

A Guide to Rose Diseases and their Management

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Symptoms of Rose Rosette Disease

INTRODUCTION

For many of us, our gardens aren't complete without roses. The joy we feel when we see a beautiful rose, along with their fragrance, makes them a focal point in the garden. There are many roses available that are easy care, however, from time to time, our roses may experience some type of disease.

These diseases can be minor nuisances or threaten to destroy all roses in the garden. Correct identification of diseases along with knowledge of disease management are critical for maintaining a thriving and aesthetically pleasing garden. This primer is divided into two sections. The first section outlines essential concepts of plant pathology and disease control. It is designed for novice growers or for growers who want to master disease problems by applying disease principles and their knowledge of the disease to solve the problem. The second section contains information about rose diseases found in North America. An experienced rosarian with a basic knowledge of plant pathology may wish to move straight to the second section.

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SECTION 1: DISEASE CONCEPTS

What is a plant disease? There are many definitions for the term disease. It may be formal: A dynamic process in which a biotic agent (pathogen) interferes with one or more essential plant functions or; it can be conceptualized more simply as an aesthetic or economic loss. Regardless of how plant disease is viewed, it interferes with the internal function of the plant (the plant's physiology). Examples of essential plant functions are reproduction, cell division, growth, photosynthesis, etc.

The key word in our formal definition is 'dynamic' which means things change over time. With rose diseases, the disease may increase in severity and possibly lead to plant death. In contrast, an injury, such as stem breakage, occurs very quickly as a single time event. Other examples of injury include an overspray of herbicide, a bad pruning cut and a late freeze.

Some plant problems occur over time, but are not caused by a biotic (living) agent. These issues are referred to as conditions or abiotic stresses and are not diseases. Abiotic stresses result from unmet plant needs, usually too much or too little of something. Examples include nutrient deficiencies such as iron deficiency (Figure 1), flooding, drought, the amount of sun etc.

Sometimes the same issue can be an injury or an abiotic stress. A onetime herbicide exposure would be labeled as an injury. However, if the herbicide is a time released granule or overspray events occur repeatedly over time, the problem would be elevated to an abiotic stress since the problem would become more severe with time.



Figure 1. Iron deficiency is an abiotic stress and is often an indicator of high pH of the soil or growing media. Symptoms include chlorotic (loss of chlorophyll) leaves with green veins. Severe iron deficiency may result in necrotic (dead tissue) leaf spots or entire leaf tips of young leaves turning necrotic.

How does a plant disease start?

Three parameters are required for disease to occur, (Figure 2A). The first parameter is a susceptible host. If the plant is not a host for the pathogen, disease will not occur. In Figure 2B, the rose cultivar 'Legends' is very susceptible to black spot.

The second parameter is the presence of a virulent pathogen. Virulence is defined as the ability of a pathogen to infect and colonize a host and to reproduce. If the pathogen is present, but not virulent (avirulent), disease will not develop.

Most plant diseases are caused by fungi or water molds. Both commonly produce wind-borne spores, which can be thought of as very small seeds. Figure 2B, shows spores of the pathogen *Diplocarpon rosae* that causes the disease “black spot.” The spores are in a water droplet. Like a seed, the spores must soak-up (imbibe) water from the environment before they can germinate.

The third required parameter needed for disease is a conducive environment for the pathogen to infect and the disease to develop. In such an environment, the pathogen will thrive and the host may or may not be stressed. For example, conidia (spores) of the black spot pathogen require at least six hours of free water to germinate (Figure 2B). In areas of the country where the humidity is very low and plant foliage dries quickly, black spot is seldom a problem.

These three parameters form what is known as the disease triangle. Disease will only occur when there is a susceptible host, a virulent pathogen and an environment conducive for disease development. Disease management involves manipulating one or more legs of the disease triangle. The more factors of each leg of the disease triangle you can manipulate in your favor, the less likely disease becomes. Mastering disease management requires good observational skills of your rose gardens environment, an idea as to the parental heritage in your various roses and thus how susceptible they are likely to be to a disease, and some knowledge of the pathogen.

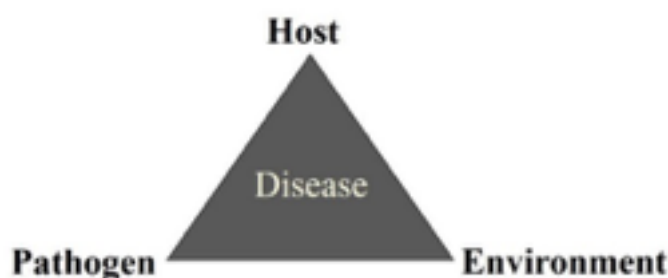


Figure 2A. The disease triangle: for disease to develop, a susceptible host, virulent pathogen and a conducive environment conducive for disease development.

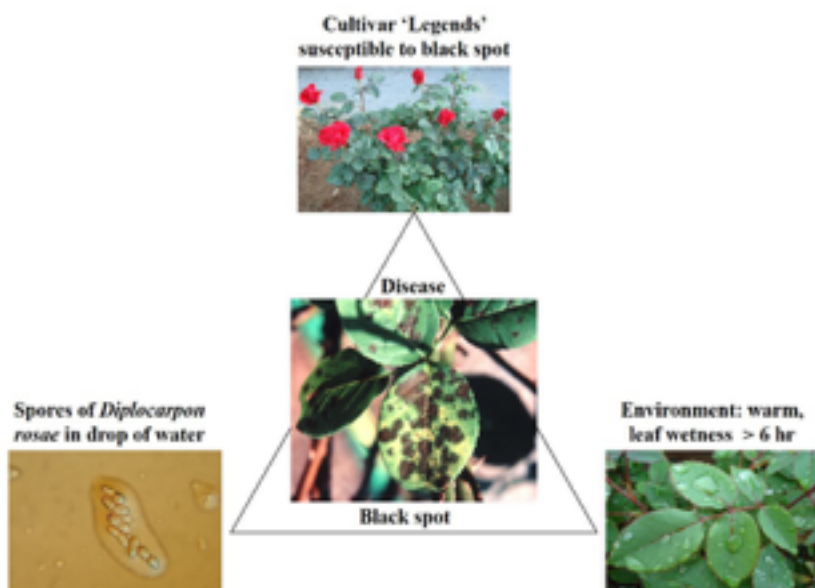


Figure 2B. Disease triangle for black spot (common foliar disease on roses) where the cultivar ‘Legends’ represents a susceptible host, wet leaves represent a conducive environment and spores (conidia) of *Diplocarpon rosae* (the black spot pathogen) must all interact for disease (leaflet symptomatic for black spot) to occur.

Plant Stress and Plant Disease

In university plant diagnostic clinics, nearly one third of 'diseased' specimens submitted for diagnosis are due to abiotic stresses, not diseases. Many of these stresses can be eliminated by using common sense approaches when starting a new garden or when introducing new roses into the garden.

Roses grow best in full sun and in well drained soils that have a pH between 6-6.5. Although roses will grow with some shade, in heavier soils and/or with lower or higher pH, the plants may become stressed and therefore more susceptible to diseases.

Another stress factor often associated with roses is overcrowding. When most rosarians see a new, attractive rose, they want one. However, they may not be willing to give up any plants they already have and do not relish the idea of making a new rose bed. Over years, 'rose census creep' leads to overcrowded beds where roses are competing for sunlight, water and nutrients. Not only do overcrowded plants become more susceptible to disease due to competition, but pathogens are more efficiently disseminated and the environment becomes more favorable when plants are overcrowded and foliage from different plants intertwines.

