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Cedar-apple and Related Rusts of Apple and Ornamentals

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This NebGuide defines and explores the basics of cedar-apple and related rusts, tree care, and control measures.

Cedar-apple rust is a fungal disease that causes substantial injury to apple and crabapple trees in Nebraska. It's caused by the fungus *Gymnosporangium juniper-virginianae* and occurs wherever apples and junipers are grown in close proximity.

Disease Cycle

G. juniper-virginianae has a complex life cycle *(Figure 1)* and two hosts are required for the fungus to complete its life cycle. One set of hosts include members of the rose family (apple) and the other set includes *Juniperus* species. Distinctly different spores and symptoms are produced on the deciduous and evergreen hosts. Spores produced on the rosaceous host infect only juniper plants and those originating on the evergreen host infect rosaceous plants.

The first sign of the disease in the spring is the production of orange gelatinous tendrils (telial horns) on the juniper host (*Figure 1a*). The telial horns are columns of teliospores that germinate and produce basidiospores. These are blown to apple trees where they germinate and infect leaves, fruit and occasionally twigs. Spore production and release are favored by wet weather during May and June. Orange spots develop at the point of infection on the rosaceous host *(Figure 1b)*.

Spores (spermatia, previously referred to as pycnidiospores) produced in these lesions fertilize compatible myce-

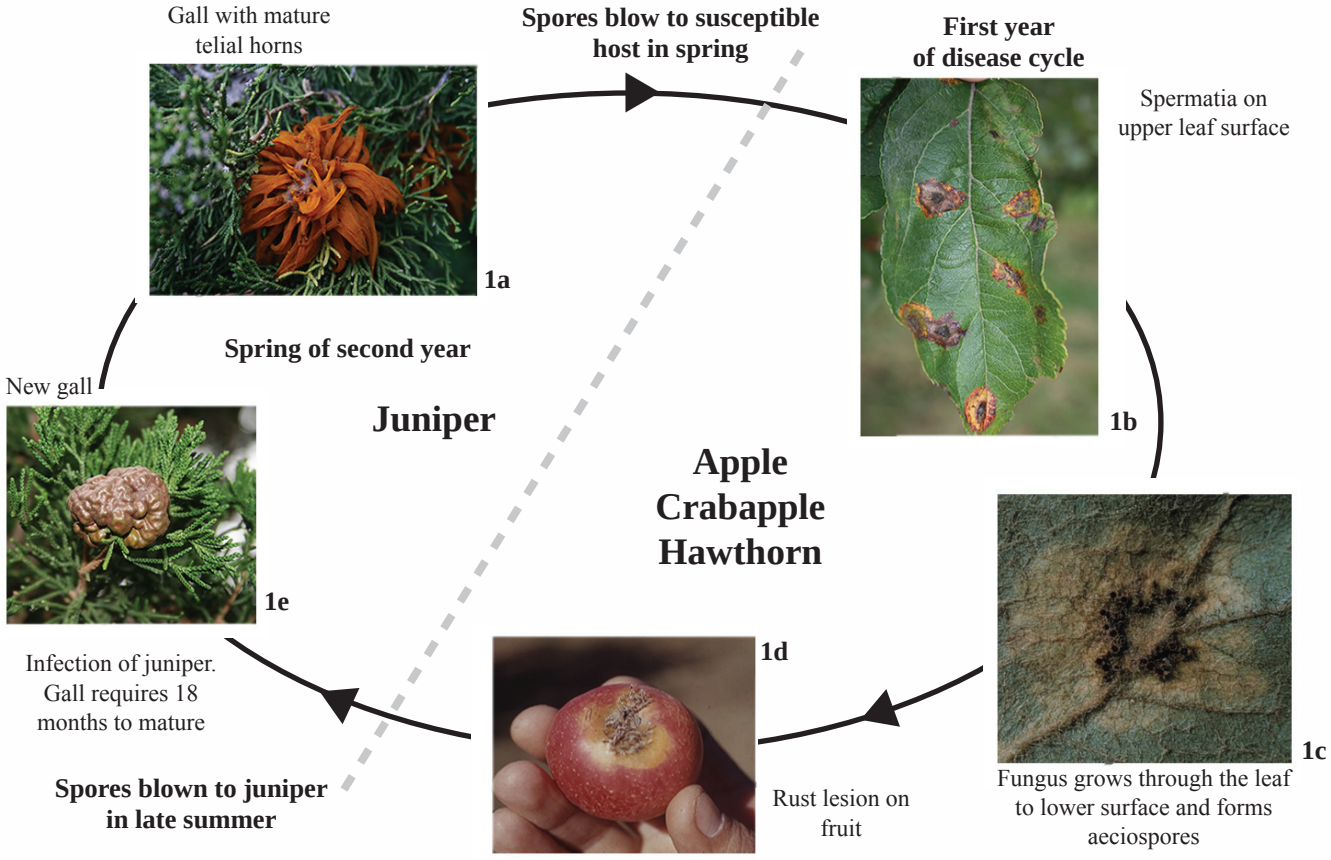

Figure 1. Life cycle of cedar-apple rust.

lium which then grow through the leaf and cause lesions on the lower leaf surface. As these lesions mature, they produce spores (aeciospores) that are windblown back to the juniper host during mid to late summer *(Figure 1c)*.

