PERFORMANCE OF LOW-MAINTENANCE ROSES IN CENTRAL FLORIDA

By

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To Nora and Andrés, your efforts made me who I now am

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
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Cultivation of roses in Florida is normally difficult as most cultivars require high maintenance to be vigorous, long-lasting plants. Warm, humid periods are favorable conditions for the development and persistence of insects and diseases that affect rose performance. Periodic applications of pesticides are therefore usually necessary to maintain quality and reduce damage to the plants. Roses planted on well drained, nutritionally poor soils in Florida typically require regular applications of water and high fertilizer amounts that could be leached by heavy rains. Development of rose cultivars has traditionally focused on improving flower characteristics with little emphasis on landscape performance. However, careful selection of cultivars can help reduce maintenance and inputs such as water, fertilizer and pesticides.

The objective of this study was to develop recommendations of own-root rose cultivars for central Florida under low maintenance conditions. Plants of eleven Old Garden roses and Modern roses were evaluated in an experiment utilizing a randomized block design with treatments replicated three times. Plants received minimum rates of water and fertilizer and diseases and insects were not controlled. Each plant was pruned once in Feb. 2009 to one third of its size and no grooming or

dead-heading was done. Weekly evaluations of plant quality and flower coverage were performed for all plants from Mar. 2008 to Jan. 2010. The incidence of black spot, Cercospora leaf spot and chilli thrips was also evaluated from Sep. 2008 to Dec. 2009. Plant size was determined by measuring height and two perpendicular widths twice a year.

Statistical differences of plant quality and flower coverage among cultivars were observed. Damage caused by the foliar diseases black spot and Cercospora leaf spot, as well as chilli thrips, were the major factors that decreased plant quality on the susceptible cultivars. Differences in susceptibility to these three factors were also found among cultivars. Recommendations are offered considering these factors and other characteristics specific to each cultivar. The cultivar ‘Mrs. B. R. Cant’ appeared to be the most suited for central Florida under the low maintenance conditions of the study Plant quality of this cultivar improved greatly during the second year of evaluation and flower production was fairly constant. ‘Duchesse de Brabant’ and ‘RADrazz’ (Knock Out®) and ‘Spice’ are cautiously recommended. Yellowing and defoliation at low severity from black spot and Cercospora leaf spot can be observed, however, flower production on these cultivars might not be greatly reduced. ‘Bailey Red’, ‘Old Blush’, ‘Belinda’s Dream’, ‘Perle d’Or’, ‘BUCbi’ (Carefree Beauty™), and ‘WEKcisbako’ (Home Run®) had severe defoliation, poor growth and reduced vigor. These cultivars are not recommended as low maintenance, own-root shrub roses for central Florida. This research shows that not all rose cultivars with the Earth-Kind® designation are reliable, low maintenance performers in central Florida.

CHAPTER 1
INTRODUCTION

Roses (*Rosa* L.) are one of the most cultivated flowers in the world due to their visual appeal in the garden or as cut flowers. The American Rose Association has described about 25,000 cultivars and at least 200 species of roses (Horst and Cloyd, 2007). Breeding has focused on several characteristics such as flower characteristics, cut flowers, potted plants, perfume and content of vitamin C on the hips (Zlesak, 2007). Landscape performance or resistance to diseases and pests has been less explored. However, low maintenance and environmentally friendly cultivars are being developed due to increasing concerns about pesticide exposure, restricted use of pesticides and the high cost of resources (Zlesak, 2007). Although cultivated roses can be grown worldwide, Florida's sub-tropical climate and poor soils make it difficult to grow roses. Factors that influence rose performance, such as adaptability of the root system, proper fertilization and susceptibility to diseases should be considered prior to planting (Manners, 1999).

Roses are classified into three categories: rose species, Old Garden Roses (OGR) and Modern Roses (MR). OGR and MR categories are divided into subcategories that group cultivars according to different characteristics, such as growth habit or parentage. The United States comprises a large territory with a variety of environmental conditions and soil types in which specimens from all three categories can be grown (Brichet, 2003). The most popular cultivars belong to the Hybrid Tea, a class of MR that contains about 10,000 cultivars (Zlesak, 2007). However, in Florida, Hybrid Teas are considered high maintenance roses requiring intense attention to pest control, fertilization and irrigation (McLaughlin and Garofalo, 2001). There are various cultivars from both MR

and OGR that will perform well with minimal care even under the unfavorable conditions of Florida. Cultivars of OGR belonging to the classes Hybrid China and Tea appear to be most appropriate for Florida since they are more tolerant of tropical climates and more disease resistant than the Hybrid Tea (McLaughlin and Garofalo, 2001).

Roses are sold as either grafted or own-root plants. Grafted roses have an advantage over own-rooted roses as rootstocks enhance several characteristics (Manners, 2000). Nevertheless, grafting or budding plants alone does not insure such improvement and, consequently, selection of a good rootstock is also necessary (Manners, 2000). Grafted roses on rootstocks of the species *R. fortuniana* have been successful in Florida's soil and climate whereas only a few roses will survive on their own roots (Manners, 1999). In spite of this, own-root plants have significance for growers and nurseries, as time and cost of production are reduced (Manners, 2000).

Florida's rainy subtropical climate favors diseases for an extended period (Miller, 1961). Infectious diseases can be caused by several agents, and produce a variety of symptoms such as necrosis, cankers, dwarfing and/or stunting (Horst and Cloyd, 2007). Foliar diseases such as black spot (caused by *Diplocarpon rosae* Wolf), powdery mildew (caused by *Sphaerotheca pannosa* var. *rosae* Wor.) and Cercospora leaf spot (caused by *Cercospora rosicola* Pass.) are predominant diseases in Florida and are limiting factors in growing roses in the state (Miller, 1961). Rose producers and gardeners in Florida rely on frequent fungicide applications to maintain healthy plants. Nonetheless, certain rose cultivars exist that are resistant to black spot and powdery mildew (Manners, 1999). Susceptibility to Cercospora leaf spot is also variable among cultivars (Hagan et al., 1999).

Roses are also susceptible to a wide range of arthropod pests such as thrips, mites, aphids, beetles and leaf cutter bees (Horst and Cloyd, 2007). Foliage, flowers and buds can be damaged by different insects such as the rose aphid (*Macrosipum rosae*), flower thrips (*Frankliniella tritici*) and western flower thrips (*Frankliniella occidentalis*). Recently detected on roses in Florida, chilli thrips (*Scirtothrips dorsalis*) can cause severe foliar damage and defoliation (Seal and Klassen, 2005).

Reduction of pesticide applications along with other high maintenance practices such as frequent watering, fertilizing and pruning can be accomplished by the selection of cultivars (Mueller et al., 2008). In Texas, cultivars with disease resistance and excellent landscape performance under minimum inputs have been identified through field evaluations. This work was conducted as part of the Earth-Kind® environmental landscape management program by Texas A & M University. In this program, cultivars with the best landscape performance and tolerance or resistance to diseases and insects have been identified for different areas of Texas (Harp et. al., 2009). Rose cultivars are rewarded the Earth-Kind® designation only if plants truly adapt to the local environmental conditions, maintain attractive plant and flower characteristics, and show tolerance to insects and diseases throughout the evaluation period (Harp et al., 2009).

Certain cultivars from different horticultural classes of OGR and MR, as well as rose species, also will succeed in Florida. Observations of a rose collection at Florida Southern College in Lakeland (central Florida) have led to recommended cultivars that will perform well as either own-root or as grafted plants (Manners, 1999). McLaughlin and Garofalo (2004) recommend own-root cultivars of Tea, Hybrid China and Noisette

roses as garden specimens for south Florida. Until now however, no studies have been conducted that evaluate plant performance throughout the state.

The study presented here is part of a larger evaluation which includes north, central and south Florida. The overall purpose of the statewide research is to develop regional recommendations of own-root, low maintenance shrub roses for landscape use. Results in this study are limited to the specific environmental conditions of central Florida and to the cultivars tested. The specific goals of the study are to evaluate performance (plant growth rate, flowering season, flowering peaks and plant quality) of twelve rose cultivars. Additionally, damage by two major diseases (black spot and Cercospora leaf spot) as well as one insect pest (chilli thrips) was evaluated to determine the extent in which these are quality reducing factors. A brief introduction of the history and classification of roses is presented with an overview of rose culture and maintenance. Subsequent chapters include a detailed description of the methodology of the study, the results obtained and a discussion of the same.

CHAPTER 2
LITERATURE REVIEW

History and Classification

Roses are one of the major flowers cultivated in the world. Roses originated in China; fossils found there date from 40 million years ago (Guoliang, 2003). Cultivation can be traced back 2000 years when wild roses were grown at China's imperial palaces and this country is considered the center of origin and diversity (Guoliang, 2003). Fossils have also been found in North America, in Colorado and Oregon, that date back more than 30 million years ago (Horst and Cloyd, 2007). Wild roses are vastly distributed only around the northern hemisphere, but developed cultivars can be grown worldwide (Cairns, 2003). A total of 200 species are now recognized by The American Rose Association (Horst and Cloyd, 2007) of which at least 60 species are native to the United States (Brichet, 2003)

Taxonomic classification of roses is difficult because they are genetically complex plants with widely variable phenotypic characteristics (Wissemann, 2003). According to Wisseman, (2003), Linnaeus, despite recognizing natural hybridization within *Rosa* species, made an attempt to classify the genus using the shape of the hip. Although this approach facilitated the differentiation of ten species in 1772, different systems appeared later utilizing characters that were more species-specific. This led to an increase in the number of species to 114 described by Döll in 1855 (Wissemann, 2003). According to a more modern classification system by Rehder, the genus *Rosa* is divided in four subgenera: *Hulthemia*, *Platyrhodon*, *Hesperhodos* and *Eurosa* (Rehder, 1960). The latter is the largest, containing about 120-200 species, whereas the first three are very small with only one or two species each (Nybom, 2009). The subgenus *Eurosa*

contains the major number of species involved in cultivated roses and is subdivided into 10 sections: *Pimpinellifoliae, Rosa, Caninae, Carolinae, Cinnamomeae, Synstylae, Indicae, Banksiae, Laevigatae* and *Bracteatae* (Rehder, 1960). In recent years, molecular methodologies such as chromosomal counts and DNA-based studies have helped to further clarify the proper treatment of the genus (Nybom, 2009; Cairns, 2003).

Categorization of rose cultivars before 1867 is further complicated by the lack of hybridization records (Zlesak, 2007). Rose cultivars may have been developed though natural or artificial hybridization in China during the first century (Guoliang, 2003) Plants may also have been selected for characteristics such as repeated flowering, bigger, double-petaled flowers and formal plant structure (Guoliang, 2003). In the sixteenth century, European roses were cultivated mainly for medicinal purposes. Interest increased and, by the seventeenth century, new varieties appeared that were valued for their decorative and horticultural properties (Joyaux, 2003). However, how these cultivars were developed or selected was not documented.

Repeat-flowering roses as well as red and yellow-colored flowers were not known in Europe before the 1800's (Guoliang, 2003; Joyaux, 2003). The introduction of Chinese cultivars such as 'Old Blush China' (also known as 'Parsons' Pink China', in 1751), 'Slater's Crimson China' (1793), 'Hume's Blush Tea-scented China' (1809) and 'Parks' Yellow Tea-scented China' (1824) and the rose breeding that followed, expanded the popularity of roses in Europe (Marriott, 2003). The species *R. moschata* Herrm. (originally from south Europe, North Africa and west Asia), *R. wichurana* Crép. (from Japan, Korea and east China), *R. multiflora* Thunb. (Japan and Korea), *R. damascena* Mill. (Asia minor), *R. gallica* L. (Central and south Europe, west Asia), *R.*

chinensis Jacq. (China)*, R. gigantea* Coll. ex Crép (Southwest China and Burma). and *R. foetida* Herrm (West Asia); were important contributions that also increased the variability of shapes, color and fragrances of cultivated roses (Rehder, 1960; Nybom, 2009) (Fig 2-1).