Disease Management

Successful rose disease management is based on several principles. The first is disease prevention. Disease prevention employs horticulturally sound practices to reduce plant stress; Cultural practices that eliminate or reduce pathogen inoculum (the units of the pathogen, such as spores, used for dissemination) or; enhance environmental conditions that do not favor the pathogen and therefore disease development.

Examples of good cultural practices that lessen the impact of many rose diseases, include promotion of good air movement by proper plant spacing and pruning practices that open bush centers, proper fertilization (plants can be more susceptible to disease if fertilization is too light or too heavy) and raking and destruction of fallen leaves, old flowers, diseased canes and prunings.

Scouting (keeping a wary eye on your plants so that diseases will be detected early) will allow controls to be applied when disease damage is light and when controls are most likely to be successful. To accomplish good disease management requires a plan that integrates different control strategies. This plan is called integrated pest management (IPM) (Figure 3).



Figure 3. An integrated pest management program for managing diseases at a satisfactory level will require being able to properly diagnose the problem and use the correct management tools (education), use of preventative and therapeutic controls (cultural control strategies), using resistant cultivars when available, scouting for problems in the garden throughout the season and when necessary, pesticides.

Host Plant

Growing plants resistant to common diseases is the least expensive and time consuming disease management strategy. Resistance mechanisms in plants can be active or passive defenses and the defenses may or may not be present in the plant before infection occurs.

Unfortunately, resistance is more complicated than just saying “I’ll use a plant that does not get disease.” Plants that are not susceptible to a disease are immune (non-hosts). A resistant plant is susceptible to the disease, but the disease is limited to either a small area on the plant (a single lesion) or the symptoms throughout the plant are mild (Figure 4). Therefore, the definition of a resistant plant often becomes a threshold the grower will accept for maximum disease damage. For example, on a line representing a scale from 0 to 100 percent diseased foliage, the designation for resistance is based on the goals of the plant breeder/plant pathologist (Figure 5). UT AgResearch uses a definition of resistance for foliar fungal diseases as <5percent of the foliage being symptomatic of disease. We were once asked by a rose breeder to use their scale where >50 percent diseased foliage = somewhat resistant. So resistance is a relative term that needs to be used with caution when reading catalog descriptions of new roses. Evaluation of resistance is also partially governed by the growing environment.



Figure 4. Black spot resistance trial where the resistant rose (left) is ‘My Girl’ and the susceptible rose (right) is ‘Peace’. The resistant plant is not immune. Approximately 2 percent of the foliage was covered with leaf spots but defoliation was minimal. However, in the susceptible plant, more than 50 percent of the foliage was covered in leaf spots and defoliation was nearly 100 percent.

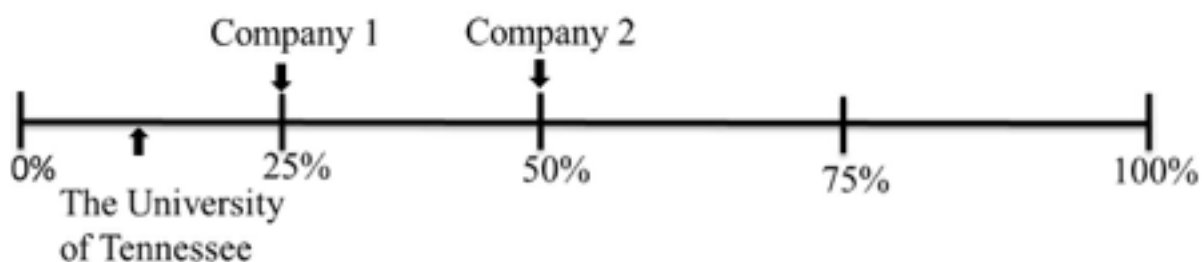


Figure 5. Disease severity (% leaf area diseased) and the term resistance are relative terms in the sense that resistance can be any level of severity that fits the goals of the grower, rose breeder/plant pathologist that is rating plants for disease. We have rated roses for foliar diseases using multiple resistance scale protocols. In this figure, plants with a disease severity of 10 percent, 25 percent and 50 percent were rated as resistant according to rating scales used at the University of Tennessee and two rose companies. For each rating, any plant whose rating was equal or left of the arrow point would be designated as resistant (rose company scales) or moderately resistant (UT scale) and plants rated to the right of the arrow would be designated as susceptible.

Resistance can be classified in different ways. The first method uses the term tolerance which refers to how well the plant performs after it becomes infected with the pathogen. In this classification method, resistance refers to how well the pathogen can multiply on (in) the host and tolerance refers to how well the plant preforms when infected. The two distinctions are independent of each other (Table 1). Note the description in the top, left corner is what is normally considered to be a resistance plant by rosarians whereas the description in the bottom, right corner is considered by rosarians to be a susceptible plant. The description in the bottom left corner is often used to describe a disease tolerant plant. A tolerant plant may have severe symptoms of a disease (severe leaf spotting), but does not defoliate and the plant blooms and grows normally. Tolerance is highly desirable because there is less selection pressure (pathogen overcoming resistance), however tolerance is very difficult to breed for.

TABLE 1. Characterization of resistance/tolerance.

	Tolerant	Intolerant
Resistant	Pathogen cannot multiply and the plant preforms well	Pathogen cannot multiply but the plant performs poorly
Susceptible	Pathogen multiplies profusely in (on) plant and the plant preforms well	Pathogen multiplies profusely in (on) plant and the plant preforms poorly

Resistance can also be classified as horizontal or vertical. Vertical resistance is inferred by a single gene, whereas in horizontal resistance is inferred by many genes. Vertical resistance is easier to achieve as a breeding goal, but is more likely to be overcome by the dynamically changing pathogen. Horizontal resistance is often much more stable than vertical resistance and may be useful for a much longer time.

Pesticides

The most commonly used pesticides for disease control in roses are fungicides. Fungicides should be used in conjunction with cultural control strategies to reduce the need for chemical sprays. In areas, such as the southeastern U.S., black spot may be so severe that cultural conditions alone are insufficient for disease control if susceptible roses are grown. In these cases, scouting is not a good strategy and preventative fungicide treatments are used. Most fungicides will not work satisfactorily if used after the disease becomes severe.

All fungicides work best if used preventatively, before pathogen infection. They will be less effective is infection is established and even less effective if infection is well established. Fungicides, like resistance, can be classified in different ways.

Some fungicides are topicals (contact pesticides). These fungicides stay on the outside of the plant and protect only the foliage that was sprayed. If new foliage emerges after the spray is applied, the new foliage will be unprotected. Also, since the fungicide stays on the outside of the plant, weather can wear it off. Most topical labels call for reapplication every seven-to-14 days. Reapply more

frequently in rainy weather which favors disease and less frequently in dry weather. Heavy dews can require reapplication every 10 days or so. Most topical fungicides kill fungi multiple ways, and resistance to them is quite rare. Examples of topical fungicides include the active ingredients copper, sulfur, captan, chlorothalonil and mancozeb.

Other fungicides may be classified as penetrants (systemic pesticides). These fungicides are taken up (absorbed) by the plant and moved in the plant tissue. There is a complete spectrum of movement of these fungicides inside the plant. Some barely get through the waxy layer on the leaf and redistribute by vapor from one part of a leaf to another. Others move somewhat more, say from one side of the leaf to the other, called a translaminar fungicide. Fungicides in this spectrum of movement offer some of our best leaf spot control.

