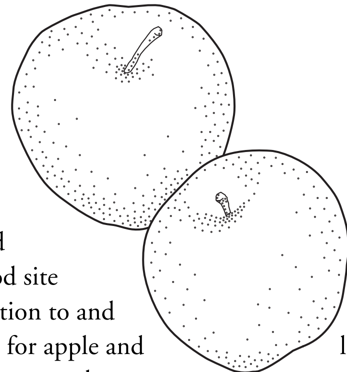
CHAPTER 1

Apples and Pears



Successful production of apples and pears depends in large part on good site selection and paying meticulous attention to and following through on details. The site for apple and pear orchards should be high with respect to the surrounding area and have excellent air drainage to avoid late spring frost losses and to reduce disease pressure. Pears are more prone to spring frost injury because they bloom earlier than apples. Proximity to a good water source for irrigation and spray water is highly desirable.

Both crops perform best on deep, friable, fertile soils with good internal drainage. Deep soils are desirable because of their greater water-holding capability and capacity to continue sizing fruit under dry conditions. Pears will generally perform better on heavier soils than apples. Soils that remain wet for long periods or that have a high water table, impervious clay pans or hardpans close to the surface, or very heavy clay texture reduce chances of success. Wet soils promote Phytophthora root rot, particularly in apples on susceptible rootstocks. Some of these problems can be remedied by managing surface water through waterways and drainage ditches and by installing drainage tile.

One to two years before planting, adjust the soil pH, phosphorus, potassium, calcium, magnesium, and other minor element levels as recommended. Adjustment of the soil pH to between 6.5 and 7.0 and incorporation of organic matter or a green manure crop are highly recommended prior to establishment. Nitrogen, applied early in the season, should be the only element required for the first several years if proper soil adjustments are made initially. Nitrogen should be applied based on the inherent fertility of the soil and annual tree growth. Excessive nitrogen applications should be avoided because they make trees more susceptible to fire blight and reduce fruit color development and storage life. Nitrogen application rates are intentionally kept low on pears to reduce fire blight susceptibility.

Foliar nutrient applications are minimized in the Midwest because it is much cheaper and more efficient to apply fertilizers to the soil. Foliar applications are generally recommended to accomplish a "quick fix" when nutrient deficiencies are detected. However, calcium and boron foliar sprays are routinely applied in many orchards. Calcium sprays are used to reduce cork spot and bitter pit, since it is often difficult to get sufficient calcium into the fruit even when soil levels are at recommended levels. Some growers also apply foliar boron sprays annually where soil levels are low. Foliar magnesium is occasionally used where foliar symptoms are apparent.

A combination of soil testing and leaf tissue analysis (sampled in mid- to late July) is recommended for monitoring tree nutrient levels and is used to make fertility recommendations. Consult your state Cooperative Extension Service for leaf-testing procedures and processing instructions.

Weed pests will deprive trees of water and minerals. Although orchards will always have some weeds, noxious perennial weeds such as johnsongrass, vining milkweed, trumpet vine, poison ivy, and yellow nutsedge should be eliminated from the site prior to planting trees.

Many midwestern growers are adopting high-density planting systems such as the French axis for apples. These systems use dwarf rootstocks, have considerably higher per acre dollar inputs, and require a considerably higher level of grower expertise and cultural management. However, these systems crop much earlier and provide a much faster return on investment than less dense planting systems.

Integrated Management of Apple and Pear Diseases

The objective of an integrated disease management program is to provide a commercially acceptable level of disease control from year to year while minimizing the cost of disease management. For each orchard, a program needs to be developed that integrates all available control tactics.

Identifying and Understanding Major Apple and Pear Diseases

Accurate disease identification is critical in making smart disease management decisions. Growers should develop a basic understanding of the pathogen biology and disease life cycles for the major apple diseases. The more you know about a disease, the better equipped you will be to make sound and effective management decisions. The following literature contains colored photographs of disease symptoms on apples and pears, as well as information on pathogen biology and disease development.

Compendium of Apple and Pear Diseases
Published by the American Phytopathological Society, 3340 Pilot Knob Rd., St. Paul, Minnesota 55121. Phone: (612) 454-7250 or (800) 328-7560.

Diseases of Tree Fruits in the East
Published by Michigan State University Cooperative Extension Service, as Publication NCR 45. Your county Extension office may have this bulletin in stock, or call Michigan State University.
Phone: (517) 355-0240.

Apple Scab

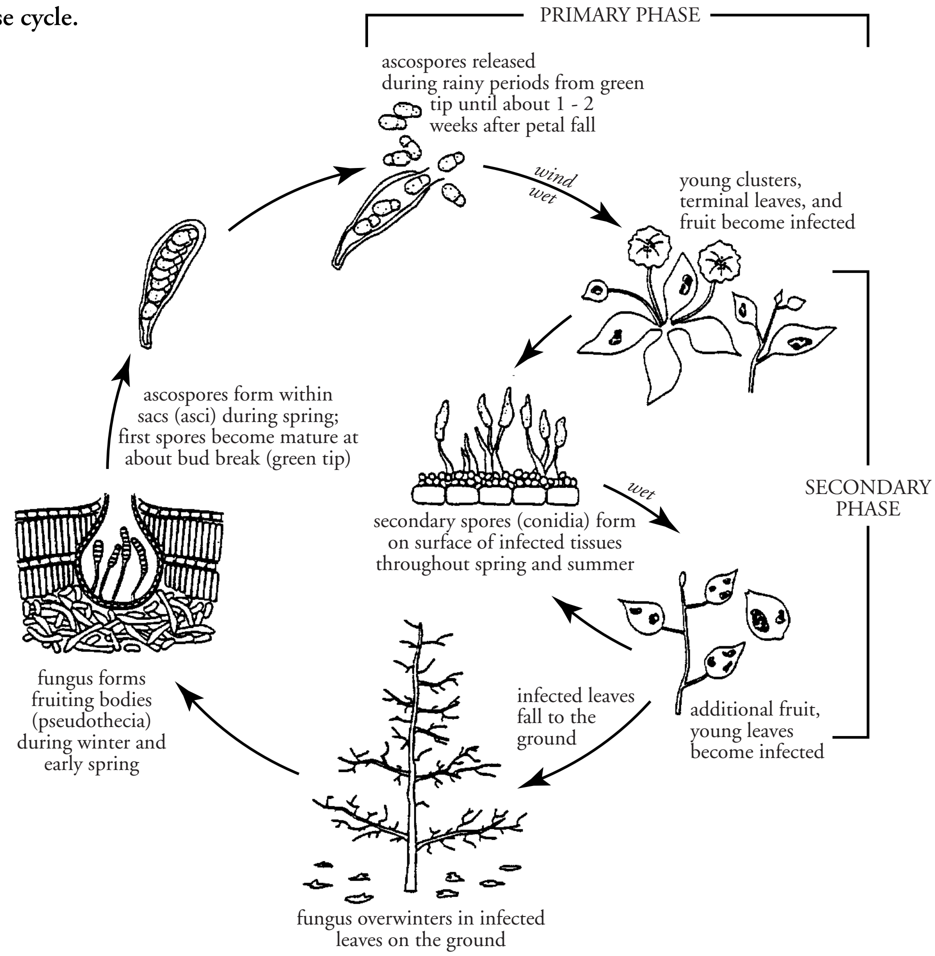
The most common disease of apple in the Midwest is apple scab, caused by the fungus *Venturia inaequalis*. Pear scab is caused by a related fungus, *Venturia pirina*, but is a minor problem compared to apple scab in the Midwest. Scab-resistant apple cultivars (Table 1) are recommended for growers who do not want to use fungicides. Contact your state Cooperative Extension Service for information on the cultivars best suited for your region. In the moist, temperate climate of the Midwest, managing orchards where scab-susceptible cultivars are grown

Table 1. Relative resistance of apple cultivars to apple diseases.

Cultivar	Apple scab	Cedar-apple rust	Fire blight	Powdery mildew
Ben Davis	3	3	4	3
Braeburn	-	-	4	-
Cortland	4	3	3	4
Delicious	3	1	2	2
Early McIntosh	3	2	2	-
Empire	4	2	2	3
Enterprise	1	2	2	2
Freedom	1	1	3	2
Fuji	3	-	4	-
Gala	3	-	4	-
Golden Delicious	3	4	3	3
Goldrush	1	4	2	2
Granny Smith	3	2	4	4
Idared	3	3	4	3
Jerseymac	4	1	3	-
Jonafree	1	3	2	2
Jonagold	4	3	4	-
Jonamac	3	2	3	3
Jonathan	3	4	4	4
Liberty	1	1	2	2
Lodi	3	4	4	2
Macfree	1	3	2	3
McIntosh	4	1	3	3
Mutsu (Crispin)	4	3	4	4
Northern Spy	3	3	2	3
Paulared	3	2	4	3
Prima	1	3	2	2
Priscilla	1	2	2	2
Pristine	1	3	-	3
Quinte	3	3	3	3
Redfree	1	2	3	3
Rome Beauty	4	4	4	3
Sir Prize	1	4	4	2
Smoothee	3	3	2	-
Spartan	3	2	3	2
Starkspur Earliblaze	3	2	3	-
Stayman	4	3	2	3
Tydeman's Red	3	1	3	2
Williams Pride	1	1	2	2
Williams Red	3	2	2	-
Winesap	4	3	2	3
Yellow Transparent	3	3	4	2

Resistance rating determined in New York by Cornell University Extension personnel; reports of T. van der Zwet and S. Beer, USDA Bulletin 631; D. Rosenberger, Northeast LISA Apple Project; and T. Sutton, *A Grower's Guide to Apple Insects and Diseases in the Southwest*. Several cultivars have been added to this table based on midwestern observations. Rating system; 1 = very resistant (No chemical control needed), 2 = resistant (Chemical control needed only under high disease pressure), 3 = susceptible (Chemical control usually needed where disease is prevalent), 4 = very susceptible (Chemical control needed where disease is prevalent. These cultivars should receive first priority when control is called for).

Figure 2. Apple scab disease cycle.



depends on the judicious use of fungicides. Knowing the apple scab disease cycle (Figure 2), the weather conditions that favor infection (Tables 2 and 3), and the basics of how fungicides work (Table 4 and Chapter 6) will help you decide which fungicides to use and when to use them.

Disease Development: During winter and early spring, the scab fungus develops in fallen leaves that were infected the previous season. The development of fruiting bodies is favored by alternating dry and wet periods. Primary scab spores (ascospores) mature in early spring about the time that leaves start to emerge. When leaves on the orchard floor have been wetted by at least 0.01 inches of rain for at least 30 minutes, ascospores are released and carried by air currents to newly emerging leaves and blossoms. The maximum rate of spore discharge is reached after 2 to 3 hours of wetness; after 6 hours, 75 percent of the ascospores that are mature during that wetness period will have been discharged. In general, maximum ascospore discharge and maximum susceptibility of leaves and fruit occur between tight cluster and 10 days after petal fall. Discharge of ascospores may continue up to 2 weeks after petal fall, but the majority are released by first cover.

The time required for infection depends on the temperature and duration of the "wetting period," the period during which leaves on the tree are continuously wet from rain or dew (Tables 2 and 3). When the infection process is not inhibited by a fungicide, primary scab lesions appear 9 to 17 days after infection depending on the temperature. Various forms of the "Mills Table" (Tables 2 and 3) are valuable for determining when conditions are favorable for infection and for deciding when fungicides with "after-infection" activity should be used. The Mills Table as modified by A. L. Jones in the 1980s (Table 2) has been validated in the field over several years and locations. The most recent modifications to the Mills Table (Table 3) have not been as widely validated but may be highly relevant to the Midwest. The newer table suggests that infection can happen in much less time at low

Table 2. Approximate minimum number of hours of leaf wetting required for primary apple scab infection at various temperatures.[a]

Degree of Infection				
Average Temp.(°F)	**Light (hr)[b]**	**Moderate (hr)**	**Heavy (hr)**	**Lesion Appearance (Days)[c]**
78	13	17	26	-
77	11	14	21	-
76	9 ½	12	19	-
63 to 75	9	12	18	9
62	9	12	19	10
61	9	13	20	10
60	9½	13	20	11
59	10	13	21	12
58	10	14	21	12
57	10	14	22	13
56	11	15	22	13
55	11	16	24	14
54	11½	16	24	14
53	12	17	25	15
52	12	18	26	15
51	13	18	27	16
50	14	19	29	16
49	14½	20	30	17
48	15	20	30	17
47	17	23	35	17
46	19	25	38	17
45	20	27	41	17
44	22	30	45	17
43	25	34	51	17
42	30	40	60	17

a From W. D. Mills, Cornell University as modified by A. L. Jones, Michigan State University.
b The infection period is considered to start at the beginning of the rain.
c Number of days required for lesions to appear after infection has been initiated.

temperatures than previous tables predicted. For example, according to Table 3, infection can take place if leaves are wet for 18 hours at 43°F, which is 7 fewer hours than predicted in Table 2. During especially wet springs when inoculum is high, one might be conservative and use data from Table 3. However, Table 2 has served many growers in many regions successfully over several years.

Within each primary scab lesion (which was caused by one ascospore), thousands of secondary spores (conidia) are produced, each of which is capable of causing a new infection. Conidia are spread by splashing rain and by wind. Germination and infection by conidia occur under about the same conditions as for ascospores. Additional conidia are produced all season long from established scab lesions. Although fruit become more resistant as they mature, secondary infection of fruit can occur in the fall but not show up until several weeks in storage. Scab can also develop on leaves, especially their lower surfaces, after harvest. This late-season scab may be from new infections, from infections that occurred several weeks earlier, or a combination of the two. In any case, late-season scab on leaves means that disease pressure will be high the following spring even though scab was managed during the growing season.

