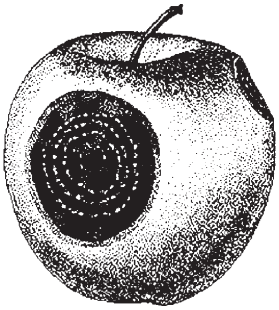


BITTER ROT, caused by the fungus *Colletotrichum gleosporoides* (sexual stage = *Glomerella cingulata*), is a summer disease of apple fruit. It is considered a more serious disease problem in southern apple growing regions, but extensive damage can develop rapidly in New England orchards during a period of prolonged warm, wet weather if inoculum sources are present. At the optimum temperature (79°F), infection can occur with a wet period as short as 5 hours. Fruit lesions appear as brown, slightly sunken spots. If the apple is cut open, the rotted area beneath the lesion is V-shaped in cross-section. Bitter rot lesions expand most rapidly at a temperature of 86°F. Spore producing structures (acervuli) develop in concentric rings, beginning at the center of the lesion when it is 1/2 to 3/4 inch across. Severely infected fruit become shriveled and persist on the tree as mummified fruit. Control of bitter rot is based on sanitation and protectant fungicide sprays. Removal of mummified fruit and dead wood on the tree or on the ground is important. Shoots killed by fire-blight can be colonized by the bitter rot fungus and serve as an inoculum source during that same growing season.

The EBDC fungicides are the most effective materials for preventing bitter rot, but their label makes them unavailable for use at the proper time. Of the other apple fungicides, only captan has a "good" rating for bitter rot prevention. If bitter rot is apparent, use captan at 2-week intervals to prevent additional infections unless the weather turns dry. Although apple cultivars do not vary widely in their susceptibility, the disease is often more severe on Empire, Freedom, Golden Delicious, Fuji, and Granny Smith.

BLACK ROT is caused by the fungus *Botryosphaeria obtusa*. The name black rot refers to fruit rot or bark canker symptoms, while leaf-spot symptoms are called 'frog-eye'. In addition, the fungus can cause a core rot around the seed cavity in developing fruit.

Frog-eye symptoms first appear about 1 to 3 weeks after petal fall. Leaf infections first look like small purple flecks which rapidly enlarge into circular lesions about 1/8" – 1 /4" in diameter. The lesions resemble "frog eyes" in that they retain a purple margin and have a light brown/tan center. Fruit (i.e., sepal) infections can occur as soon as bud scales begin to loosen. These early infections can result in blossom-end rot later in the season.

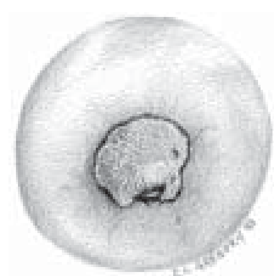
Infections of young fruit after petal fall begin as reddish flecks but then develop into purplish pimples which enlarge into dark brown necrotic areas when the fruit begin to mature. Additional infection of mature fruit result in black, irregularly-shaped lesion surrounded by a red halo. As these lesions expand, they are characterized by alternating brown and black concentric bands. The flesh of the decayed area remains firm and leathery.

Infected areas of branches and limbs are reddish brown and slightly sunken. Cankers can expand to several feet in length. Fire-blight cankers and cold-damaged tissue are rapidly colonized by the black rot fungus. Fruiting bodies (pycnidia) are abundantly produced on dead bark, dead twigs, and mummified fruit. Ascospores and conidia are released when it rains throughout the growing season. Infected leaves and fruit are often found below mummies and old fire blight cankers.

The optimal temperature for leaf infection is 80° F. The optimal temperature for fruit infection ranges from 68°F – 75°F. At these temperatures, a minimum of 4.5 hours of leaf wetness and 9 hours of fruit wetness must occur for infection, respectively.

Removing cankered wood, mummified fruit, and chopping or removing pruned wood are important steps in the management of this disease. If a black rot problem persists after implementing these sanitation tactics, then multiple applications of captan or a Topsin-M combination with captan may be needed from after petal fall through mid- to late-August to prevent fruit infections.