More active penetrant fungicides can enter the water or transpiration stream (pathway of water movement inside the plant) and in a few days the fungicide will spread upward through the plant. This is called acropetal movement. Many of these can move into and protect new growth; few penetrant fungicides are truly systemic, that is move both upward (acropetal) and downward (basipetal) inside the plant.

Some penetrant fungicides are curative that is they will inactivate the pathogens that have infected the plant but not yet expressed symptoms. Fewer can inactivate fungi expressing symptoms and very few can inactivate the fungal spores (antisporeulant). Penetrant fungicides inactivate fungi by a single mechanism. Fungal resistance to them is not uncommon.

Fungicides should be rotated to avoid loss of sensitivity to the chemical (fungicide resistance) in a pathogen population. Fungicides with the same mode of action should not be rotated with each other. For example, Bayer Systemic Fungicide (tebuconazole) and Fertilome Systemic Fungicide (propiconazole) are different chemicals and sold by different companies but have similar modes of action (how the fungicide negatively impacts the pathogen) (*See appendix*). These fungicides should not be rotated with each other for the goal of avoiding fungicide resistance. A complete list of fungicides that are safe to rotate in a spray program can be obtained via your local Extension office and/or an American Rose Society (ARS) Consulting Rosarian.

Read the label of a fungicide carefully. Many fungicides have formulations that are labelled for homeowner use and other formulations labelled for commercial use. It is illegal to use a product in a residential landscape if the label is for commercial landscape or greenhouse use only.

In Section 2, we have intentionally not listed names of fungicides for recommendations for control of rose diseases, i.e. black spot control, since new products enter and/or are pulled from the market annually. Even if a product remains on the market for several years, changes to the label may occur annually that could either add crops or diseases that can be controlled with the product or delete crops and/or diseases that can be controlled. For a list of fungicides that can be used for preventative or therapeutic control of rose diseases, contact your local Extension office and/or an ARS Consulting Rosarian. At the end of this document, we have added a short addendum that will give examples of spray regimes for control of foliar diseases.

Organic Rose Control

Many people do not wish to use traditional fungicides in their gardens. Under these circumstance, rosarians could use resistant cultivars, other cultural control measures and perhaps biorational pes-

ticides (non-toxic to people with few environmental side-effects) such as bicarbonate of soda (baking soda) to reduce the impact of rose diseases. These approaches work more favorably in some parts of the country than others. For example, rosarians, in some parts of the northern and western U.S., may find baking soda sprays to be an excellent management strategy for black spot whereas rosarians in the southeastern U.S., would observe the treatment to have little effect on disease development. Other organic fungicides include sulfur or copper. Organic fungicides can be effective, but may need to be applied more often than synthetic fungicides. Organic fungicides may also damage roses if not applied as directed on the label.

Often people are interested in organic options because they have safety concerns for themselves, pets, wildlife and the environment. However, the risk to humans, pets, wildlife and the environment are minimal if fungicides are used according to label instructions, the fungicides are stored and disposed of properly and the applicator uses a bit of 'common sense' by wearing protective clothing, chemical resistant gloves and goggles and does not spray on windy days. For more information on how to use, store and dispose of chemicals safely or to grow roses without pesticides, read the fungicide label or contact your local Extension office or an ARS consulting rosarian.

Where to Get Help

There are two different paths to expertise for rose health issues. The first is to contact a consulting rosarian in your area. ARS Consulting Rosarians have had extensive training provided by the American Rose Society and have passed testing to confirm their expertise. They are experienced rose growers and will be knowledgeable of rose health issues in your area. To find an ARS Consulting Rosarian, visit the American Rose Society webpage and look for rose societies in your area (<https://www.rose.org/find-a>). Another way is to do a web search for ARS Consulting Rosarians. For example a web search for ARS Consulting Rosarians turns up contact information for more than 50 ARS Consulting Rosarians in the TENARKY District – Tennessee, Arkansas and Kentucky (<http://www.tenarky.org/Consulting%20Rosarians2.htm>).

The other route is to contact your local county Extension office. They can aid you in disease diagnosis and management strategies. If necessary, they can help you take a proper sample to send to your state's diagnostic laboratory. There may be a small fee for this service. You can find your state diagnostic laboratory by going to <http://npdn.org> and clicking on the image of the appropriate state. Also for a fee, the Extension service can have your soil tested so that you can tailor your fertility program to your specific garden's needs and get your roses off to a good, healthy start each spring. To find your local Extension office, do a web search for Extension in your state. For example, if you search for local offices Tennessee Extension Service, you will be led to a map of the state where you can click on your county and get contact information for the local office (<https://extension.tennessee.edu/Pages/Office-Locations.aspx>).

SECTION 2: ROSE DISEASES AND THEIR MANAGEMENT

Where to start. The first step for disease control is a proper diagnosis of your problem. Use the following key to aid you in your diagnosis. If you use the key and the corresponding disease descriptions and are not confident in your diagnosis, contact a ARS Consulting Rosarian or your local county Extension office for more information.

Key to Rose Health Problems

1. White powdery substance on upper leaf surfaces and perhaps on young flower buds. Leaves may be reddish and distorted... **Powdery mildew**
2. Spots on leaf surface
 - a. Spots brown to black, edges of spots are feathery and diffuse into the green tissues. Leaves or parts of leaves may be yellow and falling off the plant... **Black spot**
 - b. Spots are angular (limited by veins) and may be red, maroon, purple or black. Plants may defoliate rapidly, even at onset of the disease. There may be areas on the stem that are red or are red and have a small stem split in them... **Downy mildew**
 - c. Spots have defined borders and are roundish. Spot borders may be maroon to purple. Center of spots may be dead tissue (brown to gray centers).
 1. If disease is occurring during hot, humid weather... **Cercospora leaf spot**
 2. If disease is occurring in late fall/winter in the Deep South or in cool weather in late spring to early summer in western or northern locations... **Anthrachnose**
 - d. Faint yellow/orange spots on top surface; lower surface spots are yellow/orange and powdery. A white tissue rubbed on the lower surface, will come away with a yellow/orange powder... **Rust**
3. Blighted (rotted) or spotted petals.
 - a. Petals turning gray, brown or tan, often with fine gray spores... **Botrytis blight.**
 - b. Petals with small pink to purple spots; spots may have clear centers... **Ghost spotting.**
4. Cankers found on stems.
 - a. Usually begin during winter months and may be 2 or more inches long by spring. Cankers are often brown, sometimes with a greenish brown leading edge on the lower side of the canker... **Stem canker.**
 - b. Leading edge of the canker is a bright yellow and may have moved into the cane from the petiole of a leaflet or from a smaller branch. Moves quickly downward. Most common in the Deep South informal name, **Cane blight (anthracnose).**
5. Plant dies quickly, usually during periods of stress due to drought. Tan to brown mushrooms at base. White fungal growth may be present on roots or in the crown of the plant (where the canes meet the soil) if a knife is used to scrape off the outside bark... **Armillaria root rot.**
6. Plants are stunted and may wilt in hot weather even if soil is moist. Leaf edges may be necrotic. May produce canary yellow leaves which turn yellow and defoliate from the ground upward. Root systems are dark brown to black, generally lack fine feeder roots and roots break easily... **Phytophthora root rot.**
7. Galls (tumors) in foliage, stems and/or roots. Galls range from marble-to- Ping-Pong ball or larger in size. Older galls may be dark and appear woody... **Crown gall.**

8. Leaves have bright yellow to white line patterns, ringspots and/or mosaics. Symptoms may disappear in heat of summer and reappear later... **Rose mosaic.**

9. Plants with reddish thicken stems, increased thorniness, strapped (usually long/thin leaves), distorted flowers, and rosettes (bunches of short stems coming from same area on a stem (cane)). Often affect part of rose is reddish. Affected stem and/or whole bush die after overwintering... **Rose rosette.**

10. Stems may be flatten and look like they were run over with a steam roller....**Fasciation.**

11. Yellowish gooey substance on mulch that dries to tan to brown color and is crusty... **Slime molds.**

12. Small cones or basket looking objects that appear to have tiny eggs in them... **Splash cup or bird's nest fungi.**

Powdery Mildew

Powdery mildew is caused by the fungal pathogen, *Podosphaera (Sphaerotheca) pannosa*. Signs of the pathogen include white, powdery fungal growth on leaves, petioles and flower buds (Figure 6). Symptoms of powdery mildew include blistering and twisting of leaves and premature reddening foliage.