Control of Apple Scab: The key to successful apple scab control is to *prevent primary infection by ascospores*. Infections by ascospores occurring prior to tight cluster can cause significant losses because conidia are produced just as leaves and fruit reach maximum susceptibility. If ascospores are prevented from establishing infections early in the season, no further scab control is needed after ascospores are depleted. However, if scab is established early in the season, a grower must fight secondary infections throughout the summer. The number of conidia produced by just a few scab lesions is greater than the total number of ascospores produced in an entire acre of leaf litter in most commercial orchards.

Fungicides vary in their properties of retention, redistribution, protection, and after-infection activity (Table 4). In general, a program aimed at controlling scab will control other diseases (e.g., powdery mildew and rust) that are important early in the season. However, if you have a particular problem with other diseases, you may have to modify or bolster your scab control program. Four general approaches to primary scab control are:

1. Standard Protectant Program (7-day interval)
Protectant fungicides must be applied at approximately 7-day intervals during primary scab "season" because growing clusters and terminals are continually producing new tissues that need protection. The old rule-of-thumb is "Repeat protectant sprays after 7 days of new growth or one inch of rain." *In extremely wet growing seasons, intervals of less than 7 days may be required.* Also, the less effective protectants (e.g.,

Table 3. A proposed revision for the minimum number of hours of leaf wetness required to produce apple scab infections.[a]

Average temperature (°F)	Hours
34	41
36	35
37	30
39	28
41	21
43	18
45	15
46	13
48	12
50	11
52	9
54-56	8
57-59	7
61-75	6
77	8
79	11

a Data of W. MacHardy and D. Gadoury; and A. Stensvand, et al., Cornell University.

ferbam, sulfur, thiram, and ziram) probably need to be applied more frequently than every 7 days. In practice the 7-day protectant program can be modified to take advantage of weather predictions. For example, if a protectant fungicide is used and no rain is predicted on days 7, 8, and 9 after the last application, the next application can be made just before the next rain. Unfortunately, springtime weather throughout the Midwest is unpredictable, and a grower assumes risk in stretching spray intervals beyond 7 days.

2. Extended Sterol Inhibitor/Protectant Program (10-day interval not to exceed 14 days)

This combination program utilizes both the protectant and after-infection activities of the different scab fungicides (Table 4 and Chapter 6) and should result in fewer sprays than the standard protectant program. The first scab spray of the season is a protectant fungicide applied between green tip and half-inch green. Sterol-inhibiting (SI) fungicides are not recommended in the first spray because there is not enough leaf tissue exposed to take up the systemic fungicide. At tight cluster, scab pressure is high, and the first SI/protectant combination spray is made. The SI/protectant combination provides approximately 5 to 6 days of protection and 3 to 4 days of curative activity, which means the spray interval can be extended to 10 days. This program can also be modified to take advantage of information on infection periods that are determined from environmental monitoring (Tables 2 and 3). For example, the interval can be extended 1 day for each day without infection on days 6 through 9 after the last application. When using SI/protectant combinations, *the interval should never exceed 14 days* because some scab lesions partially inactivated by the SI fungicides may not be completely controlled without a second spray.

In extremely wet growing seasons, intervals of less than 10 days may be required. For example, a 7- to 10-day interval using fungicides at their higher recommended rates is recommended if an infection period occurred greater than 2 days prior to the previous SI/protectant spray. The reasoning is as follows: The first SI/protectant spray will reach back 3 to 4 days, but will be most effective at halting scab development if applied within 2 days of an infection period. The purpose of the second spray is to inactivate any fungal growth that might have survived the first spray. Thus, the longer you wait after infection has occurred to apply the first spray, the more important it is to apply the second spray after only 7 to 10 days. If the second spray is not made, then the fungus may resume activity and produce lesions with conidia.

3. Post-infection Program

This program can significantly reduce the number of fungicide applications, but it should be used only by growers who are accurately monitoring infection periods. It is *not* recommended in orchards with high levels of scab inoculum from the previous year. This program is designed for orchards that had less than 2 percent fruit scab the previous year and did not have late-season scab on leaves. In the post-infection program, an SI/protectant combination should be applied within 72 to 96 hours after the start of an infection period. The sooner the spray is applied after the infection period, the more effective it will be. *Fungicides applied in a post-infection program should be used at their full recommended rates*. Post-infection

Table 4. Properties of fungicides for apple scab control.

Trade Names[a]	Common Names	Rate/100 gallons	Retention[b]	Redistribution[c]	After-infection activity[d] (hr)	Protection[e]
Benlate 50WP	benomyl	3.0 oz	Good	Good	18-24	Fair
Captan 50WP	captan	2.0 lb	Good	Good	18-24	Very Good
Carbamate 76WP	ferbam	2.0 lb	Good	Good	None	Good
Dithane M-45 80WP	mancozeb	2.0 lb	Good	Good	18-24	Very Good
Manzate 200 80WP	mancozeb	2.0 lb	Good	Good	18-24	Very Good
Nova 40% WP	myclobutanil	2.0 oz	Fair	Fair	72-96	Fair
Penncozeb	mancozeb	2.0 lb	Good	Good	18-24	Very Good
Polyram 80WP	metiram	2.0 lb	Good	Good	18-24	Very Good
Procure 50WS	triflumizole	4.0 oz	-	-	48-72	-
Rubigan 1E	fenarimol	3.0 fl oz	Poor	Poor	72-96	Fair
Sulfur 95%	sulfur	5.0 lb	Fair	Good	None	Fair
Syllit 65WP	dodine	0.5 lb	Good	Good	30-36	Very Good
Thiram 65% WP	thiram	2.0 lb	Fair	Fair	15-20	Fair
Topsin-M 70WP	thiophanate-methyl	3.0 oz	Good	Good	18-24	Fair
Ziram 76DF	ziram	2.0 lb	Good	Good	18-24	Good

a No discrimination or endorsement is implied by the Cooperative Extension Service. Not a complete list. Also see Chapter 6 of this handbook for information on attributes of different fungicides.
b Retention is the ability of the fungicide to stick to the leaf surface.
c Redistribution is the ability of a fungicide to move to unsprayed areas and onto new growth during rains and weathering.
d After-infection activity is the ability to inhibit infection that has started. Use the start of a rain as the start of infection. At average temperatures below 50°F, use the longer time; at average temperatures above 50°F, use the shorter time.
e Protection is the ability of a fungicide to protect tissue from new infections after the material is applied.

sprays should be followed with a second application of the SI/protectant 7 to 10 days later (7 is better than 10) to make sure that scab lesions are inactivated. A potential problem with this spray program is that extended rainy periods can interfere with post-infection applications that must be made within 72 to 96 hours after the start of an infection period. Indeed, extended periods of rain are a problem with any fungicide program.

4. New York IPM (Integrated Reduced Spray) Program

This is a minimal spray program. As is the case for the post-infection program, it is *not* recommended in orchards that had greater than 2 percent fruit scab the previous year or late-season scab on leaves. The first fungicide application is delayed 1 to 3 weeks; a total of four applications of an SI fungicide (e.g., fenarimol, myclobutanil) is made: 1) tight cluster (with oil); 2) pink (with insecticide); 3) petal fall (with insecticide); and 4) first cover (with insecticide). Optimal protection is achieved by mixing a protectant (e.g., captan, mancozeb, or metiram) with the SI fungicide, especially at petal fall and first cover when young fruit are highly susceptible to infection. Including a protectant with the SI should also delay development of resistance to the SI. Because this is a minimal spray program, spray coverage must be nearly perfect. Thus, the program is not suited to blocks of large trees where near-perfect coverage is impossible. The timing of the four applications is dictated by the weather (spraying when conditions will allow optimal coverage) and timing of insect and mite control rather than by infection periods. However, if intervals greater than 10 days occur (e.g., from pink until petal fall), and weather conditions have been favorable for infection, it may be necessary to compensate by increasing the sterol inhibitor to the highest rate permitted on the product label.

Monitoring for Scab: Losses from scab often occur when conidia, formed in primary infections, infect young, developing fruit. Therefore, orchard blocks should be monitored for scab lesions starting at petal fall and continuing through first cover. Examine both surfaces of spur leaves and fruit. If scab is detected, the safest recommendation is to apply an SI *at the full recommended rate* plus a protectant through second cover to suppress further development of lesions and to protect susceptible fruit. In orchards where dodine has not been used extensively, and therefore resistance to dodine is unlikely, this fungicide may help “burn out” existing lesions. However, dodine applied after bloom can cause russeting. Another option is to not make “burning out” lesions the primary goal, but rather to focus on protecting fruit with the full rate of captan or an EBDC fungicide (e.g., mancozeb, maneb, or metiram). Note that after pre-bloom, the EBDCs may not be used at rates greater than 3 lb per acre.

Powdery Mildew

Powdery mildew, caused by the fungus *Podosphaera leucotricha*, can seriously reduce the vigor and productivity of apple trees. Powdery mildew is usually not as severe a problem as scab in the Midwest, but on highly susceptible varieties (Table 1) the mildew fungus may deform, stunt, or kill twigs, leaves, blossoms, and fruit. Infected fruits may become severely russeted. Gray to white felt-like patches occur on the leaves and on 1-year-old twigs. Leaves are narrow, crinkled, and folded lengthwise, and they become thickened.

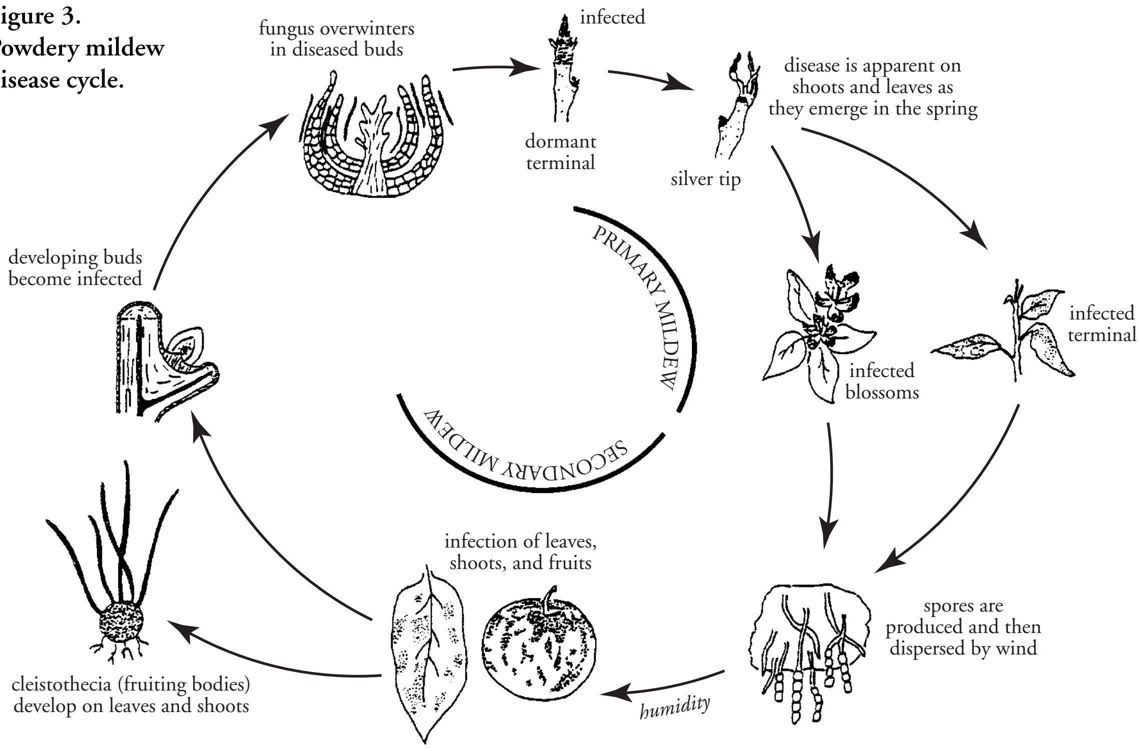
Disease Development: The powdery mildew fungus overwinters in vegetative or fruit buds infected the previous season (Figure 3). Infected terminals may have a silvery gray color, stunted growth, and a misshapen appearance and are more susceptible to winter injury than are noninfected terminals. Temperatures near –18°F kill a majority of mildew-infected buds and the fungus within them. Thus, disease pressure from powdery mildew is usually greater in growing seasons following mild winters.

As buds break dormancy, the powdery mildew fungus resumes growth and colonizes developing shoots, causing primary infections. Primary mildew infections may occur on vegetative shoots and blossoms and thereby cause a reduction in yield. The powdery white appearance on infected shoots consists of many thousands of spores, which are responsible for secondary infections. Secondary infections usually develop on leaves and buds prior to terminal bud set in midsummer and may reduce the vigor of the tree. Young fruit may become infected from about the pink stage of flower bud development up to 1 to 3 weeks after bloom. Fruit infection results in a weblike russeting on the mature fruit. Infected buds are the primary means of overwintering for the fungus. The powdery mildew fungus produces masses of small black fruiting bodies called cleistothecia on infected leaves and terminals in the late summer and fall. Although cleistothecia contain ascospores, their role in the disease cycle is not clearly understood.

