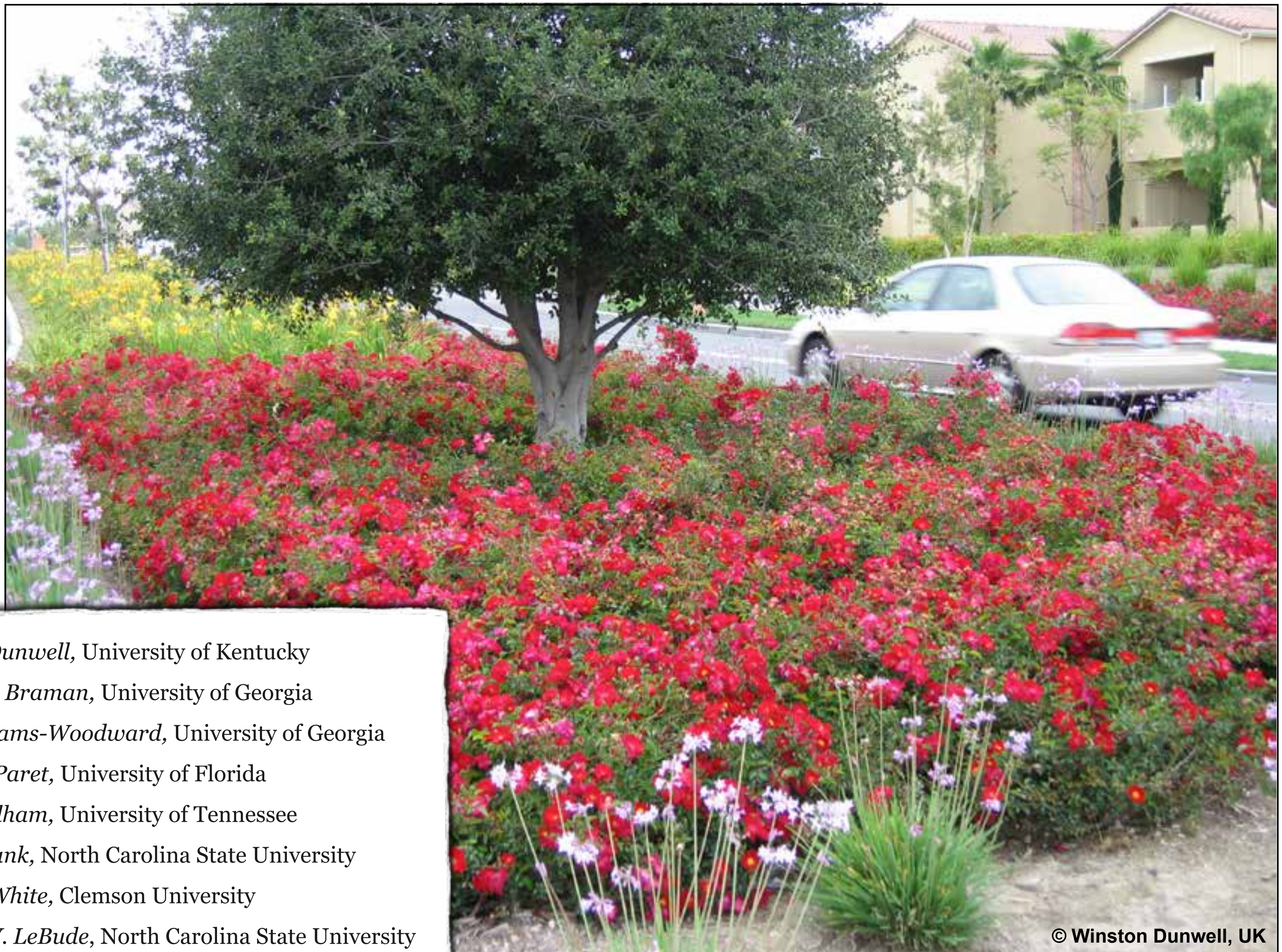
Shrub Roses - *Rosa* spp.



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Section 1

Introduction

Shrub Rose Basics

1. Introduction
2. Species and Cultivar Characteristics
3. Horticultural Management and Production Practices
   a. Propagation
   b. Irrigation
   c. Fertilization
   d. Pruning

Introduction

Shrub roses are grown worldwide with many native to the southeastern U.S. The term shrub rose includes a number of rose species and cultivars. Among shrub roses, there is large diversity in size, flower, flowering duration, habit, hardiness, heat tolerance, fragrance, and foliage characteristics. Disease resistance in some shrub rose species has led to them being used in breeding programs to develop disease-free roses. Modern shrub roses have made it possible to grow roses without pesticides, but tolerance of some insect injury may be needed or managed by non-chemical means.

Dr. Michael Dirr refers to shrub roses as "Lower Maintenance Roses" in his Manual of Woody Landscape Plants (Dirr, 2008). Carefree Beauty™ (*Rosa* 'BUCbi', 1977, Plant Patent No. 4225) is a medium pink shrub rose that started the trend for roses with dark green foliage that were disease free with fragrant, ever-blooming flowers. Carefree Beauty™ is resistant to black spot and powdery mildew and is still available in retail markets. Meidiland™ (Meilland), David Austin®, Flower Carpet®, and Carefree were some of the first roses series to capture consumer's attention as easy care roses. Knock Out® roses have been so successful that they have been extensively planted across the globe and have led to other shrub rose series such Easy Elegance®, Drift® and Oso Easy®.

Great consumer interest in roses and the difficulties in evaluating roses for regional or local performance, especially when new roses can come to market less than one year from selection (e.g., Popcorn Drift® from mutation of Peach Drift®), has led to the Earth-Kind® Roses Texas A&M program. The Earth-Kind® program was created to evaluate and select superior roses for the variable environmental conditions of Texas. Because shrub rose characteristics like disease resistance and heat tolerance can be environmentally influenced, interest in the Earth-Kind® Roses evaluation and recommendation program has led to Colorado State University, Iowa State University, Kansas State University, Louisiana State University, University of Minnesota, and the University of Nebraska joining the program (Harp, 2009; George, 2013).

Economic Value

Roses have a wholesale value of more than $151.5M and are a major proportion of the total economic value of shrub production in the United States (Table 3.1). The southeastern region (Region 4) represents 39% of total wholesale revenue. When the south central region (Region 6) is added to region 4 the two southern regions represent 56% of U.S. wholesale revenue.

Species and Cultivar Characteristics

The species and cultivar characteristics of shrub roses adapted to growth conditions in the southeastern U.S. are listed in Tables 3.2 and 3.3.

Table 3.1 Wholesale revenue generated by region for shrub roses in the U.S.[Z]

Region[Y]	States within region[X]	*Value ($1,000)*
1	CT, MA, VT	2,755
2	NJ, NY	5,871
3	VA, MD	2,499
4	NC, TN, FL, AL, GA, SC, KY, MS	59,689
5	OH, MI, IL, IN, WI	9,014
6	TX, LA, AR	25,815
7	MO	65
8	CO, UT	953
9	CA	40202
10	OR, WA, ID	4706
Total	*United States*	*151,553*

[Z] USDA, 2009
[Y] Standard federal regional boundaries
[X] States are arranged within region by descending total sales of viburnum
[W] Not all states reported revenue from this region

Horticultural Management and Production Practices

Propagation

Shrub roses are propagated by one to three node (bud) soft cuttings treated with indole-3-butyric acid at 3000 ppm talc (Dirr and Heuser, 2006; Hartmann, et.al., 2011). A single cutting is typically placed in a 72 cell tray (Figure 3.1), and two to three node cuttings are placed in 30 cell trays (Casatillo, 2013). Micropropagation is used when large numbers of a cultivar are needed, especially for distribution of new cultivars to licensed propagators and growers.

Figure 3.1 Single node cutting

Irrigation

In general, rose water needs during production are considered medium (Yeager, et.al., 2013). But because species and cultivar growth habits vary, and environments differ across the Southeast irrigation rate adjustment may be necessary. For assistance with managing irrigation systems, consult the *Best Management Practices: Guide for Producing Nursery Crops*, 3rd ed.

Fertilization

Controlled release fertilizer (CRF) is commonly used in the production of roses. Most roses (except *R. rugosa* and *R. multiflora*) are considered intolerant of salts. Pour-through tests should be done regularly during the growing season, as soluble salts above 2 dS m^{-1} (2 decisiemen/m = 200 microsiemen/cm [µS/cm] = 2 mmhos/cm) result in lack of vigor and short shoots, although no definitive leaf symptoms may occur (Karlik and Flint, 2013).

Pruning

Shrub roses are top pruned in early stages of growth by sickle bar mower with vacuum or wind driven removal of the cuttings (Figure 3.2A). Larger pots are pruned individually by hand or by machine that mows tops and sides (Figure 3.2B). During production plants that bloom precociously have the flowers removed (Figure 3.2C).

Figure 3.2 Pruning roses using (A) a sickle bar pruning machine, (B) hand pruning, and (C) hand pruning to remove precocious flowers

Table 3.2 Rose species of the Southeastern U.S.

Shrub Rose Species[1]	Common Name	USDA Plant Hardiness Zone	Origin	Flower Color	Fragrance	Notes
Rosa blanda Ait.	Meadow rose		Native	Light pink	Fragrant	Flowering duration short cold hardy to USDA Plant Hardiness Zone 3
Rosa carolina L.	Carolina rose	4-9	Native	Single, pink	Fragrant	
Rosa canina L.	Dog rose	5-9	Europe	Pink and white	Fragrant	Red or purple egg-shaped fruit
Rosa gallica L.	French rose	4-8	Europe, Asia	Pink-red	Strongly fragrant	Not a landscape plant but a parent of repeat blooming roses
Rosa glauca Pourr. (*R. rubrifolia* Villars)	Redleaf rose	2-7	Europe	Pink		Foliage color effective. Winter interest due to exfoliating bark
Rosa laevigata Michx.	Cherokee rose	8-9	Asia	White	Fragrant	Vigorously spreading to point of invasiveness. Trail of Tears plant
Rosa liciae Franch & Rochebr. Ex Crép	Memorial rose	5-8	Asia	White	Fragrant	Ground cover, climber, breeding, disease resistant, salt tolerant
Rosa moyesii Hemsl. & Wils.	Moyes rose	5-7	China	Dark red		Landscape shrub, used in breeding
Rosa multiflora Thunb.	Multiflora rose	5-8	Japan, Korea	Single, white		Used in breeding. An invasive species banned in some states. Rootstock. Host for rose rosette
Rosa roxburghii Tratt.	Chestnut rose	5-9	China, Japan	Double, pink		Pass around plant known for chestnut husk-like covering of buds and hips. Antioxidants extracted from hips (Erasmus, 2005)
Rosa rugosa Thunb.	Rugosa rose	2-7	China	Pink to white	Fragrant	Salt tolerant, limestone intolerant, large ornamental hips. Used in breeding for its hardiness, rootstock
Rosa palustris Marsh	Swamp rose	4-9	Native	Pink	Fragrant	Tolerant of wet soils
Rosa setigera Michx.	Prairie rose	4-9	Native	Pink	Fragrant	Red-orange fall color
Rosa virginiana Mill.	Virginia rose	3-7	Native	Pink	Fragrant	Relatively free of disease

[1] (Information for table from Dirr, 2008; Flint, 1997; Rehder, 1940; Wyman, 1969; Hartman, 2011)

Table 3.3 Rose cultivars for consideration in the Southeastern U.S.

