) (50WP) is a chlorinated hydrocarbon, controls both European red and two-spotted mites. Resistance to Kelthane is becoming more widespread each year, so only apply once/year on apple. Mite predators can tolerate this material.

Lannate (methomyl) (LV and 90SP) is a carbamate insecticide labeled for control of apple aphid, rosy apple aphid, codling moth, tufted apple bud moth, white apple leafhopper, fruit tree leafroller, tentiform leafminer, green fruitworm, tarnished plant bug, oblique-banded, variegated, and red-banded leafrollers, Oriental fruit moth, green peach aphid, catfacing insects, thrips, and stink bugs. Lannate LV is not registered for nectarines. Do not apply to early McIntosh and Wealthy cultivars. Lannate is damaging to mite predators; therefore, in pest management programs it should be used sparingly and only in combination with other insecticides.

Leverage (360) is a prepackaged combination of Provado (imidacloprid) and Baythroid (cyfluthrin). The combination gives good sucking insect control, combined with the broad-spectrum activity of a pyrethroid. However resistance management precautions should be used, especially since overuse of pyrethroids can stimulate secondary pest outbreaks.

Malathion (25WP, 57EC, 8EC). This organophosphate aphicide is recommended for growers desiring less toxic insecticides. Wait 3 days between last application and harvest for apples and 7 days for peaches. This material is labeled for control of aphids, codling moth, leafhoppers, mites, plum curculio, red-banded leafroller, San Jose scale, lesser peach tree borer, and Oriental fruit moth.

Movento (spirotetramat) is an aphid and scale material in the same chemical grouping as Envidor miticide. It is registered for use on apples, pears, and all stone fruit. It controls pear psylla on pears. Care should be taken not to use this material in combination or in sequence with Envidor for mites.

M-Pede insecticide/fungicide is a contact insecticide, miticide and fungicide for control of soft-bodied insects, mites and powdery mildew. The formulation is based on potassium salts of naturally derived fatty acids. This product can be applied up to harvest. M-pede may cause russetting of pome fruit when applied in heat, and may be phytotoxic to some Asian pear cultivars.

Mustang (zeta-cypermethrin) (Mustang and Mustang Maxx) is a broad spectrum pyrethroid insecticide that is effective for most tree fruit pests except spider mites. Like other pyrethroids, it is not a strong material for aphid control, so should not be used as a rescue treatment against high populations. It is also effective for apple maggot, cherry fruit fly and spotted wing drosophila.

Nealta (cyflumetofen) is a group 25 miticide. It is ovicidal, has knockdown and residual properties for all mite stages, and is effective for both European red mites and two-spotted spider mites, but not rust mites. Thorough spray coverage is required, since it is not a systemic material. It has minimal impact on most mite predators, and like all miticides it must fit into a resistance management program. Therefore, use every row and not alternate row applications, and use only 1 application before alternating to a different chemistry if needed.

Nexter (pyridaben) is a broad-spectrum miticide with some insecticidal properties. It controls spider mites and rust mites, and has activity on leafhoppers, pear psylla and aphids. It is a group 21 METI acaricide, which is the same as fenpyroximate (Fujimite/ Portal XLO), with the same spectrum of activity. These materials should be considered as one material and should not be used in rotation. Reduced efficacy has been reported where this product has not been rotated with different chemistries.

Permethrin (Ambush 2E, 25WP; Perm-up; and Pounce 3.2E, 25WP) is a pyrethroid-type insecticide labeled for control of plum curculio (suppression), rosy apple aphid, spotted tentiform leafminer, tarnished plant bug, oblique-banded leafroller, white apple leafhopper, tarnished plant bug, Oriental fruit moth, and lesser peach tree borer. No more than three applications are permitted/season for apples. Permethrin is not recommended for postbloom application. Do not apply within 7 days of harvest for peaches. Permethrin is extremely toxic to mite predators and has been shown to encourage mite buildup. See the label for other restrictions.