CALYX END ROT and **DRY-EYE ROT** Sometimes lumped together and called blossom-end rot because symptoms are very similar, these diseases are actually caused by two different fungi. Calyx end rot is a soft rot, which may expand to cover about 1/3 of the



end of a fruit, and is caused by *Sclerotinia sclerotiorum.* Dry-eye rot is a shallow, hard rot over a smaller area, often with a red border, and is caused by *Botrytis cinerea.* The diseases first appear about 1 month after petal fall, when the calyx end of infected fruit reddens and then rots. (See Moldy Core which also causes fruit to redden prematurely.) The diseases are most often seen on McIntosh, Paulared, and Delicious. Spores are produced on either mummified fruit from previous years, or on a number of wild host plants, and released from bloom through a few weeks after petal fall. The diseases occur sporadically, and are associated with wet periods during bloom, petal fall and early fruit set. While the Topsin M label does not mention these diseases, if you are applying this fungicide for other diseases at petal fall and 10-14 days later, such applications may help prevent infections in orchards where there has been an end rot problem, particularly if there was a prolonged wet period during bloom–petal fall. Captan labels list botrytis blossom end-rot as a target pest.

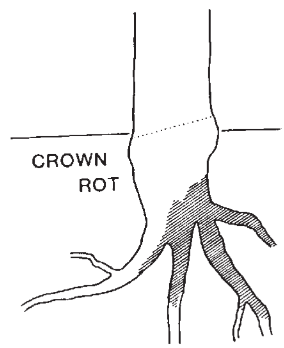
WOOD ROT FUNGI Apple trees are susceptible to many wood-rotting fungi (WRF). These fungi are usually "opportunistic pathogens" in that they invade stressed and/or weakened trees through wounds and infect the wood, progressing up and down the limb and/or trunk of the oldest wood.

Typical wood-rotting fungi include *Chondrostereum purpureum, Trametes versicolor, Schizophyllum commune,* and *Polyporus hirsutus*.

These fungi can be found on the edge of discolored heartwood present in most older apple trees. When the fungi move from older wood into younger wood near the bark, they can cause a canker to develop in the bark. Although *Chondrostereum purpureum* is a wood rotting fungus, it rarely causes any visible canker but it may cause leaves on certain limbs of infected trees to develop a silvery appearance soon after petal fall. This condition is known as "silver leaf" and is caused by the separation of the upper leaf layer from the rest of the leaf tissue. This separation is caused by a toxin produced by the fungus. The silvering is not always present each year in infected trees. If you cut through branches or the trunk, you will often see that the wood is stained and decayed. As with other wood rotting fungi, infection can cause the tree to decline for years.

WRF spores come from dead or decaying limbs, trees, or tree stumps on which bract mushrooms have developed. WRF have many tree hosts in woods surrounding orchards. Thus, it would be difficult to reduce inoculum. However, practices that promote the health of trees (i.e., proper nutrition and adequate water) and that decrease the potential for wounds or broken limbs (i.e., proper training and pruning) will decrease the potential for infection and disease development by WRF.

***PHYTOPHTHORA* CROWN, ROOT & COLLAR ROT** These fungal diseases are caused by a number of soil-inhabiting *Phytophthora* species, including *Phytophthora cactorum*. Some species may be ubiquitous soil inhabitants. Virtually all nursery stock contains *Phytophthora* inoculum. The above ground symptoms of these diseases are similar to those of vole-girdled trees, i.e. reduced vigor and growth, sparse foliage. At or below the ground, partial or complete girdling of the trunk occurs. Fruit may be small and color prematurely.



Collar rot is a disease that affects the lower trunk (scion) above the rootstock-scion junction.

Crown rot is a disease of the underground rootstock portion of the trunk and base of the primary roots. Below the bark, a distinct margin separates healthy and diseased tissue. Infected tissue is orange or reddish brown.

Root rot involves infection of the roots away from the crown.

Occurrence of these diseases is sporadic and is much more likely where susceptible rootstock is planted on a poorly drained site. Site selection and soil water management are most important in preventing crown, collar, and root rot. Soils should have adequate drainage throughout the year so that the soil is not saturated with water for prolonged periods. Water saturation of soil for 24 hours is sufficient to initiate infections. Selection of rootstocks adapted to the site is also important (see Table 5).