Shrub Rose Marketed As	Cultivar Name	Flower, Color	USDA Plant Hardiness Zone[1]	Notes
Carefree Beauty™	'BUCbi'	Semi-double, dark pink	4-9	2006 Earth-Kind® (EK®) Rose of the Year, Orange hips
Knock Out®	'Radrazz'	Single, red	5-11	2000 AARS Winner, EK® Dominant Retail Shrub Rose. J&P2 - #1
Pink Knock Out®	'Radcon'	Single, pink	5-11	J&P2 - #2
Double Knock Out®	'Radtko'	Double, red	5-11	J&P2 - #3
Sunny Knock Out®	'Radsunny'	Single, yellow	5-11	J&P2 - #4, has fragrance
Home Run®	'Wekcisbako'	Single, red	4-9	Proven Winner, Smaller than Knock Out® parent
Flower Carpet™ Red	'Noare'	Single, red	4-10	Common to southern California
Flower Carpet™ Scarlet	'NOA83100B'	Single, scarlet-red	5-10	NG2
Flower Carpet™ Pink Supreme	'Noatraum'	Double, bright pink	4-10	Royal horticultural Society (RHS) Award of Garden Merit
Flower Carpet™ Amber	'NOA97400A'	Double, orange-yellow	4-10	NG2
Scarlet Meidiland™	'Meicoublan'	Double, red	4-9	Meilland International, 1987
Oso Easy® Mango Salsa Rose	'ChewperAdventure'	Double, salmon/coral	4-9	J&P #5, Proven Winner (PW)
Sweet Fragrance Easy Elegance®	'BAInce'	Double, apricot	5-9	
Paint the Town Easy Elegance®	'BAItown'	Double, red	4-9	
Kasmir Easy Elegance®	'BAImir'	Double, red	4-9	
Yellow Brick Road Easy Elegance®	'BAIoad'	Double, yellow	5-9	
Princess Alexandra of Kent David Austin®	'Ausmerchant'	Double, pink	5-9	Fragrant
Jubilee Celebration David Austin®	'Aushunter'	Double, pink	5-9	Fragrant
Lady of Shalott David Austin®	'Ausnyson'	Double, salmon upper petal, gold yellow lower	5-9	Fragrant
Scepter'd Isle David Austin®	'Ausland'	Double pale pink	5-10	R.N.R.S Henry Edland award for fragrance
Windermere David Austin®	'Aushomer'	Double, cream-white	5-9	Fragrant

[1] Cultivar list and zone information source for cultivars from breeder or marketer
[2] Jackson & Perkins (J&P) #1 September 20, 2013
[3] "Next Generation" (NG) group bred for heat & humidity tolerance

SECTION 2

Abiotic Stressors

Figure 3.3 Nutrient deficiency symptomology in rose foliage - interveinal chlorosis (yellow foliage with green leaf veins) indicative of iron deficiency - also called iron chlorosis

ABIOTIC STRESSORS

1. Nutrient Deficiencies
2. Herbicides
3. Wildlife

Nutrient Deficiencies

Nutrient deficiencies occasionally affect shrub roses (Figure 3.3). Typical ranges of foliar nutrient concentrations for shrub roses and selected cultivars are listed in Table 3.4. Micronutrient deficiencies (especially iron and boron) are more common when substrate pH is greater than 7.5.

Herbicides

2,4-D and glyphosate injury result in clusters of deformed foliage that can mimic rose rosette. Shrub roses with glyphosate injury typically lack the rose rosette bristle-type stem thorns. Deformed foliage often becomes chlorotic, rather than changing to deep red/magenta as would rose rosette infected plants (Figure 3.4).

Figure 3.4 Deformation and foliar chlorosis of herbicide damaged rose

Wildlife

Deer consider all roses to be "candy" and can be very destructive. Deer frequently strip all leaves off the canes and eat the soft terminal growth (Figure 3.5). They seem immune to the thorns. Flower buds are particularly attractive food sources. Deer can eliminate roses with their constant feeding leading to starvation of the plants and death. Because of deer preference for roses no repellent is known to provide long-term protection. Fencing seems the only successful long-term control option. Electric fence may keep most deer out of a growing area but a few will still get in and cause damage. Deer have been known to jump over plastic "deer fence" 7.5 to 8 feet tall but it is very rare and mostly in an attempt to escape after getting into a growing area by getting under the fence. Fence companies recommend a well-maintained 10 foot tall fence for absolute deer exclusion. Rabbit control requires a hard wire fence (across the bottom of the deer fence) as rabbits will chew holes in the plastic deer fence allowing rabbits, deer and other wildlife to enter through the open areas.

Figure 3.5 Injury on terminal shoots of rose from deer browsing

Table 3.4 Typical foliar concentrations reported[Z] for macro- and micro-nutrients measured in recently mature leaves collected at mid-season from that current season's growth of *Rosa* spp.

Macronutrient	**Nitrogen (N)**	**Phosphorus (P)**	**Potassium (K)**	**Calcium (Ca)**	**Magnesium (Mg)**	**Sulfur (S)**	
	% dry weight						
Rosa spp. [Z1]	3.0 - 5.0	0.20 - 0.30	2.0 - 3.0	1.0 - 1.5	0.25 - 0.35	-	
Rosa spp. [Z2]	3.0 - 4.0	0.20 - 0.40	1.5 - 2.5	1.0 - 2.0	0.20 - 0.40	0.15 - 0.25	
Rosa spp. [Z3]	2.8 - 3.6	0.24 - 0.33	1.6 - 2.2	1.0 - 1.7	0.30 - 0.43	-	
Rosa spp. [Z4]	3.0 - 5.0	0.20 - 0.30	1.6 - 2.5	1.0 - 2.0	0.30 - 0.40	-	
Rosa spp. [Z5]	3.0 - 5.0	0.20 - 0.30	1.8 - 3.0	1.0 - 1.5	0.25 - 0.35	-	
Rosa manetti [Z6]	3.3	0.30	2.2	1.6	0.27	-	
Rosa x *odorata* [Z6]	3.2	0.30	2.3	1.5	0.29	-	
Rosa x 'Natal Briar' [Z6]	3.1	0.27	2.0	1.6	0.35	-	
Rosa x 'Dr. Huey' [Z6]	3.2	0.34	2.3	1.4	0.28	-	
Micronutrient	**Iron (Fe)** [Y]	**Manganese (Mn)** [X]	**Boron (B)**	**Copper (Cu)** [X]	**Zinc (Zn)** [X]	**Chloride (Cl)**	**Sodium (Na)**
	ppm (µg/g)						
Rosa spp.[Z1]	50 - 150	30 - 250	30 - 60	5 - 15	15 - 50	-	-
Rosa spp. [Z2]	50 - 150	50 - 200	30 - 80	3 - 15	20 - 50	-	-
Rosa spp. [Z3]	75 - 384	91 - 179	24 - 63	5 - 8	20 - 49	-	-
Rosa spp. [Z4]	80 - 150	100 - 300	40 - 80	7 - 17	15 - 50	-	-
Rosa spp. [Z5]	50 - 150	30 - 250	30 - 60	5 - 15	15 - 50	-	-
Rosa manetti [Z6]	51	93	51	3.8	36	3440	253
Rosa rugosa [Z7]	38 - 94	30 - 260	-	8 - 15	20 - 30	-	-
Rosa x *odorata* [Z6]	64	50	56	3.5	34	3433	186
Rosa x 'Natal Briar' [Z6]	51	76	91	4.1	38	7728	303
Rosa x 'Dr. Huey' [Z6]	56	92	62	3.3	46	2781	193

[Z] 1 - Karlik, 2008; 2 - Cabrera, 2003; 3 - Mills and Jones, 2006; 4 - Ortega, 1997; 5 - White, 1987; 6 Cabrera, 2002; 7 - Bagatto et al., 1991

[Y] Surface contamination of foliage from soil and presence of unavailable (physiologically inactive) and immobile Fe in plant tissues limits the information value of iron measured by foliar analyses

[X] Leaf tissue analysis of Cu, Mn, and Zn may not be reliable indicators of *Rosa* spp. nutritional status because foliage in commercial plant nurseries may be exposed to fungicides and nutrient solutions containing trace elements, and trace levels of surface contamination may persist, even after leaves are washed

Arthropod Pest Management

COMMON ARTHROPOD PESTS

1. Aphids
2. Beetles
3. Caterpillars and Sawflies
4. Gall Wasps
5. Rose Midge
6. Mites
7. Leafhoppers
8. Thrips
9. Scale Insects

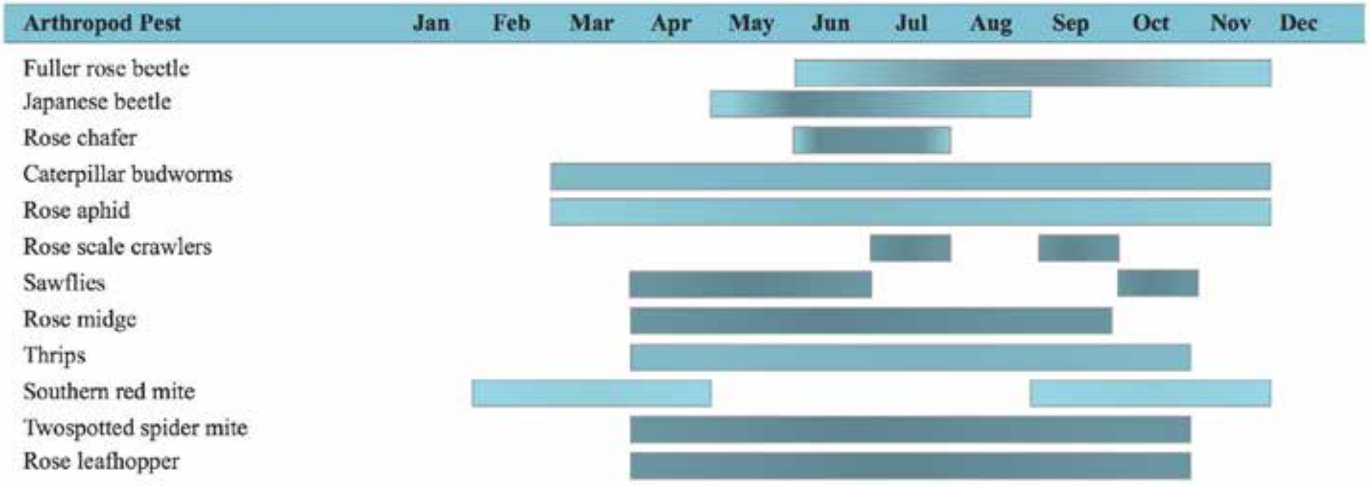
Several groups of insects and their relatives cause injury to roses. Pests can sometimes be recognized by the characteristic signs of damage. Feeding damage categories include defoliation (chewed or tattered leaves or flowers), piercing-sucking injury (chlorosis, mottling, stippling, silvering or bronzing), bud or shoot feeders (distorted or blasted buds or shoots), gall producers (abnormal plant growth), and stem borers (dieback of plant parts). Defoliators include leaf and flower-feeding beetles, various sawflies, caterpillars, and leaf-cutting bees. Spider mites, thrips, and plant bugs may cause chlorosis, discoloration, and stippling damage. Aphids, thrips, gall wasps, and midges can be responsible for deformed new growth on plants. Some of the more common pests are listed below.

Aphids

Aphids often infest roses. Several species can be involved. Rose aphid, *Macrosyphum rosae* (Figure 3.6A) is a very common pest on roses as are other species of *Macrosyphum* and cotton aphid *Aphis gossypii* (Figure 3.6B). Aphids are small, less than $^{1}/_{8}$ inch long with tube-like structures (cornicles) on the abdomen. Depending on species they may be pale green, dark green or light pink in color. Aphids can build up to large numbers because of their short development time and high reproductive rate (Figure 3.6B). The seasonal range in aphid activity is presented in Table 3.5. The honeydew that they excrete while feeding through piercing-sucking mouthparts provides a substrate that supports the growth of sooty mold. Honeydew also attracts ants that protect and "farm" the aphids, driving off natural enemies.

Figure 3.6 Rose aphid adult birthing nymph (A) and colony of cotton aphid on rose bud (B), and syrphid fly larvae feeding on rose aphid (C)

Table 3.5 Seasonal activities of the major arthropod pests of *Rosa* spp. in the mid-southern U.S., and unless otherwise noted, represent occurrence in USDA Plant Hardiness Zone 7. Depicted activity may be early or later than shown depending on location. Activities represented in the table are scale insect crawler emergence, as well as adult or nymphal activity of the most common insect and mite pests



Management
Aphids have a large number of natural predators and parasitoids. Lady beetles, lacewings, syrphid flies (Figure 3.6C), and parasitic wasps all readily attack aphids and should be the subjects of conservation biocontrol methods. Low populations of aphids can be removed with strong streams of water, repeated regularly when feasible. Large populations of aphids can reduce bloom and may require repeat insecticide applications. A number of contact and systemic insecticides are available for aphid control (Table 3.6). Horticultural oil and insecticidal soap may reduce mortality among non-target beneficial arthropods (or organisms). Systemic products may be applied as drenches, sprays, or as granular formulations and may provide more long-term suppression of aphids. Contact sprays of pyrethroids are also effective. Use of insecticides only when necessary will conserve beneficial insects and help prevent mite flares on treated plants.