Portal 5EC (fenpyroximate) (5EC) is an insecticide/miticide registered for use on pome fruit and nonbearing deciduous fruit trees. It belongs to the phenoxypyrazole class of insecticides. Its mode of action is as a mitochondrial electron transport inhibitor (METI), blocking cellular respiration (similar to Nexter and Kanemite). Practical resistance management would suggest that the use of METI (group 21 miticides (either Nexter, Portal XLO) be limited to one application/year. It will provide some control of low to moderate levels of pear psylla.

Pounce (3.2E and 25WP) – see **permethrin**.

Proaxis (gamma-cyhalothrin) is a pyrethroid insecticide with broad spectrum activity labeled in both pome and stone fruits. This insecticide is weak on aphid control, but is active on most other pests.

Proclaim (emamectin benzoate) (5SG) is an insecticide registered for use on pome fruit. It provides protection against leafrollers and leafminers in addition to suppressing codling moth, Oriental fruit moth, and pear psylla.

Rimon (novaluron) (0.83EC) is an insect growth regulator effective against codling moth, Oriental fruit moth and leafrollers on apple. Because it acts as a chitin biosynthesis inhibitor (disrupts molting), primary activity is against larval stages. However, there is some toxicity to eggs, especially when laid on treated surfaces. Rimon must be applied before egg laying occurs. Route of insect entry is primarily through ingestion with some contact activity. Rimon is rated excellent for codling moth and good for Oriental fruit moth. It sometimes causes mite problems.

Savey (hexythiazox) (50WP, 50DF) is an ovicide/miticide registered for use on apples, pear and stone fruit. Apply during the cover season on pear, but make applications before mite populations build. Do not rotate Apollo and Savey with each other.

Scorpion/Venom (dinotefuran) (35SL, 70W) are neonicotinoid insecticides that are labeled in peach and nectarine but not apples. They are effective against aphids, leafhoppers, plum curculio and stink bugs. Pest activity can be rate dependent, so the higher rates should be used on stink bugs and plum curculio. The chemistry is extremely toxic to bees, so should only be used when bees are not present, and in orchards with a weed free turf groundcover and a weed free strip under the trees.

Senstar (spirotetramat + pyriproxyfen) is a premix of the same active ingredients found in Movento and Esteem (group 23+7C). Therefore the mix contains a systemic material with all the properties of Movento plus an insect growth regulator with the same properties as Esteem. However on a liquid formulation basis, Senstar has less pyriproxyfen than the Esteem liquid formulation, so be aware of this if trying to control scales.

Sevin (carbaryl) (80S, XLR) is a broad-spectrum carbamate insecticide. It is highly toxic to bees and should not be used near bloom. It also acts as a fruit thinner on many cultivars (see section 10.5, Use of Plant Growth Regulators in Apple Orchards). For peaches, Sevin is satisfactory for control of plum curculio, Oriental fruit moth, catfacing insects, Japanese beetle, and scales. Normally, aphid and mite populations build up rapidly following Sevin applications because it is toxic to predators. For this reason, it is not generally recommended. Sevin may be applied up to 3 days before harvest.

Superior Oil is still one of the most effective materials available for European red mite and scale control in New Jersey. Oil can be applied safely between the 0.25 inch green and tight-cluster stages of bud development. After pink, there is an increasing risk of phytotoxicity. Oil applied during silver tip to 0.25 inch green is not nearly as effective as when applied during the period between 0.5 inch green and full pink. Oil controls mites by smothering the developing embryo within the overwintering egg. Because eggs are laid on recessed areas of spurs, twigs, limbs, and trunk bark, thorough coverage is required.

Tombstone/Renounce (cyfluthrin) (2E) is a pyrethroid insecticide consisting of cyfluthrin, as opposed to Baythroid which is beta-cyfluthrin. Like other pyrethroids, it is a broad spectrum material controlling internal worms, leafrollers, plant bugs, plum curculio, aphids and fruit flies, and spotted wing drosophila.

