

**Table 1.—Temperature and moisture requirements for cedar apple rust infection periods.**

# cedar apple rust

*Gymnosporangium juniperi-virginianae* Schw.

## INTRODUCTION

Cedar apple rust (CAR) is an important fungal disease of apple in North America east of the Rocky Mountains. It can defoliate trees and blemish fruit making them unmarketable. The CAR fungus requires two hosts, apple and eastern red cedar (*Juniperus virginiana* L.), to complete its life cycle. Spores produced on apple do not infect apple, but only cedar and spores produced on cedar infect only apple.


## DISEASE CYCLE


The CAR fungus overwinters in spherical galls on cedar trees (Fig. 1). Spring rains cause horn-like structures, called telia, to extrude from galls (Fig. 2). When these horns absorb water, they become jelly-like and swollen. Between rains they dry to dark brown threads (Fig. 3). The telial horns are comprised of thousands of two-celled spores called teliospores. Swelling and drying of telial horns may occur 8-10 times during the season. Each time, the horns push out further and expose more teliospores until the supply is exhausted.


During rains, after the telial horns absorb water, the teliospores germinate to produce a germ tube (basidium) from each cell. Four basidiospores are produced on each basidium (Fig. 4). At optimum temperatures, basidiospores are produced within 4 hours of the horns absorbing water.

Basidiospores are forcibly discharged into the air immediately after being formed. They can be carried long distances. Basidiospores that land on young apple tissue may germinate and infect if a film of water is present for an adequate amount of time (Table 1). One to two weeks after infection, orange pustules (pycnia) containing pycniospores appear on the upper side of leaves (Fig. 5) or on fruit (Fig. 6).

| Temperature<br>(C) | Temperature<br>(F) | Basidiospore<br>Formation | Hours Wetting Required |        |
|--------------------|--------------------|---------------------------|------------------------|--------|
|                    |                    |                           | Infection              |        |
|                    |                    |                           | Light                  | Severe |
| 2                  | 36                 | / / / / /                 | 24                     | -      |
| 4                  | 39                 | / / / / /                 | 12                     | 24     |
| 6                  | 43                 | / / / / /                 | 8                      | 10     |
| 8                  | 46                 | 7                         | 6                      | 7      |
| 10                 | 50                 | 5                         | 5                      | 6      |
| 12                 | 54                 | 4                         | 4                      | 5      |
| 14                 | 57                 | 4                         | 3                      | 5      |
| 16                 | 61                 | 4                         | 3                      | 4      |
| 18                 | 64                 | 4                         | 3                      | 4      |
| 20                 | 68                 | 4                         | 2                      | 4      |
| 22                 | 72                 | 4                         | 2                      | 4      |
| 24                 | 75                 | 4                         | 2                      | 4      |
| 26                 | 79                 | / / / / /                 | -                      | -      |
| 28                 | 82                 | / / / / /                 | -                      | -      |
| 30                 | 86                 | / / / / /                 | -                      | -      |

 No basidiospores form at these temperatures.

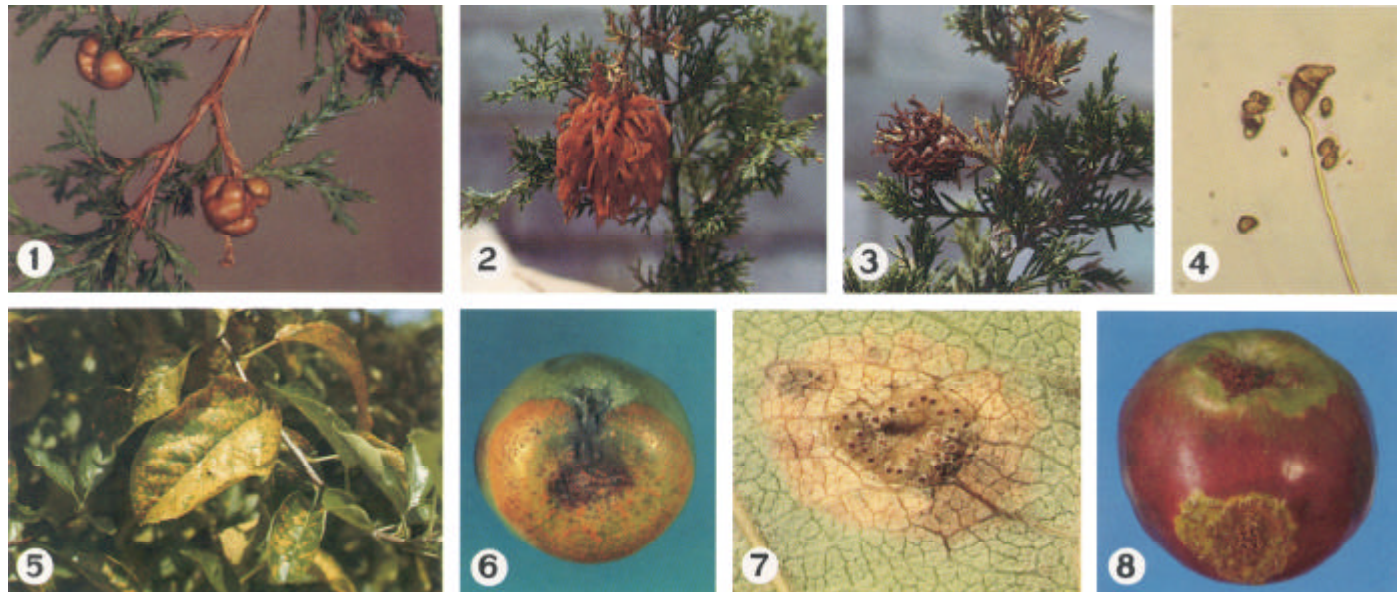
 Light infection—unlikely to cause economic loss.