In the 1800's, new cultivars of garden roses were developed with traits such as variation in plant form, flower size, color, and fragrance, and adaptability to different conditions (Marriott, 2003). During those years, these cultivars were classified by names that described growth habits such as Hybrid Teas, Floribunda or Miniature. This classification facilitated commercialization of rose cultivars to the public, but applied few botanical concepts (Cairns, 2003). Efforts were made later to develop a classification scheme that included both taxonomical principles and commercial concepts; and facilitated the registration of rose cultivars by the American Rose Society (ARS) (Cairns, 2003). During the end of the twentieth century, the World Federation of Rose Societies (WFRS) proposed a system that categorizes roses into three groups: rose species, Old Garden Roses (OGR) and Modern Roses (MR) (Horst and Cloyd, 2007). Within the latter two groups, a subdivision is made into "horticultural classes," which refers to growth and bloom types (Cairns, 2003). In 2000, the ARS proposed a scheme (similar to that of the WFRS with some modifications) that reflected the development of rose cultivars incorporating botanical and commercial principles (Cairns, 2003) (Fig.2-2). Using these principles, the ARS has described about 25,000 cultivars of roses (Horst and Cloyd, 2007).

Rose Species

Rose species are also called "wild roses." There are about 82 rose species native to China (Guoliang, 2003) and more than 60 are native to the United States and

Canada (Brichet, 2003). Naturalization of another ten exotic species has been possible due to the variability of environmental conditions in North America (Brichet, 2003). The typical flower of a rose species contains five petals and sepals, abundant stamens, and numerous styles with a sticky stigma at the top (Cairns, 2003). Pistils are enclosed in an urn-shaped receptacle, called a hip, which encloses several achenes at maturity (Rehder, 1960). Rose plants can be deciduous or evergreen and possess growth habits varying from upright, to climbing or trailing (Rehder, 1960). Rose species are once-blooming (roses that bloom once a year, usually in the spring) plants with sizes that range in height from 60 cm to 6 m (~2 to 20 ft) (Cairns, 2003).

Old Garden Roses

Cultivars of OGR are defined as all the rose types that existed prior to 1867, as defined by the WFRS (Cairns, 2003). There are different attractive characteristics of this group but the rich fragrance of flowers of most OGR is the most interesting (Cairns, 2003). There are some repeat-flowering cultivars among OGR; however, some once-flowering cultivars set large, attractive hips after a single flower production which adds to the beauty of this type (Cairns, 2003). The ARS classification scheme divides OGR in 21 horticultural classes. The once-flowering horticultural classes of Gallica, Damask, Alba, Centifolia and Moss roses were well known in Europe before 1800; however, the introduction of Chinese roses to Europe caused a decline in popularity of these classes as repeat-flowering cultivars became available (Marriott, 2003).

New horticultural classes were created through crosses of the early European classes with the newly introduced China roses. First referred to as Chinese roses and congregated in the horticultural class of China, they were reclassified later as Hybrid China by the ARS in 2000 (Cairns, 2003). Plants of the Hybrid China are dense,

abundantly branched (Manners, 1999) and have clusters of small, single or double-petaled flowers with a spicy fragrance (Cairns, 2003). A cross between ‘Old Blush China’ and ‘Autumn Damask’ gave rise to the Bourbon roses (Marriott, 2003). Named after the Isle of Bourbon (now known as the Reunion island), where the crosses occurred, these were the first repeat-flowering cultivars developed through the introduction of Chinese roses into rose breeding in Europe (Cairns, 2003). A similar cross, between a Hybrid China and a Damask rose, produced the Portland class. Bourbon and Portland cultivars were crossed again with China roses and produced the class of Hybrid Perpetual roses (Marriott, 2003). Portland roses are small plants that bear their flowers in short peduncles and Hybrid Perpetual are medium-sized plants, with fragrant flowers of colors that ranged from pink to red (Cairns, 2003). Both classes are repeat-flowering.

Tea roses were developed by crossing ‘Hume’s Blush Tea-scented China’ and ‘Parks’ Yellow Tea-scented China’ with different Bourbon cultivars. Teas are small- to medium-size bushes that hold the flowers on weak stems (Cairns, 2003). Flowers are double and produce single blooms or clusters. The class of Noisette roses was developed during the nineteenth century by Philippe Noisette of Charleston, in South Carolina, U.S. (Cairns, 2003). Noisettes are the result of two crosses; a China and musk rose (*R. moschata*) cultivar later crossed with Tea roses (Manners, 1999). Noisette cultivars are large, sprawling shrubs (Cairns, 2003) with clusters of small fragrant flowers; most varieties are highly resistant to diseases (Manners, 1999).

Modern Roses

There are 13 horticultural classes classified as MR. The ARS groups MR as the cultivars belonging to horticultural classes not in existence before 1867 (Cairns, 2003).

The year was set by the release of ‘La France’, a cultivar obtained through hybridization of a Chinese tea-scented rose and a Hybrid Perpetual rose (Guoliang, 2003). This cultivar possessed the attractive flower characteristics of Tea roses and the upright, elegant shape of the Hybrid Perpetual bushes. These novel characters gave form to the first class of MR, the Hybrid Tea, which at present has about 10,000 registered cultivars (Zlesak, 2007). Hybrid Teas became popular during the twentieth century with the development of new vigorous varieties with improved flower characteristics (Russo, 2006). One of these significant innovations was made by the French breeder Pernet-Ducher who introduced genes from *R. foetida* or the ‘Yellow Persian Rose’ and developed the cultivar ‘Soleil d’Or’; the first true yellow Hybrid Tea (Russo, 2006). Most of the modern Hybrid Teas, especially yellow-flowered ones, were developed from this cultivar which was used as a parent to increase the color range of new cultivars (Russo, 2006).

A range of MR horticultural classes arose from subsequent crosses. Polyantha roses were first obtained through hybridization between *R. multiflora* and *R. chinensis* (Rehder, 1960). Polyantha are short shrubs with small flowers grouped in multi-flowered inflorescences (Cairns, 2003). Hybrid Tea crossed with Polyantha led to the development of Floribunda cultivars characterized by an increased production of intense colored flowers (Marriot, 2003). A cross between a Hybrid Tea and a Floribunda gave rise to the class of Grandiflora (Cairns, 2003). Grandiflora roses can reach 3 m (~10 ft) in height and bear clusters of flowers resembling Floribunda cultivars with plant characteristics of the Hybrid Teas (Cairns, 2003). Miniature cultivars resemble dwarf Hybrid Teas and Floribundas and are popularly used for edging beds, containers or

interior potted plants (Cairns, 2003). Mini-Flora are an intermediate class between Miniature and Floribunda that produce intensely colored flowers that vary in shape and size (Marriott, 2003). The class of Bermuda Mystery roses comprises several cultivars from Bermuda; which are form of sports or seedlings of already established roses or imported cultivars of which names and origin have been lost in time (Brichet, 2003). Roses such as Bermuda Mystery roses are often referred as “found” roses.

Culture of Roses in Florida

Roses are very popular plants in the horticulture industry worldwide as either garden specimens or cut flowers (Horst and Cloyd, 2007). Roses possess a variety of plant forms, flower forms, colors and scents that few other plants provide and which make them versatile landscape plants (Buck, 1978). Depending on the cultivar, they can be mass planted, mixed into plant beds, containerized or used as specimens. Specialty gardens, devoted solely to roses, are common (Park Brown, 2007). Cultivar development has made rose cultivation possible around the world.

In Florida, however, growing roses can be difficult (Manners, 1999). Plant performance is diminished by the use of cultivars and/or rootstocks not suited to Florida’s climate and soil, disease pressure and inadequate irrigation and fertilization (Manners, 1999). Selecting cultivars adapted to local conditions can be one way to overcome these barriers (Mueller et al., 2008).

Climatic Conditions

Florida is located in two climate zones. The northern and central areas of the state are positioned in the humid subtropical climate zone whereas the southern area lies within the tropical savannah region (National Climatic Data Center, NCDC, 2010). Humid subtropical climates are characterized by average minimum temperatures

between -3 °C (26.6 °F) and 18°C (64.4 °F) during the winter, and very humid and hot summers when maximum temperatures are equal or higher than 22 °C (71.6 °F) (Kottek et al., 2006). Tropical savannah or equatorial climates have minimum temperatures of 18°C (64.4 °F) during the coldest month and can be divided in two areas according to the precipitation. First, monsoonal zones, where the precipitation of the driest summer month is less than 60mm (2.36 in) (as in Florida's southeastern region) and second, dry winter zones, where the driest month in winter has less than 60mm (2.36 in) of precipitation (as in the southwestern region) (Kottek et al., 2006).

Temperatures in Florida start to rise in April reaching the highest during July and August, ranging in average, from to 27.2 °C to 28.3 °C (81 °F to 83 °F). The coldest month is January with the lowest temperatures between 10 °C and 15.6 °C (50 °F and 60°F) and highest between 18.3 °C and 24.4 °C (65 °F and 76 °F) (NCDC, 2010). Relative humidity averages between 50-60 percent during the warmest part of the day and rises to 70-80 percent during cooler hours (NCDC, 2010). Precipitation average in Florida is 1372 mm (54 in) per year; with the rainy season normally beginning in late April and ending in mid-November (NCDC, 2010). During this season, thunderclouds form during the morning and brief but heavy periods of rain usually follow during the afternoon (NCDC, 2010).

Soil

Soils are formed through processes mediated by climatic factors and soil organisms. Horizons or layers of soil are created with individual properties such as color, texture and fertility (Soil Survey Staff, 2009). The absence or presence of horizons allows classification of soil in different orders (Soil Survey Staff, 2009). There are five major orders of soil in Florida which are Spodosols, Entisols, Ultisols, Alfisols

and Histosols (Shober, 2008). Additionally, soils can be grouped in drainage classes according to their ability to store and transmit water; which are defined by the physical properties of texture, structure, pore size and space (Shober, 2008). Drainage classes describe the natural soil drainage conditions according to the frequency and duration of wet periods (Soil Survey Staff, 2009). Spodosols, although rich in sandy and loamy material, are poorly drained as they contain a restricting layer that limits water permeability in certain periods of time (Shober, 2008). Similarly, the Entisols in South Florida are very poorly drained because of a thin layer of sand over limestone bedrock (Shober, 2008). In contrast, Ultisols (located in North Florida and in the central ridge) and Alfisols (in the central ridge) are formed with loamy and sandy particles which make them well drained soils; and similarly, the Entisols in north Florida are excessively drained as they are composed of large sandy material (Shober, 2008). Histosols are organic; poor to very poorly drained soils located in depressions or nearly leveled areas, common in swamp areas (Shober, 2008).

Sandy soils are dominant in Florida and are well known because of mobile nutrients such as nitrogen, potassium and phosphorus can be easily leached by heavy rains (Simonne and Hochmuth, 2010). Due to this low capacity for nutrient retention, additional applications of fertilizer should be made to satisfy crop needs (Sartain, 2001). Additionally, central Florida's sandy soils are light, excessively well-drained and warm in temperature; conditions that are favorable for nematodes (Manners, 2000). In Florida there are different species of importance, however, the root-knot nematode (*Meloidogyne* spp.) is the most common (Noling, 2010). This species is also considered the most serious for roses (Manners, 2000).

Roses are often grafted to help them cope with Florida's soil conditions. Grafting consists of joining together a piece (scion) of a desired flowering variety and the rootstock of another species to become a single plant (Oehlbeck, 2000). Grafted roses have an advantage over own-rooted roses as rootstocks enhance characteristics such as vigor, flowering and adaptation to soil and environmental conditions (Manners, 2000). There are several rootstocks available for grafting roses. Plants grafted onto 'Dr. Huey' normally survive up to six years compared with those grafted on other rootstocks (Manners, 1999). The species *R. multiflora* and *R. manettii* Crivelli have been also used as rootstocks. The first one is adapted to heavy soils and colder climates (opposite to Florida's conditions), whereas the second is mostly used for greenhouse grown roses (Manners, 1999). Plants grafted on these species do not thrive for more than three years in Florida (Manners, 1999). Roses grafted on *R. fortuniana* Lindl. rootstocks are considered to be more successful under Florida's soil and climate. Introduced in 1845, *R. fortuniana* enhances plant vigor, flower production and longevity of grafted cultivars in sandy soils; and offers tolerance to damage from the root knot nematodes (Manners, 1999).