Vendex (fenbutatin-oxide) (50WP) is an organotin miticide that is nontoxic to honeybees and relatively nontoxic to beneficial mites. It is registered for mite control on apples, pears, peaches, nectarines, prunes, plums, and cherries. Do not apply more than twice/season or more than 4.0 lb/A. Vendex is relatively slow acting, so apply before mite infestations increase. Vendex tends to be more effective early in the season when temperatures are relatively cool.

Venerate XC (biopesticide) is a liquid insecticide/miticide containing metabolites produced during fermentation of *Burkholderia spp*. strain A396. Venerate contains no viable bacteria, has a 4 hour REI and a 0 day PHI and is OMRI approved. Venerate may be useful in both organic and conventional fruit production for insecticide resistance management and residue management.

Verdepryn 100SL (cyclaniliprole) is a diamide group 28 insecticide. In apples and pears it is effective on internal worms, leafrollers, leafminers, leafhoppers, European apple sawfly, plum curculio, and pear psylla. In stone fruits it is effective for the same insects plus cherry fruit fly spotted wing drosophila and Japanese beetle. The material is highly toxic to aquatic organisms and bees. Do not use this product if there are flowering weeds in your orchard.

Versys (afidopyropen) is a new chemistry type in group 9D, and was designed for sucking insects. It is labeled for both pome fruits and stone fruits. It is effective against rosy apple aphids, spirea aphids and green apple aphids in apples, but only suppressive against woolly apple aphids. In stone fruit it is effective against all aphid species.

Voliam Flexi (thiamethoxam and chlorantraniliprole) is Syngenta's prepackaged combination of the active ingredients in Actara and Altacor (Dupont). This gives effective pest activity for sucking insects from the neonicotinoid, combined with the Lepidopteran worm activity from Altacor. Care should be taken not to overuse

Actara or other neonicotinoid materials, especially since there may be only a few times when both products are needed together.

Vydate (oxamyl) (2L) is a systemic carbamate insecticide-miticide labeled for control of white apple leafhopper, spotted tentiform leafminer, and mites. Do not apply within 30 days after petal fall because of possible fruit thinning. Do not apply more than 400 gal/A. Wait 14 days between application and harvest.

Warrior II (lambda-cyhalothrin) (1SC) (Silencer 1EC) is a micro-encapsulated pyrethroid that provides additional safety to handlers and longer field life. It is labeled for use on pome and stone fruit. Use after petal fall is more likely to cause outbreaks of mites and other secondary pests such as woolly apple aphids and scale.

Zeal (etoxazole) is a miticide registered for use in pome fruit and stone fruit. It is effective for spider mites, but not labeled for rust mites. It is in a similar chemical grouping (10B as opposed to 10A) as Apollo and Savey, and therefore should not be rotated with those materials. It is a growth regulator and is effective on the egg, larvae and nymphs. There is very little activity on adults. Treated females do not reproduce, but will continue to feed therefore Zeal should be applied before populations begin to build.

6.5.4 Third Party and Generic Labels

Patents have expired for many older insecticides and miticides, or licensing rights have been sold to formulators other than those companies who first developed and sold their better known traditional products. Many of these new products are now less expensive than the originals, yet still have similar labels. Product names may also be less familiar. Since this book commonly refers to the better known traditional trade name, it may be confusing when new products with the same active ingredient are available in their place. To help clarify what many of the generic products are in relation to the original trade names see the list of insecticides in Table 6.8.

Table 6.8 Active Ingredient, New Trade Names and Traditional Trade Names of Insecticides