Fungicides are not a substitute for good site preparation and the use of rootstocks adapted for the intended orchard site. If susceptible rootstock is already planted in wet soil (either because of poor drainage or unusually wet conditions), or if adjacent trees have the disease, then protective fungicide treatment should be considered. Note that treatment will not 'revitalize trees' showing moderate to severe disease symptoms.

The primary fungicides used for managing these diseases are 'fungistatic". They do not kill the fungus but stop it from growing for a time. Young, small trees are most prone to severe damage because trees can be girdled quickly, whereas older trees with a larger trunk diameter can sustain more damage and still recover.

Ridomil can be applied as a drench around the trunk for preventing crown and collar rot or as a banded treatment within the drip line for root rot. Ridomil drench can be applied in the early spring before growth begins, or in the fall after harvest but before the ground freezes. Alternatively, Aliette can be sprayed on the foliage at 30 to 60 day intervals. See Ridomil and Aliette labels for dosage rates and application details

FIRE BLIGHT is a sporadic disease in New England, but when it occurs, it can be devastating to susceptible cultivars and rootstocks (see Tables 5 and 6). The disease is caused by a bacterium, *Erwinia amylovora*. The bacteria overwinter in bark tissues along the edges of cankers that were produced from

infections the previous season. Rain or insects can disseminate the inoculum from the cankers to the stigmatic surfaces of blossoms where the bacteria multiply profusely. The bacteria can spread from blossom to blossom by bees or by rain. The bacteria penetrate host tissue through wounds or natural openings in the presence of water. Once inside the host, the pathogen will continue to multiply and kill plant cells.

Flowers, fruit, shoots, branches, roots, and trunks can become infected. Recently infected tissues become water-soaked in appearance and may emit a watery, milky to light orange ooze on humid days. As the tissue dies it turns from dark green to brown and black.

When susceptible cultivars are grown on susceptible rootstock, such as M26 and M9, infections of the scion or suckers at the base of the tree can spread into the rootstock and kill it within a

Table 5 – Characteristics of Apple Rootstocks (Adapted from Paul Domoto, Iowa State University).

Rootstock	Size	Hardiness	Soils	Crown and Root Rot	Fire Blight
MM.111	80–85%	Moderate	Drought tolerant but does not tolerate wet soils	Tolerant on well drained soils	Tolerant
MM.106	70–75%	Very susceptible early; hardy later	Avoid poorly drained soils	Very susceptible	Moderately susceptible
M.7 EMLA	60–65%	Moderate	Adapted to most soils except heavy clay	Susceptible under wet conditions and poorly drained soils	Tolerant
M.26 EMLA	55–60%	Good, but may be susceptible early	Best in well drained soils	Moderately susceptible on poorly drained soils	Very susceptible
Ottawa 3 (O.3)	50–55%	Good	Best in well drained soils	Resistant under most conditions	Susceptible
M.9 and its strains	30–50%	Moderate–Good	Best in well drained soils	Very resistant	Very susceptible
Budagovsky 9 (B.9)	35–40%	Good	Best in well drained soils	Resistant under most conditions	Susceptible?
P.16	25–30%	Moderate-Good	Best in well drained soils	Resistant under most conditions	Susceptible

year.

Successful management of fire blight requires an integrated approach including resistant cultivars and rootstocks; removing sources of inoculum; attention to proper nutrition and irrigation so trees are not overly vigorous; effective timing of blossom treatment, when warranted, to prevent infection; and when possible and necessary, rapid response to remove infected tissue before disease progression and spread.

FIRE BLIGHT MANAGEMENT

There are three major stages on which to focus fire blight management: dormant cankers, blossom blight, and postbloom shoot blight.

Dormant cankers. When pruning out active infections during the previous growing season, leaving a large stub will help identify areas of infection to make dormant pruning easier. Remove any cankered or damaged tissue during dormant pruning. Make dormant cuts back to the next healthy branch.