Even though the advantages of grafted roses are well known, own-root plants have significance for growers and nurseries, as time and cost of production are reduced (Manners, 2000). Own-root roses are well adapted to heavy clay soils but plant performance tends to be reduced in the sandy and limestone-based soils of Florida and they typically survive only a few years (Manners, 1999). McFadden (1962) evaluated the performance of own-root roses compared to grafted cultivars in Gainesville. The utilization of *R. fortuniana* rootstocks enhanced flower production and plants survived

for at least six years. Although own-root cultivars of old garden roses, particularly the Hybrid Chinas, will endure Florida's soil conditions, those grafted to *R. fortuniana* may be even more vigorous and productive (Manners, 1999).

Diseases, Insects and Other Pests.

There is a wide variety of pests and diseases that can affect roses. Diseases can be caused by fungi, bacteria, viruses and nematodes. Symptoms can vary from necrosis to cankers, dwarfing or stunting according to the causal agent infecting the plant tissues (Horst and Cloyd, 2007). Even though diseases in Florida can be similar to those in other areas, foliar diseases are the most limiting on roses growing in the state (Miller, 1961). The most common of these are black spot (caused by *Diplocarpon rosae* Wolf), powdery mildew (caused by *Sphaerotheca pannosa* var. *rosae* Wor.), and Cercospora leaf spot (caused by *Cercospora rosicola* Pass.) (Miller, 1961). Other leaf spots can be caused by several fungi such as *Alternaria alternata*, *Colletotrichum capsici*, *Glomerella cingulata* and others (Horst and Cloyd, 2007). Additional diseases found in Florida are downy mildew (caused by *Peronospora sparsa*), Botrytis blight (caused by *Botrytis cinerea*), crown gall (caused by the bacterium *Agrobacterium tumefasciens*), stem cankers caused by diverse fungi; and different viruses (Knox and Mizell, 2008).

Roses are also susceptible to a wide range of arthropods that can cause direct damage or are vectors of diseases, such as mites, thrips, aphids, beetles and leaf cutter bees (Horst and Cloyd, 2007). A number of aphid species attack roses, but the rose aphid (*Macrosipum rosae*) is the predominant one (Horst and Cloyd, 2007). This piercing-sucking insect damages foliage and flowers and can also transmit viruses (Buss, 1993). The yellow rose aphid (*Acythrosiphon rosae*) can also be of importance in

Florida (Knox and Mizell, 2008). Flower thrips (*Frankliniella tritici*) and western flower thrips (*Frankliniella occidentalis*) both attack flowers buds causing browning, distortion, abortion or premature petal fall (Horst and Cloyd, 2007). Chilli thrips (*Scirtothrips dorsalis*), feed primarily on foliage causing damaged leaves to curl upward turning bronze and defoliate (Seal and Klassen, 2005). These three thrips species can cause severe damage to roses grown in Florida. Other pests observed in the state are the Fuller's rose beetle (*Pantomorus cervinos*), the flower beetle (*Euphoria sepulcralis*), the leaf-footed bug (*Euthochtha galeator*), the twospotted spidermite (*Tetranychis urticae*) and different species of leaf cutter bees (Knox and Mizell, 2008). Although the presence of different insects, diseases, and mites were observed, two diseases (black spot and Cercospora leaf spot) and one insect (chilli thrips) were the major pests in our evaluation of rose cultivars in central Florida. The following is a more detailed description of each.

Black Spot

Black spot is the most common disease in roses worldwide and is caused by the fungus *Diplocarpon rosae* Wolf [conidial stage: *Marssonina rosae* (Lib.) Died.] (Drewes-Alvarez, 2003). The conidial stage was reported first in 1825 in Sweden; Wolf reported the connection of the conidial stage with the sexual stage in 1912 (Wolf, 1912). The infection cycle of the disease starts in spring when rain or overhead irrigation splash disperses spores from infected canes or leaves from the previous season onto the new foliage (Mangandi and Peres, 2009a). Conidia must be wet for several hours to infect plant tissues (Mangandi and Peres, 2009a) and can germinate within a day if conditions are favorable (Blechert and Debener, 2005). Symptoms begin 3 to 16 days after infection and appear as black or brownish spots with radiate, irregular margins on the

upper surface of the leaf, and 1 to 5 cm (0.39-1.97 in) in diameter (Fig. A-1) (Sivanesan and Gibson, 1976). About two weeks later most rose genotypes drop the infected leaves causing weakening of infected plants (Blechert and Debener, 2005). Roses vary widely in their susceptibility with Hybrid Tea cultivars being the most susceptible (Jenkins, 1955; Palmer et al., 1966).

A temperature of 17.8 ° C (64°F) is optimal for black spot development, but conidial germination still occurs from 15 °C to 27.2 °C (59 °F to 81 °F) (Horst and Cloyd, 2007). This wide temperature range allows the disease to continue to develop as long as moisture is adequate. In Florida this is possible for most of the year. Fungicide applications effectively control the disease, although cultural practices such as planting in a sunny location, avoiding overhead irrigation or irrigating early in the day to allow leaves to dry, and/or removing fallen, diseased leaves can help reduce or eliminate the need for fungicides (Mueller et al., 2008). For chemical control, an initial application of a protectant fungicide should be made at bud break, followed by bimonthly applications until leaves are completely expanded. However, during summer, applications every 7-14 days may be necessary to successfully manage the disease (Mangandi and Peres, 2009).

Black spot is not common on roses growing in the wild although susceptibility in some rose species has been observed in laboratory experiments (Walker et al., 1996). OGR cultivars of Hybrid China, Tea and Noisette roses are very resistant to foliar diseases including black spot (Manners, 1999). Disease resistance of MR however is less common. Most of the Hybrid Teas are very susceptible to black spot (Mueller et al., 2008). One reason for this might be the introduction of yellow color to cultivated roses.

The cultivar ‘Soleil d’Or’, the first cultivar with yellow-colored flowers, was used as a parent for most of the successive Hybrid Tea yellow cultivars (De Vries and Dubois, 1978). This inclusion not only increased the range of flower colors but also increased susceptibility to diseases, among those, black spot.

This variability in susceptibility to black spot can also be explained by the occurrence of physiological races of the fungus. In 1979, symptoms of black spot were found on a formerly resistant rose cultivar in Canada (Bolton and Svejda, 1979). Additionally, isolates obtained from this plant failed to infect plants of cultivars regarded previously as very susceptible to the disease (Bolton and Svejda, 1979). Later, differences in spore size, colony color and pathogenicity found in isolates in Mississippi, United States, showed morphological variation of the pathogen (Wenefrida and Spencer, 1993). Rose genotypes were also tested against isolates collected from 14 different places in eastern North America, and infection patterns demonstrated the existence of at least three different races among the isolates tested (Whitaker et al. 2007b). Molecular techniques have been also used to unveil and confirm the genetic diversity of the pathogen. An analysis using restriction fragment length polymorphism (RFLP) revealed the existence of at least three groups among ten isolates tested (Lee et al., 2000). Genetic variation of *D. rosae* was also evaluated using random amplified length polymorphism (RAPD) (Werlemark et al., 2006). Through this analysis, it was concluded that genetic variation of the pathogen can be found in nearby zones as well as in more distant geographical areas (Werlemark et al., 2006). Accurate characterization of the fungal races along with the identification of resistance genes on rose germplasm would be useful for breeding programs (Whitaker et al., 2007a).

Genetic resources could be identified that provide resistance to rose cultivars. To date, only one resistance gene, *Rdr1,* has been described in roses (Von Malek and Debener, 1998).

Cercospora Leaf Spot

There are four different species of *Cercospora* to which roses are hosts: *C. rosae* (Fuckel) v. Hohn, *C. hyalina* Muller and Chupp, *C. rosicola* Pass. and *C. puderii* Davis (Davis, 1938). *Cercospora rosae* occurs only in Europe whereas *C. hyalina* is a species discovered in South America (Davis, 1938). The other two are found in North America, *C. rosicola* Pass. (Conidial stage of *Mycosphaerella rosicola*) is the most common causal agent of Cercospora leaf spot (Davis, 1938). The first report of *C. rosicola* occurring on rose leaves in Florida was in 1885 (Ellis and Everhardt, 1885). Roses can be also affected by *C. puderii* Davis which was collected in Florida for the first time in 1915 (Davis, 1938).

Lesions of Cercospora leaf spot are circular, 0.2-0.4 cm (0.08-0.16 in) in diameter but single spots can be as large as 1 cm (0.39 in) in diameter. Lesion size is variable according to the rose species or variety (Davis, 1938). When symptoms begin to appear, a small purplish area is observed and, as the disease progresses, small necrotic areas develop and increase in size in older lesions (Fig. A-2) (Mangandi and Peres, 2009b). The spot centers of *C. rosicola* are light brown to tan, whereas those of *C. puderii* are gray to white (Davis, 1938). Microscopically, conidia of *C. puderii* are narrower (2.0-3.5 µm) compared with those of *C. rosicola* (3.5-5.5 µm) (Davis, 1938). Development of this disease in roses has not been studied to a great extent; however, the same conditions that favor the development of black spot promote the occurrence of Cercospora leaf spot (Hagan and Mullen, 2007). Spores can be dispersed by wind or

water in early spring to the surface of newly expanded leaves, where germination occurs in the presence of free water (Hagan and Mullen, 2007).

Cercospora leaf spot is often confused with black spot. Both of these diseases cause severe defoliation in heavily infected plants (Miller, 1961; Davis, 1938). The two diseases, however, can be differentiated by symptoms; black spot lesions are dark in color with irregular margins whereas spots caused by *Cercospora* are more regular in shape with purplish or reddish-brown borders and tanned centers (Miller, 1961). Evaluations of Cercospora resistant cultivars showed susceptibility to black spot (Hagan and Akridge, 2005). Research for resistance and disease control in roses has concentrated on black spot and powdery mildew; despite the elevated risk of Cercospora leaf spot, caused by *Cercospora rosicola*, occurring in shrub and ground cover rose varieties (Hagan and Akridge, 2005). Although *C. rosicola* commonly affects roses, it is considered of less importance than black spot and powdery mildew (Davis, 1938; Miller, 1961). In Florida, powdery mildew occurs during spring and fall; however, it is inhibited as temperatures rise and frequent summer rains occur (Miller, 1961).

Chilli Thrips

Chilli thrips were detected in Florida in 1991 and 1994 but, presumably, populations failed to establish as no additional reports were made (Klassen et al., 2008). Nevertheless, this pest was reported again on Knock Out® roses in Palm Beach, Florida in 2005 (Hodges et al., 2005) and in Houston, Texas in 2007 (Ludwig and Bográn, 2007) and has established itself as a significant rose pest in central Florida. Chilli thrips is the common name of *Scirtothrips dorsalis* Hood, an important pest of chilli peppers in India from which it gets the name (Thirumurthi et al., 1972). It is also an important pest in other tropical and subtropical areas (Ludwig and Bográn, 2007). This

pest has a wide distribution range and more than 100 plant species have been listed as hosts among which roses are listed (Hodges et al., 2005). Chilli thrips are also known by the common names of Assam thrips, castor thrips, chile thrips, strawberry thrips, and yellow tea thrips (Hodges et al., 2005). Thrips are difficult to differentiate without magnification. Adult thrips are 0.5-1.2 mm (0.02-0.05 in) long, yellow to grayish-white in color with incomplete dark stripes in the dorsal surface (Seal and Klassen, 2005). The life cycle is completed between 14 to 20 days and consists of six stages: egg (6-8 days), two larval stages (6-7 days), prepupal (less than 24 hours), pupal (2-3 days), and adult stage (Seal and Klassen, 2005).

Chilli thrips cause damage principally on young leaves, buds and fruits of their hosts (Seal and Klassen, 2005). All of these parts will turn bronze to black in color and young leaves curl upward and appear distorted (Fig. A-3) (Seal and Klassen, 2005). Highly infested plants become stunted and dwarfed, leaves with petioles detach from the stem causing defoliation in some plants (Seal and Klassen, 2005). In addition, chilli thrips can be also vectors of different plant viruses such as peanut necrosis virus (PBNV), peanut chlorotic fan virus (PCFV), and tobacco streak virus (TSV) (Osborne and Ludwig, 2010). Populations of chilli thrips will be higher during the dry season and tend to drop during the rainy season (Seal and Klassen 2005). Although this pest can be controlled by different insecticides, not enough is yet known to provide reliable recommendations (Osborne and Ludwig, 2010)

Maintenance of Roses

The increasing concern over the impacts of pesticides and synthetic fertilizers on the environment and human health, as well as governmental restrictions on landscape irrigation has incentivized a demand for low maintenance roses (Zlesak, 2007; Mackay

et al., 2008). In Florida, roses require nearly year-round maintenance as the environmental conditions are favorable for continuous growth (Park Brown, 2007). General recommendations for growing roses in Florida include regular irrigation especially during warm, dry periods, frequent and substantial applications of fertilizer, and continuous fungicide applications to reduce disease incidence (Manners, 1999). Florida's sandy soils are low in organic matter and nutritional content thus the addition of fertilizer is recommended. Fertilization also depends on other factors such as season, location and size of the plant (Park Brown, 2007). A common recommendation is to apply one cup of fertilizer per month year round in south Florida; and from mid-February to mid-November in north and central Florida (reducing amounts for smaller plants) (Park Brown, 2007).