Active Ingredient	New Trade Names	Traditional Trade Names	Labeled for			Manufacturer
			Apple	Pear	Peach	
abamectin	Abamectin E-AG 0.15 EC	AgriMek	X	X		Nufarm Americas
	Abba 0.15 EC	AgriMek	X	X		Adama
	Reaper 0.15 EC	AgriMek	X	X		Loveland Products
	Temprano EC	AgriMek	X	X		Chemtura Corp.
	Zoro	AgriMek	X	X		Cheminova, Inc.
bifenthrin	Fanfare 2EC, Bifenture EC	Brigade		X		Adama
carbaryl	Carbaryl 4L	Sevin	X	X	X	Drexel Chemical Co.,
	Carbaryl 4L	Sevin	X	X	X	Loveland Products
	Carbaryl 80S	Sevin 80S	X	X	X	Drexel Chemical Co.
	Prokoz Sevin SL	Sevin	X	X	X	Prokoz inc.
cyfluthrin	Tombstone, Tombstone-Helios	Baythroid	X	X	X	Loveland Products
deltamethrin	Battalion	Decis	X	X		Arysta LifeScience North America LLC
diazinon	Diazinon 50W Dicofol 4 EC	Diazinon 50W Kelthane	X X	X X	X	Adama Adama
esfenvalerate	Adjourn .66EC	Asana	X	X	X	Adama
	S-Fenvalostar	Asana	X	X	X	LG Life Sciences
hexythiazox	Onager	Savey	X	X	X	Gowan Co.
imidacloprid	Advise 2 FL	Admire 2	X	X	X	Winfield Solutions (Agriliance LLC)
	Alias 2F	Admire 2	X	X	X	Adama

Table 6.8 - continued on next page

Table 6.8 - continued

Active Ingredient	New Trade Names	Traditional Trade Names	Labeled for			Manufacturer
imidacloprid (continued)	Alias 4F	Admire Pro	X	X	X	Adama
	Couraze 1.6F	Provado	X	X	X	Cheminova, Inc.
	Couraze 2F	Admire 2	X	X	X	Cheminova, Inc.
	Gallant 1.6L	Provado	X	X	X	Agrisolutions
	Imida E-Ag 1.6F	Provado	X	X	X	Nufarm Americas
	Imida E-Ag 2F	Admire 2	X	X	X	Nufarm Americas
	Impulse 1.6 FL	Provado	X	X	X	Albaugh, Inc./Agristar
	Impulse 1.6FL	Provado	X	X	X	Albaugh, Inc./Agristar
	Macho 2FL	Admire 2	X	X	X	Albaugh, Inc./Agristar
	Nuprid 1.6F	Provado	X	X	X	Nufarm Americas
	Nuprid 2F	Admire 2	X	X	X	Nufarm Americas
	Pasada 1.6 FL	Provado	X	X	X	Adama
	Prey 1.6	Provado	X	X	X	Loveland Products
	Widow	Admire 2	X	X	X	Loveland Products
lambda cyhalothrin	Silencer	Warrior II	X	X	X	Adama
malathion	Fyfanon	Malathion 5EC			X	Helena Chemical Co.
	Fyfanon 8E	Malathion 8E			X	Helena Chemical Co.
	Fyfanon ULV	Malathion ULV			X	Cheminova, Inc.
	Malathion 57EC	Malathion 57EC			X	Loveland Products
	Malathion 5EC	Malathion 5EC			X	Micro Flo Co.
	Malathion 8A	Malathion 8A			X	Loveland Products
	Malathion 8EC	Malathion 8EC			X	Arysta LifeScience North America LLC
	Malathion 8F	Malathion 8F			X	Gowan Co.
	Malathion ULV	Malathion ULV			X	Winfield Solutions (Agriliance LLC)
permethrin	Artic 3.2 EC	Ambush/Pounce	X	X	X	Winfield Solutions (Agriliance LLC)
	Permethrin 3.2 EC	Ambush/Pounce	X	X	X	Helena Chemical Co.
	Permethrin 3.2 EC	Ambush/Pounce	X	X	X	Loveland Products
	Permethrin 3.2 EC	Ambush/Pounce	X	X	X	Tenkoz, Inc.
	Perm-Up 25DF	Ambush/Pounce	X	X	X	United Phosphorous (Cerexagri-Nisso)
	Perm-Up 3.2 EC	Ambush/Pounce	X	X	X	United Phosphorous (Cerexagri-Nisso)
potassium salts of fatty acids	Revoke L	M-Pede	X	X	X	Helena Chemical Co.