Gall formation at the point of infection does not become evident until July of the next year *(Figure 1e*). The galls increase in size until that October and become fully mature the next spring when they produce telial horns under favorable weather conditions and start the cycle over again. Two years are required for the fungus to complete its life cycle.

Symptoms on *Juniperus* Hosts

The most common alternate host of *G. juniperi-virginianae* in Nebraska is eastern redcedar (*J. virginiana*). Other susceptible hosts include Rocky mountain juniper (*J. scopulorum*), creeping juniper (*J. horizontalis*), and common juniper (*J. communi*).

Galls produced on these hosts are initially brownish-green and corky. They vary in size from 1/8 inch to more than 2 inches in diameter.

As they mature, galls become reddish-brown and their surface becomes dimpled, resembling a golf ball *(Figure 1e)*. Gelatinous tendrils extrude out of the dimples during wet weather *(Figure 1a)*. These tendrils may shrivel during dry weather but can expand again during and shortly after wet periods several times in the spring. Ultimately they dry out and harden into firm, woody structures. Once spent, the galls no longer produce the telial horns, although they may remain attached to the tree for several years. Infections of junipers rarely result in economic injury, but galls produced near twig tips may cause some dieback. In addition, small twigs may be killed if many galls are produced.

Symptoms on Apple and Other Rosaceous Hosts

Cedar-apple rust causes the most injury, physical and economic, to its cultivated apple host. Other rosaceous hosts of *G. juniperi-virginianae* include crabapple and hawthorn.

Symptoms on the upper leaf surface are yellowish-orange spots *(Figure 1b)* which vary in size depending on the susceptibility of the host and may be bordered by a red band or chlorotic halo, a characteristic also dependent on host susceptibility.

Small, dark brown spots (spermatia) develop within these spots as they mature *(Figure 1b)*. The fungus grows through the leaf and forms long (1/4-inches) tendrils (aecia) on the lower leaf surface directly below the orange spots *(Figures 1c* and *2)*.

Aecia have a papery texture and contain rust-brown spores (aeciospores). Injury to the host occurs when extensive infection leads to premature defoliation. Repeated infection for several growing seasons weakens the tree and may result in decreased productivity and death.

Fruit symptoms are similar to leaf symptoms. Infection occurs near the calyx (blossom) end and spots are yellowish-orange *(Figure 1d)*. Rust spots are superficial, extending 1/4-inch or less into the flesh. Brown spermatia (aka pycndiopsores) are also produced on the fruit. Aecia are produced less frequently than on the leaves.

Although infection sites are superficial, their presence may reduce fruit quality by causing a decrease in size, distortion or premature abortion from the tree.

Figure 2. Cedar-Hawthorn rust producing aecia on hawthorn fruit. Photo courtesy of Stephen Wegulo, Department of Plant Pathology.

Related Rusts

Two other rusts caused by *Gymnosporangium* species produce similar symptoms on the same hosts infected by *G. juniperi-virginianae*. These rusts are American hawthorn rust and quince rust.

Symptoms of American hawthorn rust, *G. globosum* (also known as cedar-hawthorn rust), are the same as those for cedar-apple rust *(Figure 2)*. Leaf symptoms are similar in color but may be slightly smaller in size. Galls on junipers have similar physical characteristics, but produce telial horns for three to five years rather than one year. *G. globosum* also has an expanded host range that includes pear, quince, and serviceberry in addition to those of *G. juniperi-virginianae*.

Quince rust (also known as cedar-quince rust) is caused by *G. clavipes*. Infections occur on fruit but not the leaves of its rosaceous hosts. The fungus also produces cylindrical galls, often referred to as cankers, rather than round galls, on junipers. These galls are perennial and increase in size from year to year. They may remain active up to 20 years. *G. clavipes* also has a larger host range than *G. juniperi-virginianae*. Additional hosts include mountain ash, chokeberry, cotoneaster, medlar, pear, photinia, quince, flowering quince, and serviceberry.

