



RUST DISEASES OF APPLES

Three rust diseases occur on apple and crabapple trees in Illinois, which are caused by species of fungi in the genus *Gymnosporangium*. These rust diseases are: cedar-apple rust, caused by *G. juniperi-virginianae*; cedar-quince rust, caused by *G. clavipes*; and cedar-hawthorn rust, caused by *G. globosum*. Cedar-apple rust is the most common and economically important rust disease occurring on apples in Illinois (Figure 1). All three diseases can occur on crabapple, hawthorn, mountain ash, pear, and serviceberry. The *Gymnosporangium* spp. have various junipers and red cedars (*Juniperus* species) as alternate hosts. These diseases can result in the following:

1. Fruit infection, resulting in lower value of fruit for commercial and home use;
2. Premature fruit drop;
3. Early defoliation, resulting in reduced size and quality of fruit during the current season; and
4. Devitalization of trees from repeated infection.

Apple and crabapple trees that have been repeatedly infected for a period of years may be stunted and may fail to produce fruit. The rust diseases can also destroy the ornamental value of susceptible junipers.



Figure 1. Cedar-apple rust on Jonathan apple in Illinois.

CEDAR-APPLE RUST

Symptoms on Apple and Crabapple. *G. juniperi-virginianae* infects the leaves, fruit, and occasionally young twigs.

On Leaves. Pale yellow spots appear on the upper surface of leaves during May and June in Illinois (Figures 1 and 2). The spots gradually enlarge to about 1/4 inch in diameter (1/2 to 3/4 cm) and turn orange, with a reddish border. As many as 300 spots may form on a single apple leaf. Pycnia (black dots) of the fungus form in these spots and exude an orange fluid containing pycniospores. As the

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pycnia develop, yellow spots appear on the under leaf surface. These spots thicken and during late spring and early summer, small, orange-yellow tubular projections (aecia) appear (Figure 3). These aecia eventually develop open, cylindrical tubes. The tubes split into narrow strips and curl backward. As the rust pustules develop, a leaf may turn yellow and drop. The defoliation of infected leaves is most prevalent during dry summers but more frequently the leaf remains on the tree until autumn.

On Fruit. Yellow-orange lesions appear on immature fruit, usually at or near the calyx end (Figure 4). These are much larger than the leaf lesions, up to 3/4 inch (2 cm) or more in diameter. The light green color of the young apple becomes a darker green around the infected area. The tubelike aecia generally appear in the fruit lesions, usually in a circle surrounding the black pycnia. Infected fruit are generally stunted and misshapen and may drop early.

On Twigs. The current-season growth of very susceptible apple and crabapple varieties may develop slightly swollen sections about one inch long that bear typical pycnia and aecia. Seriously affected twigs are stunted and may die back.

Symptoms on Juniper. Light brown to reddish or chocolate brown galls, ranging from about 1/8 inch (0.3 cm) to over 2 inches (5 cm) in diameter, develop on susceptible junipers. The round to kidney-shaped, corky galls (often called "cedar apples") develop circular pits or depressions over the surface, something like those on a golf ball. During damp spring weather a small protuberance develops in the center of each pit and the protuberances elongate rapidly. Within several hours, they develop into gelatinous, yellowish to golden brown sporehorns up to about two inches (5 cm) long (Figure 5). A single gall may produce from a few to over 100 sporehorns. When they are bent over and covered with expanded galls the size of oranges, heavily rusted junipers are very conspicuous.

During dry weather the gelatinous horns contract into wrinkled threads. When remoistened, the sporehorns swell again to their original size. During late May to mid-June, after several rains, the sporehorns exhaust their spores and wither permanently. During the summer months, the withered



Figure 2. Lesions with pycnia of cedar-apple rust on the upper surface of an apple leaf.



Figure 3. Aecia of cedar-apple rust fungus on the lower surface of an apple leaf.

sporehorns drop off. The galls turn dark brown to black and become hard. Old, blackened galls may remain on a juniper for a year or longer, but do not produce spores again.

The juniper species, varieties, and cultivars that have been reported as susceptible to cedar-apple rust include: *Juniperus chinensis* or Chinese juniper, cultivar 'Globosa', cultivar 'Pfitzeriana', and variety sargentii; several cultivars of *J. communis* or common juniper; several cultivars of *J. horizontalis* or creeping juniper including cultivars 'Alpina' and 'plumosa'; *J. pinchotii*; *J. scopulorum* or Rocky Mountain juniper, cultivars 'Funalis', 'Hilli', 'Hilli Argfentea Pyramidalis', 'Hill's Silver', 'Horizontalis', 'Moffreti', 'Pendula', 'Pillaris', and 'Viridifolia'; *J. silicicola* or southern red cedar; *J. utahensis*; and numerous cultivars of *J. virginiana* or eastern red cedar including 'Albospica', 'Canaertii', 'Chamberlainii', 'Cinerascens', 'Glauca', 'Pyramidiformis', 'Reptans', 'Schottii', 'Skyrocket', and 'Variegata'.