6.6 Nematode Control

Detection

Whenever nematode damage is suspected, and especially before planting young trees, an examination of both soil and roots is recommended. Soil and root samples must be adequate in size and collected in a manner that will make evaluation possible. The following suggestions are made so those samples will be collected properly and arrive at the Nematode Detection Laboratory in good condition.

Samples for nematode analysis will not be processed unless the following instructions are observed:

1. **Collecting**. If a large area in an orchard is believed to be involved, collect samples from the edges of the affected area. Take a mixture of roots and soil from at least 10 separate sites at depths of 12 to 15 inches. Collect at least 1.0 qt of soil. Send only a single blended sample from an orchard. Do not mix samples from several orchards. A brief history of the affected area will be helpful to the nematologist when he or she makes the diagnosis.
2. **Handling**. After collecting, place sample in a plastic freezer bag and close the bag tightly to prevent drying out. It is not necessary to add water to a freshly collected soil and root sample. Protect the sample from high temperatures and from freezing.
3. **Submitting**. Enclose with the sample, a letter that gives the following information:
   a) date sample was collected; b) crop from which sample was collected; c) name and address of grower;
   d) name and address of person submitting sample; e) description of plant symptoms; f) crop to be planted.

Contact your area fruit agent about submitting samples. All samples should be marked "For Nematode Detection." A reply will be sent as soon as possible, usually about 10 days after the lab receives the sample.

Controlling plant-parasitic nematodes are always a problem where peaches follow peaches. In some instances, they can also be troublesome in sites where peaches have not been grown previously. Where nematodes are troublesome, trees do not grow as vigorously. Further, nematode feeding increases the incidence of peach decline, and it can increase the incidence of stem pitting.

Preplant nematicide treatments are necessary to promote tree vigor and to prevent the replant problem; preplant non-chemical approaches are available as well (consult section 1.6.2, Non-Chemical Management of Nematodes, in the 2022/2023 Mid-Atlantic Commercial Vegetable Production Recommendations (*https://njaes.rutgers.edu/pubs/publication.php?pid=e001*). **Postplant** treatments are necessary to reduce tree loss from peach decline and stem pitting.

Research has shown that nematodes build up and reach damaging levels by the end of the second growing season when fumigant-type nematicides are used. The nematode buildup may occur at the end of the first growing season with nonfumigant- type nematicides. Research results indicate postplant nematicide treatments are needed yearly to prevent tree loss.

The guidelines in Table 6.9 may be used as a tool to help decide if a nematicide will be economically beneficial **These are general guidelines only, and other factors should also be considered before making a treatment decision**. For example, if the orchard has a nematode population just above the treatment guidelines, but the trees are old and production is high, then a nematode treatment would probably not be beneficial. Conversely, if over 40 ring or any root knot nematodes were found in a new planting (peaches), or in ground that was going to be planted the following year, then nematicide use would be advised.

Fumigant-Type Nematicides

Fumigant-type nematicides have been used successfully for many years. Growth response of peach trees to soil fumigation has consistently been recorded where nematicidal rates of soil fumigants were employed. In some instances, an additional growth response was recorded where disease control rates of soil fumigants were employed. Some materials also provide control of weeds and germinating weed seeds. Table 6.10 shows the recommended materials and rates.

Soil fumigants can be applied any time the soil temperature is at least 55°F at the 12-inch depth. Generally, soil temperatures reach this point from mid-April to mid-November in southern counties and from mid-April to early November in northern counties. During mid-summer, soil temperature may become too high for successful treatment (90°F). After making application, cultivate soil shallowly and irrigate with a half-inch of water.

Row Treatment

Successful treatment depends to a large extent on soil preparation and soil moisture. Soil should be worked as thoroughly as possible, with subsoiling considered highly desirable. All crop residues should be decomposed since fumigants do not penetrate sufficiently to provide satisfactory kill of nematodes within plant tissues. Soil moisture should be equivalent to that desired for seeding.