Figure 6. Signs and symptoms of powdery mildew on roses. The white powdery appearance of the leaves is due to the thallus (body) of the pathogen (fungus) and its spores. Symptoms, which are host response to infection and colonization by

the pathogen, include twisted and distorted leaves and flower buds and reddening of foliage. Symptoms may vary by cultivar.

Powdery mildew may be severe in periods of warm, humid weather when rainfall is limited. Although high humidity is needed for spore germination, free moisture inhibits germination of spores. The spores are disseminated in air currents. The fungus overwinters in infected rose canes and as sexual fruiting bodies found in leaf litter.

Management of powdery mildew includes cultural strategies such as removal of diseased foliage and canes, dormant oil sprays in the winter, resistant cultivars and fungicides. Fungicides are more effective as a protectant before disease development instead of being used to attempt control after the disease becomes severe in the garden.

Black Spot

Black spot is caused by the fungal pathogen *Diplocarpon rosae*. Symptoms include black to brown spots with diffuse (feathery) borders (Figure 7). Spots can coalesce and cause leaf blotches and blights. Often leaves turn chlorotic (yellow) before defoliating. After defoliation, canes may be bare of leaves except at the growing tips. Early in the season, spotting occurs on older leaves near the bottom of canes and progresses up the canes during the growing season. After dropping most of their leaves, susceptible plants may refoliate only to have the leaves drop off again after symptoms of black spot appear on the new leaves. The defoliation/refoliation cycle can occur several times during the growing season. Purple to black lesions may be formed on the canes in the fall. Plants with severe symptoms are stunted with smaller and fewer flowers. After several years of severe symptoms, stunted plants may die.



Figure 7. Black spot lesions can vary from brown (A) to black (B). The spots have diffuse borders (feathery edges) and this differentiates spots (lesions) of black spot from other diseases such as anthracnose and cercospora leaf spot. Lesions may coalesce and entire leaves can appear to be blighted. Symptomatic leaves often turn chlorotic (yellow) and fall from the plant. Many susceptible rose cultivars defoliate so severely that most of the canes are devoid of leaves except at the top of the plants (C).

Spores of *D. rosae* require at least six hr of free water to germinate and plants to become infected (Figure 8). Therefore, black spot is favored by warm, wet weather. High humidity that prevents foliage from drying quickly in the morning will also favor the disease. The fungus will also sporulate (produce spores) on defoliated foliage laying at the base of the plant. This is one reason why the disease seems to spread from the base of the plant upwards.



Figure 8. Black spot spores will not germinate unless exposed to free water (high humidity is not good enough). Care should be taken to reduce the time that leaves are wet each day.

Cultural controls for black spot include sanitation (cleaning of defoliated debris in late winter, early spring), proper pruning to insure good air movement through the canopy, and watering so that the length of time foliage remains wet is reduced (Figure 9). Drip irrigation can also be used to reduce the length of time that foliage is wet.

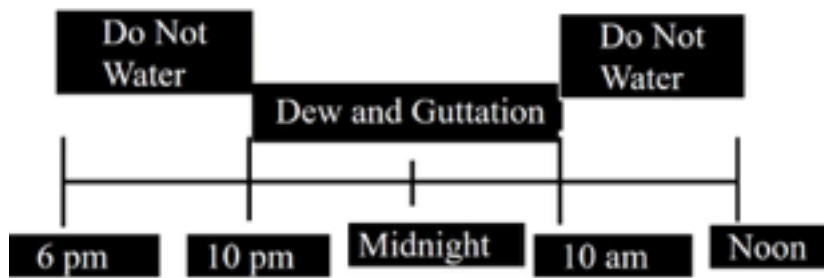


Figure 9. Timing of irrigation that would prolong leaf wetness hours in a rose garden should be avoided. For black spot control, watering outside this window of leaf wetness would be beneficial.

Resistance for black spot in modern rose cultivars is becoming more common since rose companies made black spot resistance a breeding priority. However, you must be cautious when a plant is claimed to be resistant. UT AgResearch tested over 200 cultivars for black spot resistance that had been marketed as disease resistant claims by rose companies. Only about 10 percent of the cultivars displayed acceptable levels of resistance in the multiyear study. Since that study's completion more than a decade ago, some of the roses that were rated as resistant have failed in studies in other parts of the country. The most likely reason is the ability of the black spot pathogen to make genetic changes and perhaps differences in environmental conditions. There are many races of the black spot pathogen known to exist in the United States; the list of new strains of *D. rosae* keeps growing.

In parts of the U.S. where black spot severity is high, fungicides may be required to successfully grow many cultivars of roses. These fungicides will be most effective if used preventatively. Since the pathogen is known to rapidly change genetically, it is important to rotate fungicides with different modes of action.

Downy Mildew

Downy mildew is caused by the fungal-like organism, *Peronospora sparsa*. Although the pathogen resembles a fungus morphologically, in the way it is disseminated and how it infects a host, *P. sparsa* is not a fungus. The organism is closely related to diatoms and brown algae. This lack of genetic relationship with fungi is why many fungicides that are used to control foliar fungal diseases do not work for downy mildew. Symptoms of down mildew include angular brown to red to purple lesions that may be limited by veins in the leaf. Defoliation can be severe and occur before leaf lesions are detected (Figure 10). Foliar symptoms (spots and blights) can be variable and are dependent on host genetics (Figure 11).

Figure 10. Defoliation from infections of downy mildew can be severe. Plants can become completely defoliated three days after initial infection if the environment is conducive (cool temperatures and high humidity). Plants may drop their leaves before leaf lesions appear. The photos below are from



the same poly house taken just seven days apart after downy mildew spread throughout the house.

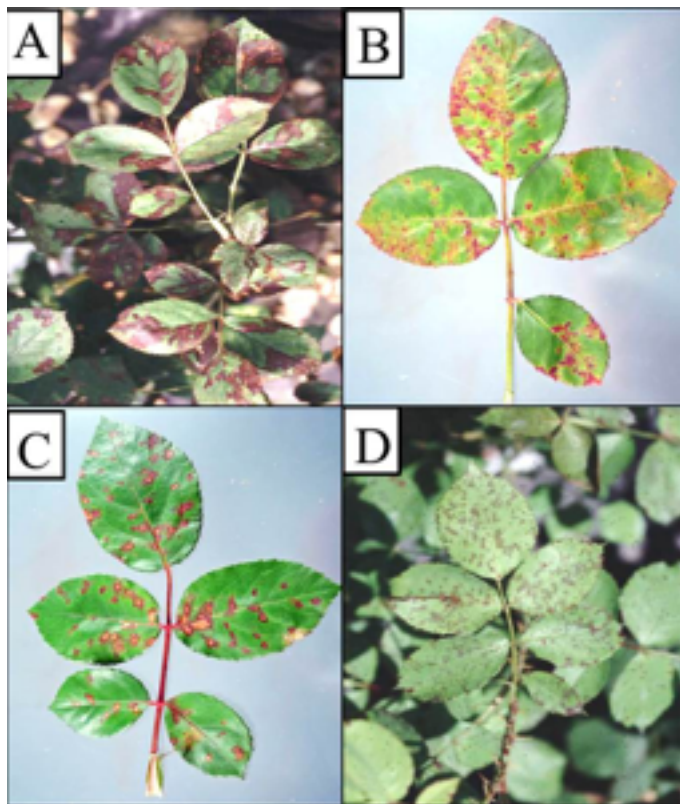


Figure 11 (LEFT). Foliar symptoms of downy mildew can vary depending on the cultivar: A) 'Rio Samba', B) 'Dolly Parton', C) 'Double Knock Out', and D) 'Climbing Joseph's Coat'.