Due to Florida's rainy subtropical climate, an extended period of favorable conditions for disease development can be expected (Miller, 1961). Although cultural practices will lessen the incidence of diseases, preventive and/or curative applications of fungicides may be necessary. Black spot is the most important disease on roses and fungicide applications for its control are recommended as soon as plants start to produce new growth after winter dormancy (Park Brown, 2007). These applications should continue during the growing season as often as every five to ten days to reduce disease incidence (Manners, 1999). Other major diseases in Florida are powdery mildew and Cercospora leaf spot. However, powdery mildew does not affect some cultivars in Florida (Manners, 1999) and the incidence period is usually shorter than that of black spot (early spring or early fall) (Miller, 1961). The susceptibility of roses to Cercospora leaf spot varies among cultivars (Hagan et al., 1999), but the severity of the

disease can be controlled by fungicide applications for black spot management (Miller, 1961).

In addition to these practices, roses also need grooming, dead-heading and pruning. Due to the longer and more active growing season in Florida, these practices should be performed on a regular basis. Grooming consist of light pruning in order to remove disease infected growth and/or to maintain a neat appearance (Park Brown, 2007). Non flowering shoots, dead wood, and shoots arising from the rootstock of grafted plants should also be removed (Park Brown, 2007). Dead-heading consist of removing faded flowers so the plant's energy is redirected to the production of new growth and flowers instead of fruit development (Park Brown, 2007). Pruning is more intense and infrequent. It is recommended that modern horticultural classes be pruned in late February or early March by removing dead, diseased or damaged canes, and shortening the length of the older canes to half of their length (Park Brown, 2007). Such pruning on some horticultural classes of OGR is disadvantageous; and should be even lighter than for MR (McLaughlin and Garofalo, 2001).

Most of the roses grown in U.S. gardens belong to the modern group of the Hybrid Teas which require regular applications of pesticides, frequent irrigation, and rigorous pruning (Mackay et al., 2008). Hybrid Tea roses in Florida have even higher demands of water, fertilizer and pesticide applications (Manners, 1999). Similarly, cultivars of the horticultural class of Grandiflora would need frequent care and grooming (Park Brown, 2007). An alternative to high maintenance practices is the selection of cultivars that are adapted to local conditions (Mueller et al., 2008). Research outside of Florida has evaluated disease resistant cultivars (Carlson-Nilsson and Davidson, 2000; Yokoya et

al., 2000) as well as performance of roses under minimum inputs (Spencer, 1993; Mueller et al., 2008; Mackay et al., 2008). Griffith Buck's program at Iowa State University, Iowa, U.S. was one of the first to develop low maintenance cultivars although the main purpose of his program was to obtain winter-hardy cultivars for Iowa (Mueller et al., 2008). Buck selected plants that retained their foliage which increased their vigor and winter survival (Minot, 2005). Intentionally, he discarded black spot susceptible cultivars which defoliated and would not thrive during the winter (Minot, 2005). Following this method, more than 80 winter-hardy, disease resistant cultivars were released (Mueller et al., 2008).

Another notable program is the Earth-Kind® environmental landscape management program of Texas A & M University. The program focuses on managing irrigation, fertilizers, pesticides and recyclable wastes in the landscape (Harp et al., 2009). For roses, this program seeks to identify the cultivars with the best landscape performance and tolerance or resistance to diseases and insects (Harp et al., 2009). The program awards the Earth-Kind® designation to cultivars that meet these criteria: (a) attractiveness of plant form and flower characteristics, (b) longevity and adaptation to the local and regional environmental conditions; and (c) tolerance to insects and diseases (Harp et al., 2009). From these studies, recommendations have been made of rose cultivars that meet low-maintenance requirements in Texas. However, these same rose cultivars are being evaluated in other 24 states of the United States and four foreign countries (Harp et al., 2009).

Selection of vigorous and disease resistant or tolerant cultivars offers an alternative to high maintenance practices and allows for successful rose growing in

Florida. Certain rose species and cultivars of both OGR and MR have performed well under the state's conditions even though rose species do not have the recurrent blooming of most cultivated roses (Manners, 1999). In Florida, Hybrid Tea cultivars are considered high maintenance roses requiring more attention to disease control, fertilization, and water supply (McLaughlin and Garofalo, 2001). Furthermore, their general poor performance and form makes them inappropriate as landscape shrubs (McLaughlin, 2004). Since the eighteenth century, Hybrid Tea cultivars have been developed for their flower characteristics ignoring disease resistance, plant form, or fragrance. Reduced vigor and increased susceptibility to diseases resulted (Marriott, 2003). In contrast, the Hybrid China and Tea roses are more appropriate for Florida due to their adaptation to tropical climates and greater disease resistance (McLaughlin and Garofalo, 2001). The Tea roses' genetic background includes species that grow wild and flourish in sunny, high rainfall locales of Asia (McLaughlin and Garofalo, 2001). Teas also have relatively few trunks reducing pruning to early spring and occasionally the rest of the year (Manners, 1999). Some cultivars of Bourbon roses could survive Florida's conditions but many would not be considered as low maintenance cultivars (Manners, 1999). Only a few cultivars of MR belonging to the horticultural classes of Hybrid Tea, Shrub, Polyantha, Floribunda and Miniature are recommended as own-root, low-maintenance cultivars for Florida.

This study evaluated field performance of own-root rose cultivars belonging to different horticultural classes of both OGR and MR under low maintenance conditions. These conditions were low amounts of water and fertilizer, no regular pruning, grooming or dead-heading and no use of pesticides. Cultivars were rated according to their plant

quality, flower coverage and susceptibility to black spot, Cercospora leaf spot and chilli thrips damage.

CHAPTER 3
MATERIALS AND METHODS

The study was conducted at the University of Florida's, Gulf Coast Research and Education Center, Plant City Campus (28°01'28.37" N; 82°06'09.56" W) from Feb. 2008 to Jan. 2010. Plant City is located in USDA hardiness zone 9a and is characterized by humid and hot summer months and warm, dry winter months. The warmest months of the year are July and August with average maximum temperature of 33.2 °C (91.8 °F) whereas January is the coldest month with average minimum temperature of 9°C (48.2 °F) (Weatherbase^{SM}, 2010). Annual average precipitation in Plant City is 1270 mm (50.7 in) received mainly from June through September [188 mm (7.4 in) – 218 mm (8.6 in)/month]. Winter months are dryer than summer months with average precipitation below 76.3 mm (3 in) per month.

Rose Cultivars Evaluated Twelve Modern and Old Garden rose cultivars were selected for the study. These cultivars were previously regarded as low-maintenance roses by Florida gardeners and/or evaluations in Texas by the Earth-Kind® program (Harp et al., 2009). Plants were planted on 23 Jan. 2008 on Seffner fine sand soil (Soil Survey Staff, 2008) previously amended with 22.7 kg (50 lbs) of composted cow manure (Black Gold Compost Co., Oxford, FL) every 0.46 m (1.5 ft) of planting bed in a central band 0.61 m (2.0 ft) wide and 7.6 cm (3 in) deep. Composted cow manure was then tilled into the upper 15.2 cm (6 in) of soil. Plants were placed 2.44 m (8 ft) apart on 2.44 m (8ft) wide beds covered with ground cloth topped with a layer of fine ground pine bark mulch 10.16 cm (4 in) thick.

The irrigation regime included an establishment period followed by a maintenance program. Water for establishment was provided by drip emitters (2 per plant) at a rate of

1.89 L (0.5 gal)/plant every day for the first two weeks after planting; every other day for the next two months and once per week for the following three and a half months. After this period, plants received 1.89 L (0.5 gal) two times per week during the dry and winter seasons (October-May) and once per week during the rainy season (June-September). Fertilizer was provided by top-dressed applications of controlled-release Osmocote Plus 15-9-12 (15N-3.9P-10K), 6 month formula (Scotts, Marysville, OH). Three applications were made the first year on 27 Mar. (Week 8), 9 June (Week 19) and 8 Sept. (Week 32) at a rate per plant of 4.54 g (0.16 oz), 7.12 g (0.25 oz) and 11.66 g (0.41oz) respectively. During the second year, 23.32 g (0.82 oz) was applied per plant on 28 Feb. (Week 56) and 25 July (Week 77). No routine pest management was conducted other than elimination of weeds by hand pulling. Plants were not pruned or groomed except for one major pruning on 25 Feb. 2009 in which the canopy of the plants was reduced by one third.

The twelve rose cultivars evaluated were ‘Bailey Red’, ‘Belinda’s Dream’, ‘BUCbi’ (Carefree Beauty™), ‘Duchesse de Brabant’, ‘WEKcisbako’ (Home Run®), ‘RADrazz’ (Knock Out®), ‘Louis Philippe’, ‘Mrs. B. R. Cant’, ‘Mutabilis’, ‘Old Blush’, ‘Perle d’Or’ and ‘Spice’. The cultivar ‘Louis Philippe’ was originally included but was eliminated from all of the analyses as three of the six plants were ultimately identified as ‘Cramoisi Superieur’ not ‘Louis Philippe’.

‘Bailey Red’ was found in North Carolina, U.S.; and introduced to commerce in 1990. The parentage is unknown although it has been classified as a Tea rose and may be related to *R. chinensis* (Cooper, 2010). ‘Bailey Red’ grows from USDA hardiness zones 6 to 9 and forms compact bushes 0.91 to 1.2 m (3 to 4 ft) tall and 0.91 to 1.2 m (3

to 4 ft) wide with medium green foliage. It produces dark red, cupped, unscented, single-petaled flowers 6.3 to 7.6 cm (2.5 to 3 in) in diameter in clusters of five or seven flowers. Flowering is continuous from mid-spring throughout the growing season and will set hips in the fall. ‘Bailey Red’ is resistant to diseases and tolerates poor soils (Cooper, 2010).

‘Duchesse de Brabant’, also known by the names of ‘Comtesse de Labarathe’ and ‘Comtesse Ouwaroff’, is a Tea rose of unknown parentage introduced in 1857 by the French breeder Philippe Bernède (Cooper, 2010). ‘Duchesse de Brabant’ was designated Earth-Kind® rose of the year in 2006. It grows in USDA hardiness zones 7 to 9 and forms small to medium size, dense, spreading bushes 1.4 m (4 ft) tall and 1.2 to 1.5 m (4 to 5 ft) wide. However, in warmer climates, ‘Duchesse de Brabant’ can reach up to 2.4 m (8 ft) in height (Cooper, 2010). It produces medium apple green, matte, slightly wavy leaves and light pink, cupped, double-petaled, fragrant, flowers with a sweet tea fragrance. The flowers are 8.9 to 12.7 cm (3.5 to 5 in) in diameter and are born in small clusters of three to five flowers. Flowering is continuous from mid-spring throughout the growing season (Cooper, 2010).

‘Mrs. B. R. Cant’ is also a Tea rose of unknown parentage. It was developed by Englishman Benjamin Cant who named the rose after his wife, and introduced it to England in 1901 (Cooper, 2010). ‘Mrs. B. R. Cant grows from USDA hardiness zone 7 to zone 9 and forms very large, dense, sprawling bushes that can reach up to 1.2 to 2.4 m (5 to 8 ft) tall and 1.2 to 1.8 m (4 to 6 ft) wide. Plants of this cultivar have semi-glossy, dark green foliage and medium pink, quartered (petals are arranged in such way that the flowers are divided into four equal parts), double-petaled flowers with a moderate

tea fragrance (Cooper, 2010). Flowers are medium in size, 7.6 to 8.9 cm (3 to 3.5 in) in diameter, and are born in small clusters of three to five flowers. ‘Mrs. B. R. Cant’ produces flowers continuously during the growing season.