The best placement of soil fumigants is at least 15 inches deep with tractor-mounted subsoil chisel equipment. Injection nozzles should be spaced between 9 to 12 inches, depending on the volatility of the fumigant used, soil moisture, and soil temperature. In areas where peach decline is not troublesome, treat an 8-foot band corresponding to the row. In areas where peach decline is troublesome, a 4- to 6-foot band is sufficient, since these blocks will require postplant treatments.

Delay planting at least 2 weeks after treatment to avoid plant injury. Since this delay may interfere with spring planting, fall treatment is generally preferable.

Table 6.9 Nematode Treatment Guidelines

Thresholds given (no./100 cc) are not based on experimental data, but rather on field experience and observations in commercial orchards.

	No./100 cc	
Nematode	**Peach**	**Apple**
Lesion	60-80	40-60
Stunt	60-80	60-80
Spiral	40	40
Stubby Root	16	16
Dagger	any - as virus vector 16+ for feeding injury	any - as virus vector 16+ for feeding injury
Ring	24	30
Cyst	not economic	not economic
Sting	8-10	8-10
Lance	40-60	40-60
Root Knot	any in new plantings	not economic

Table 6.10 Fumigant and Non-Fumigant Nematicides

Name	Application Timing	Pests Controlled	Rate/Treated A[1]
Basamid G	Preplant	Nematodes Diseases Weeds	220 - 260 lb 260 - 350 lb 220 - 530 lb
DiTera DF[2]	Preplant, Postplant	Nematodes	13.0 - 100 lb
MeloCon WG[2]	Preplant, Postplant	Nematodes	2.0 - 4.0 lb
Telone II	Preplant	Nematodes	27.0 - 35.0 gal
Telone C-17[3]	Preplant	Nematodes	32.4 - 55.5 gal
Vapam HL	Preplant	Nematodes Diseases Weeds	37.5 - 75.0 gal
Vydate L	Preplant, Postplant	Nematodes	2.0 gal (pre), 2.0 - 4.0 pt (post)

[1] Rates given are for light, sandy soils. Heavier soils require higher rates; always consult label before use.
[2] MeloCon and DiTera are biological nematicides available for use in organic orchards. Both are OMRI listed.
[3] Rate for strip application, untarped shank injection.

Non-Fumigant Nematicides

Several non-fumigant nematicides can be used legally on peaches and other tree fruit. Consult the label and use only as directed. Nonfumigant nematicides can be used successfully as preplant treatments or as postplant treatments.

Non-fumigant nematicides are formulated as sprayable materials. The earlier, granular formulations are no longer legal for use. Sprayable soil-applied nematicides can be applied with a properly calibrated weed sprayer, and they have been successfully used in combination with all of the herbicides commonly used on tree fruit. To prevent injury to non-target organisms, all soil-applied nematicides should be incorporated shallowly into the soil immediately after application.

Since these nematicides are not fumigants, they must enter the soil water and contact the nematode to effect a control. As nonfumigants, soil temperature and soil moisture are not so critical for satisfactory control. Satisfactory control has been obtained with applications any time between mid-March and late November when the ground is not frozen.

The non-fumigant nematicides presently cleared for use on tree fruit all possess some systemic activity. Consequently, when they are applied to soils, the ground should be weed-free for maximum control.

Those that are presently cleared for use include DiTera DF, MeloCon WG, and Vydate L. Vydate L is cleared for use either in a series of foliar sprays or as a preplant soil application. DiTera DF active ingredient consists of dead cells of the fungus *Myrothecium verrucavia* and the liquid in which the fungus was grown. This mixture is the agent that kills nematodes on contact. In contrast, MeloCon WG consists of living viable spores of the the fungus *Paecilomyces lilacinus* strain 251 which parasitizes many species of plant-parasitic nematodes. See Table 6.10 for recommended rates.

Banding nematicides is highly desirable. For preplant treatments, band widths should be 4-10 feet, depending on whether the block is to receive postplant nematicide treatments. Postplant treatments should be applied 1 foot beyond the drip line to as close to the trunk as possible.

6.7 Vole Control

Identification and Habitat

Voles, also known as mice, are small ground-dwelling rodents that occur throughout the North East United States. Meadow voles (*Microtus pennsylvanicus*) and pine voles (*Microtus pinetorum*) are two common types of voles.