The conditions required for infection by the powdery mildew fungus are very different from those required by the scab fungus. Unlike the apple scab fungus, the powdery mildew fungus does not require leaf wetness for infection. In fact, powdery mildew spores will not germinate if immersed in water. Rather, powdery mildew infections occur when the relative humidity is greater than 90 percent and the temperature is between 50° and 77°F. The optimal temperature range for the fungus is 66° to 72°F. The high relative humidity that often occurs before and after wetting periods is conducive to powdery mildew development. Under optimal conditions, powdery mildew will be obvious to the naked eye 48 hours after infection. About 5 days after infection, a new crop of spores is produced. Non-germinated powdery mildew spores can tolerate hot, dry conditions and may persist in the orchard until conditions are favorable for germination and infection.

Control of Powdery Mildew: Apple cultivars vary in relative resistance to powdery mildew (Table 1). Because powdery mildew does not need a wetting period to develop, control measures may be needed even during dry weather. The critical period for powdery mildew control is from about tight cluster to pink through first or second cover. The SI fungicides that are used to control apple scab (e.g., Nova, Procure, and Rubigan) are also effective against powdery mildew. Another SI fungicide, Bayleton (triadimefon), is a good mildewcide but is less effective in controlling scab. Wettable sulfur (95% WP) is a good mildewcide but is relatively weak against scab and can be phytotoxic at temperatures greater than 80°F. Thorough spray coverage, including the tops of trees, is essential for control of powdery mildew with fungicides.

Figure 3. Powdery mildew disease cycle.



Rust Diseases

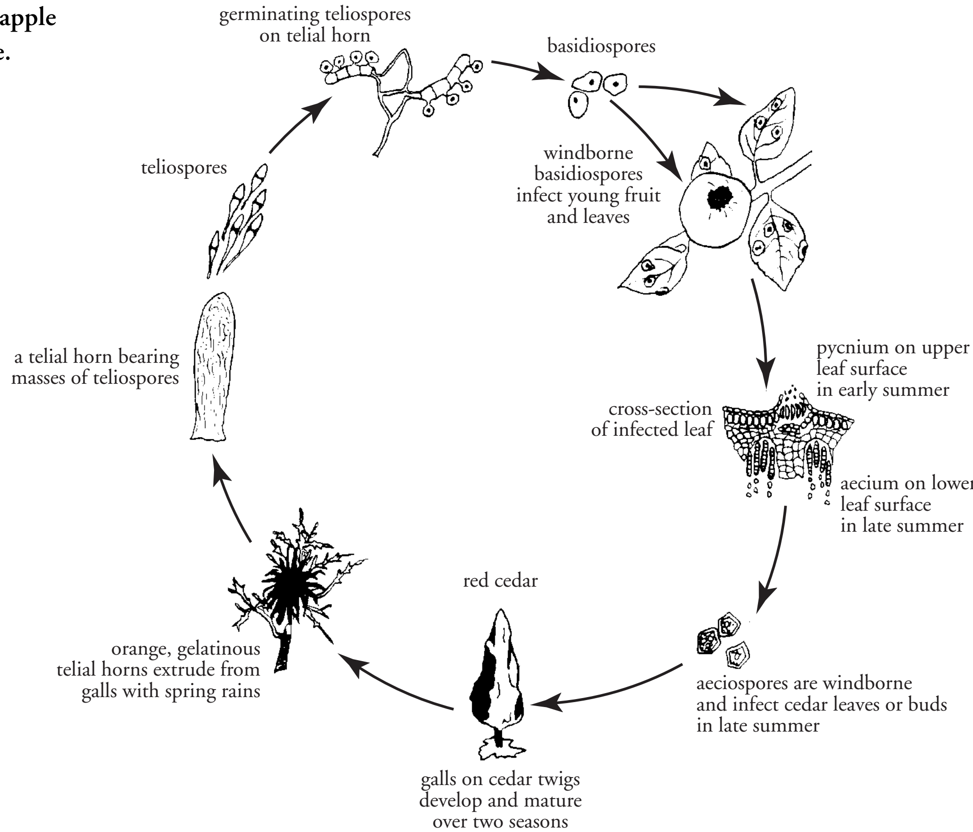
Three rust diseases commonly infect apples in the Midwest: cedar-apple rust (*Gymnosporangium juniperi-virginianae*), quince rust (*G. clavipes*), and hawthorn rust (*G. globosum*). Pears are susceptible to quince rust and hawthorn rust but not to cedar-apple rust. All three rust fungi require infection of eastern red cedar or related species of *Juniperus* to complete their life cycles. The rust diseases are usually kept in check by fungicides aimed at scab. Where fungicide use is minimal (e.g., on scab-resistant cultivars or in organic orchards), rust diseases, especially cedar-apple rust, can severely spot leaves and mar fruit. Quince rust causes fruit lesions but rarely affects leaves of apple. Hawthorn rust causes leaf lesions but rarely affects apple fruit.

Cedar-apple rust leaf spots initially develop on the upper leaf surfaces shortly after bloom. Lesions are pale yellow, but as they expand, they turn orange, which distinguishes them from other types of leaf spots. Later, small black dots (fungal fruiting structures called pycnia) appear in the orange rust spots. By late summer, tiny fungal tubes (aecia) emerge from the lower leaf surfaces. Extensive leaf infection may cause early defoliation, which in turn weakens the tree.

Fruit infection by cedar-apple rust is most common near the blossom end. The yellowish orange lesions are similar to but much larger than those on leaves. The lesions have a dark green border and are up to 1/16-inch deep; the tissue beneath the lesions is unaffected. Quince rust lesions on fruit are dark green, 3/4 to 1 1/2 inches in diameter, and become puckered at the blossom end. The tissue beneath the lesions is brown and spongy, and necrosis can extend to the core.

Disease Development: The disease cycles of the three rust fungi are similar and relatively complex. Cedar-apple rust involves two hosts, three types of fruiting structures (telia, pycnia, and aecia), and requires 2 years to complete its disease cycle (Figure 4). The fungus overwinters in reddish brown galls on cedar

Figure 4. Cedar-apple rust disease cycle.



trees. When wet in the spring, orange, gelatinous tendrils, or "horns," containing teliospores emerge. The teliospores germinate to form basidiospores which are carried by wind to apple trees. Basidiospores germinate if temperature and wetting requirements have been met (Table 5). No infection occurs below 43°F because basidiospores are not produced. Fruit are most susceptible for 2 to 3 weeks starting at bloom; leaves are most susceptible when 4 to 8 days old. Once release of basidiospores from cedar trees has ceased (generally by second or third cover), there is no further infection of apple tissues. Unlike apple scab, cedar-apple rust lesions on apple leaves will not produce spores that reinfect apple leaves and fruit. Instead, fungal mating occurs in rust lesions which result in the formation of aecia. Aecia release aeciospores which are carried by wind to cedar trees where they infect and complete the disease cycle. Galls start to develop on cedar shortly after infection but do not exude telial horns until the second spring after infection.

Control of Rust Diseases: Some apple cultivars are resistant to cedar-apple rust (Table 1). Removing cedars within a 2-mile radius of an orchard will disrupt the disease cycle, and fungicides may not be needed. Many of the fungicides directed at scab will also control rust, although captan, dodine, and benomyl do not control rust diseases. The basidiospores that infect apples are produced and released from cedar galls starting at about the pink stage of flower bud development through first or second cover; this is the most critical time for control with fungicides.

Fire Blight

Fire blight, caused by the bacterium *Erwinia amylovora*, is a serious disease of apples, pears, and related ornamental plants. Incidence and severity are influenced by cultivar and rootstock susceptibility (Tables 1 and 6), the weather, and the amount of succulent tissue present. Managing fire blight requires an integrated approach that relies primarily on

Table 5. Approximate minimum number of hours of leaf wetness required for cedar-apple rust infections on leaves of susceptible cultivars.

	Degree of Infection[a]	
Average Temperature (°F)	Light (Hours)	Heavy (Hours)
36	24	-
40	12	24
43	8	10
46	6	7
50	5	6
54	4	5
58	3	5
61	3	4
64	3	4
68 to 76	2	4
79+	-	-

a Based on the data of Aldwinckle, Pearson, and Seem, Cornell University. Assumes that cedar-apple rust inoculum (orange, swollen galls bearing teliospores with basidiospores on cedar trees) is available at the start of the rain. If inoculum is not already present (dry period prior to the rain), add 4 hours at temperatures above 50°F and 6 hours at temperatures of 46° to 50°F. Infection is unlikely at temperatures below 43°F if inoculum is not already present.

cultural practices and is supported by the judicious use of bactericides.

Disease Development: The fire blight bacterium overwinters in cankers on branches and trunks (Figure 5). In the spring, bacteria-laden ooze is exuded from the canker margins. Splashing rain and insects carry the pathogen to blossoms, and bees further spread the pathogen as they pollinate. If the weather is warm and rainy or humid, populations of *E. amylovora* double every few hours, and more than a million bacterial cells can colonize a single floral stigma. Rain or dew then washes the bacteria into openings at the base of the blossom. The pathogen can apparently move systemically within the plant to shoot tips and rootstocks. This may explain why trees sometimes are severely damaged or killed by shoot and rootstock infections even when blossom infection was minimal or absent. Sudden or "explosive" outbreaks of fire blight often appear about 1 to 2 weeks following a storm with strong winds or hail that damage succulent tissue. Apparently several simultaneous inoculations occur during the storm, and bacteria multiply rapidly in succulent shoots; this

Table 6. Relative resistance of apple rootstocks, pear varieties, and pear rootstocks to fire blight.

Apple Rootstocks

Resistant	Moderately resistant	Susceptible
Geneva 11	Bemali	Alnarp
Geneva 30	Bud.118	Bud.9
Geneva 65	Bud.490	M.9
M.7	MM.106	M.26
Novole	MM.111	M.27
Robusta 5		Mark
		Ottawa 3
		P.2
		P.16
		P.22

Pear and Asian Pear Varieties

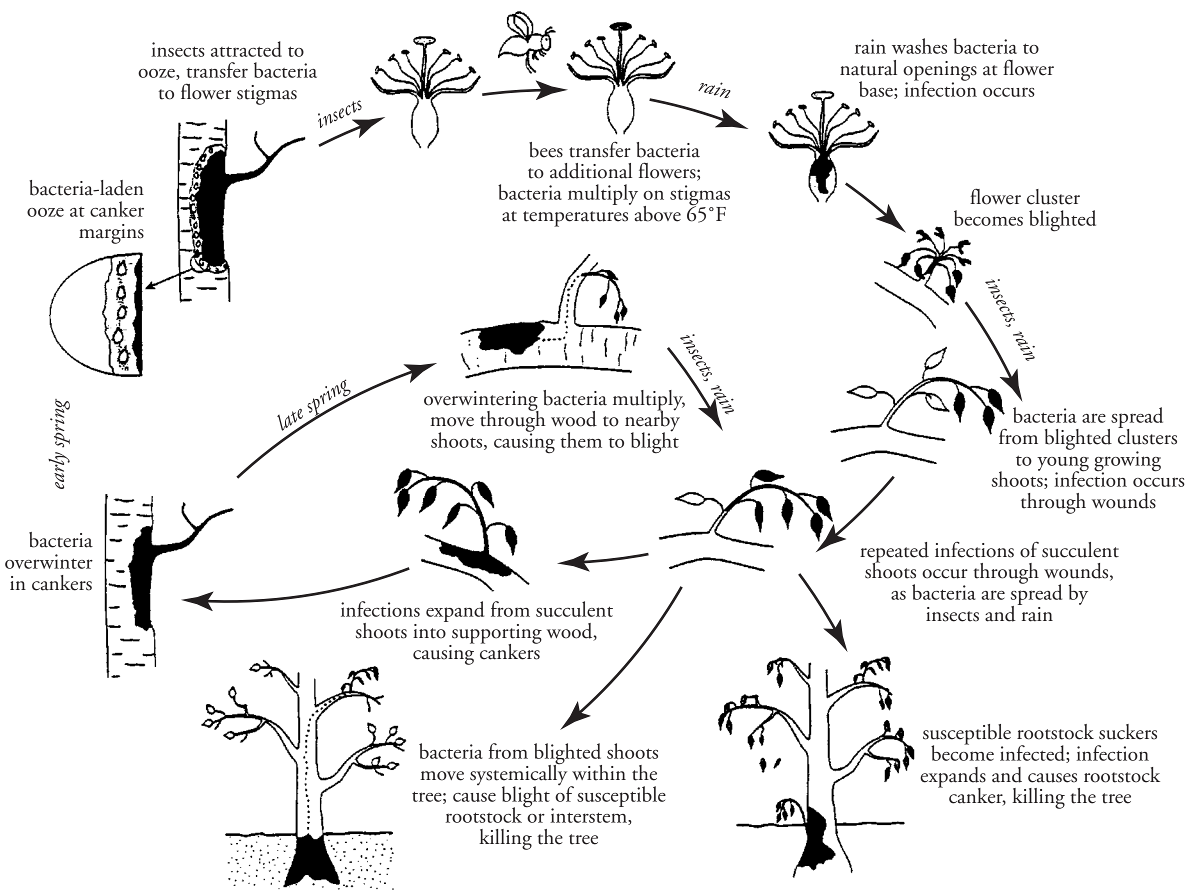
Resistant	Moderately resistant	Susceptible
Ayers	Dawn	Aurora
Harrow Delight	Douglas	Bartlett
Harrow Sweet	Garber	Bosc
Honeysweet	Harvest Queen	Clapp's Favorite
Kieffer	Lincoln	d'Anjou
Magness	Luscious	DeVoe
Maxine	Rogue Red	Earlibrite
Monterey	Seckel	Flemish Beauty
Moonglow	Spartlett	Highland
Potomac	Worden Seckel	Sierra
Tyson	Chojuro	Starkrimson
	Shinseiki (New Century)	Hosui
		Nijisseiki (20th Century)

Pear and Asian Pear Rootstocks

Resistant	Moderately resistant	Susceptible
Old Home (OH)	*P. betulaefolia* seedlings	Bartlett seedlings
OH x Farmingdale (OHF) (except OHF 51)		Provence quince
P. calleryana		Winter Nelis seedlings

Adapted from *Fire Blight–Its Nature, Prevention, and Control* by T. van der Zwet and S. V. Beer, USDA Agriculture Information Bulletin No. 631.