Signs of downy mildew (sporulation) can be found on the lower leaf surface. Look for whitish angular areas between veins (Figure 12). Although symptoms on the upper leaf surface may be very severe, signs on the lower leaves may be difficult to see without a hand lens. The sparse signs on the lower leaf surface are why the species was named *sparsa*.

The optimum environment for downy mildew development is cool temperatures (40-74°) and high humidity (>85 percent). These conditions often occur in unheated poly-houses in the spring shortly after sunset when relative humidity spikes as air temperatures rapidly decline. Spores will germinate rapidly (in four hr) in free water on leaves. The pathogen overwinters in infected canes and roots.



Figure. 12 (ABOVE). Signs of downy mildew are found on the lower leaf surface between leaf veins (see arrows) which will give the whitish patches an angular shape.

Control downy mildew may be difficult once an outbreak occurs. Sanitation (picking up dropped leaves), rouging symptomatic bushes (removal of bushes) and protectant fungicides labelled for downy mildew control may be necessary. If roses are in a poly house or green house, a good cultural practice for reducing favorable conditions for disease development is to open green-houses (and use fans if possible) to replace the air in the greenhouse before shutting the greenhouse up for colder night temperatures. At the end of the day, air outside the greenhouse contains much less water than the air in the greenhouse where plants have been transpiring (losing water through their foliage) all day.

Cercospora Leaf Spot (CLS)

This foliar leaf spot disease is caused by the fungus *Cercospora rosicola*. In some states, CLS may be as severe as black spot. Symptoms of CLS include purple, maroon and/or black lesions on upper surfaces of mature leaves (Figure 13). The spots may enlarge and have brown to gray necrotic centers. Some cultivars may defoliate with heavy disease pressure. This disease may be confused with black spot and anthracnose. However these diseases can be easily separated. Black spot lesions have diffused (irregular or feathered) borders whereas CLS lesions have discrete borders. Anthracnose and CLS can be separated by season. Anthracnose being a cool season disease and CLS is a hot season disease

Cercospora leaf spot commonly occurs in hot (>85°), humid weather. The disease was thought to be only a problem in the Deep South, but the range has expanded northward with warming temperatures. Plants thought to be resistant to black spot may defoliate from this disease in warm seasons with prolonged periods of rainy weather. Cercospora leaf spot may be a problem if black spot resistant cultivars or species are being used and fungicide sprays have been eliminated. Little research has been done with this disease and little is known about how the environment influences the pathogen's disease cycle.

Control of CLS is similar to that for black spot. Fungicides that are effective for blackspot are also effective for CLS. Recently, public and private breeders have started to focus on breeding CLS resistant plants since this disease is becoming more prevalent.

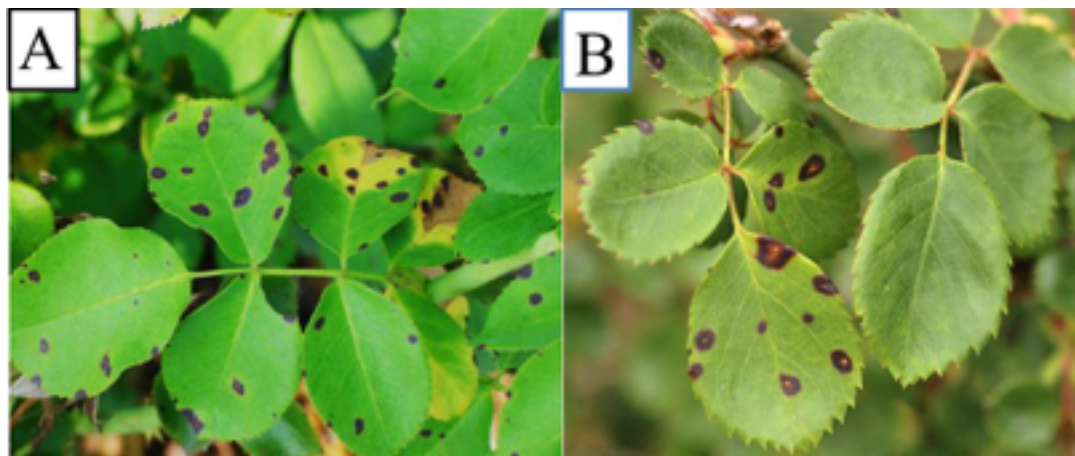
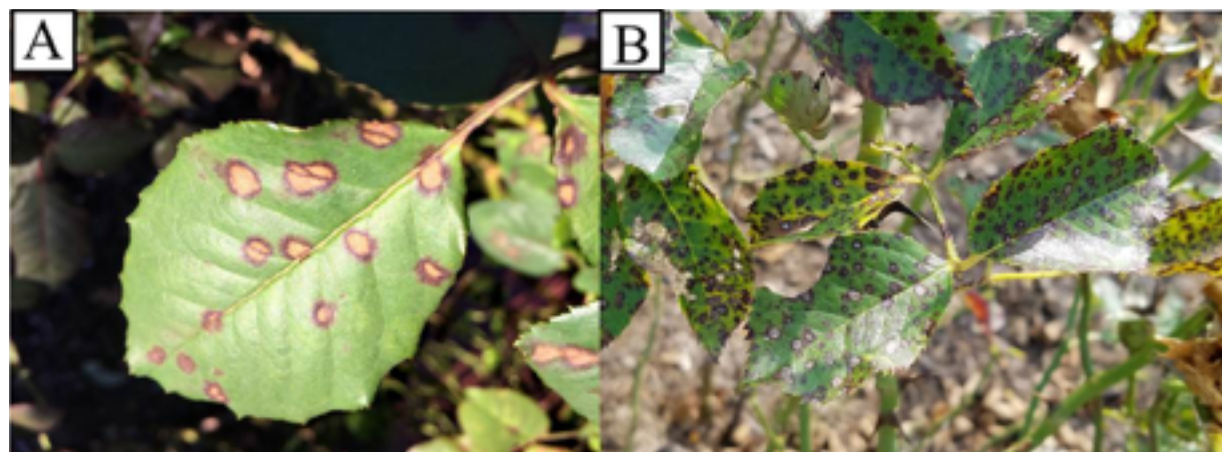


Figure 13. Leaf spots of cercospora leaf spot begin as small purple to maroon spots (A) that enlarge to have brown to gray necrotic centers (B).