If fire blight has been a problem in a block in either of the previous two seasons, dormant application of a high rate of a copper fungicide plus oil will reduce bacterial numbers and may reduce the chance of fire blight. The treatment is intended to kill bacteria on bark and bud surfaces. Applications should be made as dilutely as possible to insure thorough coverage. Full block treatments will reduce bacteria on the surfaces of all cultivars, and prevent dispersal from the unsprayed trees to the sprayed trees. Applications after green tip may russet fruit so early application is essential.

Late pink and bloom. Apply streptomycin (plus a surfactant) just *before* an anticipated infection event. Application within 24 hours before start of a fire blight infection period is ideal. Streptomycin application as much as 72 to hours prior to infection condtions will help prevent infections to a substantial degree. Application within 0–24 hours after the start of an unprotected infection period is also worthwhile. Need for additional treatment should be determined starting 3 days after an application to protect newly-opened blossoms before the next rain occurs. Do not apply on an alternate row middle basis. Antibacterial activity depends upon absorption by the blossoms, therefore, streptomycin should not be applied immediately before or during a rain. Antibiotic applications made in the evening before an expected infection event are particularly effective as uptake will be more thorough when the material dries more slowly on the plant tissues. Avoid high volume foliar sprays for other purposes during bloom when fire blight infection risk is high, since these may trigger an infection. Because of concerns about resistance, try to limit applications to three per year.

Postbloom. Monitor orchards extensively for early fire blight symptoms. Feeding by potato leafhopper (not other leafhoppers) may aid the spread of fire blight in blocks with active strikes. A low tolerance for potato leafhopper is advised if fire blight is active in the block. Aphids and pear psylla have also been implicated in the spread of active infections to shoots; therefore, control of these possible vectors is recommended in infected blocks.

To reduce the chance of developing resistance, routine applications of streptomycin are not recommended to control the spread of shoot blight. Alternation with other available materials is recommended (see product list). Also, Apogee (see Apogee section) has been very effective in reducing the incidence of shoot blight when applied from petal fall to very early shoot growth.

Remove fire blight strikes before extensive necrosis develops using the “ugly stub” method. This method leaves a branch stub at the cut, rather than making a normal cut right at the branch bark union. This allows the natural barriers at the branch bark union to seal off the branch, while providing an easily spotted target for winter pruning, and removing visible

Table 6 – Susceptibility of Selected Apple Cultivars to Fire Blight

Cultivar	Rating
Braeburn	very susceptible
Cortland	susceptible
Delicious	moderately resistant
Early McIntosh	moderately resistant
Empire	moderately resistant
Fuji	very susceptible
Gala	very susceptible
Ginger Gold	very susceptible
Golden Delicious	susceptible
Idared	very susceptible
Jerseymac	susceptible
Jonagold	very susceptible
Liberty	moderately resistant
Macoun	susceptible
McIntosh	susceptible
Mutsu	very susceptible
Northern Spy	susceptible
Paulared	very susceptible
Priscilla	moderately resistant
Red Free	susceptible
Spartan	susceptible
Spigold	very susceptible

inoculum sources during the growing season.

Rules for "ugly stub" pruning:

- Begin cutting when symptoms first appear, before extensive necrosis (discoloring or other damage) is present.
- Make cuts 8 to 12 inches or more below the visible symptoms.
- Make cuts into wood that is at least 2 years old.
- Do not cut back to the next healthy limb or spur, but leave at least a 4 to 5-inch naked or "ugly stub."
- Remove all ugly stubs during the dormant period when the temperature is too cold for the fire blight bacteria to multiply.

If a hail occurs in fire blight-affected orchards, an application of streptomycin is advised within 24 hours after the start of the hail event.

Predictive Models. Weather-based models predict fire blight risk and help estimate the need to apply streptomycin or other control options during bloom.

One commercially available model is the Maryblyt® computer program developed by the late Dr. Paul Steiner of the University of Maryland. The program *assumes the bacterial pathogen is present* and identifies an infection period when four requirements are met: (1) flowers are open; (2) at least 198 degree hours greater than 65°F have accumulated in the days preceding a wetting period; (3) at least 0.01" rain or dew that day, or at least 0.10" of rain the day before; and (4) an average daily temperature equal to or greater than 60°F. When all of these conditions are met, the first symptoms of blossom blight are predicted to appear when an additional 103 degree days have accumulated (base 55°F). This model is also very helpful in predicting when to start looking for infections which may have occurred and facilitates their early removal.