 No infections have been observed at these temperatures.

**Note:** Only use this table when determining CAR infection on susceptible apple varieties that are located close to eastern red cedars.

**Instructions:** [Using hourly temperature records]. Basidiospores are formed when the temperature during a wetting period averages 11-25 C (52-77 F) for 4 continuous hours. It takes slightly longer when the temperature averages 7-11 C (45-52 F) (Table 1, part A). Once you have determined basidiospores were formed, determine if infection has taken place (Table 1, part B). Average the temperature starting at the time when you determined basidiospores had been formed. The hours listed in part B is the minimum time required for light or severe infection.

One to two months after the appearance of pycnia, the rust produces other fungal structures, called aecia, on the underside of the leaf (Fig. 7) or on fruit (Fig. 8). The aecia produce aeciospores which are released into the air during dry conditions in late summer. Aeciospores that land on young leaves of cedar may germinate, infect, and cause gall formation. Generally, in the second year after infection, the gall matures and produces teliospores, thereby con-



tinuing the disease cycle (Fig. 9). Because most galls produce teliospores for only one season, a new crop of galls is required each year if infection of apples is to occur.

## INFECTION OF APPLE

Before apple can be infected, adequate moisture must be present in a temperature range of 8-24 C (46-75 F) to allow for formation of basidiospores on cedar galls. Then, the basidiospores will infect apple when susceptible leaf and fruit tissues are wet for certain lengths of time at specific temperatures (Table 1).

Leaves are most susceptible to infection when 4-8 days

of age, and fruit are susceptible from tight cluster through bloom.

## CONTROL

Control strategies for CAR are based on fungicides, removing nearby red cedars, and using resistant varieties. Table 2 presents four categories of resistance for 44 cultivars. CAR can be minimized on susceptible cultivars if red cedars are eliminated from their vicinity. Where susceptible cultivars are grown in proximity to red cedars, a fungicide program should be followed from tight cluster through first cover. Use chemicals on a schedule recommended by the local extension service.

**Table 2.—Resistance of apple varieties to the cedar apple rust fungus.**

| Very Resistant                    | Resistant      | Susceptible           | Very Susceptible |
|-----------------------------------|----------------|-----------------------|------------------|
| Delicious<br>(and its red sports) | Akane          | Burgundy              | Golden Delicious |
| Jerseymac                         | Early McIntosh | Cortland              | Jonathan         |
| Liberty                           | Empire         | Idared                | Lodi             |
| McIntosh                          | Gravenstein    | Jonagold              | Prima            |
| Milton                            | Jonamac        | Julyred               | Rome Beauty      |
| Nova Easygro                      | Macoun         | Macfree               | Twenty Ounce     |
| Novamac                           | Niagara        | Monroe                | Vista Bella      |
| Priscilla                         | Paulared       | Mutsu                 | York Imperial    |
| Tydemans                          | Puritan        | Northern Spy          |                  |
|                                   | Spartan        | Quinte                |                  |
|                                   | Viking         | Rhode Island Greening |                  |
|                                   |                | Sir Prize             |                  |
|                                   |                | Stayman               |                  |
|                                   |                | Wayne                 |                  |
|                                   |                | Wealthy               |                  |

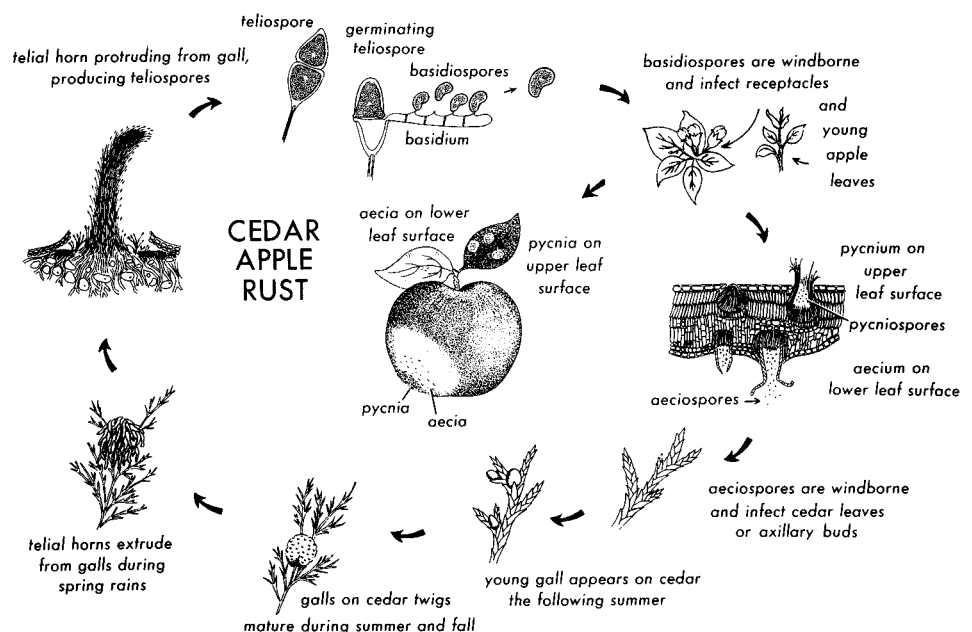
**Very Resistant:** No chemical control is ever needed.

**Resistant:** Chemical control is needed only under high disease pressure.

**Susceptible:** In areas where the disease is prevalent chemical control is usually needed.

**Very Susceptible:** Control is always needed and these varieties should receive first priority when chemical control is called for.

Cedar apple rust disease cycle. Adapted in part by Rose McMillen from G. Agrio's Plant Pathology, 2nd Edition. Used with permission of the author and publisher, Academic Press, Inc.



**Figure 9**

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