Beetles
Beetles that feed on rose flowers and foliage include Japanese beetle, rose chafer, rose curculio, and Fuller rose beetle. The Japanese beetle is one of the most serious pests of roses where it occurs. The following discussion taken largely from (Chappell et al. 2012) and used by permission of the authors.

Japanese Beetle
Japanese beetle (*Popillia japonica* Newman) adults attack flowers, fruit, and foliage of more than 300 species of plants, including crape myrtles, which are among their most preferred species. Since its introduction in 1916 via infested nursery stock, it has become one of the most damaging pests in the eastern United States (Held, 2004). Japanese beetle adults skeletonize leaves and feed heavily on flowers (Figure 3.7). The adult beetles are 0.31 to 0.43 inches long and metallic green and copper-brown in color. They are active day fliers that disperse readily over long distances. This beetle has an annual life cycle, requiring one year to complete development (egg to egg). The majority of the life cycle is spent underground as a larva, feeding on the roots of turfgrass and other susceptible plants. Eggs (as many as 60 per female) are deposited into moist soil, hatching and then developing through three instars. The winter is spent as a third instar larva with pupation occurring in the spring. Adult beetles emerge from the ground in early summer, usually following a rainfall event (seasonal activity Table 3.5). They are highly mobile and gregarious, capable of rapidly defoliating susceptible plants. A range in susceptibility has been identified among roses, with yellow-flowered cultivars proving more susceptible than those with red flowers (Held and Potter, 2004).

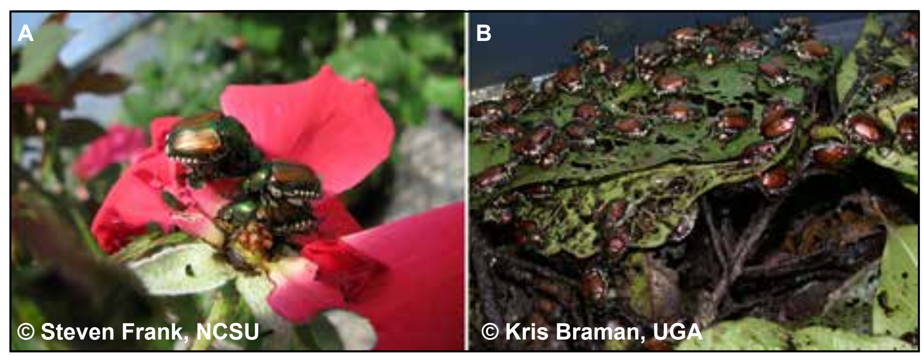


Figure 3.7 Japanese beetles attacking rose flowers (A) and skeletonizing leaves (B)

Traps that use both a floral lure and sex attractant can be used to indicate first flight of Japanese beetles. They should be placed at least 200 feet away from plants that you are trying to protect. The attractant in the traps can attract beetles to nearby plants as well as to the traps and are thus ineffective for managing beetles but do serve as a monitoring tool.

Management

Predation by birds, small mammals, and generalist insect predators can reduce populations of immature Japanese beetles. Two wasp species [*Tiphia vernalis* Rohwer and *T. popilliavora* Rohwer (Hymenoptera: Tiphiidae)] parasitize larvae, and a tachinid fly [*Hyperecteina aldrichi* Rohwer (Hymenoptera Tiphiidae)] attacks adult beetles. The bacteria *Bacillus popilliae* exclusively attacks Japanese beetles but is recommended for large scale, regional application rather than individual site applications. Microscopic entomopathogenic nematodes occur naturally in the soil and together with a symbiotic bacterium, can ultimately kill grubs by means of septicemia (blood poisoning). Nematodes that have been shown to be most effective against Japanese beetle grubs are *Steinernema glaseri* and *Heterorhabditis bacteriophora*. The latter is commercially available.

Japanese beetles can be controlled on susceptible plants with foliar applications of short-residual insecticides, which require repeated applications to maintain uninjured plants during adult flight periods. Systemic insecticides can provide longer residual control (Table 3.6). Follow the United States Domestic Harmonization Plan when shipping nursery stock from areas that may be infested with Japanese beetles to beetle-free areas (Anderson, 1974).

Rose Chafer

Rose chafer (*Macrodactylus subspinosus*) skeletonizes leaves in a very similar fashion to the Japanese beetle (Figure 3.8A). The rose chafer prefers sandy soils for the developing grub. It overwinters as a larva. Adults are strongly attracted to flowers of rose and peony, but they are also foliar feeders (seasonal activity Table 3.5). There is one generation per year.

Rose Curculio

Rose curculio (*Merhynchites* spp.) is a red to black snout weevil about ¼ inch long that prefers yellow and white roses (Figure 3.8B). It punches holes in flowers and buds and may create ragged holes in blossoms or kill the developing bud. If weevils are numerous, terminal shoots may be killed as well.

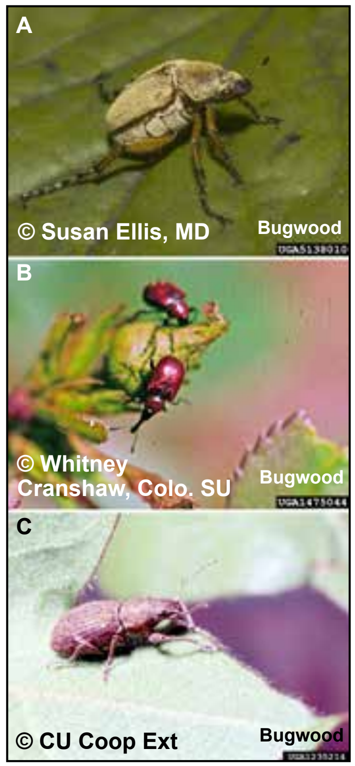


Figure 3.8 Rose chafer adult (A), rose curculio adults (B), and fuller rose beetle adult (C)

Larvae feed within buds, often killing them before they open. They can develop on flowers that remain on the plant or that fall off onto the ground. There appears to be one generation per year. Cultivated and wild roses are the main hosts, but the curculio can also develop on brambles. Handpick adults off plants and destroy infested buds. A broad-spectrum insecticide can be applied to kill adults if the infestation is severe (Table 3.6).

Fuller Rose Beetle

Fuller rose beetle [*Pantormorus cervinus* (Boheman), formerly *Naupactus* (=*Asynonychus*) *godmanni*], adults chew flowers and foliage leaving notched or ragged edges (seasonal activity Table 3.5). Adults are pale brown weevils that are about $^{3}/_{8}$ inch long (Figure 3.8C). They are flightless and hide during the day, often on the undersides of leaves; feeding takes place at night. The larvae are root feeders but do not seriously damage roses.

Caterpillars and Sawflies

Caterpillars of many moth species may injure roses including tussock moths, fruit tree leafrollers, tent caterpillars, and geometrid loopers that feed on rose leaves. Damage is usually not severe and treatment not usually necessary. Handpick or clip out rolled leaves.

Figure 3.9 Sawfly larvae and damage (A), the rose slug (B), the bristly rose slug (C), and damage on rose leaves from bristly rose slug (D)

Small leaf-feeding caterpillars can be killed with an application of the microbial insecticides *Bacillus thuringiensis* or spinosad. Some caterpillars, like the tobacco budworm, may occasionally bore into flower buds. Look for the caterpillar or its frass inside. Prune out and destroy damaged buds.

Adult sawflies (not pictured) are small, dark, non-stinging wasps. Sawfly larvae can skeletonize rose leaves (Figure 3.9C-D). Caterpillar-like sawfly larvae can often be identified by the number of fleshy prolegs behind the three pair of true legs. Sawflies have five or more pair of prolegs, while caterpillars have less than five. Sawflies deposit their eggs singly along the edges of leaves. Three sawflies injure roses, the rose slug, the bristly rose slug, and the curled rose sawfly (Figure 3.9B-C). The rose slug, *Endelomyia aethiops*, is a black to pale green, slug-like larva of a sawfly. Young larvae skeletonize the lower leaf surface while mature larvae chew large holes in leaves.

Management
These pests have many natural enemies. Sawflies are best controlled when young. They may be washed off with a strong stream of water or killed with an application of insecticidal soap or spinosad. *Bacillus thuringiensis* will not work because these are wasp larvae and not the larvae of butterflies or moths.

Begin to scout for sawfly larvae in early spring. Rose slugs feed through early summer and are less common later in the season. The curled rose sawfly also has one generation per year. The bristly rose slug has several generations throughout the summer. Sawflies often feed on the undersides of leaves, so inspect all leaf surfaces.

Gall Wasps
A large number of gall wasps, at least 40 *Diplolepis* species, make galls on roses. Many different types of galls can be present on all parts of the plant. Rose root, globular, mossy rose (*D. rosae*; Figure 3.10), and spiny rose gall wasps are a few of these species. Many create very elaborate growths on the plant, ranging from hard woody galls to globular or hairy galls. Some are on leaves while others appear on stems.

Figure 3.10 Gall growth on rose leaf initiated by the mossyrose gall wasp

Figure 3.11 Deformed leaves and terminal bud damaged by rose midge

Rose Midge
Rose midges (*Dasineura rhodophaga*) are tiny, brown-red flies ($^1/_{25}$ inch) that overwinter in the pupal stage in the soil. Adults lay their eggs inside the sepals of flower buds or on plant terminals. Rose midge activity ranges from June to September (Table 3.5). Hatching larvae, creamy white to pale pink maggots, move into flower buds to feed, leaving the injured buds to wither, blacken, and die (Figure 3.11). Two to four generations can occur annually. Rose midge could be confused with the beneficial midge (*Aphidoletes aphidimyza*) which feeds on aphids. *Aphidoletes* larvae, usually pale to bright orange, are found on stem, bud, or leaf surfaces feeding within aphid colonies, whereas rose midge larvae are out of view at the base of developing buds in terminals.

Mites
Spider mites (*Tetranychus* spp.) and red mites (*Oligonychus ilicis*) cause leaves to be stippled or bleached, and may cause leaves to dry up and fall off (Figure 3.12). Some species produce webbing while others do not. They are tiny and can be sampled by shaking the plant and knocking the mites onto an index card or piece of notebook paper.

In the growing season, adults are about $^1/_7$ mm long, a little larger than a period on a page. They have one oval body segment with eight legs. They are greenish-yellow with a black

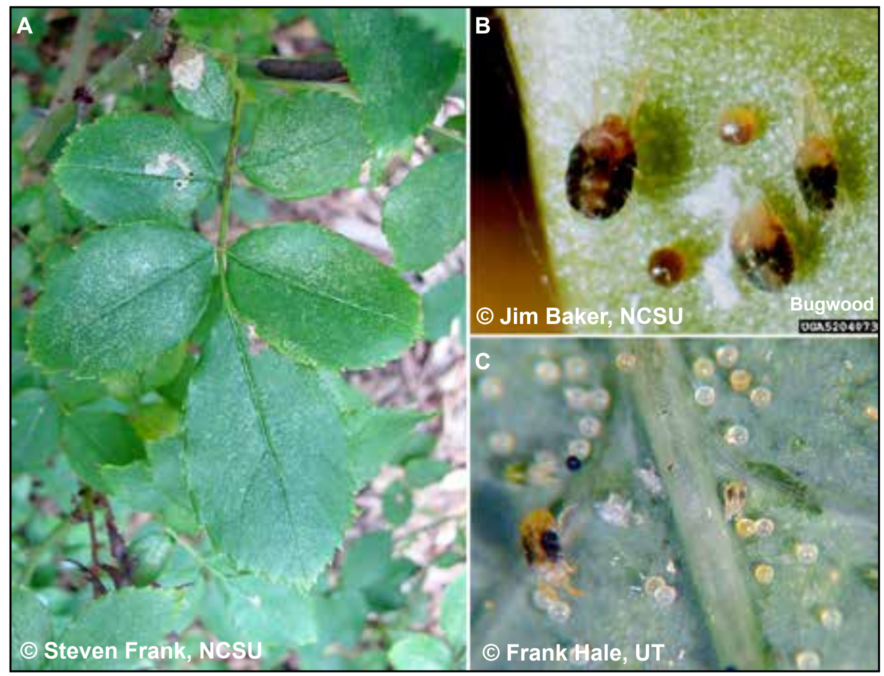


Figure 3.12 Characteristic stippling of rose foliage from mite feeding (A), southern red mite adults, immatures, eggs, and casts (B), and twospotted spider mite adults, immatures, and eggs (C)

spot on each side of the body. Eggs are white to yellow. Reddish-orange adult females overwinter in bark cracks. Spider mites have a very broad host range. They feed on conifers, deciduous trees and shrubs, as well as herbaceous plants.