Another fire blight risk assessment model is Cougarblight, developed by Dr. Timothy Smith of Washington State University. Dr. Smith cites three major factors that affect the number of fire blight strikes per tree and the extent of damage if the apple blossoms are wetted: 1) the tree (cultivar, age, vigor, and the number of blossoms present); 2) the relative presence of fire blight bacteria in the area (did you have blight in the local area within the past several years, last season, or is it present this year?); and 3) the potential for bacterial growth in blossoms during the past few days.

Table 7a – Estimated daily fire blight degree hours for the Cougarblight model

Daytime high temperature	Degree hours per day if night-time low is under 50ºF	Degree hours per day if night-time low is 50ºF or above	Daytime high temperature	Degree hours per day if night-time low is under 50ºF	Degree hours per day if night-time low is 50ºF ot above
60° F	0	0	***80° F***	195	230
62	2	5	***81***	212	250
63	5	12	***82***	228	265
64	10	22	***83***	243	280
65	14	29	***84***	257	292
66	20	35	***85***	266	302
67	26	42	***86***	274	310
68	33	50	***87***	280	315
69	42	60	***88***	285	320
70	52	70	***89***	288	325
71	62	80	***90***	290	330
72	74	92	***92***	287	335
73	87	105	***93***	284	333
74	100	120	***94***	280	330
75	115	134	***95***	274	325
76	130	151	***96***	267	317
77	146	169	***97***	260	309
78	162	189	***98***	254	302
79	178	209	***99***	246	293

Using the Cougarblight model:

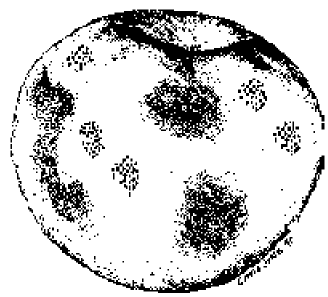
The relative risk of fire blight is calculated each day that blossoms are open in the orchard. The grower/manager determines the past days' high and low temperature with a local, carefully set up thermometer or weather service report, then totals the degree hour estimates for the past three days. The manager then adds to that total the potential degree hours for the present day, based on predicted high and low temperatures. The grower may then choose a course of action based on:

1. TEMPERATURES – the amount of heat that has occurred over the four-day period as defined by the degree hour chart (Table 7a). Degree hour totals may range from 0 to over 1200.
2. PRESENCE OF BACTERIA – the potential for presence of active fire blight cankers in the area, at the present time or in the recent past. Risk increases with proximity and number of cankers.
3. CONDITION OF THE TREES – the potential for serious fire blight damage to the trees if they are infected in their present condition, considering flower numbers, tree age, rootstock, vigor and cultivar.
4. THE WEATHER – the possibility of infection being triggered by flower wetting by rain, heavy dew (or light wetting from nearby sprinklers).
5. PERSONAL SITUATION – the practical considerations relative to spray application. Growers also differ in their ability to tolerate risk, so personal action thresholds may differ under very similar orchard conditions.

The manager then refers to the infection risk chart to determine if the risk estimate for the day is low, marginal, high or extreme (see Table 7b). In most instances, control measures will not be necessary unless the risk level is high or extreme. Note that "Marginal Risk" is a precautionary level when conditions are nearing those that would result in fire blight.

FLYSPECK and SOOTY BLOTCH

These two diseases blemish the fruit and present difficult disease management decisions, because they do not occur with the same intensity every year, and they occur at a time when growers would like to minimize pesticide applications. The diseases are caused by different fungi, and often occur together on unprotected fruit.



Sooty blotch is more easily controlled with fungicides, and in most cases one or two summer fungicide applications provide adequate protection. Flyspeck is

Table 7b – Infection risk relative to 4-day degree hour totals at the time of blossom wetting.