Control

Effective control includes both cultural and chemical approaches. Many cultivars of apple, crabapple, hawthorn, and juniper show some degree of resistance or tolerance to disease development. Planting a resistant cultivar is always advisable as doing so will reduce time and money invested in chemical control. Planting a rust-susceptible cultivar will require annual fungicide treatment to maintain the health and aesthetic value of the tree. *Tables I-IV* present a partial list of popular resistant and susceptible cultivars of apple, crabapple, hawthorn, and juniper. Infection typically will not kill the tree but does reduce overall plant vigor and aesthetic value.

Unfortunately some very popular older cultivars of apple and crabapple are susceptible to cedar-apple rust as well as other rusts caused by *Gymnosporangium* species. If you've already established these plants in your landscape or orchard, chemical control measures may be necessary. *Table V* lists fungicides labeled for rust control. The infection period for the rust fungi on flowering trees is generally from the pink stage

Table I. Reaction of selected apple cultivars to cedar-apple rust.[a]

Very Resistant[b]	*Resistant*	*Susceptible*	*Highly Susceptible*
Jerseymac	Carrol	Burgundy	Braeburn
Liberty	Dayton	Cortland	Cameo
McIntosh	Early McIntosh	Honeycrisp	Fuji
Mollies Delicious	Empire	Jonafree	Gala
Redfree	Enterprise	Jonagold	Ginger Gold
	Freedom	Pristine	Golden Delicious
	Granny Smith	Northern Spy	Goldrush
	Grimes Golden	Spartan	Jonathon
	Jonamac	Stark Bounty	Lodi
	Maiden Blush	Stark Splendor	Prima
	Paula Red	Williams Pride	Rome Beauty
	Priscilla		Wealthy
	Red Delicious[c]		
	Starkspur Earliblaze		
	Winesap		

[a]From West Virginia University Kearneysville Tree Fruit Research and Education Center, 67 Apple Harvest Lane, Kearneysville, WV 25430, Cedar-apple rust, *Gymnosporangium juniperi-virginianaeI,* by K.S. Yoder and A.R. Biggs.
[b]Very Resistant = no control needed, Resistant = control needed under high disease pressure, Susceptible = control usually needed where disease is prevalent, Highly Susceptible = control always needed where disease is prevalent. These cultivars should receive first priority when control is necessary.
[c]Very susceptible to cedar-quince rust.

Table II. Crabapple cultivars resistant to cedar-apple rust.

Red Flowering	*Pink Flowering*	*White Flowering*
Cardinal	Callaway	Adams
Centurion	Camelot	Adirondack
Indian Summer	Canterbury	Dolgo
Prairefire	Candied Apple	Donald Wyman
Profusion	Coralburst	Lancelot
Selkirk	Louisa	Molten Lava
	Red Splendor	Professor Sprenger
	Robinson	Red Jewel
	Strawberry Parfait	Royal Splendor
	Sugar Tyme	Sentinel
	Winter Gold	White Angel

Table III. Hawthorn (*Crataegus* spp.) cultivars resistant to cedar-hawthorn rust.

Cockspur Thornless (*C. crusgalli* var. *inermis*)	Copenhagen (*C. intricate*)
Autumn Glory (*C. laevigata*)	Princeton Sentry (*C. phaenopyrum*)
Waxyfruit (*C. pruinosa*)	Winter King (*C. viridis*)

Table IV. Juniper species and cultivars resistant to cedar-apple rust.

Juniperus chinenis (Chinese juniper)	*Juniperus communis* (Common juniper or ground juniper)	*Juniperus horizontalis* (creeping juniper)	*Juniperus sabina* (Savin juniper)	*Juniperus scopulorum* (Rocky Mountain juniper)	*Juniperus squarnata* (Flaky juniper)	*Juniperus virginiana* (Eastern red cedar)	*Juniperus rigidia* (Stiff-leaved juniper)
Fermina	Aurea	Admirabilis	Broadmoor	Dewdrop	Albo-variegata	Aurea	*Juniperus procumbens* (Japanese garden juniper)
Fortunei	Aureo-spica	Adpressa	Fostigiata	Medora	Fargesii	Berg's Rust Resistant	*Juniperus conferta* (Shore juniper)
Herzii	Cracovia	Argenteus	Knap Hill	Moonglow	Mereri	Burkii	*Juniperus formosana* 'Hyata' (Formosa juniper)
Japonica	Depressa	Douglasii		Pathfinder	Wilsonii	Globosa	*Juniperus ashei* (Ashe juniper)
Keteleeri	Hibernica	Eximius		Platinum		Kosteri	
Leeana	Oblonga pendula	Filicinus		Silver Globe		Pseudocupressus	
Mas	Pyramidalis	Glomerata		Sky Rocket		Pyramidalis	
Oblonga	Saxatilis	Lividus		Welchii		Skyrocket	
Pedula	Saxatilis pallas	Petraea		Wichita Blue		Triparita	
Pfitzeriana	Suecia	Plumosa				Venusta	
Pfitzeriana compacta							
Pfitzeriana glauca							
Plumosa aurea							
Pyramidalis							
Sargentii							

of the blossoms until petal drop (May and June). Susceptible trees need to be sprayed regularly during this time. Read and follow chemical labels closely for reapplication intervals and plant growth stage *(Table VI)*.