Spider mites suck leaf juices, causing minute white-to-yellow stipples to appear. When large spider mite populations feed, the stipples coalesce and leaves may turn white to yellow to grayish-brown and then die. Some plants are particularly susceptible to spider mite toxins, and even low populations may cause leaves to die.

Management
Look for early signs of stippling with the beginning of hot summer weather to detect mite presence (Table 3.5). Examine the underside of damaged leaves or tap them over white paper and look for spider mites with two spots on the body. Also look for predators, such as phytoseiid mites and lady beetles, and note their relative abundance in relation to the number of mites present. In dry, hot, sunny locations, this spider mite may produce one generation a week. Use horticultural oil or insecticidal soap sprays for low mite populations to conserve any beneficials present. When damage becomes objectionable, mite populations are high, and there are not beneficials, consider using a residual miticide spray (Table 3.6). Reevaluate in one week.

Conserving natural enemies, providing sufficient irrigation, and reducing dust may all help control mites. Overhead irrigation or periodic washing of leaves with water can be very effective in reducing mite numbers. Releases of predatory mites have been used in some situations. An eriophyid mite (*Phyllocoptes fructiphilus*) is responsible for transmitting rose rosette disease. This tiny, yellowish, tubular, four-legged mite feeds on new growth. These mites are wind borne with new infestations mainly occurring in the spring.

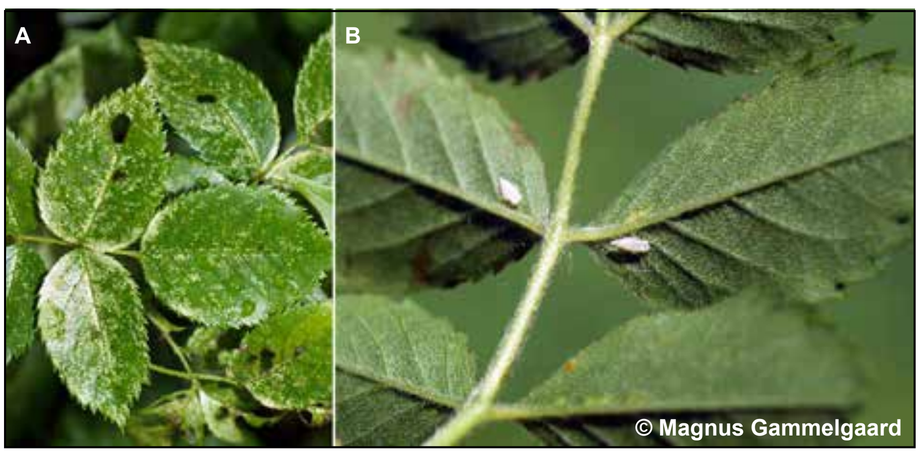


Figure 3.13 Characteristic stippling from rose leafhopper infection (A) and rose leafhopper adults (B)

Leafhoppers
Rose leafhopper (*Edwardsiana rosae*) causes stippling larger than mite stippling, but tends to be a problem only in certain localities (Figure 3.13). Good indications of pest presence include stippling, cast skins, and the absence of webbing on the underside of leaves.

Management
Initiate scouting in late April (USDA Plant Hardiness Zone 7) to detect rose leafhoppers (Table 3.5). Plants can tolerate moderate stippling. Use an insecticidal soap if an infestation is severe.

Thrips[1]
Western flower thrips (*Frankliniella occidentalis*) cause injury primarily to rose flowers, causing blossom petals to streak with brown or become distorted and can be very severe if attacked early at the bud stage. The tiny yellow or brown thrips insects can be found within the blossoms. Leaves emerging from terminal buds can also be distorted and chlorotic (Figure 3.14A).

Thrips problems are more likely to be severe where many rose bushes located close together provide a continuously blooming habitat. Fragrant, light-colored or white roses are most often attacked and can be severely damaged (Figure 3.14B). Frequent clipping and disposal of spent blooms may reduce thrips problems. Control with insecticides is difficult because materials are mostly effective on early developmental stages, which are commonly found within buds or flowers where most pesticide applications cannot penetrate.

Chilli thrips (*Scirtothrips dorsalis*) is a polyphagous (eats multiple types of food) species and has been documented to attack more than 100 recorded host plants from about 40 different families, but roses are a common host. Field identification of *S. dorsalis* is extremely difficult and often times impossible to differentiate from other thrips in the field. Adults have a pale body with dark wings and are less than 2 mm in length (Figure 3.14C). Immature *S. dorsalis* thrips are pale in color as are the immatures of many other thrips species (Figure 3.14D). The life cycle is very similar to western flower thrips, however, *Scirtothrips dorsalis* is mainly a foliage feeder and unlike western flower thrips does not feed on flower pollen. Feeding can turn affected plant parts brown or bronze or even result in a blackened "burnt" appearance on some affected foliage plants. This thrips has been reported to potentially vector some important plant viruses.

Management
Thrips species prefer to inhabit dense plant tissues and flower parts where they are not easily dislodged. This behavior, as well as frequency at which eggs are deposited within

[1]Discussion of Chilli thrips (*Scirtothrips dorsalis*) management is largely based on text prepared for Viburnum (Klingeman et al. 2014) (see Chapter 5, in: *IPM for Shrubs in Southeastern US Nursery Production, Part 1*. 2014. White, S.A. and W.E. Klingeman, eds.). Reprint of this content herein is made possible by permission of the original content authors.

Figure 3.14 Leaf distortion and chlorosis (A) resulting from thrips feeding, damage to flower bud (B), chilli thrips first instar larvae (C), and chilli thrips adult (left) and western flower thrips adult (right, D)

leaf tissues, makes detection extremely difficult during both scouting and nursery inspections prior to shipping. Peak thrips activity possible from May through August (Table 3.5). When affected tissues are suspected, plant portions should be collected and transported in a sealed plastic bag for accurate identification. Sampling for thrips may be assisted by washing affected plant portions with 70% ethanol, then scouting the screened portion of the rinsate. Yellow sticky cards are also effective at collecting *S. dorsalis*, while other thrips species are preferentially attracted to blue colored cards (Kumar et al., 2013). Several classes of insecticides are available for thrips control (Table 3.6).

Natural enemies including minute pirate bugs (*Orius* spp.) and the phytoseiid mites (*Neoseiulus cucumeris* and *Amblyseius swirskii*. Predatory mites (*Euseius* spp.) can also be

Figure 3.15 Rose scale on *Rubus* spp. The female is white or greyish-white. The male is much smaller and elliptical

effective predators of chilli thrips and other thrips species. Other pest thrips species have been managed, in part, by several predatory thrips species, lacewings (*Chrysoperla* spp.), ladybird beetles, and predatory mirid bugs (Kumar et al., 2013).

Foliar sprays and soil drenches of neonicotinoids (IRAC class 4A) imidacloprid, thiamethoxam, and dinotefuran, the spinosyns (IRAC class 5) spinosad and spinetoram, and borax (IRAC class 8D) provided at least 10 days suppression of thrips (Table 3.6; IRAC, 2013) (Table 3.6). *Beauveria bassiana* (as Botanigard®) (not IRAC encoded) extended 5 days of larval thrips suppression. Pyrethroids (IRAC class 3) were largely ineffective for thrips control (Seal and Kumar 2010). A landscape study in Texas supported efficacy of acephate (as Orthene®) against chilli thrips (Ludwig and Bogran, 2007).

Scale Insects

Several armored scale insects occasionally attack roses, but the most damaging is rose scale (*Aulacaspis rosae*). Small and soft-bodied, scale insects secrete a material that forms a shell or "scale" over the insect itself. The rose scale are typically found on woody parts of rose plants (Pijnakker and Leman, 2011). Alternate host plants of *A. rosae* include raspberries and logan berries (*Rubus* spp.), black currant (*Ribes nigrum*), *Agrimonia* spp., *Cycas* spp., *Dianthus* spp., hydrangea (*Hydrangea* spp.), laurel (*Laurus* spp.), sweet grass (*Muhlenbergia* spp.), and flowering pear (*Pyrus* spp.) (Ben-Dov et al., 2014).

Female rose scales are round and dirty white and 0.06 to 0.10 inches (1.5 to 2.5 mm) long (Figure 3.15). Males are approximately 0.05 inch (1 mm) in length and elongate with a snow white scales. When mature, these insects insert their mouth-parts into the plant tissue and remain there, protected under their scale covering, for their entire life span. Females deposit eggs (50 to 150) beneath the old scale covering, and one to four generations are possible per year (Pijnakker and Leman, 2011). When the eggs hatch, the young, six-legged scale insect "crawlers" disperse throughout the new tissue and attach themselves to the plant (crawler activity Table 3.5). Heavily infested canes may become encrusted in the scales. Scales become most abundant under high humidity and reduced sunlight. They not only spoil the plant's appearance, but also greatly reduce plant vigor.

Management

Management actions for scale insect pests are best timed to coincide with visual confirmation of crawler emergence and activity. Young nymphs are easy to control, but the scale coverings of adult females are difficult to penetrate with insecticides, made even more difficult when plants are heavily infested.

Biological control agents for control of rose scales infestations are available. The most successful biological antagonist of rose scale is the predatory beetle, *Rhizobius lophantae.* Greenhouse growers have reported complete control of a rose scale infestation using *R. lophantae* introduced at 20 beetles per hotspot/infestation (>50 scales). It is critical to introduce *R. lophantae* early in an infestation (as soon as a hotspot/ infestation detected) to obtain satisfactory control. With an established rose scale infestation, control with *R. lophantae* may require up to one year for beetle numbers to adequately predate scales (Pijnakker and Leman, 2011).

In shrub roses, rose scales are found primarily on the old wood, in the heart of the plant or lower parts of the plants (bent shoots). However, with heavy infestations, crawlers reach the flower buds. The effects of plant protection products, even systemic insecticides, is often reduced due to limited contact. Growers need to spray carefully for an optimal coverage to get between the bent shoots. Repeat pesticide applications may be necessary to control scale populations and limit crop damage.

Control agents (physical and insecticidal) should be applied when crawlers are active (Table 3.5). Frequency of application to maintain control of crawlers varies with pest biology (7 to 14 day intervals). Products with less potential to harm biological control agents should be considered before use if insecticides. These include azadirachtin, pyrethrin and piperonyl butoxide, insecticidal soaps, horticultural oils, mineral oils (to prevent crawler establishment), algae extracts, and products with physical mode of action (Table 3.6). Wetting agents can be used to optimize coverage and spray penetration. Systemic insecticides (e.g., imidacloprid) can affect older nymphal stages and adult females via the plant juices. Chemical insecticides effective against scale insects are acetamiprid, deltamethrin, dimethoate, imidacloprid, methiocarb, pyriproxyfen, spirodiclofen, spiromesifen, thiacloprid, and thiamethoxam (Pijnakker and Leman, 2011).