Figure 5. Fire blight disease cycle.



leads to the sudden appearance of symptoms throughout a block of trees.

Control of Fire Blight: Methods for consistent and reliable control of fire blight are not available. Relatively resistant cultivars and rootstocks (Tables 1 and 6) should be planted whenever possible. Highly susceptible combinations (e.g., Gala on M.26) should be avoided. Fertilization, especially nitrogen application, should be adequate for tree health without promoting rapid growth and prolonged succulence. Susceptible varieties should be pruned to improve tree shape and promote rapid drying of foliage but should not be pruned aggressively.

Pruning fire blight strikes during the growing season is a controversial issue. Removing sources of the pathogen is desirable, but pruning can actually make fire blight worse by increasing the amount of succulent tissue and by spreading the pathogen on tools. If fire blight strikes are so numerous that is not practical to remove them all, then wait until the dormant season. If fire blight strikes are few, it may be practical to remove them. They should be removed by making cuts at least 12 inches below visible symptoms. The computer program MARYBLYT, available from pest management suppliers (see Appendix B), is useful for predicting the onset of symptoms. With this knowledge, growers with small trees and adequate labor can scout for and remove the first infected tissues before symptoms become widespread. This will not eliminate further symptoms but may reduce the spread of fire blight. Missed strikes and cankers should be pruned during the dormant season.

Chemical control of fire blight is effective during the spring when the pathogen is at the surface of cankers and on flowers. After the bacterium has invaded tissues, it is beyond the reach of chemicals. Sprays of copper sulfate when cankers are active but before leaves have emerged, and fixed copper at 1/4-inch green tip, may reduce populations of the fire blight bacterium. Be aware, however, that if little rain (less than 2 inches) falls between an early copper application and petal fall, the copper residues could be great enough to damage fruit finish.

Streptomycin applied during bloom will reduce blossom infections unless streptomycin-resistant strains of *E. amylovora* are present. The MARYBLYT program is useful for accurately timing streptomycin applications. Without information from MARYBLYT, applications should be made every 3 to 4 days during bloom if the average temperature is 65°F or greater and there is rain or relative humidity of 60 percent or greater. Streptomycin works best when *not* tank-mixed with fungicides and when applied at night or when drying conditions are slow. Streptomycin applications made after bloom are generally ineffective at controlling shoot infections. The number of streptomycin applications should be kept to a minimum to reduce the risk of selecting streptomycin-resistant strains of the pathogen. Streptomycin resistance is a serious problem in commercial orchards in southwestern Michigan, parts of Missouri, and the western states.

Collar and Crown Rot

Root, crown, and collar rot, caused by the soil-borne fungus *Phytophthora cactorum* and other species of *Phytophthora*, is a perennial problem in midwestern apple orchards. *Phytophthora* belongs to a group of fungi known as the "water molds" because water is critical for many stages of its life cycle. Although *Phytophthora* species are common in agricultural soils, disease is most frequently found in areas with heavy, poorly drained soil and is especially severe on MM.106 and M.26 rootstocks. The pathogen attacks the lower trunk just at or below the soil surface. Cankers may extend up the trunk to the rootstock-scion union or beyond if the scion is susceptible to *Phytophthora*. Cankers at the base of the tree have dark, sunken bark; infected tissue beneath the bark appears reddish brown to dark brown. Leaves on affected trees may be small and pale during the summer and turn reddish in late summer. With relatively recent infections, a sharp line often delimits healthy from infected tissue. However, Phytophthora rots are easily confused with fire blight infections of rootstocks. Distinguishing the two diseases requires evaluation of host susceptibility, site conditions, disease history, and often culturing of the pathogen(s) from infected tissue in the laboratory.

Control of Collar and Crown Rot: Good water management and site selection are the most important factors for control of *Phytophthora* diseases. Orchard soils should be well drained and leveled *before* planting. For trees that are already planted, drainage should be improved in the vicinity of the trunk, making sure water is not allowed to pool around the base of the trunk. If subsurface drainage is a problem, the only solution may be to install drainage tile—a task more easily done before trees are planted. Relatively resistant rootstocks include M.9, Mark, Bud.118, and Bud.9. However, some of these rootstocks are highly susceptible to fire blight (Table 6).

In areas of orchards historically affected by root, crown, or collar rot, fungicides may be needed to minimize damage. Fungicides will not be effective if the cultural practices discussed above are not followed, and they will not revitalize trees showing moderate to severe rot symptoms. See the current *Commercial Tree Fruit Spray Guide* and the product label for details on using fungicides to manage root, crown, and collar rot.

Summer Diseases

Bitter rot, black rot, and white rot (bot rot) are the most common summer rot diseases of apple. Flyspeck and sooty blotch cause superficial blemishes which detract from the appearance of apple and pear fruit. The summer diseases have the potential to cause serious losses, especially in the more southern regions of the Midwest and on trees not sprayed with fungicides. In the northern regions of the midwest, some fruit rot fungi invade winter-injured tissue and are associated with branch cankers. Any condition that reduces tree vigor will increase susceptibility to branch and trunk infections. Flyspeck and sooty blotch fungi, and some of the fruit rot fungi, survive on a wide range of woody plants. The fruit rot fungi are similar in many respects:

- they survive in dead or weakened tissue, including fire blight cankers and mummified fruit;
- they produce enormous numbers of spores which are readily disseminated by rain and wind; and
- the diseases they cause are favored by warm, humid weather.

Bitter Rot

Symptoms vary slightly, depending on which spore type (ascospore of *Glomerella cingulata* or conidium of *Colletotrichum gloeosporioides* or *C. acutatum*) causes the infection. Lesions incited by conidia are sunken, light brown, and often marked with concentric circles of spore masses that appear creamy and salmon- to pink-colored under humid conditions. Lesions incited by ascospores are usually not sunken and are darker than those caused by conidia. Spore-producing bodies are scattered over the lesion in dark brown to black clusters. Bitter rot decay extends in a cone shape toward the core, which helps distinguish bitter rot from other fruit rots. The rotten spots are soft but firmer than white rot lesions.

Black Rot

In addition to affecting fruit, the black rot fungus, *Botryosphaeria obtusa*, causes leaf spots (frog-eye leaf spot) and branch cankers. The optimal temperature for fruit infection is 68° to 75°F with 9 hours of wetting. Fruit symptoms often start at the blossom end. Dark brown lesions expand and eventually can encompass the entire fruit. Lesions are often marked by concentric alternating brown and black rings. The rotted area is firm, leathery, and dotted with dark fungal fruiting bodies. Fruit infection can occur throughout the growing season; however, rot symptoms generally appear as fruit reach maturity.

The optimal temperature for leaf infection is 80°F with 4 1/2 hours of wetting. Leaf spots first appear about 1 to 3 weeks after petal fall as purple flecks that expand to about 1/4-inch in diameter. The margins of spots remain purple, while the centers turn tan to brown so that the spots resemble a "frog's eye." Spots can enlarge and become irregular in shape as they are invaded by other fungi later in the season. The leaf spot phase is not economically important unless it results in significant defoliation.

Branch cankers initially appear as slightly sunken reddish brown areas on the bark. Fire blight cankers and winter-injured tissue are frequent sites for black rot canker initiation. Cankers can expand to several feet in length and girdle limbs. Branches are weakened and sometimes killed.

White Rot (Bot Rot)

White rot (*Botryosphaeria dothidea*) lesions begin on fruit as small, circular, tan spots that are sometimes surrounded by a red halo. Duchess, Golden Delicious, Grimes Golden, Gallia Beauty, Rome, and Yellow Transparent varieties are all highly susceptible to white rot. Jonathan and Red Delicious are generally less affected. The rot extends in a cylindrical shape toward and surrounding the core. Eventually the entire fruit becomes soft, watery, and light tan. Under cooler conditions the rot may be darker and closely resemble black rot. Branch infections start out as reddish brown bark lesions that expand and sometimes exude fluid. Cankers are more severe if trees are stressed by drought.

Flyspeck and Sooty Blotch

Flyspeck and sooty blotch are two separate diseases that frequently occur together on the same fruit. Flyspeck appears as clusters of tiny, black dots. Sooty blotch appears as dark, sooty smudges. The fungi that cause flyspeck (*Zygophiala jamaicensis*) and sooty blotch (*Peltaster fructicola*, *Gastrumia polystigmatis*, *Leptodontium elatius*, and others) overwinter on the twigs of many woody plants, especially brambles. Spores of sooty blotch fungi are spread during rain. The flyspeck fungus is spread as airborne ascospores which are released during rain or as airborne or waterborne conidia. Fruit infection can occur any time after petal fall but is most prevalent during mid- to late summer. Both diseases are favored by temperatures between 65° to 80°F and by high relative humidity at the fruit surface (greater than 90 percent for sooty blotch and greater than 95 percent for flyspeck). Conditions such as these are most frequent when nighttime temperatures remain near 65° to 70°F or during extended warm rainy periods. The diseases flourish in orchards subject to heavy dews or fog. Under ideal conditions, sooty blotch and flyspeck symptoms can develop within 14 days of infection, but symptom development is arrested by high temperatures and low relative humidity. Thus, the period between infection and symptom development ranges from 25 to more than 60 days in the Northeast and may be similar in the Midwest. Sooty blotch and flyspeck infections not yet visible at harvest can develop during storage.

Control of Summer Diseases

A combination of annual pruning, adequate fruit thinning, orchard sanitation, and protective fungicides is the key to controlling summer diseases.

Pruning and Thinning: Pruning systems that open the tree canopy to light should also improve air movement and thereby reduce relative humidity and the time that leaves and fruit are wet. For example, summer pruning, as opposed to dormant pruning, reduced the incidence of flyspeck on apple fruit by 50 percent in research conducted in Massachusetts. Keeping the orchard mowed should also promote air movement, enhance rapid drying, and in turn, reduce summer diseases. Thinning of fruit is important to improve spray coverage and drying. Clustered fruit often have flyspeck on their inner faces even when an adequate fungicide program has been used.

Sanitation: Dead or weakened wood in or near an orchard can serve as a reservoir for the fungi that cause summer diseases. Therefore, removal and destruction of dead and dying plant material, including the current year's fire blight strikes, is necessary to keep the level of summer disease fungi to a minimum. Removing unwanted vegetation that might be a reservoir for pathogens, particularly wild brambles, should also reduce disease pressure in the orchard.

Fungicides: Different fungicides are recommended for the different summer diseases. In general, protectant fungicides (e.g., captan, ziram) that are permitted later in the season are used alone or mixed with benomyl (Benlate) or thiophanate-methyl (Topsin-M). See the current *Commercial Tree Fruit Spray Guide* for specific recommendations.

Insect and Mite Pests of Apples and Pears

Control of the major insect pests of apples in commercial production involves timely insecticide applications. Unlike some crop pests, pests of apples can be very elusive, and damage can often occur without individual pests being seen. To maintain healthy, productive trees and fruit, producers should recognize what pests to look for, understand pest biology, use appropriate preventive measures, and apply timely controls when needed.

Identifying and Understanding Major Apple and Pear Pests

It is important for growers to recognize all stages of the insects and mites that attack apples and pears. Proper identification is critical to making the correct management decisions. In addition, growers should develop a basic understanding of the pest. The more you know about the pest, the better equipped you will be to make sound and effective management decisions. The following literature contains color photographs of pests of apples and pears, as well as information on their biology.

Common Tree Fruit Pests
Authored by Angus Howitt and published as North Central Regional Extension Publication #63 by Michigan State University Cooperative Extension Service. Phone: (517) 355-0240.

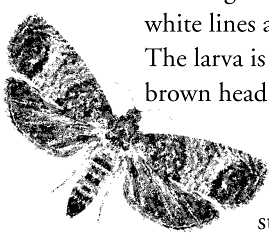
Mid-Atlantic Orchard Monitoring Guide
Edited by Henry Hogmire and published as NRAES 75 by the Northeast Region Agricultural Engineering Service, Cooperative Extension Service.
Phone: (607) 255-7654.

Codling Moth

(*Cydia pomonella*; order Lepidoptera, family Tortricidae)

Damage: Codling moth is a serious pest of apples and pears. Larvae damage apples and pears by chewing their way into the center of the fruit. “Frass,” or fecal material, is pushed out through the side of the fruit skin or the calyx end. Wounds caused by codling moth larvae promote the development of fruit rots. Most of the damage is caused by second- and third-generation larvae.

Appearance: The adult moth is about 3/8-inch long and blends in well with the bark. The adult moth’s forewings are gray-brown crossed with light gray and white lines and with deep gold or bronze wing tips. The larva is white, often tinged with pink, and has a brown head.



codling moth

Life Cycle and Habits: The fully developed larva is the overwintering stage. Pupation occurs in spring beginning about the same time as bloom, with adults first active in late April or early May. Female moths lay the scale-like eggs singly on developing fruit or adjacent leaves or stems just after sundown each night. Upon hatching, the larva enters into the calyx end or side of the fruit, then tunnels to the center where it feeds and develops. Brown frass is often noticed near the calyx end of the developing fruit. Larval development is completed in 3 to 5 weeks. Larvae exit the fruit to pupate in a thick silken cocoon on the bark or other protected areas. In the Midwest, there are two generations and sometimes a partial third one.