Anthracnose

Anthracnose is a fungal disease caused by *Sphaceloma rosarum*. This disease is common in the northern half of the country and in the Deep South where roses may hang on to foliage into winter months. Symptoms of anthracnose in northern areas occur in the spring and include leaf spots on upper leaf surfaces with red, maroon or purple borders. Lesion centers often turn brown or gray and may drop out of the lesions giving the leaflet a shot hole appearance (Figure 14). In severe cases, leaf drop may be severe. The disease may move out of the leaf into the petiole and into the cane where it may rapidly form a bright yellow canker. Spores of the pathogen are spread by splashing rain. Having plants well-spaced and use of drip irrigation may slow the spread of this disease. Fungicides approved for black spot and CLS are effective.

Figure 14. Anthracnose foliar lesions have red, maroon to purple borders and necrotic centers that



may be brown (A) or gray (B). Photo A courtesy of Clyde Graves.

Botrytis Blight

Botrytis blight, also called gray mold, is a fungal disease caused by *Botrytis cinerea*. The disease is common on petals of older flowers, but can be found on flower buds and leaves (especially when leaves are touching each other) following periods of cool, wet weather. Rose blooms with high petal count are affected by this disease because blooms may hold water between the petals for protracted periods of time. Signs of the pathogen (greenish to grayish fuzz) are often visible with a hand lens on blighted petals and leaves early in the morning with a hand lens while humidity remains high.

Management of botrytis blight during rainy weather may be difficult. Prune out any blighted foliage or blooms as soon as possible to reduce the number of spores. Dead head (pruning of blooms) bushes on a regular schedule to prevent older blooms from serving as a source of the fungus. Companion plants grown with roses are becoming more common. Avoid 'self-cleaning' plants such as geraniums as these plants are a common host of Botrytis. Fungicide resistance is a problem for greenhouse grown roses; rotate fungicides with different modes of action.



Figure 15. *Botrytis blight is common of older flowers that are near or beginning to drop petals (A). Flower buds can also become blighted following long periods of rain (B). Blooms with high petal counts may have lower petals blighted by this disease after rains due to water be held between the petals for protracted periods of time (C).*

Ghost Spotting

Ghost spotting is caused by several fungi including species of *Bipolaris*, *Botrytis*, *Cercospora* and *Cladosporium*. Symptoms include small pink to white spots with pink borders (Figure 16). Spots can coalesce to blight petals.

Ghost spotting may be severe during prolonged periods of rain. Control is difficult and usually limited to dead heading affected blooms. Many years ago in Knoxville, Tennessee, a rose show was held shortly after several weeks of rainy weather. Many of the roses on display were heavily damaged with ghost spots on the petals. One entrant won practically every award because he had protected his buds and developing flowers by placing umbrellas made of cardboard buckets attached to tomato stakes over his blooms to protect them from the rain (and thus ghost spotting). Protectant fungicides are of little use due to the environment (rain) conducive for this disease. Systemic fungicides are also ineffective as little fungicide accumulates in the petals.

Figure 16. Ghost spotting is caused by several different fungi and can be difficult to control in rainy weather. Symptoms include small whitish lesions with pink to purple lesions. Lesions can coalesce to blight petals.



Rust

Rust is caused by the fungus *Phragmidium mucronatum* and *P. tuberculatum*. This disease is a common problem in the Western U.S. and occasionally a problem in the East. Recently roses in a wholesale nursery in a southern state were decimated by rust. Symptoms include faint yellow spots on upper leaf surfaces; signs are yellow-to-orange pustules on the lower leaf surface (Figure 17). Some rose cultivars tolerate rust; intolerant cultivars may completely defoliate with only one to a few pustules on leaves.

Rust is most severe in humid, cool weather. Although rust can be severe in western states bordering the Pacific Ocean each year, most of the country is spared consistent outbreaks of this disease due to hot temperatures in the summer and very cold temperatures in the winter which inhibit rust survival. Rose rust is monoecious (has only one host).

Control is often achieved by removing infected leaves and canes with pustules. In locations with a history of rust, protectant fungicide sprays may be necessary. Some cultivars are more resistant or tolerant to rust than others.

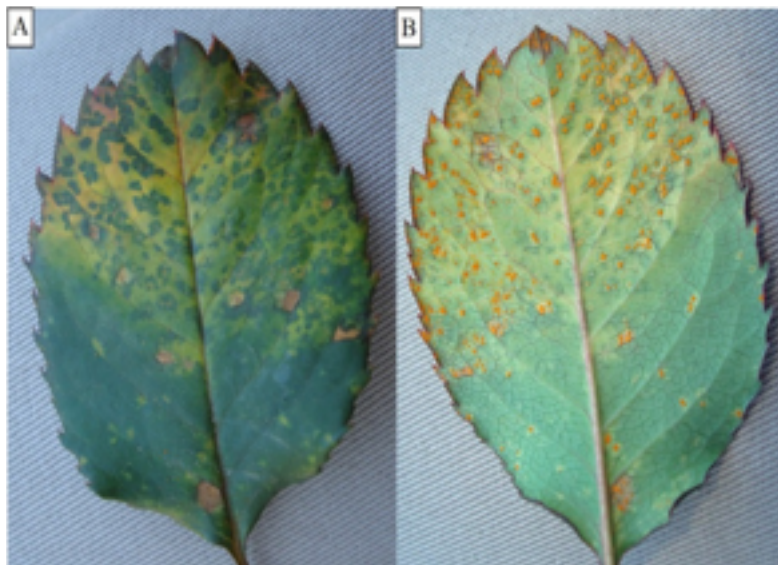


Figure. 17. Symptoms of rose rust include yellow spots on upper leaf surfaces (A). If the leaves are turning yellow, the yellow spots may be surrounded by a green halo. This is called the green island effect. Signs of rust are yellow/orange pustules of spores on lower leaf surfaces (B).

Stem Canker

Stem canker on rose canes (stems) are caused by several fungi including *Cryptosporella umbrina* and *Coniothyrium spp.* Symptoms begin as small red to purple lesions on canes that enlarge to 1-3 inch tan-to-brown cankers on stems (Figure 18). Canes may die rapidly above the canker. Signs of



pathogens are small gray-to-black fungal fruiting bodies on canker tissue. Brown stem canker often occurs during winter months. Control is limited to pruning out cankers as soon as detected. Cankers tend to grow to the base of a node, so make pruning cuts as close to the top of a node as possible. Pruning cuts should also be at an sight angle that will prevent water from sitting on top of the cane. Do not use dull pruners or anvil style pruners as crushing wounds from these pruners take longer to heal. Fungicides are not effective for management of canker diseases.

Figure 18. Stem cankers on roses during winter months are common and can destroy entire rose bushes. Cankers can be several inches long and are commonly whitish brown.

Armillaria Root Rot (ARR)

Armillaria root rot of rose can be caused by several species of the fungus *Armillaria*. This disease is becoming more prevalent in gardens across the U.S. Armillaria root rot is often found in rose beds near sites where a tree was removed. Stump grinding may not be sufficient since large roots will remain below soil line. Symptoms include rapid bush decline. Brown to honey colored mushrooms will often be seen sprouting from the mulch at the base of the dying plant (Figure 19). Control of



this disease is extremely difficult. *Armillaria spp.* are soil inhabitants (live indefinitely in soil) and the fungus will invade more soil each year. When this happens, roses may die throughout the rose bed as the fungus moves out from its site of origination. The only way known to stop the advance of ARR is to dig a small width trench four feet deep between where ARR is known to happen and the healthy plants nearby. Once the trench is dug, place a four foot high piece of sheet metal in the trench before backfilling the trench. However, this method is impractical for most gardeners. Often affected beds are returned to grass or used to plant herbaceous ornamentals.