Table 3.6 Pest-directed insecticidal activity and Insecticide Resistance Action Committee (IRAC) codes for use developing an insecticide rotation plan to manage key pests of shrub roses for nursery (N) and greenhouse (G) and landscape (L) management systems. Check current products for labeled pesticides, sites for control and plant safety and efficacy on pest species. Several products listed are available only to certified professional applicators and may not be available for homeowner use[Z]

IRAC Code[Y]	Chemical Class (Mode Of Action)	Active Ingredient	Brand Name[X]	Nursery / Greenhouse / Landscape	Aphids	Beetles	Caterpillars	Sawflies	Spider Mites	Thrips	Armored Scales
1A	Carbamates (Acetylcholinesterase [AChE] inhibitors)	carbaryl	Sevin SL	N, G, L	X	X	X	X			X
		methiocarb	Mesurol 75W	N, G	X				X	X	
1B	Organophosphates (Acetylcholinesterase [AChE] inhibitors)	acephate	Acephate, Orthene	N, G, L	X	X	X	X	X	X	X
		chlorpyrifos	Chlorpyrifos, Dursban 50W	N	X	X	X	X	X	X	X
			Duraguard 20 ME	N, G	X	X	X	X	X	X	X
		malathion	Malathion 5EC	L	X	X	X		X	X	X
		dimethoate	Dimethoate 4E, 4EC	N	X	X			X	X	X
3A	Pyrethrins and Pyrethroids (Sodium channel modulators)	bifenthrin	Onyx	L	X	X	X		X	X	X
			Onyx Pro	N, L	X	X	X		X	X	X
		bifenthrin	Talstar	N, G, L	X	X	X		X	X	X
		cyfluthrin	Decathlon	N, G	X	X	X	X		X	X
			Tempo	L	X	X	X	X		X	X
		lambda-cyhalothrin	Scimitar CS	L	X	X	X	X	X	X	X
			Scimitar GC	N, G, L	X	X	X	X	X	X	X
		deltamethrin	DeltaGard T&O 5EC	N, L	X	X	X	X	X[W]		X
		tau-fluvalinate	Mavrik Aquaflow	N, G, L	X		X		X	X	
		permethrin	Astro	L		X	X	X			X
			Perm-Up	N		X	X	X			X
3A + 4A	Pyrethrins and Pyrethroids + Neonicotinoids	cyfluthrin + imidacloprid	Discus N/G	N, G	X	X	X	X		X	X
		bifenthrin + imidacloprid	Allectus SC	L	X	X	X	X			X
		lambda-cyhalothrin + thiamethoxam	Tandem	L	X	X				X	X
		bifenthrin + clothianidin	Aloft LC SC, LC G	L	X	X	X			X[W]	X
4A	Neonicotinoids (Acetylcholine receptor [nAChR] agonists)	acetamiprid	Tristar 30SG, TriStar 8.5 SL	N, G, L	X	X	X	X		X	X
		clothianidin	Arena	L	X						
		dinotefuran	Safari	N, G, L	X	X				X[W]	X
			Zylam SL	L	X	X	X	X		X	X

Table 3.6 *continued* Pest-directed insecticidal activity and IRAC codes for use developing an insecticide rotation plan to manage key pests of shrub roses[Z]

IRAC Code[Y]	Chemical Class (Mode Of Action)	Active Ingredient	Brand Name[X]	Nursery / Greenhouse / Landscape	Aphids	Beetles	Caterpillars	Sawflies	Spider Mites	Thrips	Armored Scales
4A	Neonicotinoids (Acetylcholine receptor [nAChR] agonists)	imidacloprid	Merit	L	X	X		X		X[W]	
			Marathon	N, G	X	X					
		thiamethoxam	Meridian	L	X	X		X		X[W]	
			Flagship	N, G	X	X		X		X[W]	
5	Spinosins (Nicotinic acetylcholine receptor channel [nAChR] agonists)	spinosad	Conserve SC	N, G, L			X	X		X	
			Entrust 80W & SC	N, G		X[V]	X[U]				
6	Avermectins (Chloride channel activators)	abamectin	Avid 0.15 EC	N, G, L					X	X	
		milbemectin	Ultiflora	N					X	X	
7A	Juvenile hormone analogues (Juvenile hormone mimics)	s-kinoprene	Enstar AQ	G	X					X	X
7C		pyriproxifen	Distance	N, G, L	X						X
8D	Miscellaneous, non-specific inhibitors (Multi-site action)	sodium tetraborohydrate Decahydrate	Prev-AM Ultra	N, G	X				X	X[T]	X
9B	Compounds of non-specific mode of action	pymetrozine	Endeavor	N, G, L	X						
9C		flonicamid	Aria	G	X					X[W]	X
10A	Mite growth inhibitors	clofentazine	Ovation SC	N, G					X		
		hexythiazox	Hexygon DF	N, G, L					X		
10B		etoxazole	TetraSan 5 WDG	N, G, L					X		
11	Microbial endotoxins	*Bacillus thuringiensis* subsp. *aizawai*	Xentari	N, G			X				
		Bacillus thuringiensis subsp. *kurstaki*	Dipel Pro DF	N, G			X				
12B	Organotin miticides (Inhibitors of mitochondrial ATP synthesis)	fenbutatin-oxide	ProMITE 50WP	N, G, L					X		
13	Chlorfenapyr (Uncouplers of oxidative phosphorylation via disruption of H proton gradient)	chlorfenapyr	Pylon	G					X		
15	Benzoylureas (Inhibitors of chitin biosynthesis, type 0; insect growth regulator)	novaluron	Pedestal	N, G			X			X	
16	(Inhibitors of chitin biosynthesis, type I; insect growth regulator)	buprofezin	Talus 70DF	N, G, L	X						X
20B	(Mitochondrial complex III electron transport inhibitors)	acequinocyl	Shuttle O Miticide	N, G					X		
			Shuttle 15 SC	L					X		

Table 3.6 *continued* Pest-directed insecticidal activity and IRAC codes for use developing an insecticide rotation plan to manage key pests of shrub roses[Z]

IRAC Code[Y]	Chemical Class (Mode Of Action)	Active Ingredient	Brand Name[X]	Nursery / Greenhouse / Landscape	Aphids	Beetles	Caterpillars	Sawflies	Spider Mites	Thrips	Armored Scales
21A	METI acaricides (Mitochondrial complex I electron transport inhibitors)	fenazaquin	Magus Miticide	N, G, L					X		
		fenpyroximate	Akari 5SC	N, G					X		
		pyridaben	Sanmite	N, G					X		
		tolfenpyrad	Hachi-Hachi	G	X		X			X	X
23	Tetronic and tetramic acid derivatives (Inhibitors of acetyl CoA carboxylase)	spiromesifen	Judo	N, G					X		
			Forbid 4F	L					X		
		spirotetramat	Kontos	N, G	X				X	X	X
25	beta-ketonitrile derivatives (Mitochondrial complex II electron transport inhibitors)	cyflumetofen	Sultan	G					X		
28	Diamides (Ryanodine receptor modulators)	chlorantraniliprole	Acelepryn	L	X		X				
Unknown	mode of action unknown	azadirachtin	Azatin XL, Aztrol	N, G, L	X	X			X	X	X
		bifenazate	Floramite SC	N, G, L					X		
		pyridaryl	Overture	G						X	
Not Required	not required to have an IRAC code	*Beauveria bassiana*	BotaniGard 22WP, ES	N, G, L	X	X	X		X	X	
		horticultural oil	Ultra-Fine Oil	N, G, L	X		X	X	X	X	X
		insecticidal soap	M-Pede	N, G, L	X		X	X	X	X	X
		Isarea formosarosea	Preferal	N, G, L	X		X		X	X	
		Metarizium anisopliae	Met52, Tick-EX	N, G, L	X				X	X	
		neem oil	Triple Action Neem Oil	L	X				X		X
		neem oil	Trilogy	N, L	X				X	X	
		neem oil	Triact 70	N, G, L	X				X		X

[Z] Check labels carefully to determine if any ornamental phytotoxicity has been reported. It is always sound management practice to test for pesticide safety to plants on a small portion of ornamental plants before spraying the entire nursery crop or range

[Y] Insecticide Resistance Action Committee (IRAC) 2014 database

[X] Trade names of products are provided as examples only. No endorsement of mentioned product nor criticism of unmentioned products is intended

[W] Thrips management primarily by population suppression, rather than direct mortality

[V] Chrysomelid leaf beetle control only; not for control of Japanese beetles

[U] For use when spider mites are not present, or before mite populations begin to increase

[T] Pest management primarily by population suppression, rather than direct mortality, demonstrated when sodium tetraborate plus orange oil and biodegradable surfactants [as TriCon™, BioWorks, Inc. (no longer commercially available)] was applied as foliar spray (Seal and Kumar 2010)

Section 4

Disease Management

Fungicide application to rose crop

Common Disease Pests

1. Black Spot
2. *Cercospora* Leaf Spot
3. Downy Mildew
4. Bacterial Leaf Spot
5. Powdery Mildew
6. *Phytophthora* Root Rot
7. Rose Rosette Virus
8. *Botrytis* Blight
9. Crown Gall

Although many shrub rose cultivars are generally considered to be disease-resistant, most are very susceptible to diseases under nursery production conditions, particularly in the southeastern U.S. Large blocks of closely spaced plants, daily overhead irrigation, and high fertility create environmental conditions conducive to disease development and increase plant susceptibility. Significant economic loss can occur from unmarketable plants and cost of control in increased fungicide use and labor costs. Once plants are installed in most landscapes, the plants are generally disease-free. In production, the most common and serious diseases are black spot, *Cercospora* leaf spot, downy mildew, powdery mildew and *Phytophthora* root rot. Other diseases can occur including rose rosette-associated virus, bacterial leaf spot, *Botrytis* blight, and crown gall.

Black Spot

Black spot, caused by the fungus *Diplocarpon rosae* F.A. Wolf (syn. *Marssonina rosae* [Lib.] Died.), is the most common disease affecting roses. Although many of the shrub roses are rated as resistant to black spot (Table 3.7), evaluations have been conducted in field- or landscape-planted variety trials. Under nursery conditions, where environmental conditions favor disease development, even resistant cultivars often show symptoms in the southeastern U.S.

Black spot is identified by the round, light brown to black spots with feathered edges on infected leaves (Figures 3.16). Infected leaves turn bright yellow and drop from the plant. Severe infection can cause complete defoliation of infected plants. The fungus produces spores within the spots inside blister-like structures (acervuli) that are water-splashed to adjacent leaves and plants. Infection and disease development occurs when relative humidity is above 85% and temperatures are between 75-86°F (24-30°C) (Philley et al., 2001). Seven hours of leaf wetness is required for spores to germinate and infect. Symptoms develop within a few days to two weeks after infection.

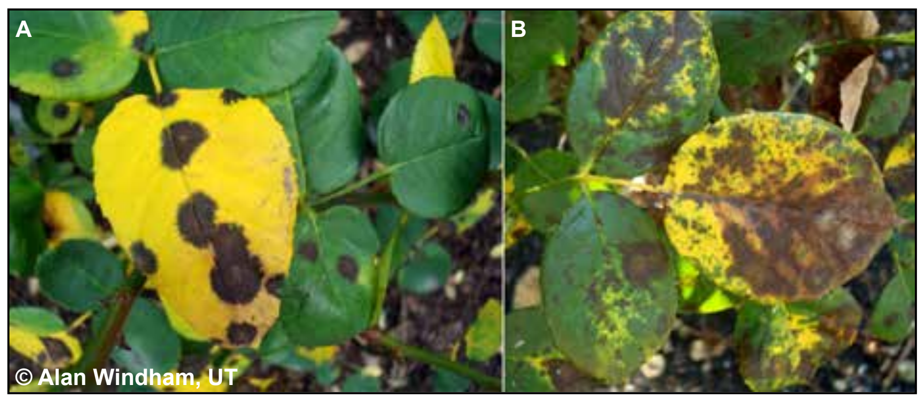


Figure 3.16 Black spot infection induces: (A) leaves turn bright yellow with brown to black necrotic lesions with a feathered margin, and (B) small, irregular, coalescing, brown spots with a jagged margin are blighting large sections of the leaf

Management
The fungus survives in infected canes and fallen leaf litter and removal of these clipped or senescent plant portions is essential in reducing black spot inoculum. Avoid wetting the leaves as much as possible to reduce extended periods of leaf wetness. Irrigate only when leaves will dry quickly. Do not irrigate late in the afternoon or early evening as this provides the necessary hours of leaf wetness needed for infection. Increasing plant spacing can aid in plant drying. Black spot resistant cultivars are available and should be selected for production when possible (Table 3.7). Fungicide sprays are needed to reduce infection. Applications need to be applied preventively beginning at bud break. Once leaf symptoms are present, control is extremely difficult. Fungicides that can reduce disease development include chlorothalonil, fluoxastrobin, metconazole, myclobutanil, propiconazole, tebuconazole, thiophanate methyl, triadimefon, and trifloxystrobin (Table 3.8). Foliar applications need to be applied at 7 to 14 day intervals. Weekly applications may be needed during summer months when rainfall and temperatures favor disease development.

Although chlorothalonil is very effective in reducing black spot disease development, it is known to be phytotoxic when applied during hot weather, particularly when applied at shorter intervals. Symptoms associated with chlorothalonil phytotoxicity include bronzing or chlorosis of leaves, irregular 'burnt' or brown spots in the upper leaf surface, and premature leaf drop (Hagan et al., 2005). Use chlorothalonil in rotation with other fungicides particularly in the spring and fall when plants are not suffering from heat stress. Rotate fungicides with different FRAC codes to reduce fungicide resistance development. Repeated applications of triazole (FRAC 3) fungicides can retard and distort new shoot growth.