‘Mutabilis’ is a Hybrid China rose introduced in 1896 of unknown parentage (Cooper, 2010). ‘Mutabilis’ was designated Earth-Kind® rose of the year in 2005. It grows from USDA hardiness zones 6 to 9 and forms very large, dense bushes usually 1.2 to 1.8 (4 to 6 ft) tall but it can reach up to 3.0 m (10 ft) tall. ‘Mutabilis’ can grow between 1.5 and 1.8 m (5 and 6 ft) in width. Leaves are thin, dark plum in color when young and turn dark green at maturity. Flowers are small, 5.1 to 10.2 cm (2 to 4 in) in diameter, single-petaled and born in clusters of three to five flowers having a slightly fragrance. Blooms are yellow when first open but they change to pink, carmine and crimson as they age (Cooper, 2010). ‘Mutabilis’ is a continuous flowering cultivar producing flowers throughout the growing season.

‘Old Blush’, also know by the names of ‘Blush China’, ‘Monthly Rose’ and ‘Old Pink Lady’ among others (Cooper, 2010) is a Hybrid China rose of unknown parentage. ‘Old Blush’ is suspected to be the popular ‘Parson’s Pink China’, one of the first repeat-flowering cultivars introduced in 1751 to Europe. It grows from USDA hardiness zones 6 to 9 and forms branched, upright bushes that can reach heights of 1.5 to 1.8 m (5 to 6 ft) and widths between 0.9 and 1.8 m (3 and 6 ft). Leaves are pointed and dark green. The medium pink, double-petaled flowers darken with sun exposure and have a moderate fruity fragrance. Flowers are medium in size, 7.6 to 10.2 cm (3 to 4 in) in diameter, born in clusters of three to seven flowers (Cooper, 2010). ‘Old Blush’ produces flowers continuously during the growing season.

‘Spice’ is a found rose of unknown parentage although some believe it to be ‘Hume’s Tea Scented China’ (Cooper, 2010). It belongs to the group of ‘Mystery roses’ found in Bermuda. ‘Spice’ was designated Earth-Kind® rose in 2006. It grows in USDA hardiness zones 7 to 9 and forms densely branched, upright bushes that can grow 1.2 to 1.8 m (4 to 6 ft) tall and 0.9 to 1.2 m (3 to 4 ft) wide. Flowers are blush pink to white, double-petaled with a spicy fragrance (Cooper, 2010). ‘Spice’ is a continuous flowering cultivar producing flowers throughout the growing season.

‘Belinda’s Dream’, a Modern Rose that belongs to the class of Shrubs, was introduced in 1988 by the American breeder Robert Basye (Cooper, 2010). ‘Belinda’s Dream’ was developed from a cross by the cultivars ‘Jersey Beauty’ and ‘Tiffany’ (Cooper, 2010). ‘Belinda’s Dream’ was the first cultivar designated as an Earth-Kind® rose. It is adapted to USDA hardiness zones 5 to 9 and forms upright shrubs reaching heights between 0.91 to 1.8 m (3 to 6 ft) tall and widths between 0.91 to 1.2 m (3 to 4 ft). It produces leaves which are glossy and dark bluish-green in color and medium pink, double-petaled flowers with a strong fruity fragrance. Flowers are medium in size ranging between 8.2 and 10.8 cm (3.25 to 4.25 in), and are born in clusters of three to five flowers. ‘Belinda’s Dream’ produces flowers continuously during the growing season.

‘BUCbi’ (Carefree Beauty™) is also a Modern Rose that belongs to the class of Shrubs. It was introduced in 1977 by the American breeder Griffith Buck from a cross between an unnamed seedling and 'Prairie Princess' (Cooper, 2010). ‘BUCbi’ (Carefree Beauty™) was designed as Earth-Kind® rose in 2006. It grows from USDA hardiness zones 4 to 9 and forms upright bushes reaching heights between 0.91 to 1.5 m (3 to 5

ft) tall and widths between 0.91 to 1.2 m (3 to 4 ft). Foliage color is olive green and blooms are medium pink (shading to light pink), double-petaled, with a moderate fragrance. Flowers are medium in size ranging between 7.6 and 11.4 cm (3 to 4.5 in), born in clusters of two to four flowers. ‘BUCbi’ (Carefree Beauty ™) produces flowers in cycles during the growing season

‘WEKcisbako’ (Home Run®), a Modern Rose that belongs to the class of Shrubs, was bred in 2001 by the American breeder Tom Carruth crossing a seedling of ‘City of San Francisco’ × ‘Baby Love’ with ‘RADrazz’ (Knock Out®) (Weeks Roses, 2010). ‘WEKcisbako’ (Home Run®) was introduced to commerce in United States in 2006. It grows in USDA hardiness zones 4 to 9 and forms upright bushes reaching heights up to 1.2 m (4 ft) tall and widths up to 1.2 m (4 ft). Young leaves are red in color and darken to deep green at maturity. Flowers are bright red, single-petaled flowers with a sweet juniper fragrance. Flowers are medium in size 6.3 to 9.1 cm (2.5 to 3.6 in) in diameter, and born in clusters of two to six flowers. ‘WEKcisbako’ (Home Run®) blooms continuously during the growing season (Weeks Roses, 2010).

‘RADrazz’ (Knock Out®) is a Modern Rose which also belongs to the class of Shrub roses. It was bred by William Radler in 1999 and introduced to commerce in United States in 2000. ‘RADrazz’ (Knock Out®) was awarded Rose of the Year in 2000 by the All American Rose Selection (AARS) due to the outstanding garden performance of this cultivar and it was designated as Earth-Kind® rose in 2004. It grows from USDA hardiness zone 5 to 10. It forms compact, rounded bushes reaching heights between 0.91 and 1.2 m (3 to 4 ft) tall and widths between 0.91 and 1.2 m (3 to 4 ft). Young leaves are maroon and turn mossy green as they age (Conard-Pyle Co., 2010). Flowers

are cherry red, single-petaled, with a light tea rose fragrance. Flowers are medium in size ranging from 7.6 to 8.9 (3 to 3.5 in) in diameter, born in clusters of two to five flowers. ‘RADrazz’ blooms continuously during the growing season (Conard-Pyle Co., 2010).

‘Perle d’Or’ belongs to the class of Polyantha roses and was bred in France by Joseph Rambaux from a cross between an unnamed Polyantha and 'Mme. Falcot'. ‘Perle d’Or’ was introduced to commerce in France by Francis Dubreuil in 1884. ‘Perle d’Or’ was designated Earth-Kind® rose in 2007. It grows in USDA hardiness zones 6 to 9 and forms small, compact bushes reaching heights between 0.91 to 1.2 m (3 to 4 ft) tall and widths between 0.91 to 1.2 m (3 to 4 ft) (Cooper, 2010). Leaves are thick, light green in and stems have few thorns. Flowers are a blend of yellow colors that fade to white in summer, double-petaled, and are intensely fragrant. Flowers are small in size, 2.5 cm (1 in) in diameter, and are born in clusters of six to 50 flowers. ‘Perle d’Or’ blooms continuously during the growing season (Cooper, 2010).

Data Collection and Statistical Analyses

The experimental design was a randomized complete block with two plants per plot replicated three times. Weekly evaluations of plant quality and flower coverage were conducted for all cultivars. Data on plant quality and flower coverage were collected for two years. The first year consisted of the period from March 2008 through February 2009 and the second year from March 2009 to January 2010. Plants were measured twice during both years. During the first year, initial plant size (height and two perpendicular widths) were recorded after planting (January 2008) and at the end of the growing season in November 2008. The second year, plants were measured after

pruning in February 2009 and later in January 2010. Plant heights and width were averaged for each cultivar each year separately.

Flower coverage was assessed as the percent of canopy covered by flowers using a scale from 1 to 5 where 1= 0% (no flowers present), 2= 1-25% of canopy covered with flowers, 3= 26-50%, 4= 51-75% and 5= 76-100% canopy coverage (Fig. B-1) (Wilson and Knox, 2006). A similar scale (1-5) was used to measure plant quality as follows: 1= Very poor quality, not acceptable plants, severe leaf necrosis or yellowing is observed; 2= Poor quality, not acceptable, large areas of necrosis or yellowing, poor form; 3= Fair quality, marginally acceptable, somewhat desirable form and color; 4= Good quality, very acceptable, nice color, good form, desirable; and 5= Excellent quality, very desirable landscape performance (Fig. B-2) (Wilson and Knox, 2006).

Assessments to quantify damage caused by black spot, Cercospora leaf spot and chilli thrips were conducted on all cultivars twice a month from Sept. 2008 to Apr. 2009 and weekly from June 2009 to Dec. 2009. A scale from 0 to 5 was used to determine the percentage of foliage with black spot and Cercospora leaf spot symptoms where 0=no symptoms, 1=1-20% symptomatic leaves, 2=21-40%, 3=41-60%, 4=61-80%, 5=81-100% of symptomatic leaves (Moyer et al., 2006). A similar scale was used to evaluate the percentage of foliar curling and/or bronzing caused by chilli thrips feeding damage.

Data on plant quality and flower coverage were collected for 84 weeks. Since these variables were categorical, rating frequencies were analyzed each week separately using Fisher’s exact test. This test is used to determine associations between two categorical variables. For our analyses, statistical relationships between

cultivars and plant quality and flower coverage were obtained with the FREQ procedure in the SAS software (Cary, North Carolina, USA). Disease severity ratings were analyzed by obtaining the area under the disease progress curve (AUDPC) of the severity ratings. The AUDPC measures the intensity of the disease between two times dividing the disease progress curve into rectangles (Madden and Campbell, 1990). The approximate total area of the disease progress curve is calculated by adding the area of each rectangle; and division by the period between data points standardizes the value. The AUDPC for black spot and Cercospora leaf spot were calculated for each individual plant according to the formula: AUDPC=$\Sigma[(\text{Rating}_1 + \text{Rating}_2) \div 2) \times (\text{difference of days between Rating}_2 \text{ and Rating}_1)]$ for an interval of 67 weeks. AUDPC values were analyzed with the SAS mixed procedure and differences among cultivars were compared using orthogonal contrasts. A damage severity index (DSI) was calculated to analyze chilli thrips foliar damage to the rose plants. The index was calculated for each plant and was obtained by multiplying the number of times each plant was evaluated symptomatic (within 1 to 5, rating of zero is not included since that indicates healthy plants) by its corresponding number on the damage scale (1 to 5); for a total period of 57 weeks. The result was then divided by the total number of times a plant was rated as damaged. The formula can be summarized as DSI= $[\Sigma\ (\text{Frequency}_1 \times \text{Rating value}_1)] \div$ (total of symptomatic readings). The severity damage index was subjected to an analysis of variance using SAS software ANOVA procedure. Tukey's test was used to separate differences among DSI means.

CHAPTER 4
RESULTS AND DISCUSSION

The objective of this study was to develop recommendations for low maintenance shrub roses for landscape use. Own-root roses of 11 cultivars were evaluated under the environmental conditions of central Florida. Plant quality and flower coverage were evaluated weekly for all cultivars. Plant quality ratings were significantly affected by three main factors: severity of black spot, Cercospora leaf spot and foliar damage caused by chilli thrips. Differences among cultivars of the severity levels of these pests are explained first; followed by their effects on each cultivar.

Black spot Severity

Mean values of the area under the disease progress curve (AUDPC) for the severity of black spot and Cercospora leaf spot were significantly different among the eleven cultivars tested (Table 4-1). All cultivars showed symptoms of black spot and different levels of susceptibility were observed. In our evaluation, all MR cultivars, except ‘Belinda’s Dream’, had lower AUDPC values than those of the OGR. The MR cultivars ‘WEKcisbako’ (Home Run®) and ‘RADrazz’ (Knock Out®) had the lowest AUDPC values indicating low susceptibility to black spot. Although statistically similar to each other, they were significantly more resistant than the others. Both of these cultivars belong to the horticultural class of Shrub roses. The cultivars ‘Perle d’Or’ and ‘BUCbi’ (Carefree Beauty™) were also found to have low susceptibility to black spot in our evaluation. These findings are similar to earlier observations. Manners (1999) observed average resistance on ‘Perle d’Or’ indicating that disease severity did not affect growth and flowering. He mentioned also that most leaves on ‘BUCbi’ (Carefree Beauty™) were healthy and fungicide sprays should not be necessary on this cultivar.