Figure 4. Apple fruit with cedar-apple rust.

CEDAR-QUINCE RUST

Symptoms on Quince. Cedar-quince rust, caused by *G. clavipes*, affects quince, flowering quince, Juneberry or serviceberry, chokeberry, hawthorn, mountain ash, photinia, and pear leaves, fruit, and young stems. Twigs may die back. This disease is generally not as prevalent as cedar-apple rust. Cedar-quince rust sometimes infects apple fruit but not the leaves. Fruit of susceptible cultivars, such as Golden Delicious, Red Delicious, Stayman, and Winesap, become puckered at the blossom end and develop a sunken, dark green area. Under the craterlike, dark green area, the flesh is brown and spongy, often extending to the core of the fruit. The formation of pycnia and aecia is not common. Apples are susceptible to the cedar-quince rust fungus during the period from early bloom through third cover spray (approximately 5 weeks post petal fall).



Figure 5. Cedar-apple rust on Juniper.

Symptoms on Juniper. Perennial, spindle-shaped swellings form on the twigs and branches of common juniper (*Juniperus communis*), eastern red cedar (*J. virginiana*), mountain juniper (*J. sibirica*), and prostrate juniper (*J. communis* var. *depressa*). Young branches may be killed. Elongated, swollen patches or cankers may occur on twigs and on the trunk. In damp spring weather,

older galls are covered with conspicuous, cushion-shaped masses of gelatinous, orange to brown sporehorns.

CEDAR-HAWTHORN RUST

Symptoms on Apple and Crabapple. Cedar-hawthorn rust, caused by *G. globosum*, is a minor disease of apple, crabapple, mountain ash, and pear trees, but a major disease of ornamental hawthorns. The orange leaf spots are small on apple and crabapple, but larger and gray to brown on hawthorns. Few, if any, aecia are produced on apple or crabapple, and these are clustered in the center of the pustule. Fruit infections are rare on apples. Defoliation and deformation of fruits and twigs on hawthorns are very common and particularly severe.

Symptoms on Juniper. The galls produced on junipers resemble those of cedar-apple rust, except that they are smaller (usually under ½ inch), more irregular in shape, and do not develop the regular arrangement of circular depressions. The gelatinous sporehorns are also shorter, fewer in number, and wedge-shaped.

The juniper species, varieties, and cultivars reported as susceptible to cedar-hawthorn rust include: *Juniperus chinensis* cultivar 'Globosa' and var. sargentii; *J. communis*; *J. horizontalis* cultivar 'Alpina'; *J. pinchotii*; *J. scopulorum* cultivars 'Hill's Silver', 'Horizontalis', 'Moffeti', 'Pendula', and 'Viridifolia'; *J. silicicola*; and numerous cultivars of *J. virginiana* including 'Albospica', 'Berg's Rust Resistant', 'Canaertii', 'Chamberlaynii', 'Cinerascens', 'Cupressifolia', 'Elegantissima', 'Glauca', 'Nova', 'Pendula', 'Pyramidiformis', 'Reptans', 'Schottii', and 'Variegata'.

DISEASE CYCLES

Disease Cycle of Cedar-

Apple Rust. Cedar-apple rust is the most common of the three rust diseases that affects apples and crabapples. The disease cycle for cedar-apple rust, essentially the same as the cycles for cedar-quince and cedar-hawthorn rusts, is given in detail in (Figure 6).

The fungus overwinters as mycelium in the galls on junipers. The sporehorns begin to extrude in the spring, usually when the apple buds are in the pink to early bloom stage. As the galls become rain-soaked, the thorns appear, become jelly-like, and swell very rapidly. A single, large cedar gall produces numerous teliospores,

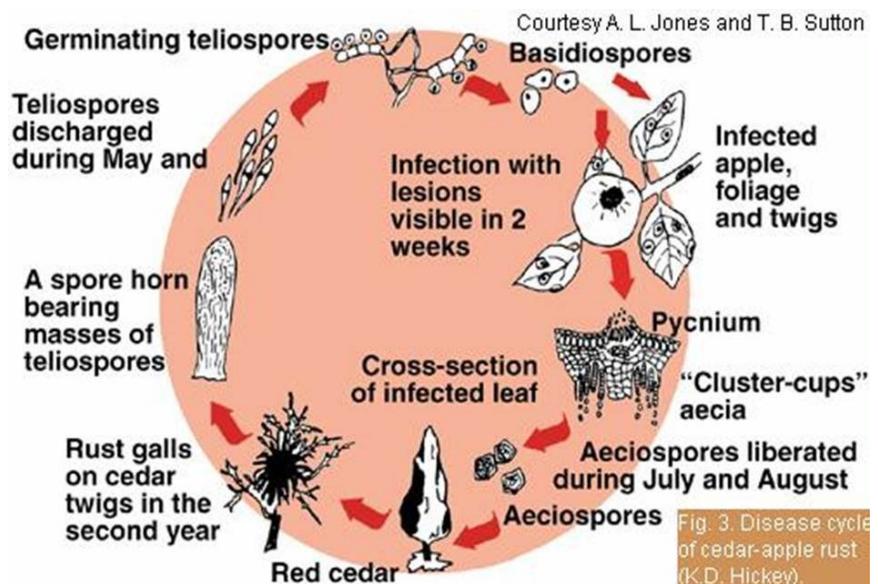


Figure 6. Disease cycle of cedar-apple rust.