Potential Pathogen Presence Estimated by Fire Blight History:	Low	Marginal	High if flowers present	Extreme if flowers present
I. *No fire blight in the area during the past two seasons*	0 – 400	400 – 500	**500** – 800	800 +
II. *Fire blight present in the area, but not within one mile of your orchard last year*	0 – 350	350 – 400	**400** – 650	650 +
III. *Fire blight in your orchard or neighboring orchard last year*	0 – 150	150 – 300	**300** – 500	500 +
IV. *Active strikes or cankers are presently in your or neighboring orchard*	0 –100	100 – 200	**200** —500	500 +

more difficult to control.

Growth of the pathogens depends on humidity. If relative humidity is very high (95% or above) then the pathogens will grow. In drier air they apparently remain inactive. Optimum temperatures for growth are at 60^{o}F to 75^{o}F, making warm summer nights ideal for sooty blotch and flyspeck development. Many conditions can contribute to maintaining high humidity in apple tree canopies, and therefore increase incidence of sooty blotch and flyspeck. Practices which improve air circulation and drying will reduce the diseases. Summer pruning, thinning to break up fruit clusters, mowing, and cutting dense hedgerows or nearby woods are recommended where flyspeck and sooty blotch are problems.

Cultural practices can significantly reduce these disease problems, but fungicides are generally required to maintain commercial fruit quality in all except the most northern parts of New England. Timing of fungicide applications will depend on rain and the fungicides used. Use Table 14 in Part II: *Notes on Fungicides and Bactericides* to guide your application of summer fungicides. To prevent flyspeck infection, fungicide coverage should be renewed on or before the depletion date of the previous spray.

A recently devised management tactic is to delay the first fungicide application targeted exclusively against flyspeck. This is based on three assumptions. One is that the amount of flyspeck that overwinters inside the orchard is insignificant. This is because the host tissues it survives on (the waxy cuticle of fruit) are removed in the fall.

The second assumption is that infection by flyspeck ascospores in the orchard is largely prevented through peak flyspeck ascospore release (about 2 to 4 weeks after petal fall in Central Mass.) by fungicides applied for apple scab. Thus, most of the inoculum for flyspeck infections comes from conidia produced on wild hosts surrounding the orchard.

The third assumption is that it takes a few weeks for the ascospores released in the border areas to germinate and grow colonies that produce conidia.

If these assumptions are true, then summer fungicides for controlling flyspeck are not needed until about one month after petal fall. At that point, flyspeck conidia will become available from unmanaged alternate host plants in the orchard perimeter, and those conidia will begin blowing into the orchard.

Captan and ziram do not have any eradicant activity against flyspeck and therefore must be applied as protectants before these immigrating conidia can cause infections. Topsin M provides some degree of eradicant activity against flyspeck and the strobilurins, Flint and Sovran, are quite effective as eradicants against summer diseases. During many growing seasons, the last scab spray is applied about 1 month after petal fall. If a block of apples has a history of summer disease symptoms, this final scab spray should be a material that is good against flyspeck and sooty blotch.

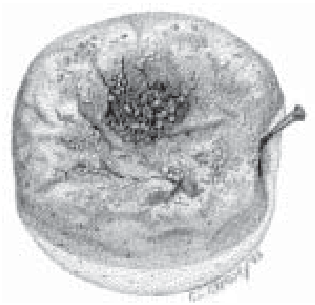
The timing of subsequent sprays in a given block of apples will vary according to the level of summer disease risk. Extent of risk is influenced by the amount of fungal inoculum in the border areas in May, physical factors such as the size and proximity of border areas and the degree of openesss of apple canopies, as well as dynamic weather factors such as rainfall and leaf wetness during the growing season. A three week spray interval during the summer is still fairly standard where flyspeck is a concern (depending on which materials are being sprayed, although growers who have low-risk blocks are finding that a four week interval works during a dry year.

Late-ripening cultivars and lightly-colored cultivars may require an additional or later spray than the average cultivar. See Table 14 for more information on summer disease management.

MOLDY CORE is characterized by visible fungal growth in the seed cavity and core of some apple cultivars, particularly Delicious and McIntosh. In storage, the disease may progress into the flesh immediately surrounding the core causing a dry rot. While *Alternaria* spp. are commonly isolated from moldy core apples, other fungi are also associated with the disease. Sometimes, moldy core disease will cause fruit to redden prematurely during July or August. More frequently, fruit do not show any external symptoms.