Monitoring and Thresholds: Management of codling moth in commercial orchards relies on regular examination of the fruit, pheromone trapping, and the use of degree-day models. Pheromone traps for this pest need to be monitored from pink through harvest. Typically, the first moth catch is at bloom, and two or three generations should be expected throughout the year. Traps help determine timing of sprays; sprays should target larvae emerging from eggs.

The biofix for the codling moth is the starting date of the first sustained flight of male moths captured in pheromone traps. Generally, this is when the fifth moth has been captured in the trap. A few moths often emerge very early in the spring ahead of the rest. Using the fifth moth as the biofix better represents when the majority of the codling moths begin to emerge. This usually occurs just after petal fall. Sprays should be applied when 250 degree-days (50°F threshold) have accumulated after the cumulative capture of five moths per trap. Typically, 1,000 degree-days are needed to complete each generation. Growers should use an action threshold of an average of five or more moths per week throughout the season. An insecticide application should be made 250 degree-days later if the number of moths exceed this threshold.

For one season, a grower will need a minimum of two wing traps (two plastic trap tops, two wire hangers), ten to 25 wing trap bottoms (sticky cardboard), and ten pheromone lures. Hang codling moth pheromone traps in the southeast quadrant of the tree, 6 feet off the ground. Avoid hanging traps in outside rows.

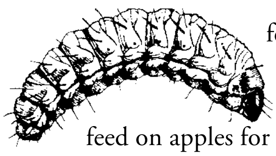
Mating Disruption: Isomate C-plus and CheckMate CM are registered for the control of codling moth. They dispense the sex attractant of the codling moth and are designed to prevent male moths from locating females for mating. This strategy, termed mating disruption, is most likely to succeed in blocks of at least 5 acres and where initial populations of codling moth are low. If mating disruption is used for codling moth control in smaller blocks, or where infestations are greater, border sprays or at least one or two cover sprays will also be necessary. Controlling codling moth by mating disruption will not control other insect pests that are controlled by cover sprays (plum curculio and apple maggots, for example). Isomate C-plus has performed better than CheckMate CM in most studies.

Chemical Control: Control of codling moth later in the season is assisted by good control of the first generation.

Plum Curculio

(*Conotrachelus nenuphar*; order Coleoptera, family Curculionidae)

Damage: Plum curculio attacks apples and pears. Surface feeding and egg laying by overwintering adults can scar or misshape the fruit by harvest, and

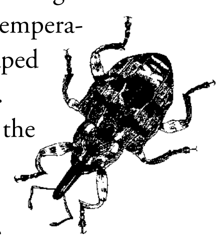


plum curculio larva

feeding by larvae may cause some premature fruit drop. Newly emerging adults in the summer feed on apples for a short time, causing round feeding scars that penetrate the fruit about 1/4-inch.

Appearance: The adult is a typical snout beetle, 1/4-inch long, dark brown with patches of white or gray. There are four prominent humps on the wing covers. The snout is one-quarter the length of the body, with mouth parts located at the end. The larva is a legless, grayish white grub with a brown head. Its length is about 1/3-inch when fully grown.

Life Cycle and Habits: Plum curculio overwinters as adults in ground litter or soil, usually outside the orchard. Adults migrate into the orchards each spring. Typically, the first signs of damage coincide with the onset of 60°F nighttime temperatures. Eggs are laid on crescent-shaped flaps cut in the skin of young fruit. Often border rows near woods are the first to show injury. Apples and pears attacked by plum curculio will drop from the tree early in the season, along with poorly pollinated fruit. When larvae are fully developed, they leave the fruit, drop to the ground, and pupate 1 to 2 inches below the surface. Adults emerge in midsummer and may feed on the fruit before leaving the orchard to find overwintering sites. There is one generation per year.



plum curculio adult

Monitoring and Thresholds: Currently there are no methods to accurately predict when plum curculio damage will occur. However, plum curculio pyramid traps are currently being tested in several midwestern states.

Chemical Control: Plum curculio is usually controlled with petal-fall and first-cover insecticide sprays directed at the adult before egg laying. Considerable egg-laying damage can occur over a short period of time. Where plum curculio has been a problem in the past, use preventive sprays at petal fall and first cover to reduce damage. Cool weather during petal fall may delay the immigration of the adults into the orchard. Under these conditions, a first-cover and possibly a second-cover spray may be needed to control plum curculio.

Apple Maggot

(*Rhagoletis pomonella*; order Diptera, family Tephritidae)

Damage: Apple maggot mainly attacks apples. Egg punctures and larval feeding cause fruit to be dimpled, and if it is soft, the fruit will soon rot.

Appearance: Adult apple maggot flies have dark bands on their wings and white bands around the abdomen. There is a large white spot on the thorax. The larva, when fully grown, is about 1/3-inch long, cream colored, and legless.

Life Cycle and Habits: Apple maggot passes winter as a pupa, and adults emerge from June to September, with most adults emerging in June and July. They puncture the skin of an apple and insert an egg into it. The maggots hatch and feed by tunneling throughout the apple flesh, leaving tiny brown trails. Apple maggots are common in northern Illinois, Indiana, and Ohio and absent in the southern parts of these states. They seldom cause damage south of U.S. Highway 40. There is one generation per year (maybe two in southern range). Check with local Extension personnel for apple maggot incidence in your area.

Monitoring and Thresholds: Traps are used to monitor for apple maggot flies from early June through mid-August. Use yellow sticky traps or red spheres baited with fruit volatile lures. Place along edges of blocks nearest an abandoned orchard or woodlot; if these are not present, then along the southern edge of blocks. If traps are not used in every block, put them in the earliest-maturing variety or blocks closest to abandoned orchards. Place the trap in the outer part of the midcanopy (eye-height) of the tree in a relatively exposed spot; prune back any clusters or shoots within 6 to 12 inches of the trap.

apple maggot

Compare the appearance of the trapped flies with pictures of the apple maggot to be sure you are not counting a non-target species; pay particular attention to the dark patterns in the wings, which differ in the apple maggot fly and the cherry fruit flies. First trap captures usually occur in early to mid-June. Growers should spray when five apple maggot flies are trapped per ball (note: or one fly per trap if fruit volatile lure is *not* used). Season trapping needs include three red ball traps and three hangers, three fruit volatile lures (note: not a pheromone), and one tube or can of Tanglefoot. The fruit volatile lure lasts all season and does not need to be replaced periodically.

Chemical Control: Control of the apple maggot needs to be directed at the adult flies before egg laying occurs. Additional sprays may be needed if traps' catch counts remain above five flies. Often in commercial orchards, sprays applied to the first several border rows are sufficient to control apple maggot flies entering the orchard.

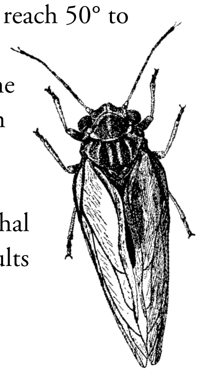
Pear Psylla

(*Cacopsylla pyricola*; order Homoptera, family Psyllidae)

Damage: The most troublesome insect pest of pears is usually the pear psylla. It sucks plant sap and injects a toxin into leaves as it feeds, causing wilting and leaf drop. It may take the tree several years to recover from the reduction in vigor. Psylla excretes honeydew on leaves, which can kill leaf tissue and lead to a condition known as psylla scorch. Black sooty mold can grow on honeydew, which can further affect the appearance and vigor of pears.

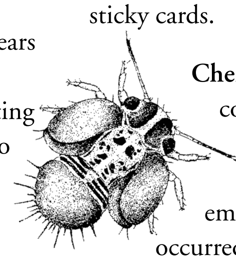
Appearance: The pear psylla is a small insect, only 1/10-inch when fully grown. The adult has a stout body with a wide head and thorax, red eyes, and wings longer than the body. The clear wings are held roof-like over the sides of the body. It looks like a miniature cicada. Eggs are yellowish orange and may be seen with the aid of a magnifier. Newly hatched nymphs are yellowish, 1/80-inch. Late-stage nymphs are hard shelled, and wing pads are apparent.

Life Cycle and Habits: Adults overwinter on the trees in bark crevices. Adults emerge, mate, and begin laying eggs when temperatures reach 50° to 60°F. Eggs are deposited in crevices in the bark and near the terminal buds. Most eggs hatch by petal fall. Nymphs move to the axils of leaf petioles and young fruit to feed. Five nymphal stages are passed before the adults appear. Females of the later generations deposit most of the eggs along the leaf midribs. There are three to four generations per year.



pear psylla adult

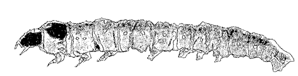
Monitoring and Thresholds: Look for adults on spurs and branches on warm days just before bud burst, and on the tender new shoots the remainder of the season. Eggs in late dormant to bud burst are found singly or in rows on spurs and twigs or around bud scales. Through the remainder of the season, look on the undersides of tender new growth for rows of eggs along the leaf midribs. Small nymphs are found from green cluster throughout the season on tender new growth; larger nymphs are found on leaves that are hardening off. Nymphs and adults can be monitored with beat cloths and adults with yellow sticky cards.



pear psylla nymph

Chemical Control: Pear psylla is difficult to control and has become resistant to many insecticides. A delayed dormant oil should be applied as adults are emerging, but before egg laying has occurred. This is green tip in most years, but monitoring will determine more exact timing. The most important times to treat for pear psylla are at the pre-bloom (white bud) and petal fall stages.

Leafrollers

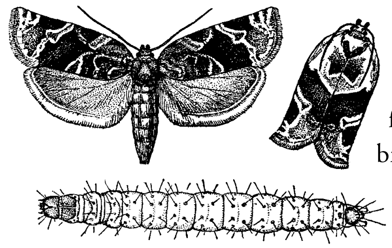


fruit-tree leafroller larva

(order Lepidoptera, family Tortricidae)
RED-BANDED LEAFROLLER (*Argyrotaenia velutinana)*
OBLIQUE-BANDED LEAFROLLER (*Choristoneura rosaceana*)
FRUIT-TREE LEAFROLLER (*Archips argyrospila*)

Damage: *Red-banded leafroller* larvae feed on apple foliage and fruit, with the last generation of the season doing the most serious damage. The larva attaches a leaf to the fruit surface with silk and feeds on apple skin and flesh. Some other species of leafrollers that can be found in the Midwest include the *oblique-banded leafroller* and *fruit-tree leafroller.*

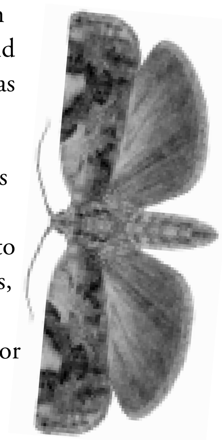
Appearance: The red-banded leafroller is brown, about the size of the codling moth, and has broad reddish bands on each forewing. Larvae are green and slender with a light brown head; they reach a length of about 2/3-inch. The oblique-banded leafroller is brown with three dark bands on the front wings. Wing spread is about 1 inch. Larvae are small and



red-banded leafroller

green with black heads. The fruit-tree leafroller is a brown moth slightly larger than the codling moth. Thin light markings appear in various patterns across the front wings. The larva is a slender, pale green worm. The head is black with a black spot just behind the head. The larva reach about 3/4-inch in length.

Life Cycle and Habits: The red-banded leafroller overwinters as a pupa in debris on the ground. Adults emerge in early spring and lay eggs in masses on undersides of larger limbs. Eggs hatch at about bloom. Newly hatched larvae fold or roll leaves together with webbing and feed on foliage. There are second, third, and fourth generations in southern areas of the Midwest.

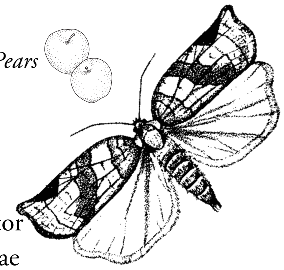


fruit tree leafroller adult

The fruit-tree leafroller overwinters in the egg stage on twigs. Hatch occurs about the time buds begin to open. Larvae feed on buds, blooms, leaves, and fruits. In June, fully grown larvae pupate inside folded or rolled-up leaves. Moths appear 2 weeks later, lay their eggs, and die. Only one generation occurs each year.

Overwintering of the oblique-banded leafroller occurs as partially grown larvae inside tightly woven cases on the host trees. During spring, larvae emerge and feed until late May. Pupation occurs, and adults emerge in June. One or two generations may occur each year. Damage is done by young larvae mining the leaves, with larger larvae feeding inside rolled-up leaves.

Monitoring and Thresholds: Leafroller populations can be sampled by both tree examination and pheromone traps. Because these species have wide host ranges, pheromone trap catch numbers are of limited value in determining economic thresholds and the need to spray. Pheromone trap catches will indicate when to monitor carefully for the larvae. Pheromone traps should be in place by the green tip for red-banded leafroller, pink for fruit-tree leafroller, and mid-May for oblique-banded leafroller and maintained through September. Monitor for larvae by examining the number of larvae per 100 expanding leaf terminals or fruit clusters. Use an average of four larvae per 100 expanding leaf terminals or fruit clusters for making management decisions.



oblique-banded leafroller

Chemical Control: In the Midwest, cover sprays for codling moths and other orchard pests usually control leafrollers as well. Egg hatch of the red-banded leafroller often coincides with petal fall, so sprays applied at this time will control it. In some areas, the oblique-banded leafroller has become resistant to organophosphate insecticides, so chemicals with different modes of action may be required.