According to Manners (1999), horticultural classes of MR are more susceptible to black spot than those of OGR. Manners (1999) listed a few cultivars of Shrub and Polyantha roses that performed well in Florida. According to his observations, the Shrub cultivars 'Belinda's Dream' and 'BUCbi' (Carefree Beauty™) were resistant to black spot as symptoms were practically never seen on the first and occasional symptoms were observed on the latter. He also listed 'Perle d'Or' (a Polyantha) as having average resistance meaning it may show some symptoms but no fungicide will be required to maintain its plant quality. 'BUCbi' (Carefree Beauty™) was among the most resistant cultivars to black spot in an evaluation of roses in Iowa (Mueller et al., 2008) and 'Perle d'Or' and 'RADrazz' (Knock Out®) showed low levels of infection in Texas (Mackay et al, 2008).

Cultivars with intermediate susceptibility were 'Mrs. B. R. Cant', 'Spice', and 'Duchesse de Brabant'. The OGR cultivar 'Mutabilis' was the most susceptible of all the cultivars having the highest AUDPC value. Cultivars that were classified as highly susceptible were also 'Belinda's Dream', 'Old Blush' and 'Bailey Red'. This is inconsistent with Manners' work (1999) that classified 'Mrs. B. R. Cant', 'Duchesse de Brabant' and 'Mutabilis' as resistant cultivars to black spot. With the exception of 'Belinda's Dream', all cultivars showing high or intermediate susceptibility to black spot in our study were OGR, more specifically belonging to the classes of Hybrid China and Tea. Cultivars of these classes are generally considered to be highly resistant to the disease (Manners, 1999). In previous studies in south Florida, symptoms of black spot and defoliation were observed on cultivars of Hybrid China and Tea roses but were temporary (McLaughlin and Garofalo, 2004).

Aronescu (1934) indicates that the fungus *D. rosae* penetrates the rose leaf cuticle by mechanical means; however, enzymatic reactions could facilitate hyphal movement through the following layers. Goodwin et al. (2007) suggested that components on the cuticular layers of rose leaves are associated with black spot susceptibility. Deposits of waxes, especially in the surface of the cuticle, provide a glaucous or glossy appearance to leaves that contribute to disease resistance on plants (Jenks and Ashworth, 1999). Cultivars such as ‘Mrs. B. R. Cant’ and ‘RADrazz’ (Knock Out®) are considered to have glossy foliage and these cultivars showed intermediate and low susceptibility to black spot respectively. However, ‘Belinda’s Dream’, which also has glossy foliage, was among the most susceptible cultivars. Goodwin et al. (2007) found that two components of cuticular waxes (alkanes and esters) were related to black spot susceptibility on five rose cultivars [‘RADrazz’ (Knock Out®), 'Mister Lincoln', 'Garden Party', 'Purple Passion', and 'Bicolor']. Their evaluation concluded that susceptibility to the disease was inversely proportional to the amount of alkanes and directly proportional to the esters’ concentration. According to Goodwin et al. (2007) ‘RADrazz’ (Knock Out®) was rated the lowest on disease infection among all cultivars. They advise however that a larger number of cultivars are necessary to corroborate these results. Cuticular layers could have influenced the results of our study; however, further examination of leaf wax profiles would be necessary to confirm this.

Differences in susceptibility among cultivars might also be explained by the occurrence of different races of the black spot pathogen (Carlson-Nilsson and Davidson, 2000). Whitaker et al. (2007a) differentiated three races of *D. rosae* among isolates collected from 14 different geographical sites of northeast U.S. They mention

that genetic diversity can even be found among isolates within the same race. The rose cultivars utilized in our trial were obtained from nurseries located at three different states (California, Alabama and Texas). Variation in black spot susceptibility among our cultivars may be related to the possibility that the plants were previously infected by pathogenic races in those sites rather than those races already present in central Florida. Further analysis would be necessary to associate Florida's races with those in other part of the country. Whitaker et al. (2007a) advise however, that geographical origin of the pathogen might not be important since roses are commercially traded throughout the country and internationally.

Cercospora Leaf Spot Severity

Regarding Cercospora leaf spot, most OGR had lower AUDPC values than MR, except 'Spice' and 'Duchesse de Brabant'. The lowest value was found on 'Old Blush', an OGR, which was significantly more resistant than the rest of cultivars, whereas the most susceptible cultivar was the MR 'WEKcisbako' (Home Run®). OGR 'Mutabilis' had the second lowest AUDPC value (Table 4-1). Cultivars classified moderately susceptible were 'Bailey Red', 'Mrs. B. R. Cant', 'Spice' and the MR cultivar 'Belinda's Dream'. High susceptibility was observed on the MR cultivars 'RADrazz' (Knock Out®), 'Perle d'Or', 'BUCbi' (Carefree Beauty™), 'WEKcisbako' (Home Run®) and the OGR 'Duchesse de Brabant'.

Twelve cultivars of Shrub roses were assessed in North Carolina, U.S., for disease susceptibility without pesticide applications (Bir et al., 1996). Similar to our observations, those cultivars tested in North Carolina showed differences in susceptibility to black spot and Cercospora leaf spot. In another evaluation of 60 rose cultivars in Tennessee, U.S., cultivars highly susceptible to black spot showed more resistance to Cercospora leaf

spot and vice versa (Mynes et al., 2008). When comparing the AUDPC values of both diseases on our cultivars, it was observed that highly resistant cultivars to black spot such as ‘RADrazz’ (Knock Out®) and ‘WEKcisbako’ (Home Run®) were also among the most susceptible cultivars to Cercospora leaf spot. The opposite was also noted, ‘Old Blush’ and ‘Mutabilis’, two OGR cultivars with the most resistance to Cercospora leaf spot were among the most susceptible to black spot. Mynes et al., (2008) have suggested that mechanisms of resistance in roses for both diseases could be different. Cercospora leaf spot on roses has been regarded as less important than black spot or powdery mildew, thus little information on the disease is available. Studies are needed that describe specific conditions for disease infection and development as well as resistance mechanisms in rose cultivars.

Chilli Thrips Damage

Chilli thrips is a recently established pest reported first on Knock Out® roses in Florida in 2005 (Hodges et al., 2005). Mean values of damage severity by chilli thrips (measured by the DSI) were significantly different among rose cultivars (Table 4-2). All cultivars had typical damage such as curling, deformation and bronzing of the leaves. The cultivar ‘Mrs. B. R. Cant’ had the lowest DSI value; however, it was not different from ‘Old Blush’ and ‘Bailey Red’. These three OGR cultivars were classified as tolerant to the damage. ‘RADrazz’ (Knock Out®) showed intermediate tolerance to the damage along with the other MR cultivars. The remaining three OGR cultivars were the most susceptible to the insect feeding injury: ‘Spice’, ‘Duchesse de Brabant’ and ‘Mutabilis’ had the highest DSI values respectively, hence were classified as low tolerant. A possible explanation may be that these cultivars continuously produced new foliage that sustains chilli thrips populations, whereas cultivars such as ‘Mrs. B. R. Cant’, ‘Old Blush’

and ‘Bailey Red’ produced less profuse foliage and were more cyclical in their foliage production. No information is available about tolerance of rose cultivars to chilli thrips damage.

Performance of Rose Cultivars

Flower coverage and plant quality data were collected for 84 weeks over two years. Plants were evaluated for 43 weeks in the first year (25 Mar. 2008 through 25 Feb. 2009) and for 41 weeks during the second year (25 Mar. 2009 through 27 Jan. 2010).

Flower Coverage

Flower coverage and plant quality data were analyzed for each week to explore the statistical differences among cultivars on different weeks. Significant differences in flower coverage were found on 60 weeks, 26 in the first year and 34 during the second (Table 4-3). Weeks that differed statistically were distributed along all months (except June) during the first year whereas during the second year all weeks differed statistically from Mar. 2009 through Aug. 2009. All non-significant weeks were from May 2009 to Jan. 2009 and Sept. 2009 to Dec. 2009, except for Oct. 2009, when all the cultivars showed similar ratings. During Feb. 2009 and Jan. 2010 (before pruning) most plants were rated as one in the rating scale. All cultivars used in the trial were repeat-flowering roses. Fewer differences within weeks were observed during the first year than the second year. However, it is possible that the plants were establishing and did not fully express their flowering traits. By the second year, plants were established and, thus, genetic and environmental factors affecting flowering could have been more apparent.

Although all cultivars used for this study were repeat-flowering, individual flowering characteristics of the class affected flower coverage ratings. The MR cultivars were

specifically selected for increased flower display in the garden, commonly to the detriment of disease resistance or field performance (Marriot, 2003). ‘Belinda’s Dream’, ‘RADrazz’ (Knock Out®), ‘BUCbi’ (Carefree Beauty™), and ‘WEKcisbako’ (Home Run®) belong to the horticultural class of Shrub roses and ‘Perle d’Or’ is a Polyantha rose. Both classes belong to MR and are well known for producing large clusters of flowers (Cairns, 2003). Hence these cultivars could have shown higher flower coverage than the OGR cultivars.

Additionally, plant forms and sizes were modified from the large OGR to more compact MR cultivars; and small, single-petaled, single born flowers have taken a back seat to bigger, double-petaled, clustered blooms (Cairns, 2003). Flower coverage then would also vary according to the phenotypical characteristics of each cultivar. Flower coverage could also be influenced by plant vigor. None of the cultivars were grafted in our trial, and all had disease and insect pressures which affected their plant vigor.

Plant Quality

Significant differences in plant quality among cultivars were found in all weeks except for week 16 in May 2008 and week 60 in Mar. 2009. Cultivars showed significant differences in plant quality from the beginning of the evaluation; however this is probably explained by the fact that the plants came from different sources and were different sizes (see Table 4-4). At four weeks after planting, cultivars ‘RADrazz’ (Knock Out®) and ‘WEKcisbako’ (Home Run®) were rated as good quality plants; these were the largest and most robust plants at time of planting. ‘Belinda’s Dream’, ‘Bailey Red’ and ‘BUCbi’ (Carefree Beauty™) were rated as fair quality and the rest of the cultivars were rated as very poor quality plants. Although a general improvement of quality was observed in all cultivars in the first months, various factors affected plant appearance.

For example, OGR ‘Mutabilis’ and ‘Mrs. B. R. Cant’ occasionally produced out of shape canes which downgraded their appearance, whereas MR like ‘RADrazz’ (Knock Out®) and ‘WEKcisbako’ (Home Run®) had neat, compact forms. Symptoms of black spot and Cercospora leaf spot and chilli trips damage were observed since early evaluations but decline in plant quality started in June due to the high damage caused by these pests to some cultivars. Other cultivars performed better throughout the evaluation, thus plant quality ratings show statistical differences from week to week except on those mentioned previously.

All plants were pruned and measured at the end of the first year on 25 Feb. 2009 before the new growing season started. Evaluations resumed one month later on 25 Mar. 2009. At this point, insect and disease pressure was low, plants had produced new foliage and the general plant appearance was uniform for all cultivars. Hence, no significant differences were found on week 60 (25 Mar. 2009). However, differences began to appear at week 61(4 Apr. 2009). Factors affecting plant quality ratings were similar for both years, namely black spot, Cercospora leaf spot and chilli thrips. The effect of these factors, as well as others, on individual cultivar performance (plant quality and flower coverage) is described below. It is noteworthy that although powdery mildew has been cited as an important disease of roses in Florida, no symptoms of this disease were observed during our two year evaluation.

‘Bailey Red’

‘Bailey Red’ was among the most susceptible cultivars to black spot only significantly less susceptible than ‘Mutabilis’. Disease symptoms were observed continuously throughout the evaluation period and the cultivar received a rating of five (81-100% of leaves were symptomatic) during the months of Oct. 2008 to Feb. 2009

(data not shown). Although symptoms of Cercospora leaf spot and chilli thrips damage were observed, this cultivar showed lower susceptibility to these compared to the most susceptible cultivars.