Presumably, infection occurs through the calyx when it remains open, allowing spores to enter the seed cavity. Once the fungus is within the fruit, it is protected and fungicides have no effect. No specific management tactic for this disease has been developed, although fungicides applied during bloom may provide some control.

POST-HARVEST ROTS. Several fungi, notably *Penicillium spp.* (causing blue mold) and *Botrytis spp.* (causing gray mold) are involved in postharvest storage rots on apples.



Generally, these rots are not a problem unless apples become wet, as in the process of applying diphenylamine (DPA) as a scald inhibitor. Significant problems have occurred with Empire.

Several practices should be part of an integrated management approach for postharvest rots.

1. Disinfect boxes and bins before they are reused. You can do this by washing or soaking them with 1 part commercial bleach plus 9 parts water, or other disinfectants.

2. Harvest fruit at the proper maturity level. Smooth orchard roads. Handle fruit so as to minimize bumping and bruising.

3. During harvest, place bins and boxes on sod and not on bare soil. This is to prevent entry of decay organisms from the soil.

4. Cool fruit rapidly after harvest to minimize opportunities for decays to become established.

5. Remove culls and leaf debris from the packing shed daily.

Dipping for Post-harvest rots

Post-harvest treatment of apples for control of storage rots should not be done except when fruit must be treated for storage scald prevention or have post-harvest calcium treatments**.** The dip tank is where most post-harvest rot starts. If you do use dip solutions, keep drench solutions clean. Consider pre-rinsing loads with a hose before drenching.

Most drench tanks would benefit from improved agitation. Fungicides settle to the bottom of drencher holding tanks unless agitated, reducing the fungicide dose on the apples. Mertect 340-F must be constantly agitated because it appears to settle out of suspension very quickly. This problem can be solved by installing a re-circulator in the bottom of the tank, such as a grid of PVC pipes with outlet jets, to create turbulence that re-suspends fungicide that has settled. A filter can be built into this system, further reducing rot inoculum.

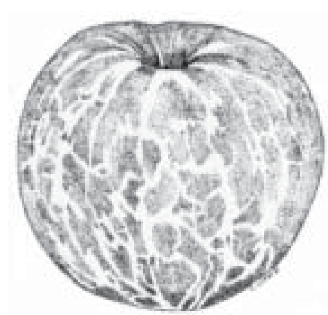
If postharvest fungicides are needed, thiabendazole (e.g., Mertect 340-F) plus captan is the only option at present. Use captan at the highest label rate. The fungicide should be changed or recharged at least as frequently as the label recommends. Captan is subject to breakdown in high pH water. Preliminary evidence suggests that long term control of *Penicillium* can be enhanced by maintaining treatment solution pH below 7.

Fungicide	Amount per 100 gals. drench
Mertect 340-F	16 fl. ozs.
or Decco Salt No. 19	6.7 ozs. (192 grams)
plus	
Captan 50WP	2.5 lbs.
or Captan 80WP	1.6 lbs.
or Captec 4L	1.25 quarts

Captan-treated fruit may be unacceptable for some export markets that have lower residue allowances for captan that those established for the United States.

Also, commercial formulations of calcium hypochlorite and sodium hypochlorite are available with postharvest labels. However, chlorine is not compatible with the scald inhibitor diphenylamine. Thus, chlorination is most useful for disinfecting flume water on apple packing lines rather than as a postharvest treatment prior to storage.

POWDERY MILDEW The fungus, *Podosphaera leucotricha*, can infect foliage, shoots, blossoms and fruit. Infected shoots have a slower growth rate; severely infected leaves are stunted and never attain their normal size or shape. Infected leaves can become curled and brittle, often dying prematurely. Photosynthesis is adversely affected and severe infections result in reduced growth and vigor of the tree. Mildew can affect yield directly through the abortion of severely infected blossoms or the russeting of infected fruit.



The fungus survives only on living tissue. It overwinters as mycelium predominantly in the apical buds of vegetative shoots. Winter temperatures of below –11°F negatively impact overwintering inoculum by killing the bud in which the fungus overwinters and thus the mycelium dies.