Tufted Apple Budmoth

(*Platynota idaeusalis*; order Lepidoptera, family Tortricidae)

Damage: Young larvae of tufted apple budmoth feed along midribs of leaves, then bite into the petiole to make a characteristic notch. Like other leafrollers, older larvae of the tufted apple budmoth use webbing to attach a leaf to a fruit, then they chew on the surface of the fruit underneath the leaf. Fruit damage is similar to that of red-banded leafroller, but the budmoth-damaged patches are usually smaller and more separated than the more continuous patches of feeding damage caused by red-banded leafroller. Characteristic fruit damage by tufted apple budmoth is the same as that of the variegated leafroller (*Platynota flavedana*), which is the major leafroller in central Virginia and parts of West Virginia. Tufted apple budmoth is the major leafroller in Pennsylvania and other mid-Atlantic states. It is present in the Midwest but is not as serious a pest as it is in Pennsylvania.

Appearance: Fully grown larvae are 3/4-inch long, light grayish brown with a dark stripe down the back, and they have a chestnut brown head capsule and a dark brown plate just behind the head. Egg masses are flat, dime-sized, and contain about 150 eggs; eggs are green when freshly laid and bronze when close to hatching. Adults are small moths that are mottled grayish brown, lighter at the wing base, and darker at wing tips. There are tufts of scales on the top of the middle of the forewings.

Life Cycle and Habits: Tufted apple budmoth overwinters as larvae in rolled leaves beneath fruit trees. Adults emerge in early May and lay eggs on the upper surface of leaves. Eggs hatch in 10 to 14 days. First generation eggs hatch in June. Second generation eggs hatch in August. There are two generations per year.

Cultural Control: Remove apple suckers and suppress the groundcover under apple trees to eliminate the early spring habitat of tufted apple budmoth.

Monitoring and Thresholds: A sex pheromone trap is available to monitor adult males of this species. Use one trap per block if less than 5 acres, or two traps per block if more than 5 acres. Set up traps by the first of May. Attach the trap to a limb in the outer third of the tree canopy, at a 5- to 6-foot height. Fruit damage is usually negligible if there are fewer than 50 moths per trap during the 3-week period after the first moth is caught. If the number of moths per trap during the 3-week period after the first moth is caught is 100, then about 3 percent of fruit is likely to be damaged at harvest; if 200 moths are trapped, then about 9 percent fruit damage is predicted at harvest.

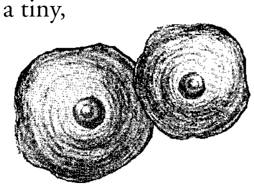
Chemical Control: Insecticide is effective if used when eggs are hatching and larvae are small, before they are protected within rolled leaves. The best time to spray to control the first brood is when 10 percent of eggs have hatched, which is 530 degree-days (base 45°F) after the first moth was caught in a pheromone trap, and spray again after 60 percent of eggs have hatched, which is 805 degree-days after the first moth was trapped. The best time to spray to control the second brood is at 10 percent egg hatch, which is 2,280 degree-days (base 45°F) after the first moth was caught, and spray again after 60 percent egg hatch, which is 2,665 degree-days after the first moth was trapped. Control is improved if spray volume is at least 100 gallons per acre.

San Jose Scale

(*Quadraspidiotus pericosus*; order Homoptera, family Diaspididae)

Damage: San Jose scale can infest apples, pears, peaches, and plums. The young crawlers feed on limbs, leaves, and fruit, causing red, spotted areas. Infested leaves usually drop, and limbs lose vigor and die. Fruit will have an undesirable finish because of the red, spotted appearance caused by scale feeding and the presence of the scale.

Appearance: The yellow female is underneath a gray, round, and flattened scale-like cap. When mature, the scale is about 1/20-inch in size. The male is a tiny, yellow, two-winged, gnat-like insect. The minute crawlers are orange-yellow and oval, and they have six legs.



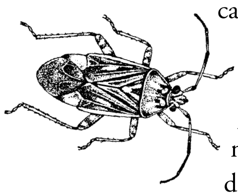
San Jose scale

Life Cycle and Habits: San Jose scale overwinters as a nymph under a scale on tree limbs and resumes feeding when sap begins to flow in the tree. In the spring, adult males emerge about mid-May and seek out wingless females. Mating occurs and crawlers emerge about 1 month later. These tiny yellow insects move around on bark, foliage, and fruit until they locate a suitable site to settle down permanently. Once settled, the crawler sticks its mouthparts into the tree and secretes a waxy shell over its body. There are two or more generations per year.

Monitoring and Thresholds: Scale should be monitored by two methods: 1) adult traps about 2 months in early spring and 2) the appearance of the crawler stage. Assemble traps and hang in scale-infested trees by April 1. At least twice per week, remove each trap from the tree and examine the surface with a hand lens (magnifier) for adult scales. Once adult scales have been captured, begin calculating degree-day accumulation (see "Chemical Control"). Crawlers can be detected easily by wrapping a small amount of black electrical tape with the sticky side out around an infested limb. Pay particular attention to the edge of the tape. Crawlers also can be detected with a hand lens and a straight pin to probe or "flip" over mature scales and look for tiny, orange-yellow crawlers.

The presence of reddish blemishes on fruit at harvest indicates damaging numbers on the trees. If such damage is noted, inspect bark of trees for scale, especially 1-year-old wood. During pruning operations, look for purplish red halos on young bark that are indications of scale infestation. Often this very small insect goes unnoticed until large populations have developed. Growers should be on the lookout for scale on the fruit at harvest and evidence of scale on new wood during pruning.

Chemical Control: Because this insect spends much of its life cycle under a protective cover or scale, timing of insecticide applications is very important. Sprays should be applied when crawlers are observed or 400 degree-days (base 51°F) after adults are captured. Insecticidal control is most effective when used in conjunction with a well-applied dormant oil and a good pruning and training program. Usually, dormant oil applications are more effective against scale than delayed-dormant applications.



tarnished plant bug adult

Tarnished Plant Bug

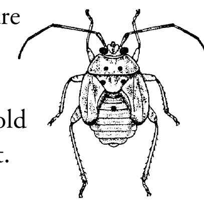
(*Lygus lineolaris*; order Heteroptera, family Miridae)

Damage: Their feeding with piercing, sucking mouthparts on fruit when it is very small causes deep depressions or dimples in apples and pears that are noticeable at harvest time. Several species of *Lygus* can cause similar damage to apples.

Appearance: Adults are 1/4-inch long, mottled brown insects with wings folded over the abdomen. A yellow-tipped triangle is present in the middle of their backs. Nymphs are small and greenish and resemble the adult without wings. Both nymphs and adults have a beak used for sucking plant juices. They move rapidly when disturbed.

Life Cycle and Habits: Adult tarnished plant bugs overwinter under bark, in leaf litter, and in other such protected places. The adult feeds on opening buds or flowers in early spring, and later on developing fruit. They lay eggs in the plant tissue of their many hosts. Nymphs emerge about 1 week later and feed for about 3 weeks before reaching adulthood. Several generations of this insect occur each year. They are often abundant on pigweed and other flowering weeds.

Monitoring and Thresholds: Pay particular attention to plant bugs before bloom. Adults are difficult to find in trees and will fly when disturbed. Hold a beat cloth under a scaffold, and strike the scaffold sharply once or twice with the mallet. Sample five scaffold limbs per tree. Examine 100 fruit clusters for tarnished plant bugs; the threshold is five nymphs or adults per 100 fruit clusters.



tarnished plant bug nymph

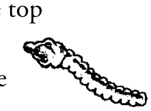
Cultural Control: Tarnished plant bugs overwinter in, feed on, and may build up in number on ground-cover plants. Cover crop management is important to prevent tarnished plant bugs from moving into fruit trees. Because tarnished plant bug is attracted to flowering broadleaf weeds, management of annual weeds through regular mowing is an important practice for this pest.

Chemical Control: Control is most effective at the pink stage. This insect also damages young peach buds, causing deformed fruit at harvest. Sprays at the pink stage to peaches are effective for its control.

Spotted Tentiform Leafminer

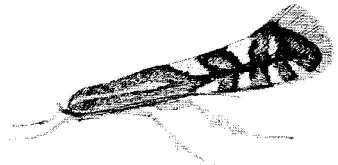
(*Phyllonorycter blancardella*; order Lepidoptera, family Gracillariidae)

Damage: The larva of this moth is a leafminer that feeds inside the leaf between the upper and lower surfaces. At first, the new mines are visible only on the bottom surface of the leaves as a pale blotch. As the leafminer grows, the mine can be seen on the top of the leaf; it looks like a circle of speckles about 1/2-inch in diameter. High populations can cause severe defoliation, leading to reduced fruit and terminal growth, early leaf drop, and reduced fruit set the following season.



spotted tentiform leafminer young larva

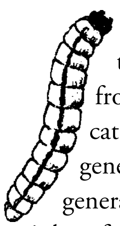
Appearance: Adults are 1/8-inch long, golden brown moths with white spots or bands. The eggs are small, flat, elliptical, and laid singly on the undersides of leaves. Eggs are transparent early, but soon turn creamy to yellow. Small larvae are extremely flat and



spotted tentiform leafminer adult

legless; they live in the small space between leaf surfaces. Larger larvae have visible legs and a head capsule and thus more closely resemble caterpillars than the small larvae.

Life Cycle and Habits: This insect overwinters as pupae in leaf litter. Small eggs are laid singly on the undersides of leaves. Small larvae begin to appear around bloom. These larvae feed in a "U" shape pattern which delineates the area that will be the mine. This is normally only visible from the underside of the leaf. Larger, tissue-feeding larvae feed on both the upper and lower leaf surfaces. After about a month of feeding, larvae pupate within the mine, and adults begin to appear in about another month. This insect has three generations per year.



spotted tentiform leafminer larva

Monitoring and Thresholds: Pheromone traps can be used to monitor adult activity from green tip through harvest. The first catch usually occurs at green tip with the first generation peak at early pink and the second generation peak in late June. Scout for eggs at pink or for larvae at petal fall and in July.

Scout for eggs of spotted tentiform leafminer at pink stage. Use a hand lens to see the small, round, translucent eggs. Examine three fruit clusters each from at least three trees, and count the number of eggs on the undersides of the second, third, and fourth leaves in each cluster (start counting leaves from the bottom of the bud). If an average of nine or more eggs per fruit cluster is detected at pink, then use an insecticide for leafminer larvae at petal fall. If fewer than nine eggs per fruit cluster are detected at pink, then an insecticide for leafminer larvae will probably not be needed at petal fall, but scout for early mines at petal fall to help make the final decision.

Scout at petal fall for early mines of the first generation. Early mines are visible only on the underside of the leaf, not on the top. Examine three fruit clusters from each of at least three trees, and count the number of early mines on the undersides of the second, third, and fourth leaves in each cluster. If four or more new mines per fruit cluster are detected, then use an insecticide for leafminer larvae at petal fall.

Scout in early to midsummer for early mines of the second generation of spotted tentiform leafminer. The ideal time to scout can be determined by using a pheromone trap and degree-day counts; scouting should be done 500 to 700 degree-days, base 43°F, (about 3 weeks) after the number of leafminer moths begins to sharply increase in pheromone traps. To scout in midsummer, examine five mature terminal leaves per tree from at least five trees, and count the number of new mines on the undersides of these leaves. If 2 1/2 or more new mines per leaf are detected, apply an insecticide effective against sap-feeding leafminer larvae.

Chemical Control: If leafminers have been a persistent problem in previous years, apply an insecticide spray targeted at adults at peak emergence. If leafminer has not been a persistent problem, then do not spray for adults, but scout for eggs at pink and for young larvae at petal fall and in July.

This insect has developed resistance to Guthion, Imidan, and other commonly used cover sprays. Grower experience has shown that Provado or Agri-Mek applied at petal fall provides satisfactory season-long control and does not harm beneficial mites and insects. A pyrethroid (Asana, Ambush, Pounce) or carbamate (Lannate) can be used, but these may lead to mite outbreaks later in the season due to their toxicity to predatory mites.

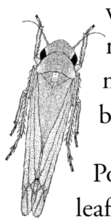
White Apple, Rose, and Potato Leafhoppers

(order Homoptera, family Cicadellidae)
WHITE APPLE LEAFHOPPER (Typhlocyba pomaria)
ROSE LEAFHOPPER (Edwardsiana rosae)
POTATO LEAFHOPPER *(Empoasca fabae)*

Damage: Whitish spots or stippling on upper leaf surface are evidence of white apple leafhopper and rose leafhopper feeding. Sticky honeydew secretions from leafhopper feeding frequently cover lower fruits and are called "tar spotting." Damage is caused by nymphs and adults removing chlorophyll and sap from the lower leaf surface which can affect fruit development and bud formation. Adults can be a nuisance if they are abundant at harvest as they can be inhaled by pickers. The potential for rose leafhopper is largely dependent on the density and proximity to orchards of the primary overwintering host, floribunda rose.

Damage by potato leafhopper is less common and is characterized by yellowing and necrotic leaf margins. While these damaged areas are typically V-shaped, intense feeding can cause the entire leaf margin to be affected. The bronzed, dried appearance of leaf tips is referred to as "hopper burn." Leaf margins on injured leaves often curl downward. While white apple leafhopper is found on cluster leaves and not on actively growing terminal shoots, potato leafhopper is more of a threat to young, nonbearing fruit trees and young, tender foliage.