***Cercospora* Leaf Spot**
Cercospora leaf spot is similar to black spot disease. It is very common on shrub roses and may be mistaken for the more notorious black spot. Several fungal species have been reported to cause *Cercospora* leaf spot including *Cercospora rosicola* Pass. (syn. *Passalora rosicola, Mycosphaerella rosicola*) and *Pseudocercospora puderi* B.H. Davis ex Deighton (syn. *Cercospora puderii*). Both cause similar symptoms on susceptible rose cultivars including small, round, tan to gray lesions with a narrow, dark border and purplish halo that may coalesce into irregular necrotic areas (Figure 3.17; Sinclair and Lyons, 2005). Premature leaf drop is also common with this disease. Shrub rose cultivars differ in their susceptibility to this disease (Table 3.7). Spores of the fungus are produced within the leaf spots mostly on the upper leaf surface in 'fuzzy' clusters containing conidiophores and spores. This characteristic can be used to distinguish *Cercospora* leaf spot from black spot, which produces its spores within blister-like structures on the upper leaf surface. *Cercospora* spores are dispersed by water-splashing to adjacent leaves and plants.

Management
Management of the disease is similar to that described for black spot. *Cercospora*-resistant cultivars are available and should be selected for production when possible (Table 3.7). Reducing leaf wetness is essential in reducing spore germination, infection and disease spread. The fungus survives within fallen leaf litter; therefore, removal of leaf debris is necessary to reduce inoculum survival. Fungicides applied to prevent black spot disease development will also control *Cercospora* leaf spot. Fungicides such as azoxystrobin, chlorothalonil, copper hydroxide, fluoxistrobin, mancozeb, myclobutanil, propiconazole, pyraclostrobin, thiophanate methyl, and trifloxystrobin are effective in reducing disease development when applied preventively. Applications after symptoms are evident will have little effect in managing this disease. Rotation of fungicides with different FRAC codes is necessary to reduce fungicide resistance development (Table 3.8).

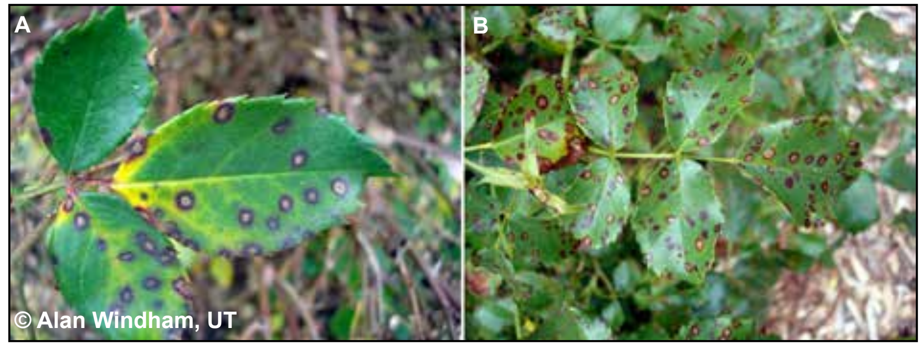


Figure 3.17 Gray leaf spots with a dark border and purple halo are characteristic of *Cercospora* leaf spot (A). Symptoms of a severe *Cercospora* leaf spot infection include leaf spots with a dark purple-brown border

Downy Mildew
Downy mildew caused by the oomycete pathogen, *Peronospora sparsa* Berk has become a serious problem causing significant losses to growers. Symptoms of downy mildew can be variable, making diagnosis difficult, and growers often attribute leaf lesions and defoliation to other leaf spot diseases. Downy mildew pathogens are host specific. *Peronospora sparsa* infects all rose species, as well as blackberry and raspberry (*Rubus* sp.).

Symptoms of downy mildew begin as small reddish flecks and expand to tan, purplish, or brown lesions often concentrated along leaf veins. Lesions appear angular because major leaf veins restrict pathogen growth. Purplish to brown lesions are more prevalent during wet conditions; whereas, tan lesions that resemble chemical phytotoxicity damage are more common during drier conditions (Figure 3.18 A-D). Infected leaves eventually turn yellow or brown and drop from the plant. Severe defoliation may occur on susceptible cultivars (Figure 3.18E). Bud infection may lead to stunting and malformation of leaves and flowers (Sinclair and Lyons, 2005). In severe cases, purplish patches can be seen on the branches. As the pathogen name implies, sporulation of the pathogen can be sparse and difficult to see in the field. Under favorable conditions, white to grayish sporulation consisting of sporangia on branched stalks (sporangiophores) can be seen on the lower leaf surface (Figure 3.18F). Sporangia are spread by water-splashing and wind where they germinate to release zoospores that infect wet leaves. Sporangia of other downy mildew diseases are

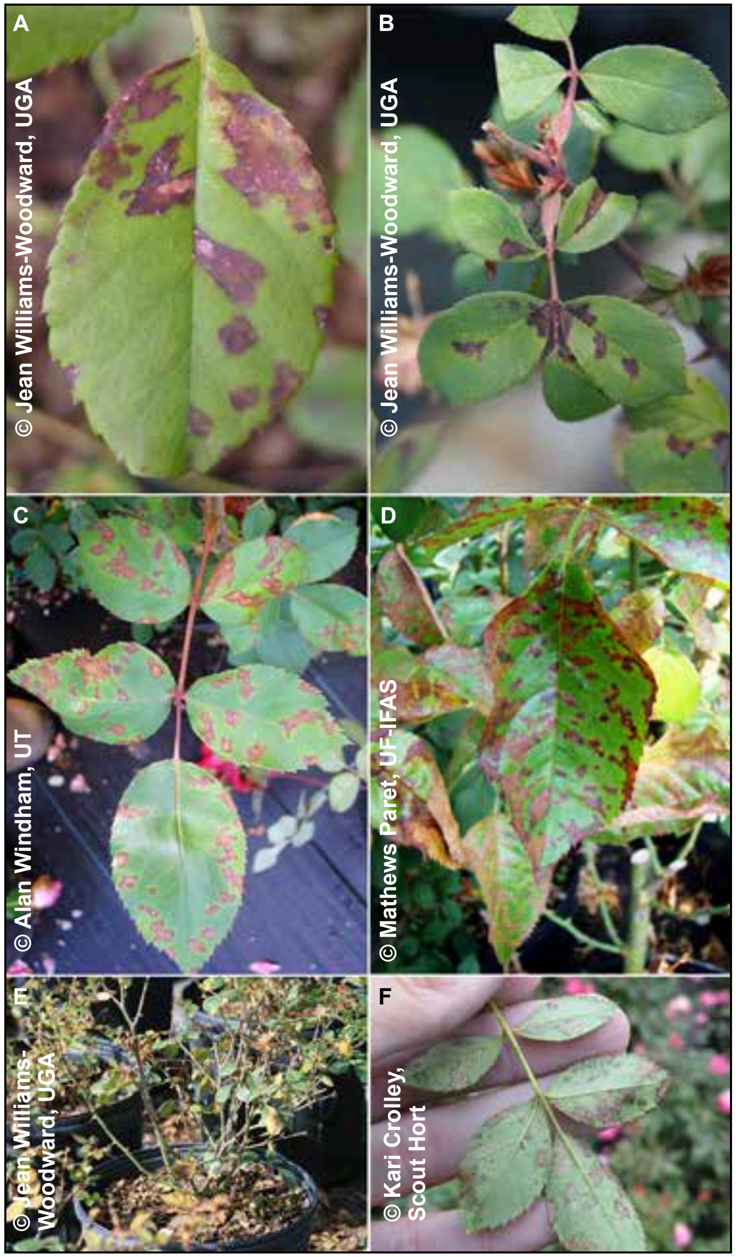


Figure 3.18 Downy mildew symptomology: purplish brown, angular leaf spots due to downy mildew infection on Double Knock Out™ (A, B), tan to brownish-purple, angular leaf spots (C, D), defoliation in a block of Knock Out™ roses (E), and white to grayish sporulation on the leaf underside (F)

known to be carried for miles during thunderstorms and hurricanes and this may be a means of introducing rose downy mildew into new areas. It is likely that all cultivated roses are susceptible to downy mildew. Because downy mildew disease can occur sporadically based upon environmental conditions, cultivar evaluations are difficult to conduct.

Disease development is dependent upon environmental conditions. In the southeastern USA, the disease is most commonly seen from the fall to spring months. It can be very severe on roses growing in poly-houses with overhead sprinkler irrigation. Downy mildew pathogens are "water-molds" similar to *Phytophthora* and *Pythium* root pathogens. Leaf wetness is necessary for pathogen infection and spread. Infection requires only 2 hours of leaf wetness under optimal temperatures 59-68°F (15-20°C) and relative humidity of 85% (Aegerter et al., 2003). Disease severity increases significantly as duration of leaf wetness extends up to 10 hours. When leaf wetness duration is extended, the pathogen can infect leaves at less than optimal temperatures as low as 41°F (5°C) to as high as 77°F (25°C) (Aegerter et al., 2003). Symptoms do not develop until 4 to 7 days after infection. Disease symptoms do not develop under hot, dry environmental conditions. During unfavorable conditions, the pathogen remains dormant as hyphae and oospores (survival spores) within infected leaves, buds, canes, roots, and crown tissues (Aegerter et al., 2002). Downy mildew can easily be spread via propagation of infected tissues.

Management

Since water plays such an important role in downy mildew disease development and spread, it is essential that leaf wetness duration be minimized. Avoiding overhead irrigation during conditions conducive to the spread of the disease is essential in reducing disease incidence. Downy mildew sporulation is most prevalent during early morning hours. Avoid sprinkler irrigating at this time as it will spread sporangia that can infect the wet leaves. It is better to overhead irrigate at mid-day because plant foliage will typically dry faster, sporangia are less prevalent, and sunlight exposure of 6 hours will kill downy mildew sporangia. Increase air circulation by increasing plant spacing to aid in plant drying.

Downy mildew infected plants should be removed to reduce disease spread. Do not propagate from infected plants. Removing fallen leaf litter from nursery beds and containers is critical in reducing inoculum load. Fungicides can manage downy mildew when applied preventively (Table 3.8). Suppressive applications after disease is present have minimal effect in slowing the disease epidemic. Preventive fungicide applications can be applied at two-week intervals using the lower labeled rates; however suppressive applications need to be applied weekly and at the higher labeled rates. Drench incoming plants with mefenoxam or a tank mix of mefenoxam and fluopicolide. Drench again in early fall or spring when environmental conditions favor disease development. Rotate fungicides with different FRAC code numbers as downy mildew pathogens frequently develop fungicide resistance. Fungicides effective against downy mildew include azoxystrobin, cyazofamid, copper hydroxide, dimethomorph, fluopicolide, fluoxistrobin, fosetyl-Al, mancozeb, mandipropamid, mefenoxam, phosphorous acid, potassium phosphite, pyraclostrobin, and trifloxystrobin.

Bacterial Leaf Spot

Bacterial leaf spot caused by *Xanthomonas* sp., is a new disease of rose affecting nursery production. The disease has been reported in Florida on shrub rose varieties 'RADrazz' (Knock Out®) and 'RADtco' (Double Knock Out®) (Huang et al., 2013; Vallad, 2009). This disease causes chlorotic and necrotic spots on the foliage rendering the plants unmarketable (Figure 3.19). High relative humidity of >75% throughout the growing season provides a favorable condition for the development of the disease and the spread of *Xanthomonas* sp. on roses (Paret et al., 2013). Most commercial nurseries use overhead irrigation for rose production that further contributes to disease incidence and spread.

Figure 3.19 Chlorotic and necrotic bacterial leaf spots on rose foliage

Management

When possible, minimize length of time leaves stay wet after irrigation events by using adequate spacing to promote air movement within the rose plant canopy. Information on plant resistance to bacterial leaf spot is currently not available. Preliminary studies on the use of Acibenzolar-S-methyl (Actigard™), a systemic acquired resistance inducer that activates plant defense systems by increasing the transcription of stress-related genes, seems to reduce bacterial leaf spot severity (Vallad, 2009).