Figure 19. Plants may die rapidly once infected by *Armillaria spp.* At the base of affected plants will be brown to honey colored mushrooms. Photo courtesy of Dr. Baldo Villegas.

Phytophthora Root Rot

This root rot can be caused by more than one species of *Phytophthora*. The disease may occur in roots or at the soil collar. Symptoms include dark brown roots (Figure 20) and stunted root systems. Above ground symptoms include stunted plants. If root rot is severe, foliage may wilt.

Although *Phytophthora* species are not true fungi, they are known as water molds. This disease is much more severe in poorly drained soils. If drainage is a problem, use raised beds with soils that will drain well (sandy soils). Do not over-water rose beds. If *Phytophthora* root rot is severe, discard the plant. Planting back in the same hole may be futile if drainage issues are not corrected.



Figure 20. *Phytophthora* root rot is characterized by dark brown roots that are easy to break apart. Plants with such root systems are often stunted.

Crown Gall

Crown gall is a bacterial disease caused by *Agrobacterium tumefaciens*. Symptoms are galls (tumors) located in aerial parts of stems (often near pruning cuts), at the soil line or on roots (Figure 21). Some cultivars can tolerate large and/or numerous galls without loss of vigor. Other cultivars are very intolerant and may decline rapidly with only one small gall (the size of a marble). As galls age, they can harden and appear to be woody (turn brown to black).

Agrobacterium tumefaciens is a soil inhabitant (the pathogen's population is stable in soil indefinitely). Digging an infected plant up and replacing the diseased plant with another plant may not yield satisfactory result. For most roses, digging up the rose and replacing two bushels of soil (approximately two wheel barrows of soil) that the diseased rose was growing in may be necessary to eliminate the problem. Another solution would be to abandon the infested bed and return it to grass. Carefully inspect all new plants, including roots, to ensure that this pathogen is not introduced into your garden. Crown gall can also be spread by pruning with bacteria contaminated pruners. If you have had crown gall problems in the past, thoroughly clean pruners with a sanitizer such as



70 percent isopropyl alcohol, Lysol, etc. between pruning rose bushes. Bleach (20-50 percent aqueous solution) is an effective sanitizer but may corrode metals and therefore dull pruners.

Figure 21. *Crown gall symptoms include galls that can range from less than a marble in size to being larger in diameter than a baseball. Galls can form on stems, at the soil line and on roots. As galls get older, they turn from whitish tan to brownish black and may appear to be woody (hard). Photo courtesy of John Olive.*

Rose Viruses

There are more than 30 viruses known to infect roses. Only half of these viruses cause symptoms and/or affect growth of infected roses. Symptoms of virus infection include: mosaic, mottle leaves, line patterns, ringspots, leaf curl or witch's broom (rosette) (Figure 22). Rose mosaic may be caused by one or more viruses in this group: Prunus Necrotic Ringspot Virus, Apple Mosaic Virus and Arabis Mosaic Virus. Roses infected with a virus associated with rose mosaic may produce fewer blooms with shorter stems. (source: <http://www.rose.org/rose-care-articles/rose-mosaic-virus-effects/>) Rose rosette virus kills infected roses. Rose Rosette Virus will be covered separately.

Most rose viruses are not spread by pruning or by vectors. They are disseminated through propagation of infected plants. Management is simple. Inspect plants before purchase; don't bring a symptomatic plant home. If the rose is not for exhibition and tolerating the infection, there is no reason to remove it since the viruses in the plant cannot spread to other roses in the garden.



Figure 22. *Symptoms of rose viruses include mosaics, ringspots, line patterns and vein banding. Often symptoms fade in the heat of summer (become masked) but return in the fall and/or next spring.*

Rose Rosette Disease (RRD)

This lethal disease of roses is caused by Rose Rosette Virus (RRV). Symptoms of the virus are variable and include mosaics, strapped leaves (usually thin), a profusion of shoots with short internodes on one cane (witch's broom or rosette), hyperthorniness (profusion of thorns), thickening of stems, reddening of foliage and stems, distorted buds and flowers, stem (cane) death, and plant death (Figure 23). Some large shrub roses can survive with the disease for many years. However, most plants symptomatic for RRD will decline and die in 3-5 years (Figure 24). Young plants may die in the first year of symptoms.

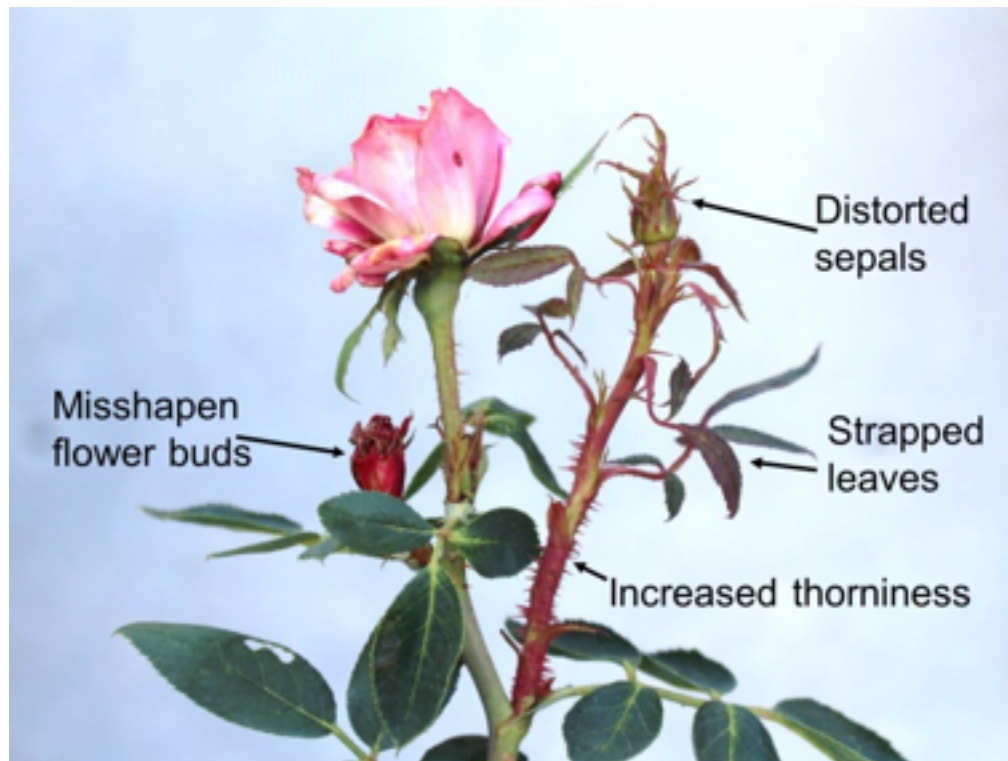


Figure 23. Symptoms of rose rosette disease can include strapped leaves, thickened stems, increased thorniness (hyperthorniness) and distorted flower buds.

reddening of foliage and stems, distorted buds and flowers, stem (cane) death, and plant death (Figure 23). Some large shrub roses can survive with the disease for many years. However, most plants symptomatic for RRD will decline and die in 3-5 years (Figure 24). Young plants may die in the first year of symptoms.

The virus is transmitted by the eriophyid mite, *Phyllocoptes fructiphilus* (Figure 25). These mites are the size of dust particles and only visible with a microscope (>40X). The mite is wingless, has four legs and no eyes.