Appearance: White apple leafhopper and rose leafhopper adults are very similar in appearance. The long, slender adults are wedge-shaped, with a convex back. The body is a light yellow, and the head is slightly darker. Juveniles are generally pale white and wingless; they scurry around when disturbed. While white apple leafhopper nymphs are without noticeable markings, older rose leafhopper nymphs have a few small black spots on the back of the thorax and wingpads.



white apple leafhopper adult

Potato leafhopper is light green. White apple leafhopper can be distinguished from potato leafhopper by the tendency of white apple leafhopper to walk forward and backward, while potato leafhopper walks sideways as well as forward and backward.

Life Cycle and Habit: White apple leafhopper overwintering eggs begin hatching at pink, and hatching is usually complete by petal fall. The nymphs move to the undersides of the leaves to feed. First-generation adults begin to appear in June. There are two generations of white apple leafhopper per year. The second generation adults are often noticeable during harvest.

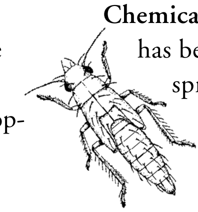
Rose leafhopper overwinters as eggs on wild roses and brambles. Nymphs emerge in the spring and feed on the wild hosts. In June, adults disperse and move to apples. The second and third generations feed on apples.

Potato leafhopper develops throughout the year in the southern United States near the Gulf of Mexico and migrates northward each growing season rather than overwintering in northern states. The appearance of potato leafhopper is therefore less predictable because its migration depends on the jet stream and weather patterns.

Monitoring and Thresholds: Scout from bloom through petal fall for nymphs of the white apple leafhopper. Examine a leaf from the middle of a fruit cluster on 25 clusters on each of five trees. If an average of three or more nymphs per leaf is detected, then use an insecticide specifically targeted for leafhopper in addition to your cover spray insecticide at petal fall. With the rose leafhopper, and the second generation of white apple leafhopper, examine 25 leaves per tree and treat with an insecticide if there is an average of three or more nymphs per leaf.

Growers should monitor young apple plantings for potato leafhopper and initial signs of damage. Consider treatment of young blocks when potato leafhoppers first appear, particularly where they have been a problem in the past.

Chemical Control: The white apple leafhopper has become resistant to commonly used cover spray insecticides, such as Guthion and Imidan. Provado is very effective against this insect, and it is less disruptive on mite management. In orchards where leafhoppers have become troublesome, it is important to include an effective leafhopper control in the first cover spray. Young leafhoppers are easier to control than adults. The first brood is an easier target than the second brood because the hatch is more synchronous.



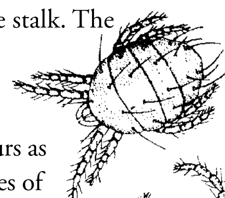
white apple leafhopper nymph

European Red Mite

(*Panonychus ulmi*; order Acari, family Tetranychidae)

Damage: European red mites feed by withdrawing juices and chlorophyll from leaves and can build up to the point where leaf bronzing is visible by mid- to late July. Under such conditions, mites can cause serious injury to the current year's crop. Injury will be expressed on fruit as poor color or a reduction in size and quality. If damage is both heavy and early enough in early to midsummer, the next year's crop can be affected by a reduction in the number of fruit buds. The earlier mites build up in the growing season, the more serious the potential injury.

Appearance: This mite is red, with newly emerging females being bright velvety red, changing with time to brick red. There are often noticeable white spots at the base of six to eight hairs on its back. Males are dull green to yellowish brown. Females are more globular shaped; males are narrower with a more pointed abdomen. Eggs are of two forms. Overwintering eggs are red-orange and globular and somewhat flattened (onion shaped) with a slender stalk on top. Eggs produced during the growing season are yellowish orange and spherical without the stalk. The first mite stage (instar) has six legs and succeeding instars have eight legs.



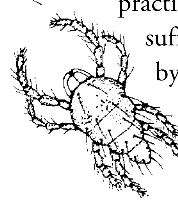
European red mite female

Life Cycle and Habits: Overwintering occurs as eggs laid in roughened bark around the bases of buds and spurs. Egg hatch in the spring begins around tight cluster stage. Newly hatched mite larvae crawl onto the unfolding leaves and begin feeding. The life stages are egg, larva, protonymph, duetonymph, and adult, with a resting stage between each active stage. Development from egg to adult may take from 1 to 3 weeks and is very temperature dependent. There can be six to eight overlapping generations per season. Summer eggs are laid on the undersides of leaves, unlike winter eggs that are laid on twigs and branches.

Monitoring and Thresholds: Scout for European red mite each week from petal fall to August. Start by taking four leaves from each of five trees, examine them for the presence or absence of mites (do not count the number of mites per leaf, just rate each as infested or not infested). Then refer to the mite sampling charts (Figure 6) that correspond to the appropriate time: early season, mid-season, or late-season. On the chart, plot a point that shows how many infested leaves you found in your 20-leaf sample. The point will fall in one of three decision zones: treat with a miticide, do not treat, or take additional samples. If the point on the chart falls in a "continue" zone, then collect leaves from additional trees until you reach a decision. The maximum number of leaves to examine is 100 per block.

Biological Control: European red mite is rarely a serious pest in backyard and unmanaged orchards. Predatory mites, lady beetles, and the banded thrips help to maintain European red mite at below damaging levels. This mite is considered a secondary pest; it typically builds to damaging levels only after its natural enemies have been depleted by insecticide applications used to control codling moth or other pests. Minimizing insecticide usage and selecting insecticides that are least toxic to beneficial organisms—in particular, avoiding the use of pyrethroid insecticides—will help to minimize problems with this mite.

Control with Oil: Over the years, a superior oil application applied close to the time mites hatch has proven to be one of the best control practices. The oil coats the eggshell, thereby suffocating the developing mite embryo by blocking respiration. In recent years, a number of orchards had mites that showed various degrees of resistance to miticides. Because of this problem, a good oil application becomes even more important during the dormant to delayed dormant period.



European red mite male

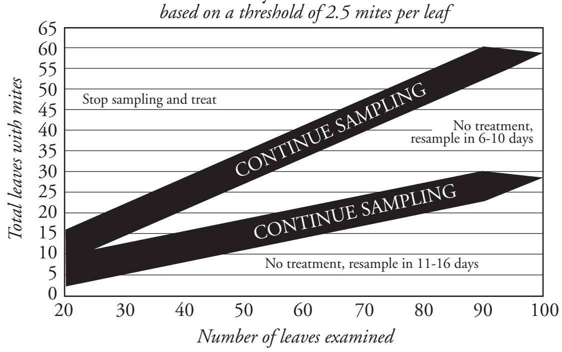
Chemical Control: Recent work has shown that tight cluster (Apollo), pink (Savey), or petal-fall miticide (Agri-Mek) sprays significantly help season-long mite control, provided mite predators are conserved. The use of early miticides will often delay mite buildup, so that by late June or early July, very low populations are present in the field. Because this coincides with the establishment of mite predators, early control measures often increase the likelihood of good predator-to-prey ratios, permitting the predator to keep mites below treatment levels.

Growers routinely using early-season mite sprays on their mite-prone varieties should develop a plan to manage the development of mite resistance to these sprays. Apollo and Savey have very similar modes of action. Because of this, alternating Apollo and Savey is a poor resistance management strategy.

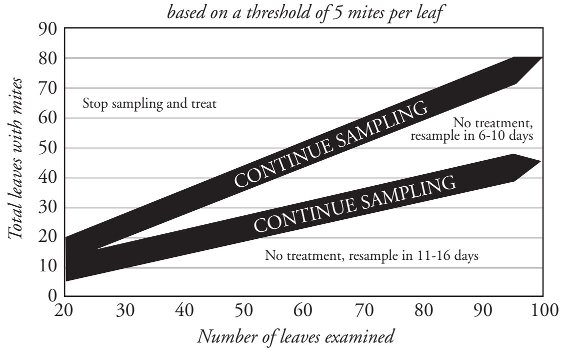
Figure 6. European red mite sampling charts.

Procedure: Collect four leaves from each of five trees, examine them for presence or absence of mites, then plot the number on the chart. If the point falls in the *continue* zone, then collect leaves from additional trees until a decision is reached.

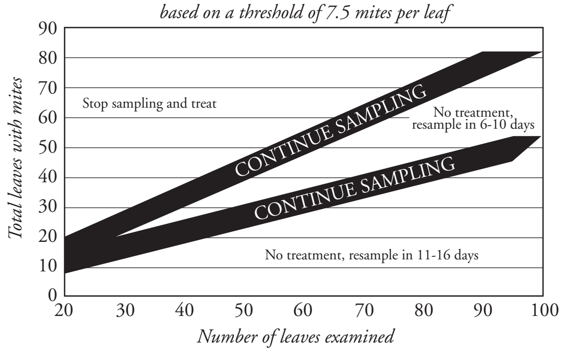
Early-season Chart
based on a threshold of 2.5 mites per leaf



Mid-season Chart
based on a threshold of 5 mites per leaf



Late-season Chart
based on a threshold of 7.5 mites per leaf

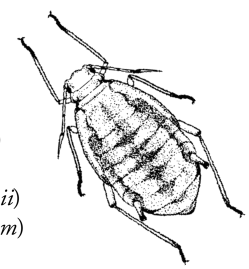


Source: Cornell Cooperative Extension Service, *1992 Pest Management Recommendations for Commercial Tree-Fruit Production.*

During midsummer, Carzol, Pyramite, Kelthane, and summer oils are rescue treatments that may be used against established mite populations. Carzol, Kelthane, and Pyramite are highly toxic to mite predators. In the summer, it may be necessary to make two summer oil applications 7 to 10 days apart to reduce established populations. Carzol provides control of adults only and would have to be applied repeatedly to reduce mite populations. Kelthane gives some control of mites in cool and warm temperatures, but it should only be applied as a back-to-back application to the same generation of mites to prevent the buildup of resistance. Vendex provides a long-residual control, but control is poor to fair. Pyramite is most effective against immature motile stages.

Aphids

(order Homoptera, family Aphididae)
ROSY APPLE APHID (*Dysaphis plantaginea*)
GREEN APPLE APHID (*Aphis pomi*)
APPLE GRAIN APHID (*Rhopalosiphum fitchii*)
WOOLLY APPLE APHID (*Eriosoma lanigerum*)



apple grain aphid

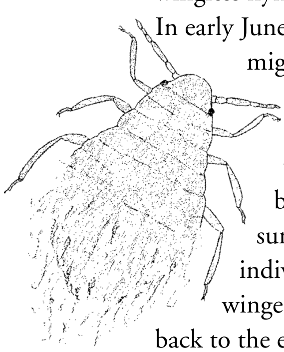
Damage: Generally three species of aphids, the green apple aphid, rosy apple aphid, and apple grain aphid, attack apple foliage in the Midwest. However, the rosy apple aphid causes the most severe damage and is the most difficult of the three to control. Large numbers of any type of aphid can stunt new growth and cause sooty mold to develop on fruit and leaves, but the rosy apple aphid injects a toxin with its saliva that causes the leaf to curl and the fruit to abort or to be small or distorted. Relatively low numbers of rosy apple aphids can cause considerable damage. Problems usually begin to appear at pink and into early summer before the aphids move to alternate hosts. Feeding by the woolly apple aphid on roots results in knots and stubby, gnarled root growth. Young trees are often severely injured by this pest. Although woolly apple aphids feed above ground, the feeding on the roots produces the greatest damage.

Appearance: Apple aphids are small pear- to teardrop-shaped insects. Color varies from purple to gray to rosy for rosy apple aphid, and to light green for green apple aphid and apple grain aphid. Generally a pair of projections (cornicles) will be present on the fifth or sixth segment. Mouthparts are piercing-sucking.

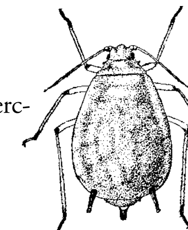
Woolly apple aphid colonies appear as a cottony mass clustered in wounds of the trunk and branches of the tree. The aphids themselves are purplish, but are covered with waxy white threads.

Life Cycle and Habits: The life cycle of these aphids begins with the overwintering egg stage. Overwintering eggs are found on twigs, around buds, or in crevices in the bark. Eggs begin hatching in early spring about green-tip stage. The first generation of nymphs are all wingless females, called stem mothers. These females give birth to live young, and a generation is completed about every 14 days. In early summer, some winged young are produced; these fly to new host plants and start new colonies. During late summer and early fall, both male and female forms are produced, which mate and lay overwintering eggs. These eggs are green when first laid, but soon turn shiny black as they mature.

The woolly apple aphid passes the winter in two forms, the egg and the immature nymph. Nymphs hibernate underground on roots of apple trees. Wherever apples and elms are close together, overwintering eggs are deposited in cracks or protected places on the elm. During spring, eggs hatch into wingless nymphs which feed on elm buds and leaves. In early June, a winged form is produced which migrates to apples and other hosts. These individuals feed on wounds in the branches and trunk, and many work their way down to the roots and trunk below ground surface. During the summer, repeated generations of wingless individuals will be produced. In the fall, winged individuals are produced which fly back to the elm and lay overwintering eggs, while some wingless forms remain on the apple tree on both aboveground and belowground parts throughout the winter. Now that elms are relatively uncommon, this aphid generally spends its entire life cycle only on apples.