Mature voles have stocky bodies and could be 5 to 7 inches long. Though both types of voles can exist in the same orchard, there is a difference in terms of habitat preference. Meadow voles primarily feed in open vegetation as long as there is enough ground cover, while pine voles prefer underground burrow systems just below the ground surface and survive on roots and root bark. Pine voles attack young apple trees during fall and winter when they run out of other food sources.

Damage

Both types of voles are able to cause great damage in orchards, especially to apple and peach trees. Meadow vole damage is often clearly visible in the form of girdling at the base of the trunk. Girdling damage usually occurs in fall and winter when other food sources are scarce and trunks of young apple trees are easily accessed. Pine voles are difficult to notice until the tree growth begins to decline by which time it is difficult to save the tree.

Vole Monitoring

The first step in controlling the damage is to identify vole species and the extent of the damage. The meadow voles create extensive surface runways in the grass which are about 1.5 inch wide and are often visible after close moving. Bits of leaves and vole droppings in pathways are the surest signs of meadow vole presence. To differentiate the species, specifically the pine voles, place 20 traps per orchard close to tree trunks, active runs, and heavily shaded areas. Next day check the traps; if the caught vole has a tail shorter than its hind leg, a pointy nose, sunken eyes, and brownish fur, it is a pine vole. If the tail is longer than the hind leg then it is a meadow vole. The next step in controlling voles is to determine their population. In a simple apple sign test, place an apple slice at every 20-30 trees and 24 hours after placing them, inspect the teeth marks. Number of apple slices with gnaws in relation to total number of trees gives a percentage index of vole populations.

Vole Management

Non-Rodenticide Methods

Maintaining a vegetation-free zone below the trees discourages voles from living close to the trunk where they can cause great damage. Regularly mowing the ground cover down to 3 to 5 inches is a recommended practice to include as part of an integrated vole damage management program. It not only limits the availability of food for voles' survival, but also make them exposed to predators. Sanitizing the orchard floor by removing leaves and pruned twigs which attract the voles is also helpful.

Cylinder-shaped wire guards made from hardware cloth mesh of 1/4 inch placed around the tree trunks can protect the young apple and peach trees. However, make sure to bury the hardware cloth at least 6 inches below the surface to control both meadow and pine voles. This exclusion method may not be very practical and cost effective in large orchards.

Rodenticides

Sometimes to control large scale vole populations, chemical rodenticides are the only practical option available. Chemical treatment within the herbicide strip near the tree rows is the most effective to control vole population (Table 6.11).

For small scale orchards the easiest way is to place baits in the active runs at each hole. Alternatively, baits can be hand broadcasted, however it is not recommended because it can be dangerous to grazing animals and other non-intended species. Applying baits in furrows is more effective for meadow voles and less effective for pine voles. Zinc phosphide is seldom recommended because of its high toxicity to all vertebrates, however bait stations can reduce the chances of bait getting into contact with non-intended animals or humans. Bait stations are easy to make using 2 to 3 inch PVC pipes in 'L' or 'T' shape in which horizontal pipe provides an opening for voles to enter, the vertically connected pipe has bait filled in which gets released in a smaller doses (*http://extension.missouri.edu/p/G9445*). After putting out bait stations or placing baits in active runs or in furrows, perform the apple sign test as mentioned above (see "Vole Monitoring") to confirm control.

Table 6.11 Vole Control with Rodenticides

Name	Type of bait[1]	Product Formulation	Comment
Zinc Phosphide	Fast acting, acutely toxic	Pellet	More effective against meadow voles. However when applied by coating an apple slice, use about 1 tsp (4 grams) per bait station, it was effective to control pine voles.
Chlorophacinone, Diphacinone	Slow acting anticoagulants	Pellet	More effective against pine voles. Weather resistant hence can be used any season. Several application at 3 weeks interval may be required for effective control.

[1]Make sure you have the necessary pesticide applicator license to handle these chemicals.