Powdery Mildew

Powdery mildew of rose is caused by the fungus, *Podosphaera pannosa* (Wallr.) de Bary (syn. *Sphaerotheca pannosa*). It occurs primarily during the spring and fall seasons. Cloudy, warm, humid weather favors disease development. Infection is favored when air temperature ranges from 70 to 81°F (21 to 27°C) and relative humidity is between 90 and 100% (Philley et al., 2001). When daytime temperatures exceed 90°F (32°C), new infections cease. As opposed to other diseases affecting rose, where disease severity is linked to prolonged periods of leaf wetness, powdery mildew disease is inhibited by leaf wetness. Syringing plants to keep the foliage wet can reduce powdery mildew infection. Unfortunately, this technique will also increase the severity of all the other rose foliage diseases.

Powdery mildew disease is easily recognizable as white, powdery patches of hyphae and spores. Powdery mildew growth can expand to cover entire leaves, flowers, and new shoots (Figure 3.20). Young succulent tissues are more susceptible to infection than mature leaves. Powdery mildew fungi are obligate pathogens that require living tissue to grow. Infection does not kill tissues, but can interfere with photosynthetic efficiency and reduce plant growth and flowering. Powdery mildew spores are spread primarily by air currents, and disease may be apparent within 1 week of infection. The fungus survives in mild climates, such as the southeastern USA, as hyphae in dormant buds, stems, and in leaves remaining on plants. Its sexual stage is rarely seen. As new growth begins in the spring, the shoots arising from infected dormant buds become covered with powdery mildew. The fungus then, spreads from these infected shoots to the rest of the plant and adjacent plants.

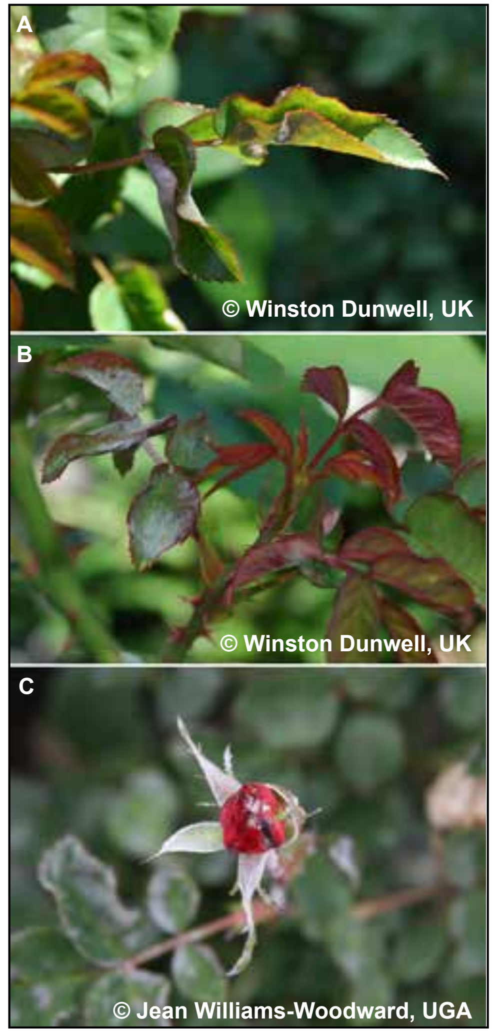


Figure 3.20 Incipient powdery mildew infection on young rose tissue (A), expanding to cover almost the entire leaf with white, powdery patches (B), and damage and malformation of rose sepals and flower petals due to powdery mildew infection (C)

Management

Rose cultivars vary in their susceptibility to powdery mildew. Most of the shrub roses are resistant (Table 3.7); however, under severe disease pressure and favorable environmental conditions, some shrub roses will develop powdery mildew. To prevent powdery mildew epidemics, scout plants for the first sign of the disease. Check beneath leaves and at the base of flower buds as disease often begins in these areas. Reducing humidity and increasing plant spacing can help reduce infection and disease spread.

Many fungicides relabeled for powdery mildew control on roses and most also control black spot and *Cercospora* leaf spot (Table 3.8). If plants are already under a spray program for black spot, then powdery mildew is likely also being controlled. A few fungicides are good on powdery mildew, but not other foliage diseases including copper hydroxide, copper sulphate pentahydrate, neem oil, potassium bicarbonate (do not use if plants are undergoing heat or drought stress), and triflumizole (Table 3.8).

Phytophthora Root Rot

Phytophthora root rot is a serious disease affecting roses. The primary pathogen is *Phytophthora cinnamomi* Rands, an oomycete or "water-mold" pathogen that has a large host range and infects numerous ornamental plant species in nursery production (Jeffers and Baxter, 2001). Symptoms of root disease are often overlooked until infection is severe and plants are close to death. Initial symptoms are only evident on the roots and include darkly discolored and softened roots, feeder roots may be lacking, and dark brown discoloration may extend upward into the crown and lower stem. Aboveground symptoms include an overall lack of plant vigor, pale green to yellow foliage, wilting, premature leaf drop, and eventually stem dieback and plant death.

Phytophthora infection is favored by prolonged periods of saturated soil. The pathogen survives in native soil, contaminated rooting substrate and nursery beds. It is spread by water-splashing and on contaminated tools, equipment, containers, shoes, and infected plant material. *Phytophthora* produces sporangia that release motile zoospores in saturated conditions. Zoospores move within water and can be washed out of containers and into recirculating irrigation water sources. Zoospores infection of roots is most likely in the spring and the fall, when environmental conditions are favorable. However, aboveground plant symptoms are often not seen until the summer months, when warmer temperatures increase plant water demand.

Management

Phytophthora root disease management requires good water management and sanitation to reduce introduction and spread of the pathogen during production. Discard severely infected plants to reduce disease spread. Avoid over-irrigating plants and use well-draining rooting substrates to reduce potential for infection via extended periods of saturated rooting conditions. Do not reuse rooting substrate or containers without cleaning and disinfesting them prior to use. Since sporangia and zoospores can be splashed onto plant foliage, do not propagate from infected plants. Fungicide drenches can reduce root disease development by protecting roots from infection in the spring and fall (Table 3.8). Mefenoxam is the most commonly used fungicide. However, resistance to mefenoxam and has been reported within 6% to 66% of the *Phytophthora* isolates recovered from nurseries and greenhouses in the southeastern USA (Hwang and Benson, 2005; Olson and Benson, 2011; Olsen et al., 2013). Other effective fungicides include cyazofamid, fluopicolide, fluoxastrobin, fosetyl-Al, mandipropamid, mono- and di-potassium salts of phosphorous acid, and potassium phosphite. These are the same products that are also used for control of downy mildew disease when applied to the foliage. Foliar applications can help reduce foliage blights several species of *Phytophthora*, including *P. nicotianae* and *P. citrophthora*.

Figure 3.21 Symptomology of rose rosette disease including the witches' broom (A), magenta foliage coloration (B), unusual leaf shape (C), thorn proliferation along stem (D), and a landscape planting completely infected with rose rosette (E) and at point of removal (F) in the landscape

Rose Rosette Virus-Associated Disease

The rose rosette virus is a deadly disease of commonly cultivated roses (Bischoff, 2012). The disease was first reported on wild rose in the Manitoba province, Canada in 1940 (Conner, 1941). An increased incidence of the disease was reported in Arkansas, Kansas, Missouri, and Oklahoma on multiflora rose in rural areas and on cultivated roses in urban areas in 1978-1982 (Crowe, 1983). Rose rosette has been reported in all regions of the U.S., but is particularly widespread in the north-central, south-central, and southeastern regions (Epstein and Hill, 1995). The incidence of rose rosette has increased exponentially with the increase of shrub roses in landscape plantings.

The symptoms of rose rosette are as complex and varied as the rose species that are affected by the disease. Infected plants generally exhibit a witches' broom (rosette) type symptoms (Figure 3.21A). New growth may be a deep magenta (Figure 3.21B). Infected leaves may be strap shaped, rugose, crinkled or otherwise deformed (Figure 3.21C). Some, but not all, roses may have an increase in thorns on canes (Figure 3.21D). Thorns may be so numerous that the canes are referred to as "furred". Epstein and Hill (1999) described three stages of rose rosette, starting with leaf distortion and witches' broom and ending in a weakened plant with small leaves, a stunted root system and death (Figure 3.21E-F). Infected roses have starch reserves that are greatly reduced, which negatively affects winter hardiness.

The causal agent of rose rosette has been reported to be graft transmissible, and several reported that it was likely caused by an unidentified phytoplasma (Horst, 2007). However, because therapy with tetracycline was unsuccessful, phytoplasmas did not cause rose rosette disease. Others speculated that the causal organism was a virus or virus-like (Epstein and Hill, 1995). Further research associated a double stranded RNA with roses exhibiting symptoms of rose rosette (Di et al, 1990). In 2011, a RNA virus was found in 84 of 84 roses affected with rose rosette and the virus was assigned to the genus *Emaravirus* (Laney et al, 2011). Early research on rose rosette determined that the causal organism could be vectored by an eriophyid mite, *Phyllocoptes fructiphilus* (Allington, 1968).

The host range of rose rosette among roses is extensive. Multiflora rose (*R. multiflora*) is particularly susceptible to the disease. Rose rosette virus has been used as a biocontrol agent for multiflora rose infestations with pasturelands being reclaimed within 5 to 6 years of introduction of infected plants (Armine, 1990). All cultivated roses (shrub type, hybrid tea, floribunda, grandiflora and miniature roses) are thought to be susceptible to the disease. Other roses reported to be susceptible are: *R. woodsii*, *R. bracteata*, and *R. eglanteria*. Roses reported to be resistant are: *R. setigera*, *R. aricularis*, *R. arkansana*, *R. blanda*, *R. palustris*, *R. carolina*, *R. californica* and *R. spinosissima* (Epstein and Hill, 1999).

Management
Research in the management of rose rosette in nursery production and ornamental plantings is in early stages. Stock plants used in propagation of roses should be routinely and regularly assayed for the rose rosette virus using molecular techniques to ensure that plants shipped to retail markets are not infected. Symptomatic plants should be discarded and not propagated. In landscape plantings, removal of rose rosette infected plants as soon as they are detected is advised. It is not clear at this time, if miticide sprays to prevent establishment of eriophyid mites are an effective means of preventing or slowing the spread of the disease.

Figure 3.22 *Botrytis* infection causing stem dieback on Knock Out® rose

Botrytis Blight
Botrytis blight, caused by the fungus, *Botrytis cinerea* Pers., mostly affects flowers and weakened new growth. The pathogen is ubiquitous and can infect an extremely large number of plants. Infection is favored by rainy, cool weather. Optimal temperatures for infection and disease development are when temperatures are between 61 and 72°F (16-22°C) and relative humidity is >85% (Sinclair and Lyons, 2005). Botrytis blight can be a serious problem in poly-covered houses in the southeastern USA during the winter months on cold injured tissues. It is an infrequent problem in field and nursery production if air circulation is good around plants.

Botrytis infection on flowers starts as tiny water-soaked, translucent spots that rapidly turn tan with a darker margin. In damaged tissue, *Botrytis* can girdle small shoot tips and branches killing the growth above the point of infection (Fig. 3.22). *Botrytis* infection can be identified by the mass of gray-brown powdery spores produced on infected tissues under humid conditions. The spores are easily dislodged and are spread by water-splashing and air movement. Bare-root rose plants in storage may also be severely infected by *Botrytis*.

Management
Botrytis management relies on sanitation and humidity control. *Botrytis* survives as a saprobe, living off decaying tissues. Therefore, good sanitation is essential to reduce inoculum load. Remove all senescent flowers and dead stems, discard severely affected plants, and remove fallen leaf litter and soil debris from the production area. Improve air circulation within poly-houses to reduce humidity levels and aid in plant drying. Production activities such as pruning can spread *Botrytis* spores. Fungicides should be applied before production activities take place to reduce spore production or immediately after to reduce spore germination on the damaged (pruned) tissues. There a quite a few fungicides labeled for control of *Botrytis*. Within nursery production, a spray program to

control black spot disease will also control *Botrytis* infection. If *Botrytis* infection has been a problem or conditions are favorable for disease development, the better fungicides to use against *Botrytis* are chlorothalonil, iprodione, and fenhexamid.