In general, plant quality ratings on ‘Bailey Red’ were high during Spring and Summer 2008 and in Spring 2009 (Fig. 4-1). Plant quality ratings during these periods were equal to or above three in the rating scale more than 50% of the time. Plant quality ratings were highest in July, 2008 as plants were most frequently rated as four (data not shown). These ratings began to decrease in early August and continued to decline to a rating of one from October until the end of the growing season. During the second year, initial ratings on week 60 (25 Mar. 2009) were slightly lower than those of the other cultivars; however, there were no significant differences that week. Quality ratings improved by mid-April but started to decrease by mid-June due to severe symptoms of black spot since Apr. 2008. Plants were consistently defoliated from this infection which decreased growth and vigor and caused misshapen plants.

‘Bailey Red’ can grow to 1.2 m (4 ft) tall and wide; however, the average size of plants attained in our study was much smaller. Initial plant measurements averaged 0.23 × 0.27 m (0.74 × 0.89 ft) and reached sizes of 0.38 × 0.49 m (1.24 × 1.61 ft). Highest flower ratings were observed the first year in the month of July, whereas in the second year the highest ratings were at the end of April and beginning of May. During these months, flower coverage of most plants was frequently rated as four (Fig. 4-2). ‘Bailey Red’ produces clusters of up to seven flowers reaching 7.6 cm (3 in) in diameter. This cultivar received high flower rates since plant size was small and the clusters of

flowers covered a bigger area of the plant. Lack of vigor could have also diminished flower production of the cultivar.

‘Duchesse de Brabant’

‘Duchesse de Brabant’ was susceptible to both black spot and Cercospora leaf spot and symptoms were observed continuously throughout the evaluation period. Symptoms of black spot were most severe in Feb. 2008 reaching values of three or more. ‘Duchesse de Brabant’ forms large, bushy plants that reduce air circulation within the canopy thus promoting microclimate conditions favorable for disease development. However, Cercospora leaf spot was even more severe than black spot on this cultivar; plants were frequently rated with values of three or higher during the entire evaluation period. This cultivar was rated the second most susceptible to chilli thrips damage after ‘Mutabilis’.

‘Duchesse de Brabant’ plant quality ratings were highest during spring and summer the first year and in spring the second year (Fig. 4-3). Plant quality ratings during these seasons were equal to or above three more than 50% of the time. At four weeks after planting, this cultivar was categorized as very poor quality. Although plant quality started to increase in May 2008 reaching values of three, severity levels of Cercospora leaf spot and chilli thrips damage kept this cultivar from getting better ratings in the following months of the first year. In the second year, the highest quality ratings for this cultivar occurred in Mar. and Apr. 2009 with plants frequently receiving values above four. However, ratings began to decrease in May 2009 as the severity of Cercospora leaf spot increased and chilli thrips damage became more evident. Plant quality ratings decreased as yellowing and defoliation occurred. Leaf loss however was

less severe than on other cultivars such as ‘BUCbi’ (Carefree Beauty™) where total defoliation occurred.

‘Duchesse de Brabant’ can grow to form bushes 1.2 m (4 ft) tall [up to 2.4 m (8 ft) in warm climates] and 1.5 m (5 ft) wide. Even though the average size of plants attained in our study was smaller, plants had an adequate size. Initial plant measurements averaged 0.33 × 0.42 m (1.08 × 1.38 ft) and reached sizes of 0.69 × 0.90 m (2.27 × 2.97 ft). ‘Duchesse de Brabant’ is a constant flowering cultivar blooming continuously throughout the growing season (Fig. 4-4). Highest flowering rates were observed in Dec. 2008 and in Apr. 2009; months in which flower coverage was frequently rated as four.

‘Mrs. B. R. Cant’

‘Mrs. B. R. Cant’ was moderately susceptible to both diseases and chilli thrips. However, this cultivar showed the most tolerance to chilli thrips foliar damage along with two other OGR cultivars. Major levels of black spot symptoms were observed in Feb. 2008 with ratings above three; however, plants were rated most frequently during the evaluation period as one. Although symptoms of Cercospora leaf spot were observed, severity levels were low; symptoms were sporadically seen and evenly distributed during the evaluation period. Foliar damage caused by chilli thrips was constant however; low levels were routinely recorded. In contrast to other cultivars, ‘Mrs. B. R. Cant’ did not produce new foliage often. It is possible that, since no young tissue was consistently available for chilli thrips to feed on, large populations may have failed to establish on this cultivar. This characteristic could also have contributed to the cultivar’s low susceptibility to Cercospora leaf spot and intermediate susceptibility to black spot. In other words, the extended time between growth flushes may have reduced the

probability of continuous infection. Another cultivar characteristic that may have contributed to low disease severity is plant shape. In comparison to some of the densely foliated cultivars that showed higher susceptibility to black spot, ‘Mrs. B. R. Cant’ has a large, open canopy.

Overall, plant quality ratings for ‘Mrs. B. R. Cant’ were high during all seasons for both years except winter 2008 (Fig 4-5). Plant quality of this cultivar at four weeks after planting was very poor due to its small size [0.28 × 0.50 m (0.92 × 1.64 ft)]. Quality steadily increased gradually showing the best rating in Sept. 2008. It slightly decreased in Jan. and Feb. 2009, but after pruning, plant quality ratings were equal to or above four and were maintained throughout the growing season until late December. Very little yellowing and defoliation caused by black spot and Cercospora was observed in this cultivar.

‘Mrs. B. R. Cant’ can grow to form bushes up to 2.4 m (8 ft) tall and 1.8 m (6 ft) width. Under the research conditions, initial plant measurements averaged 0.28 × 0.50 m (0.92 × 1.64 ft) and reached sizes of 0.84 × 1.30 m (2.77 × 4.28 ft). The average size of plants of this cultivars was slightly smaller, however, it reached adequate sizes at the end of the growing season. The cultivar produced large flowers as big as 8.9 cm (3.5 in) in diameter in small clusters of three flowers. High flower coverage ratings equal or above four were observed in the months of Dec. 2008 and Nov. 2009. In general ‘Mrs. B. R. Cant’ produces flowers constantly during the growing season and is diminished only during the winter season (Fig. 4-6)

‘Mutabilis’

‘Mutabilis’ was one of the most susceptible cultivars to black spot and chilli thrips damage showing the highest AUDPC and DSI values. Levels of black spot symptoms

were high throughout the evaluation period except for the first weeks in Apr. 2009. This cultivar however, was rated the second most tolerant cultivar to Cercospora leaf spot. Symptoms of Cercospora leaf spot where only seen in Sept.-Oct. 2008 and Oct. 2009. High levels of foliar damage caused by chilli thrips were constant, although symptoms decreased during Oct. 2009. ‘Mutabilis’ produced new foliage very often; young tissue was observed every week during the growing season. This constant production of new leaves might have helped to sustain populations of chilli thrips. Similarly, black spot development could have been facilitated by the presence of soft tissue and a dense canopy.

‘Mutabilis’ best plant quality ratings were observed in Apr. 2009 with plants frequently rated as four and five. Ratings for the rest of the year were frequently three or lower (Fig 4-7). Initial plant quality of this cultivar at four weeks after planting was very poor. Ratings slightly increased by June 2008 and decreased again from August through December. Second year ratings were high in April (plants rated equal or higher than four) but decreased by mid-May and stayed lower (ratings equal to two or lower) until the end of the evaluation. Severe black spot infection and chilli thrips caused continuous defoliation. It was observed that plants of this cultivar lost more than 50% of its foliage to these factors. Chilli thrips feeding also caused severe dwarfing and deformation of new growth. Hence, plant quality ratings on ‘Mutabilis’ were frequently low.

‘Mutabilis’ can grow to form bushes up to 1.8 m (6 ft) tall and 1.8 m (6 ft) width, however, plants having 3.0 m (10 ft) in height have been observed. Average size of plants under the study conditions was smaller than those previously observed. Initial

plant measurements averaged 0.40 × 0.66 m (1.31 × 2.17 ft) and reached sizes of 0.72 × 0.98 m (2.37 × 3.22 ft). The cultivar produces flowers as big as 10.2 cm (4 in) in diameter; in clusters of three or five flowers. Flower production was constant during both years however; flower coverage rates were usually low as plants were most frequently rated with two in the rating scale (Fig. 4-8). The decrease in vigor caused by the factors mentioned above could have contributed to less flower production. Additionally, plants of this cultivar were large, hence lower levels of flower coverage were observed.

‘Old Blush’

‘Old Blush’ was among the most susceptible cultivars to black spot; however it was the most resistant to Cercospora leaf spot. Susceptibility to chilli thrips damage was also low on this cultivar – it was the most resistant along with ‘Mrs. B. R. Cant’ and ‘Bailey Red’. Black spot symptoms and defoliation were observed since the beginning of the evaluations in Feb. 2008. Symptoms of black spot were constant throughout the evaluation period and were most severe in Oct.-Nov. 2008 and Feb.-Mar. 2009. This early weakening of the plant before its establishment decreased its vigor and could have increased its susceptibility to the disease. Cercospora leaf spot symptoms were seen at low levels during the early weeks of Sept. - Oct. 2008, but rarely for the rest of the evaluation period. Foliar damage caused by chilli thrips was continuous; however plants were mostly rated as one. Growth of this cultivar was very poor; new foliage was infrequent and was rapidly infected by black spot. Similar to ‘Mrs. B. R. Cant’, establishment of chilli thrips on this cultivar could have been affected by the lack of young leaves in which to feed.

The best plant quality ratings of ‘Old Blush’ were observed during summer 2008 and spring 2009 (Fig. 4-9). In Apr. 2009, plants were frequently rated above four. Initial

plant quality of this cultivar at four weeks after planting was very poor due to its small size and low vigor. It increased by June 2008; however, disease severity, low vigor, and misshapen growth caused plant quality to decrease again from July through the end of the year. Second year ratings were high during April but decreased by mid-May and remained low until the end of the evaluation. Uneven growth in any direction was always observed on plants of this cultivar.

'Old Blush' can grow to form bushes up to 1.8 m (6 ft) tall and 1.8 m (6 ft) width. The average size of plants in this evaluation was smaller. Initial plant measurements averaged 0.34 × 0.51 m (1.12 × 1.67 ft) and reached sizes of 0.48 × 0.58 m (1.59 × 1.91 ft). The cultivar reportedly produces flowers as big as 10.2 cm (4 in) in diameter; in clusters of three to seven flowers. In our evaluation, this cultivar produced flowers constantly however; flower coverage rates were usually low. Low vigor could have limited flower production. Flower coverage ratings above three were observed in low frequencies throughout spring-winter 2008 and spring-fall 2009 (Fig. 4-10). Similar to 'Bailey Red', this cultivar received high flowering ratings during those periods since plant size was small and the clusters of flowers covered a bigger area.

'Spice'

'Spice' was damaged by black spot, Cercospora leaf spot and chilli thrips. It was among the most susceptible to black spot and chilli thrips damage. Susceptibility to Cercospora leaf spot was intermediate. Black spot symptoms were persistent throughout the evaluation. Highest values were observed in Feb. and Apr. 2009 with levels up to four. High levels of foliar damage caused by chilli thrips were observed in late Sept. 2008 through Nov. 2008 and decreased during the cooler months. A large amount of damage was also observed in April and May 2009, but decreased in the

following months. Symptoms of Cercospora leaf spot where observed from Sept. 2008 through Nov. 2008 and during July 2009. Symptoms were rare on this cultivar during the other months. ‘Spice’ formed very small, bushy, compact plants with reduced air circulation, which could have facilitated disease persistence. ‘Spice’ also produced new growth irregularly and was less prone to defoliation.

The best plant quality ratings for ‘Spice’ were observed in general during summer 2008 and spring 2009 (Fig. 4-11). Plants were frequently rated above four in Apr. 2009. Initial plant quality of this cultivar at four weeks after planting was very poor due to its small size and low vigor. Ratings increased slightly from June 2008 to Aug. 2008 and decreased from Sept. through Dec. 2008. During the second year, ratings were high from Mar. 2009 until mid-May. These decreased slightly thereafter but remained fair. Despite this cultivar’s high susceptibility to black spot, it does not defoliate and thus was able to maintain its quality.