each producing four sporidia or basidiospores. Each basidiospore is capable of initiating an infection. As the sporehorns begin to dry, the sporidia are forcibly discharged. These sporidia are carried by air currents to nearby developing apple leaves, fruit, and young twigs. The basidiospores generally are not carried great distances by the wind, as they dry quickly and lose their vitality. A few infections of apple and crabapple may occur up to 5 miles from a juniper, but most infections develop within several hundred feet. About 30 days after apples and crabapples have bloomed, the sporehorns have exhausted their spores. By this time, most leaves and fruit are no longer susceptible. Apple leaves become resistant to cedar-apple rust about 28 days after they unfold.

Within 5 to 6 hours after landing on a leaf, the basidiospores become attached. Short germ tubes directly penetrate the cuticle and the upper leaf tissue. After 10 to 14 days, small yellow spots can be seen on the upper leaf surface and black pycnia develop on these spots. Several weeks later, the aecia form on the underside of the leaf. The aecia produce tremendous number of brown aeciospores. The aeciospores are produced in cylindrical tubes and fall out of the tubes in chains. They are carried by air currents to nearby junipers.

The aeciospores become lodged in the juniper leaf axils and in the cracks or crevices of twigs. There they attach, germinate, and infect the twigs in the warm, moist weather of late summer and early fall (75°F or 24°C is optimum). The young, pea-size, greenish-brown galls become evident in the leaf axils the following spring. These galls continue to grow during the year. They normally do not produce spores until the second spring. The complete disease cycle, therefore, usually requires almost 2 years.

DISEASE MANAGEMENT

Cedar-apple and related rusts are fairly easy to manage on both apple and crabapple and on juniper hosts.

1. Grow resistant species, varieties, and cultivars of apples (Tables 1) and crabapples. A careful selection will greatly reduce the problem with these diseases. The resistance of a species, variety, or cultivar may vary greatly from one locality to another, depending on the physiologic races of the rust species prevalent in the area.
2. Destroy nearby worthless, wild or cultivated apples, crabapples, and junipers. Although eradicating (removal) rust-susceptible junipers within 1 to 2 miles of commercial apple orchards has been advocated for many years, it is usually impractical. Removal of infected junipers within ½ mile will significantly influence incidence on apple and crabapple. In ornamental plantings where only a few rather small junipers are infected, snip off and destroy the galls sometime during the fall, winter, or early spring. Some smaller galls may be missed, but the chances of apple and crabapple trees becoming infected will be considerably reduced, especially if you can convince your neighbors to do likewise.
3. Spray apples and crabapples for rust control starting at the pink-bud stage. Commercial orchardists should follow the suggested spray program outlined in the "Midwest Fruit Pest Management

Guide” (<https://ag.purdue.edu/hla/Hort/Documents/ID-465.pdf>). This guide is revised annually. Follow label recommendation carefully.

Table 1: Relative susceptibility of apple cultivars to cedar-apple rust disease. Adapted from the website of the University of Arkansas (<https://www.uaex.edu/publications/pdf/FSA-7538.pdf>).

Highly susceptible	Moderately susceptible	Moderately resistant	Highly resistance
<div data-bbox="154 562 415 1291" style="border: 1px solid black; padding: 5px;">Arlet Braeburn Cameo Fuji Gala Ginger Gold Golden Delicious Goldrush Jonathan Lodi Prima Rome Beauty Spigold Summerred Twenty Ounce Wealthy Winter Banana York Imperial</div>	<div data-bbox="443 562 777 1507" style="border: 1px solid black; padding: 5px;">Beacon Ben Davis Burgundy Cortland Gloster Honeycrisp Idared Jamba Jonafree Jonagold Julyred Monroe Mutsu Northern Spy Pristine Quinte Raritan Rhode Island Greening Spijon Stark Bounty Stark Splendor Stayman Wayne Williams Pride</div>	<div data-bbox="805 562 1117 1470" style="border: 1px solid black; padding: 5px;">Arkansas Black Barry Briemac Carroll Dayton Early McIntosh Empire Granny Smith Grimes Golden Jonamac Macoun Maiden Blush Niagara Paulared Priscilla Puritan Scotia Spartan Starkspur Earliblaze Viking Wellington Winesap Yellow Transparent</div>	<div data-bbox="1144 562 1427 1071" style="border: 1px solid black; padding: 5px;">Baldwin Delicious Enterprise Gravenstein Holly Jerseymac Jerseymac Liberty McIntosh Milton Mollies Delicious Redfree Redfree</div>