Crown Gall

Crown gall is caused by the bacterium, *Agrobacterium tumefaciens,* which enters the plant through wounds made during grafting, planting, pruning, or insect feeding (APS, 2007). Often, plants are infected in the nursery and the disease develops later, after planting in the garden. Symptoms are a gradual decline in plant health, often associated with the presence of spherical, woody growths at the crown or on stems (Fig 3.23). Galls have rough surfaces and may grow up to 6 inches in diameter.

Management

Diseased plants should be removed and destroyed for management of the disease. Sanitation of equipment used in rose management is highly relevant for preventing spread of this disease.

Figure 3.23 Crown gall on a rose stem

Table 3.7 Disease resistance ratings[Z] of select shrub rose cultivars to black spot, *Cercospora* leaf spot, and powdery mildew in the Southern U.S.

	Disease Rating[Y]		
Cultivar	**Black Spot**	**Cercospora Leaf Spot**	**Powdery Mildew**
'About Face'	S	R	R
'Austrian Copper'	S		R
'Baby Love'	S	R	R
'Ballerina'	S	R	R
'Be-Bop'	S	R	R
'Belinda's Dream'	MR	R	R
'Betty Prior'	S	R	
Blushing Knock Out®	R	R	R
'Bonanza'	S	R	R
Bonica®	S	MR	
'Brite Eyes'	R	R	R
'Butterfly Rose'	S	R	
Carefree Beauty™	MR	S	R
Carefree Delight™	MR	S	R
Carefree Marvel™	R	MR	R
Carefree Spirit™	R	R	R
Carefree Sunshine™	MR	S	R
Carefree Wonder™	S	R	
Cherry Meidiland®	S	R	
Coral Drift®	R	S	MR
Coral Meidiland®	S		R
Double Knockout®	R	R	R
Double Pink Knockout®	R	R	R
Easy Going™	S	R	R
'Elisio'	S		R
'Eureka'	S	R	R
'Fiesta'	MR	MR	
Fire Meidiland®	MR	MR	
First Light™	S	R	R
Flower Carpet®	R	MR	R
Fuchsia Meidiland®	R	MR	R
'George Vancouver'	MR		MR
'Golden Eye'	MR	MR	

Table 3.7 *continued* Disease resistance ratings[Z] of select shrub rose cultivars

Cultivar	Disease Rating[Y] Black Spot	Cercospora Leaf Spot	Powdery mildew
'Gourmet Popcorn'	S	R	R
Happy Trails™	R	S	
'Heart N' Soul'	S	R	R
Home Run®	MR	MR	R
Hot Cocoa™	S	R	R
Ice Meidiland®	MR	R	R
Ivory Drift®	R	MR	R
Jeeper's Creeper™	S	R	
Joe's Red Creeper™	S		R
'Johann Strauss'	S	R	R
'Julia Child'	S	R	R
'Kaleidoscope'	S		R
'Kashmir'	MR	MR	
Kent™	S	R	R
Knock Out®	R	R	R
Lady Elsie May®	S	MR	R
Lillian Austin™	MR	R	
Livin' Easy™	S	R	
'Lovely Fairy'	R	MR	R
'Madam Hardy'	S	R	
Magic Meidiland®	R	R	
'Modern Ruby'	S		R
'Moje Hammarburg'	R	R	
'My Girl'	MR	MR	
'My Hero'	MR	MR	
Mystic Meidiland®	MR	R	R
'Nearly Wild'	S	R	
'Nozomi'	S	R	
'Palmengarten Frankfurt'	MR	MR	R
Panda Meidiland®		MR	
Peach Drift®	R	MR	R
Pearl Meidiland®	S	R	
Pearl Sevillana™	MR	R	
'Petite Pink Scotch'	R	MR	S

Table 3.7 *continued* Disease resistance ratings[Z] of select shrub rose cultivars

Cultivar	Disease Rating[Y] Black Spot	Cercospora Leaf Spot	Powdery mildew
Pink Drift®	MR	MR	
'Pink Grootendorst'	MR	R	
Pink Knock Out®	R	R	R
Pink Meidiland®	S	S	
Polar Ice™	MR	S	
Polar Sun™		MR	
'Pretty Lady'	S	R	R
'Rabble Rouser'	S	R	R
Rainbow Knock Out®	R	S	S
Ralph's Creeper™	S	R	
Raven™	S	R	
Red Cascade™	MR	R	MR
Red Drift®	R	MR	R
'Rockin' Robin'	S	R	R
Royal Bonica®	S	R	
Ruby Meidiland®	MR	MR	R
Scarlet Meidiland®	MR	S	R
'Sea Foam'	S	R	
Sevillana®	S	R	
'Simon Fraser'	R		S
'Sweet Chariot'	S	R	
Tequila™	MR	R	R
The Fairy™	R	S	
'Therese Bugnet'	MR	S	S
'White Dawn'	R	R	
White Drift®	MR	R	S
White Flower Carpet®		MR	R
White Meidiland®	S	MR	R
'Wild Spice'	MR	MR	
'Wild Thing'	MR	MR	
'Wildberry Breeze'	R	R	

[Z] (Hagan and Akridge 2009, 2010; Hagan and Dawkins, 2008, 2009, 2010; Hagan et al., 2002; Hong et al., 2001; Rivas-Davila et al., 2005)
[Y] Disease Ratings (R = Resistant; MR = Moderately resistant; S = Susceptible) are the average ratings from 2 to 9 field evaluations for each cultivar from previously reported studies

Table 3.8 Fungicidal activity arranged by Fungicide Resistance Action Committee (FRAC) codes to help develop a fungicide rotation plan for managing key plant pathogens of shrub roses. Check current products for labeled pesticides, sites for control and plant safety and efficacy on fungal species[Z]. Within columns, products indicated by "X" are labeled for use against the listed pathogen type. Several listed active ingredients are available only to certified professional applicators and may not be available for homeowner use. Site conditions, phytotoxicity information and available formulations are also subject to annual revision; therefore, table recommendations should be validated by consulting the most current product labels

FRAC Code	Class Description	Active Ingredient(s)	Brand Names	Downy Mildew *oomycetes*	Leaf Spots & Blights, Anthracnose, Petal Blights *fungal*	Powdery Mildew *oomycetes*	Stem/Root Rots by Water Molds *oomycetes*	Stem/Root Rots *fungal*	Action and Management Notes
1	Benzimidazoles[Y]	thiophanate-methyl	Cleary's 3336™		X	X		X	Broad spectrum fungicide for various fungi
		thiophanate-methyl	AllBan®		X	X		X	
1+14		etridiazole + thiophanate-methyl	Banrot® 400*				X	X	
		thiophanate-methyl + mancozeb	Zyban® *		X	X			
1+M5		thiophanate-methyl + chlorothalonil	Spectro® 90 WDG		X	X		X	
2	Dicarboximides	iprodione	Chipco® 26019**		X			X	Resistance common in *Botrytis cinerea*
3	DMI or SI Triazoles	propiconazale	Banner® MAXX® II		X	X			Effective on powdery mildew. Not effective on downy mildew
		triadimefon	Bayleton®			X			
		myclobutanil	Eagle® 20		X	X			
		triflorine	Funginex®		X	X			
		triadimefon	Strike® 50 WDG**			X			
		tebuconazole	Torque™		X	X			
		metconazole	Tourney®		X	X		X	
4	Phenylamides	mefenoxam	Subdue® MAXX® **	X			X	X	Effective against diseases caused by oomycetes (water molds), including damping off, root and stem rots, and foliar diseases. Use as soil drench or foliar application
7+11		pyraclostrobin + boscalid	Pageant® *,**	X	X	X	X	X	Effective on mildews, foliar pathogens, and most fungi
11	QoI Strobilurins	fluoxistrobin	Disarm® O	X	X	X	X	X	Effective on mildews, foliar pathogens, and most fungi. Fungicide resistance risk high. Some control of oomycetes
		azoxystrobin	Heritage®		X	X			
		pyraclostrobin	Insignia®	X	X	X	X	X	
		trifloxystrobin	Compass® **	X	X	X	X	X	

Table 3.8 *continued* Fungicidal activity arranged by FRAC codes to help develop a fungicide rotation plan for managing key plant pathogens of shrub roses

FRAC Code	Class Description	Active Ingredient(s)	Brand Names	Downy Mildew *oomycetes*	Leaf Spots & Blights, Anthracnose, Petal Blights *fungal*	Powdery Mildew *oomycetes*	Stem/Root Rots by Water Molds *oomycetes*	Stem/Root Rots *fungal*	Action and Management Notes
12	Phenyl Pyrroles	fludioxonil	Medallion®		X			X	Broad spectrum fungicide, not effective against oomycetes (water molds)
		cyprodinil + fludioxonil	Palladium™ *		X	X		X	
14	Aromatic Hydrocarbons	etridiazole	Terrazole®				X		Effective against water molds (oomycetes)
		etridiazole	Truban®				X		
		PCNB	Terraclor®					X	
		triflumizole	Terraguard® **		X	X		X	
14+1		etridiazole + thiophanate-methyl	Banrot® 400*				X	X	
17	Hydroxyanilides	fenahexamid	Decree® **		X	X			Protection from *Botrytis* spp. in outdoor and greenhouse nursery crops
21	Ubiquinone QiI	cyazofamid	Segway®	X			X	X	Effective against water molds (oomycetes)
28	Carbamates	propamocarb	Banol® **	X			X		Control of oomycetes (water molds). Not for use in landscapes
33	Phosphonates	phosphorus acid	Alude™	X			X		Effective as a protectant treatment of water molds (oomycetes) such as Phytophthora, Pythium, and Downy Mildew pathogens
		fosetyl-AL	Aliette®	X			X		
		potassium phosphite	Vital®	X			X		
40	Cinnamic Acid Amides	mandipropamid	Micora™	X			X		Locally systemic. Control of oomycetes (water molds). Not for use in landscapes
		dimethomorph	Stature® SC	X			X		
43	Pyridinemethyl-benzamides	fluopicolide	Adorn®	X			X		
M1	Copper, fixed	copper hydroxide	CuPro™ 2005		X	X			Effective as protectants on broad spectrum including most fungi and mildews. No systemic activity. Fungicide resistance risk low
		copper hydroxide + mancozeb	Junction™ *		X	X			
		copper sulphate pentahydrate	Phyton 27	X	X	X		X	
M3	Dithicarbamates & relatives	mancozeb	Manzate® Flowable T&O		X				Effective as protectants on broad spectrum including most fungi and mildews. No systemic activity. Fungicide resistance risk low
		mancozeb	Dithane®		X				

Table 3.8 *continued* Fungicidal activity arranged by FRAC codes to help develop a fungicide rotation plan for managing key plant pathogens of shrub roses

FRAC Code	Class Description	Active Ingredient(s)	Brand Names	Downy Mildew *oomycetes*	Leaf Spots & Blights, Anthracnose, Petal Blights *fungal*	Powdery Mildew *oomycetes*	Stem/Root Rots by Water Molds *oomycetes*	Stem/Root Rots *fungal*	Action and Management Notes
3+M3	Demethylation inhibitor + Dithiocarbamate	mancozeb + myclobutanil	Clevis™		x	x			Effective as protectants on broad spectrum including most fungi and mildews. No systemic activity. Fungicide resistance risk low
M4	Multi-site inhibitors	phthalimides	Captan		x			x	Effective as protectants on broad spectrum including most fungi and mildews. No systemic activity. Fungicide resistance risk low
M5	Chloronitriles	chlorothalonil	Daconil Weather Stik®		x	x			Effective as protectants on broad spectrum including most fungi and mildews. No systemic activity. Fungicide resistance risk low
		chlorothalonil	Manicure® 6FL		x				
NC	No Class Needed	potassium bicarbonate	Armicarb® 100		x	x	x		Contact fungicide. Apply at dormancy. Low risk for resistance
		neem oil	Trilogy®	x	x	x			

[Z] This table reports information on fungicide labels and does not reflect product efficacy. Refer to fungicide labels for rates and usage, specific host information, possible phytotoxicity, re-entry intervals and resistance management

[Y] This group was formerly known as De-Methylation Inhibitors (DMI) and are now classified as Sterol Biosynthesis Inhibitors (SBI or SI)

* Chemical contains more than one active ingredient, thus more than one FRAC code is assigned

** Not for use in residential landscapes. Commercial use only. See label

This table reports information on fungicide labels and does not necessarily reflect product efficacy. FRAC codes group fungicides by their mode of action and resistance risk. Fungicides groups should be rotated in order to prolong the effectiveness of fungicides

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