As the surviving infected buds open in the spring, the overwintered mycelium will grow, covering the expanding tissue (i.e., blossom, leaves, shoot) and producing conidia which will give the tissue a 'powdery' appearance. These conidia are the "primary inoculum" that infect other young tissue which in turn will provide inoculum for "secondary infections". This infection cycle repeats until the apical bud sets on vegetative terminals and all the leaves harden off and become resistant to infection. Unlike apple scab, water is not needed for infection and is considered detrimental to germination. Optimal temperature for germination is between 68–72° F with relative humidity as low as 70%. Thus, relatively warm winters and warm, relatively dry springs favor disease development.

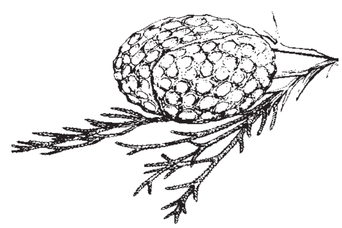
Cultivars vary in their susceptibility to the disease (see Table 2). Highly susceptible cultivars include Ginger Gold, Cortland, Gala, Paulared, Idared, Rome Beauty, Granny Smith, and Jonathan.

The SI fungicides (Nova, Procure and Rubigan) are very effective against powdery mildew, unless resistance has developed to these fungicides in your orchard. Applications should be made in the period between bloom and apical bud set on vegetative terminals (about 24 days past petal fall). During this period, the petal fall and 1st cover sprays are particularly important in mildew management because they coincide with the period of active shoot growth. However, if SI resistance has developed in an orchard with very susceptible cultivars, applications should start at tight cluster or no later than pink. Note that all of the SIs listed have activity against apple scab, so, applying SIs for scab, will provide the added benefit of mildew management.

The strobilurin fungicides (i.e., Sovran, Flint) also have activity against both powdery mildew and scab (see Table 12). Sulfur is also effective against powdery mildew but applications have to begin earlier (i.e., tight cluster) and, because of short residual activity, re-applied every 7 days for good results under high disease pressure. Topsin-M has been used against powdery mildew but poor control has been reported in some orchards in recent years and resistance is suspected.

Mildew can infect only young, immature tissue. Once the leaves harden off, the threat of infection is gone and fungicide applications directed at powdery mildew are not warranted.

RUSTS Cedar apple rust and quince rust are of major importance in southern New England and can be severe in northern New England on susceptible cultivars during wet springs. The rust fungi require two hosts: apple and cedar. Cedar-apple rust is caused by the fungus *Gymnosporangium juniperi-virginianae*, and is recognized by the brilliant yellow and orange leaf spots and fruit lesions. Cultivar susceptibility varies (see Table 2). The fungus overwinters in galls on eastern red cedar. In the spring, following the second winter, these galls mature and liberate spores during rainy periods. These spores infect apple leaves and fruit. In the latter part of the growing season, spores will be produced in the apple lesions which can re-infect cedar. After about mid-June, once the cedar galls are no longer producing spores, the risk of further infection of apple is over.



The quince rust fungus, *Gymnosporangium clavipes*, does not cause leaf lesions, but fruit infections cause dark green lesions near the calyx end which often distorts the fruit. Quince rust is more common on Red Delicious. The quince rust fungus overwinters on low-creeping junipers, where galls appear as spindle-shaped enlargements on the stems. These swellings are hard to detect, and are perennially active, releasing spores during moist spring weather. Quince rust is most likely to cause economic damage when trees stay wet for more than 48 hours between tight cluster and late pink with an average temperature above 50°F.

In addition to planting rust resistant cultivars, removal of eastern red cedar and other juniper trees surrounding the orchard aids in preventing rust infections.

For susceptible cultivars, rust disease management requires fungicide applications. Spores are released from galls during rainy periods from around the last week of April until mid-June, with peak releases from early pink to full bloom. A fungicide effective against rust should be applied during this period if rust diseases have been a problem in the orchard (see Table 12). SI fungicides have post-infection activity against the cedar apple rust fungus; applications should be made within 3 days from the start of an infection period. The strobilurin fungicides (Sovran, Flint) are only rated as "fair" in managing cedar apple rust and are considered "poor" against quince rust. Mancozeb and Polyram are likely the best fungicide option against quince rust.