When temperatures reach

the mid 80's, mites will release themselves from their host plant and float in air currents (called ballooning). Mites can survive up to 5 days off a host and be blown a considerable distance from the source plant. When *P. fructiphilus* females hatch, they lay eggs that yield only males as long as they are unfertilized. Once fertilized, females lay eggs that yield only females. During summer months, large populations of mites can develop on rose plants and plants symptomatic for RRD may have as many as forty fold more mites than healthy roses.

Figure 24. Plants infected with Rose Rosette Virus may die in 3-5 years after becoming symptomatic.



2011

2012

2014

In this retail mall, the hedge of shrub roses died from rose rosette disease.



Figure 25. *Phyllocoptes fructiphilus*, the rose mite, is 156 X 48 microns in size (about the size of a dust particle), has four legs, no eyes and no wings. It can balloon in the air for up to five days. This is an adult female. Photos courtesy of Katherine Solo and Gary Baughan.



Figure 26. Eriophyid mite populations can be very high on plants infected with rose rosette. The plant should be bagged before removal. For ease of removal, the bagged top can be cut from the root ball. The root ball needs no special treatment since the mites are not in the soil. Photo by Ann Peck.

Rose rosette disease can also be spread from one location to another by movement of diseased plants. Infected plants may remain without symptoms (asymptomatic) for up to one year and these plants are very difficult to detect until they are planted and display symptoms of RRD. When plants with symptoms are detected, the safest thing is to bag the top of the bush to prevent movement of mites (Figure 26) and cut the bagged bush off at the soil line. The root ball can be dug and discarded. Root systems do not have to be bagged as the mites do not live in soil.

Pruning symptomatic foliage from an infected plant will not save a plant. When a symptomatic plant is removed, a new plant can be placed in the same location one week later. Adjacent plants should be watched for several months to make sure they were not infected as well. If symptoms are detected in a neighboring plant, it should be removed

as well. Quick removal of infected plants will aid in keeping mite populations low and reduce movement within the garden. If the plant cannot be removed quickly, pruning of rosette(s) will reduce vector populations temporarily since mite populations are forty fold or greater on rosettes than on asymptomatic tissues. However, removal of rosettes will not 'cure' the plant and the plant will still need to be removed.

Multiflora rose is an exotic, invasive plant that is also a host of the virus and mite. This rose is often found along fence lines and forest edges in rural areas and can serve as a source of both the mite and virus. In urban areas, the greatest source of the mite and virus are large plantings of shrub roses that are infected with RRV and infested with *P. fructiphilus* (Figure 27).

Some miticides have been proven to be effective in reducing the impact of RRD in roses. However, when to begin spraying and the interval between sprays is still unknown. Therefore, miticides cannot be recommended at this time. If a rose garden is free of symptomatic plants but a population of symptomatic plants is upwind from the location, a barrier such as a privacy fence or tall vegetation will impede mite dissemination and aid in reducing the threat to the garden. Employees of state and federal laboratories and private rose companies are working together to develop resistant roses. There are no rose cultivars known to be resistant to RRV at this time.

Although RRD has killed thousands of roses in eastern states, the disease is manageable. One of the weak links in the disease cycle is the mite vector. It cannot see a rose bush nor can it intentionally fly to one. It relies on large numbers floating in the air and landing on a rose by chance. In the rose garden the following steps can reduce the threat of RRD greatly. The first steps are:

1. Know the symptoms associated with RRD.
2. Remove any bush at first symptoms to prevent mite populations from building on the bush to levels where mites are ballooning to other bushes
3. Wait one week and transplant another bush into the hole left from the plant removal in step 2.
4. Carefully monitor bushes around the location of the removed plant to ensure you stopped the disease in its tracks.



Many gardeners have followed these steps and have successfully managed this disease.

Figure 27. In urban areas, commercial beds of shrub roses can serve as reservoirs of Rose Rosette Virus and eriophyid mite vectors.



Figure 28. Rose fasciation is characterized by flatten stems that look like the stem was run over by a steam roller (A). Fasciated stems often have distorted leaves and flower buds (B).

ODDITIES IN THE GARDEN

Rosarians are observant and love to be among their roses. Sometimes things appear and we do not know if it is a potential threat to the garden or something to observe and just be amazed. Below are a few of these rose garden “oddities.”

Fasciation

Fasciation in roses involves the flattening of a stem and a profusion of flower buds (Figure 28). Most plant fasciations are thought to be genetic mutations. Fasciation in some herbaceous plants may be the result of a bacterium known as *Rhodococcus*. The cause of fasciation in rose is unknown. Whatever the cause, the phenomenon does not spread to other roses in the garden.

Slime Molds

Slime molds are small organisms that are more closely related to protozoa than to fungi. They are not plant pathogens. Slime molds are often observed on hardwood mulch in rose beds and may creep up onto rose foliage. However, they do not harm the rose and after a hard rain disappear from the foliage. To avoid slime molds, use a mulch other than hardwood mulch.



Figure 29. *Slime molds do not harm roses but are often seen in rose beds.*

Splash Cup or Bird's Nest Fungi

Bird's nest fungi are decomposers of mulch and are not plant pathogens. They are commonly observed in mulch around roses and the patches can be large.



Figure 30. *Bird's nest fungi are common in mulch in rose gardens but are no threat to rose bushes.*

APPENDIX: DISEASE MANAGEMENT PROTOCOLS FOR FOLIAR FUNGAL DISEASES

If fungicides are needed to manage diseases, use fungicides that are labeled for residential gardens. Read the product's label before using the fungicide. It is a violation of federal law to use a pesticide in any way other than specified on the label. Wear personal protective clothing and do not spray on windy days. If you have questions, contact your County Extension office and/or an ARS Consulting Rosarian. The advantages of using pesticides labeled and packaged for residential gardens include: are less expensive, easier to measure, not as concentrated if accidentally exposed to chemical before it is diluted with water and less waste from pesticides being left over beyond their shelf life.

Often there are multiple products with the same active ingredients when you shop for fungicides at garden centers and box stores. Other products labelled for homeowner use with the same active ingredients would be as effective. ***Use of a specific brand in the appendix is for example only and is not an endorsement of one product over another.***

Powdery Mildew: at first signs of powdery mildew spray with either Bayer Advanced Disease Control Fungicide, Fertilome Systemic Fungicide, or Spectracide Immunox every 10-14 days. If problem persists, rotate with Daconil or Mancozeb. Then go back to the first product used. Continue rotation as needed.

Black Spot. The first spray of the season should be with Mancozeb. This fungicide is active for both black spot control and downy mildew. Seven to ten days later, use Bayer Advanced Disease Control Fungicide, Fertilome Systemic Fungicide, or Spectracide Immunox with a 7-14 day interval. After two sprays, rotate with either Mancozeb or Daconil and then go back to one of the three systemic fungicides.

Downy Mildew. Apply Mancozeb or Agri Fos every 7-10 days as long as the environment is conducive for downy mildew.

Cercospora Leaf Spot. Follow black spot protocols.

Anthracnose. When the environment is conducive for anthracnose, use the black spot protocol.

Rust. Follow black spot protocols.

Table 1. Information about fungicides used as examples above. Other products with the same active ingredient will be as effective.

Fungicide Example	Active Ingredient	Type of Protection
Agri Fos	mono and dipotassium salts of phosphorous acid	systemic
Bayer Advanced Disease Control*	tebuconazole	systemic
Daconil	chlorothalonil	protectant
Fertilome Systemic Fungicide*	propiconazole	systemic
Mancozeb	zinc and manganese ethylene bisdithiocarbamate	protectant
Spectracide Immunox*	myclobutanil	systemic

*Chemicals have similar mode of action and should not be rotated with each other.

About the Authors



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