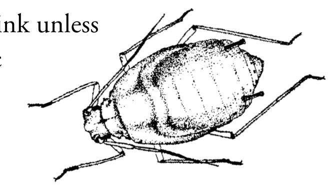
woolly apple aphid



green apple aphid

Cultural Control: Although all apple varieties are attacked by rosy apple aphid, 'Cortland,' 'Ida Red,' and 'Golden Delicious' are particularly susceptible. Rootstocks vary in susceptibility to woolly apple aphid injury. Use MM.111 or MM.106 if woolly apple aphid is a serious problem.

Monitoring and Thresholds: Apple growers should monitor their trees carefully at pink for rosy apple aphids. A few colonies can rapidly infest the entire tree. Examine ten fruit clusters from the inner canopy of each of ten trees. If *any* rosy apple aphids are found in this sample, then use an insecticide for aphid control at pink. If rosy aphid is not detected at pink, do not use an insecticide at pink unless the block has a history of economic injury from plant bugs. After petal fall, treat for rosy apple aphid if 5 percent of the terminals or fruit clusters have live colonies. A number of predators often control rosy apple aphid, so distorted leaves should be opened to determine if the aphids or predators are still present before making control decisions.



rosy apple aphid

Monitor for green apple aphid from petal fall until new growth hardens off (usually by mid-July). Examine five terminals on each of five trees. Look for aphids and natural enemies, particularly the gall midge larva (an orange maggot) that commonly preys on apple aphids. Treatment is suggested if 30 percent of the terminals are infested and natural enemies are not present.

Careful examination of woolly apple aphid colonies is necessary to determine if live aphids or predators are present. Predators can completely destroy an aphid colony, but leave the waxy residue.

Chemical Control: Because rosy apple aphid infestations will curl the leaves, early control is important. Once the leaves are tightly curled, adequate spray coverage and control are more difficult. For that reason, rosy apple aphids are best controlled at the pink stage of bud development while they are still exposed and before the serious leaf curl has occurred. The cover sprays for codling moth may control light infestations of woolly apple aphid.

Dogwood Borer

(*Synanthedon scitula*; order Lepidoptera, family Sesiidae)

Damage: On young apple trees, dogwood borer can cause serious damage, possibly girdling trees. The larvae feed primarily in burrknot tissue on clonal rootstocks. All commercial dwarfing and semi-dwarfing rootstocks have a tendency to develop burrknots. As the burrknot tissue is consumed, the larvae move outward and begin to feed on the cambium adjacent to the burrknot.

Appearance: The adult dogwood borer is a wasp-like, black and yellow, clearwing moth. With a wing span of 3/4-inch, it is smaller than the peach borers. The female has a wide yellow band on the fourth abdominal segment; the male has a narrow yellow band on the same segment. The larvae are white to pink, have a brown head capsule, and are 1/2-inch when fully grown.

Life Cycle and Habits: The dogwood borer lays eggs in burrknot tissue or in graft unions on clonal rootstocks such as M.7, M.26, etc., or interstems; the larvae tunnel throughout the burrknot tissue and adjacent cambial tissue. There is one generation per year.

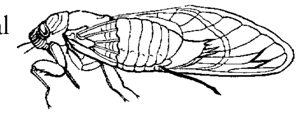
Monitoring and Thresholds: Pheromone traps can be used from petal fall through harvest to monitor for adult dogwood borers. The first trap catch usually occurs in late May or early June and peaks in early July. Control by trunk application at peak egg hatch, 8 to 9 days after peak flight.

Cultural Control: White latex paint brushed on the exposed portion of the rootstock before egg laying begins can prevent new infestations and also protect against southwest injury to the bark. Minimize the use of plastic trunk guards, which create humid conditions on the trunk that are favorable to borer development.

Chemical Control: Infestations of dogwood borer are uncommon, and routine trunk sprays are not recommended. But in orchards where dogwood borer is a problem, new infestations can be controlled by applying an insecticide to the trunk at the time of peak egg hatch.

Cicadas

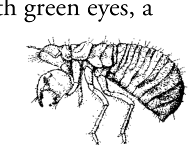
(order Homoptera, family Cicadidae)
PERIODICAL CICADA (*Magicicada septendecim*)
ANNUAL CICADA (several species)



periodical cicada adult

Damage: While periodical cicadas emerge at 13- or 17-year intervals, annual cicadas may be seen each year. The worst damage results from egg laying when females slit the bark on twigs and lay their eggs in the wounds. These small branches can turn brown and die, sometimes breaking off. On young fruit trees, newly developed trunk or scaffold branches can be so severely damaged that new branches must be grown. Damage can be severe in newly planted orchards or new plantings of shade trees or shrubs. Juvenile feeding on roots causes the most long-term damage. Once nymphs have burrowed into the ground and reached the roots, no control method is available. During years one through five of an infestation, damage probably will not be noticeable. However, for years 6 to 13 (or 17), juvenile cicadas may be extremely destructive to plants. Serious damage by annual cicadas is uncommon, and their activity in orchards is generally limited to feeding.

Appearance: The periodical cicada and the annual cicada are confused because of superficial similarities. The periodical cicada is 1 1/2-inches long, with red eyes, a black body, and clearwings with orange veins; it appears from April to June. In contrast, the annual cicada is 2- to 2 1/2-inches long, with green eyes, a green to black body, and light green wings with dark green veins; it appears from July to September.



periodical cicada nymph

Life Cycle and Habits: After emergence and mating in late April through June, female periodical cicadas lay eggs in rows in pockets they cut in small branches and twigs of trees with their knifelike egg layers. Females prefer grapevines and oak, hickory, apple, pear, and peach trees for egg laying. Eggs hatch in 6 to 8 weeks. Nymphs fall to the ground and burrow down to the root system where they stay for the next 13 (or 17) years. Damage occurs as they use their piercing-sucking mouthparts to feed on the roots.

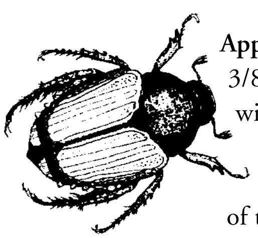
Cultural Control: Small trees can be covered with a protective netting like cheesecloth secured at the bottom around the trunk. This covering will need to stay on for 4 to 6 weeks or until egg laying is complete. Since the trees are growing rapidly at this time, care must be taken to keep the netting from deforming the scaffold branches. With older trees, damaged branches can be removed during winter pruning operations.

Chemical Control: Trees can also be sprayed. Orchards under a routine spray schedule may adjust this schedule to coincide with the time when large numbers of cicadas are present. Spray requirements will vary depending on the severity of the outbreak.

Japanese Beetle

(*Popillia japonica*; order Coleoptera, family Scarabaeidae)

Damage: The adult beetles feed on leaves of a wide variety of trees and shrubs. Adults feed on the upper surface of foliage, chewing tissue between the veins and leaving a lace-like skeleton of the leaf. They usually feed in groups, starting at the top of a plant and working downward. The beetles are most active on warm, sunny days and prefer plants that are in direct sunlight. A single beetle does not eat much; it is group feeding by many beetles that results in severe damage. Trees that have been severely injured appear to have been scorched by fire. Japanese beetles will feed on fruits that have been damaged by other insects.



Japanese beetle

Appearance: Adult Japanese beetles are 3/8-inch-long, metallic green beetles with copper-brown wing covers. A row of white tufts of hair project from under the wing covers on each side of the body.

Life Cycle and Habits: Japanese beetles overwinter underground in the grub stage and pupate near the soil surface in the spring. Grubs spend 10 months in the soil where they feed on roots of grasses and can be serious pests of turf. Adults emerge from the ground and begin feeding on various plants in June. Activity is most intense over a 4- to 6-week period beginning in late June. By mid-July, numbers of beetles gradually diminish. Individual beetles live about 30 to 45 days. There is a single generation per year. Orchard trees that may be severely attacked include apple, cherry, black cherry, peach, and plum.

Monitoring and Thresholds: There are few threshold guidelines relative to when apples need to be treated for Japanese beetles. However, the first Japanese beetle colonizers in the early summer will attract others into the orchard, so early control can reduce later infestations.

Japanese beetle traps are available that lure both male and female beetles into the trap. This trap is so effective at attracting beetles that it can actually increase both the number of beetles in the vicinity of the trap and the damage they cause. Despite the bad reputation the trap has earned because of its super-attractiveness, the trap is still effectively used if it is placed at some distance away from the orchard.

Chemical Control: Carbaryl is the most effective insecticide used in managing Japanese beetles. However, because carbaryl can greatly increase problems with European red mites, other insecticides are recommended to manage low to moderate Japanese beetle populations in apples. Repeated insecticide applications may be necessary at 7- to 10-day intervals to prevent reinfestation during the adult flight period or after heavy rains. Use of a spreader/sticker in the spray mix can increase the duration of effectiveness.

Summary of Insect and Mite Pest Management Procedures on Apples and Pears

Cultural controls when establishing a new orchard:

- Choose a planting site with suitable soil and good water drainage.
- Remove alternate hosts for codling moth and plum curculio.
- Remove alternate hosts, especially brambles for flyspeck and sooty blotch, and cedars for rust.
- Purchase certified virus-free stock from a reputable nursery.
- Avoid rootstocks that are highly susceptible to woolly apple aphid.
- Avoid cultivars that are highly susceptible to rosy apple aphid.
- Avoid fire blight-susceptible rootstock/cultivar combinations.

Cultural controls while maintaining an orchard:

- Prune trees to ensure adequate spray coverage in all parts of the trees.
- Provide adequate but not excessive nitrogen fertilizer, especially to fire blight-susceptible trees and to avoid flushes of growth attractive to aphids.
- Destroy fruit that falls in early to midsummer.
- Prune to ensure good air circulation and adequate spray coverage in all parts of the trees and to remove fire blight infections.
- Keep broadleaf groundcover under trees to enhance predatory mites.
- Keep orchard mowed to discourage tarnished plant bug.

Monitoring for pests:

Insect traps

- Hang pheromone traps for leafrollers and spotted tentiform leafminers in trees at green tip and examine twice per week.
- Hang pheromone traps for San Jose scale at pink and examine twice per week through May, or use sticky tape to monitor for crawlers from mid-May through early June.
- Hang pheromone traps for codling moth at pink and examine twice a week through harvest.
- In the northern Midwest, hang canary-yellow sticky traps and red spheres in early June to monitor for apple maggot and maintain them through mid-August.
- Use degree-day forecasting to time spray applications for San Jose scale and codling moth, in conjunction with pheromone traps.

Disease prediction

- Use a commercial scab predictor or temperature and leaf wetness measurements to monitor scab infection periods.
- Use the MARYBLYT computer program to monitor development of fire blight and predict the onset of symptoms.

Scouting

- Pruning: look for scale injury to new wood.
- Tight cluster through pink: look for plant bugs and rosy apple aphid.
- Tight cluster through first cover: look for aphids.
- Petal fall through second cover: look for plum curculio damage and leafhoppers.
- Early June: begin looking for European red mite and Japanese beetle.
- Harvest: evaluate for San Jose scale, codling moth, plum curculio, and leafroller control. Also, examine leaves, especially the undersides, for late-season scab.

Applying insecticides and miticides:

- To minimize the emergence of pests that are resistant to pesticides, avoid repeated application or season-long use of pesticides with the same mode of action.
- Use a delayed dormant oil application to control European red mite and San Jose scale.
- Use broad-spectrum insecticide only against codling moth, plum curculio, and leafrollers.
- Use narrow-spectrum insecticides if problems are detected with aphids, leafhoppers, leafminers, and San Jose scale.
- Avoid using products known to be highly toxic to predatory mites or predaceous insects.

Consider using mating disruption for codling moth management.

Apple Orchard Management Calendar

	Pre-season	Dormant	Silver tip	Green tip	Half -inch green	Tight cluster	Pink	Bloom	Petal fall	First cover	Second cover	Third cover	Summer cover	July	August	September	Harvest	October	November	December
Dormant Pruning, Brush Removal, Leaf Chopping	X	X	X	X																
Ridomil for Collar Rot		X																	X	
Fertilization	X																			
Pre-emergence Herbicides	X	X																		
San Jose Scale		X					●			X	X	X								
European Red Mites				X	X	X	X		X	X	X	X	X	X	X	X	X			
Spotted Tentiform Leafminer				●	X		X		X				X	X	X	X	X			
Scab Infection				●	X	X	X	X	X	X	X	X	X	X	X	X	X			
Rosy Apple Aphid					X		X													
Green Apple Aphid							X		X	X	X	X	X							
Powdery Mildew						X	X	X	X	X	X									
Rust Infections							X	X	X	X	X									
Tarnished Plant Bug							X													
Foliar Boron and Nitrogen							X		X											
Fire Blight Infections				●				X	X	X	X									
Codling Moth							●		X	X	X	X	X	X	X	X	X			
Plum Curculio									X	X	X									
Red-banded Leafroller									X	X	X	X	X	X	X	X	X			
Chemical Thinning									X	X	X									
White Apple Leafhopper									X			X	X	X	X	X	X			
Fruit Rots										X	X	X	X	X	X	X	X			
Blister Spot									X	X										
Cork Spot and Bitter Pit									X	X	X	X	X	X	X	X	X			
Flyspeck and Sooty Blotch											X	X	X	X	X	X	X			
Apple Maggot											X	X	X	X	X	X	X			
Oblique Banded Leafrollers											X	X	X	X	X	X	X			
Japanese Beetle											X	X	X							
Post-emergence Herbicides											X	X	X	X	X	X	X			
Irrigation											X	X	X	X	X	X	X			
Watersprout and Sucker Removal												X	X							
Foliar Analysis													X							
Put out Rodent Bait.	X																	X	X	X
Trunk Borers																				

● Put pheromone traps in place or begin taking environmental data.for pest prediction