Chemical control is usually not recommended on junipers since the disease rarely causes economic injury on this host. However, treating junipers before galls are actively producing teliohorns or when aeciospores are being released from apples may reduce disease development. One disadvantage of applying fungicides to junipers is that treatments may be needed from July to September and are costly in both time and product.

Growers interested in controlling the disease on junipers also may find it helpful to physically remove galls from the twigs. Galls may be picked or pruned from infected tissue. Cankers associated with quince rust also can be removed but prune the affected area 3 inches below the visible canker. This is practical if a few plants are infected and the number of galls per plant is limited.

Table V. Fungicides[a] available for cedar-apple rust on edible and ornamental apple.

Fungicide Active Ingredient	*Trade Name*	*Edible Apple*	*Ornamental Apple*	*Commercial (C)/ Homeowner (H) Use*
Boscalid + Pyraclostrobin	Pristine Fungicide (BASF Corporation)	Yes	Yes	C
Captan	Complete Fruit Tree Spray (Bonide Products Inc.)	Yes	No	H
	Gordon's Liquid Fruit Tree Spray (PBI/Gordon Corporation)[b]	Yes	No	H
Chlorothalonil	Pegasus DF (Phoenix Environmental Care LLC)	No	Yes	C
	Peregrine (Phoenix Environmental Care LLC)	No	Yes	C
	Prosolutions Thalonil 6L (Agriliance LLC)	No	Yes	C
Chlorothalonil + Thiophante methyl	Prominence WDG (Prokoz Inc.)	No	Yes	C[c]
Copper	Natural Guard Copper Soap Liquid Fungicide (Voluntary Purchasing Groups Inc)	Yes	No	H
Kresoxim-methyl	Sovran (BASF Chemical Company)	Yes	Yes	C
Mancozeb	Dithane (Dow AgroSciences)	Yes	Yes	C
	Fore 80WP Rainshield (Dow AgroSciences)	No	Yes	C
Mancozeb + Myclobutanil	Clevis (Prokoz Inc.)	Yes	No	C
Maneb	Maneb 75 DF (United Phosphorous Inc.)	Yes	No	C
	Maneb 80 WP (United Phosphorous Inc.)	Yes	No	C
Manganese	DuPont Manzate Flowable Fungicide (E.I. duPont de nemours)	Yes	Yes	C
	Penncozeb (United Phosphorous Inc.)	Yes	Yes	C
Myclobutanil	Nova 40W (Dow Agrosciences)	Yes	No	C
	Rally 40WSP (Dow Agrosciences)	Yes	No	C
Propiconazole	Banner Max (Syngenta)	No	Yes	C
	Bonide Fung-Onil Systemic Disease Control Lawn and Landscape RTS (Bonide Products Inc.)	No	Yes	H
	Bonide Infuse Systemic Disease Control Lawn and Landscape RTS (Bonide Products Inc.)	No	Yes	H
	Gordon's System Fungicide (PBI/Gordon Corporation)	No	Yes	H
Triflumizole	Procure 480SC (Chemtura Corporation)	Yes	No	C

[a]This list is presented for information only and no endorsement is intended for products listed nor criticism meant for products not listed. Consult the product label for specific application rates and plant growth stage. Read the label carefully before making any application.
[b]Product also contains an insecticide.
[c]Labeled for only greenhouse use.

Table VI. Fruit tree growth stage description.

Growth Stage	*Description*
Dormant	Absence of growth fall, winter or spring
Silver Tip	Swollen buds become noticeable and silvery, fuzzy leaf tissue begins to emerge from the tip of the bud
Green Tip	Green leaf tissue is visible at the tip of the bud
Tight Cluster	The spur leaves have folded back exposing the flower cluster inside the bud
Pink/Pre-Bloom	The flower buds have grown enough to expose the petals of the flowers
King Bloom	The center "King Bloom" has opened
Full Bloom	80% or more of the flowers on the tree are open
Petal Drop/Fall	Last petals have fallen from blossoms

Eradicating nearby junipers has been recommended as a control, but its effectiveness is debatable. While it may reduce the amount of inoculum reaching susceptible apples, widespread eradication is not practical due to the large number of junipers in the state. Established juniper windbreaks also play an important role in erosion control. A much better means of control is to select resistant cultivars of plants for orchards, landscapes, and windbreaks near orchards.

This publication has been peer reviewed.

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