‘Spice’ can grow up to 1.8 m (6 ft) tall and 1.2 m (4 ft) wide, but did not achieve this size in our evaluation. The average size of plants attained in our study was smaller than those reported. Initial plant measurements averaged 0.23 × 0.51 m (0.75 × 1.67 ft) and reached sizes of 0.49 × 0.74 m (1.60 × 2.44 ft). The cultivar produces small flowers 5.1 cm (2 in) in diameter. Flower production was continuous throughout the growing season during both years. Best coverage rates were observed during fall 2008, although plants were most frequently rated as two on the rating scale (Fig. 4-12).

‘Belinda’s Dream’

‘Belinda’s Dream’ was the only cultivar among the MR cultivars tested that showed high susceptibility to black spot. Severity of chilli thrips and Cercospora leaf spot was at intermediate levels. High levels of black spot were observed in mid Dec. 2008 through

Feb. 2009 during the first year and although lower during the second year (values of one), levels remained the same until the end of the evaluation period. Severity of foliar damage from chilli thrips was variable throughout the evaluation. Cercospora leaf spot symptoms were observed from September to Dec. 2008 at variable levels but were rarely seen before or after that period.

In general, the best performance of ‘Belinda’s Dream’ was observed during spring and summer 2008 and spring 2009 (Fig. 4-13). The highest plant quality ratings (threes and fours) occurred in Apr. 2009. ‘Belinda’s Dream’ was rated as fair at the initial evaluation four weeks after planting. Values increased through June but decreased from mid-July until Feb. 2008. Evaluations after the Feb. 2009 pruning showed a moderate improvement in quality, however, plant quality ratings decreased by mid-May to undesirable levels. The incidence and severity of the above mentioned factors affected vigor and growth on this cultivar. Only a few strong branches were produced and these usually died back rapidly. Although plants of this cultivar started with good quality, they never formed full, compact bushes and were always uneven with unfilled spaces within the canopy.

‘Belinda’s Dream’ can grow to form bushes up to 1.8 m (6 ft) tall and 1.2 m (4 ft) wide. Average size of plants under the study conditions confirmed the poor performance of the cultivar in this evaluation. Initial plant measurements averaged 0.24 × 0.27 m (0.79 × 0.89 ft) and reached sizes of 0.42 × 0.39 m (1.39 × 1.28 ft). The cultivar produces flowers larger than 10.2 (4in) in diameter. General flowering of this cultivar was better during the summer season of both years (Fig 4-14). Flower coverage ratings were usually low with frequent ratings of two.

‘BUCbi’ (Carefree Beauty™)

‘BUCbi’ exhibited severe symptoms of Cercospora leaf spot and was the second most susceptible after ‘WEKcisbako’ (Home Run®). It differed significantly from ‘WEKcisbako’ (Home Run®), but was not different from the cultivars ‘Duchesse de Brabant’ and ‘Perle d’Or’. This cultivar frequently received ratings equal to or above three in the severity scale; but highest levels were noticed in Oct, 2008 and June 2009. This high level of infection probably caused the severe defoliation on this cultivar which reached more than 50% for extended periods of time. Symptoms of black spot occurred from late April to early June during the second year, but were rarely seen and were not severe. Susceptibility to foliar damage caused by chilli thrips was intermediate as symptoms were observed constantly. Highest damage was observed in Oct. 2008.

General plant quality on ‘BUCbi’ (Carefree Beauty™) was better during spring 2009 (Fig. 4-15) and showed the best plant quality ratings in Apr. 2009. ‘BUCbi’ (Carefree Beauty™) was rated as fair quality at the initial evaluation at four weeks after planting. These values remained constant until Aug. 2008 when plants of this cultivar began to decline and continued to do so until Feb. 2009. Evaluations after the February pruning were high. Plants were frequently rated above four and disease pressure was low. Values decreased to one by mid-May and stayed low until the end of the evaluation. This decrease in plant quality ratings was due to high defoliation.

‘BUCbi’ (Carefree Beauty™) can grow to form bushes up to 1.5 m (5 ft) tall and 1.2 m (4ft) width. Plants under the research conditions were smaller and showed poor growth. Initial plant measurements averaged 0.17 × 0.26 m (0.56 × 0.85 ft) and reached sizes of 0.54 × 0.65 m (1.78 × 2.14 ft). The cultivar produces flowers larger than 10.2 cm (4 in) in diameter in clusters of up to four flowers. Although ratings above three were

observed at different seasons (Fig. 4-16), flower coverage rates were most frequently rated with two on the rating scale. Lack of vigor in plants of this cultivar caused a low production of flowers.

‘WEKcisbako’ (Home Run®)

‘WEKcisbako’ was the most susceptible cultivar to Cercospora leaf spot. Symptoms were persistent but variable throughout the evaluation. On the other hand, this cultivar was one of the most tolerant to black spot. Symptoms were only observed in early Oct. 2009. Susceptibility to foliar damage caused by chilli thrips was intermediate and the most severe damage was observed in Oct. and Nov. 2008.

‘WEKcisbako’ (Home Run®) showed better plant quality ratings during spring and summer 2008 and spring 2009 (Fig. 4-17). This cultivar showed best plant quality ratings in July 2008 and Apr. 2009. Plants of this cultivar were rated as good quality at the initial evaluation due to the fact that robust plants were planted. Higher values were consistent from February through early July 2008. Ratings decreased in late July and this trend continued with ratings of one from Sept. 2008 through Feb. 2009. Evaluations after pruning at week 60 (25 Mar. 09) were high (equal or above four), but values began to decrease by week 61 (4 Apr. 2009). By May 2009, all plants received quality ratings of one which continued until the end of the evaluation. Plant quality on this cultivar was affected by the constant defoliation and yellowing probably caused by the high severity of Cercospora leaf spot infection. Plants showed poor, asymmetrical growth and sparse canopy with bare spots. Branches of ‘WEKcisbako’ (Home Run®) also died back continuously.

This cultivar can reach sizes up to 1.2 m (4 ft) tall and 1.2 (4 ft) width. However, this was not observed due to poor growth and diseases. Initial plant measurements

averaged 0.27 × 0.36 m (0.89 × 1.18 ft) and reached sizes of 0.46 × 0.36 m (1.51 × 1.18 ft), reflecting the poor performance of this cultivar. ‘WEKcisbako’ (Home Run®) produces flowers as large as 8.9 cm (3.5 in) in diameter in clusters of up to six flowers. Flower production was constant except during winter 2009 (Fig. 4-18) and was best during spring and summer 2008. Flower coverage rates were low despite the small size of the plants.

‘RADrazz’ (Knock Out®)

‘RADrazz’ was one of the most resistant cultivars to black spot, along with ‘WEKcisbako’ (Home Run®). Symptoms of black spot were only seen twice in Sept. 2009 and Oct 2009. ‘RADrazz’ (Knock Out®) was also among the most susceptible cultivars to Cercospora leaf spot. Symptoms of this disease were observed continuously with highest ratings during Jan. and Feb. 2009. Susceptibility to foliar damage caused by chilli thrips was intermediate. Chilli thrips damage was constant but low except in Oct. 2008 when ratings of four were observed. In contrast to other Cercospora susceptible cultivars which defoliated, this cultivar retained most of its foliage year-round. ‘RADrazz’ (Knock Out®) forms compact and dense bushes which could have contributed to the persistence of Cercospora leaf spot on this cultivar. Continuous production of new foliage also helped to maintain populations of chilli thrips.

‘RADrazz’ (Knock Out®) showed higher plant quality ratings during spring and summer 2008 and spring 2009 (Fig. 4-19) with the best ratings in July 2008 and Apr. 2009. This cultivar was rated as good quality at the initial evaluation at four weeks after planting. Like ‘WEKcisbako’ (Home Run®), the plants were the most robust of all the cultivars planted. Plant quality rating increased until July when the highest ratings (of four) were observed frequently. These values started to decrease in Aug. 2008,

reaching the lowest rating of one by Jan. and Feb. 2009. Evaluations after pruning were high and frequently above four. These values started to decrease by mid-June and were variable for the remainder of the evaluation. Low quality ratings on ‘RADrazz’ (Knock Out®) were generally due to severe yellowing and the presence symptomatic leaves rather than to defoliation.

This cultivar can reach sizes up to 1.2 m (4 ft) tall and 1.2 (4 ft) width. Although average size of plants under the research conditions was smaller than this, ‘RADrazz’ (Knock Out®) showed satisfactory growth. Initial plant measurements averaged 0.16 × 0.26 m (0.52 × 0.85 ft) and reached sizes of 0.72 × 0.86 m (2.37 × 2.82 ft). This cultivar produces flowers as large as 8.9 cm (3.5 in) in diameter in clusters of up to 5 flowers. Flower production of this cultivar was constant (Fig. 4-20) and was best during summer 2008. Compared to other cultivars, and despite the severity of disease damage, ‘RADrazz’ (Knock Out®) had enough vigor to grow to a size typical of this cultivar. Flower production, although diminished by damage, was at desirable levels. This cultivar produced numerous clusters of flowers that were able to cover the canopy of the plant at times. Flowering peaks were observed in July 2008 and Apr. 2009.

‘Perle d’Or’

‘Perle d’Or’ was high susceptible to Cercospora leaf spot. Values of AUDPC for Cercospora leaf spot were similar to those of ‘Duchesse de Brabant’ and ‘BUCbi’ (Carefree Beauty™). Symptoms of Cercospora leaf spot were observed continuously and were most severe in Oct. 2008 and Aug. 2009. The disease caused constant and severe defoliation on all plants of this cultivar. Symptoms of black spot were observed infrequently throughout the evaluation period. Susceptibility to foliar damage caused by chilli thrips was intermediate and the most severe damage was observed in Oct. 2008.

The best plant quality ratings for ‘Perle d’Or’ were observed in general during spring 2009; whereas the rest of the year the plant quality was frequently very poor (Fig. 4-21). This cultivar showed best plant quality ratings in Apr. 2009. ‘Perle d’Or’ was rated with very poor quality at four weeks after planting due to its small size and lack of vigor. Values slightly increased until June, but decreased thereafter and by Sept. 2008, plants were consistently rated as one until Jan. 2009. Evaluations after pruning were high with ratings above four and remained high until mid-May 2009. By the end of June and for the rest of the year, plant quality values remained at one. Similar to other cultivars, the main reason for its poor quality ratings was due to its high susceptibility to Cercospora leaf spot and which resulted in severe defoliation. Poor growth, uneven-shaped plants and a tendency to die back constantly were also counted as quality decreasing factors for this cultivar.

‘Perle d’Or’ can reach sizes up to 1.2 m (4 ft) tall and 1.2 m (4 ft) width. Average size of plants under the study conditions was smaller. Initial plant measurements averaged 0.29 × 0.44 m (0.95 × 1.44 ft) and reached sizes of 0.45 × 0.33 m (1.48 × 1.09 ft). Canes on this cultivar were particularly prone to die back thus reducing the size of the canopy. ‘Perle d’Or’ produces small flowers of 2.5 cm (1 in) in diameter in clusters of up to 50 flowers. Flower production of this cultivar was constant and was better during spring-summer 2008 and spring 2009 (Fig. 4-22). Flower coverage rates were usually poor as plants were most frequently rated with two or less in the rating scale. Occasional high flowering ratings were due to the production of large clusters of flowers that covered a large canopy area of the very small plants.

Table 4-1. Mean values of the area under the disease progress curve (AUDPC) for the severity of black spot and Cercospora leaf spot in 11 cultivars of Old Garden (OGR) and Modern (MR) roses.

		Black spot		Cercospora leaf spot	
Cultivar[x]	Group	AUDPC[y]		AUDPC	
‘WEKcisbako’ (Home Run®)	MR	14	a[z]	1819	h
‘RADrazz’ (Knock Out®)	MR	19	a	1429	e
‘Perle d'Or’	MR	100	b	1482	fg
‘BUCbi’ (Carefree Beauty™)	MR	186	b	1618	g
‘Mrs. B. R. Cant’	OGR	828	c	138	c
‘Spice’	OGR	866	c	210	d
‘Duchesse de Brabant’	OGR	919	d	1552	g
‘Belinda’s Dream’	MR	1029	e	194	d
‘Old Blush’	OGR	1149	f	36	a
‘Bailey Red’	OGR	1251	g	137	c
‘Mutabilis’	OGR	2172	h	57	b

[x]Trade name in parenthesis.
[y]AUDPC=$\Sigma((\text{Rating}_1+\text{Rating}_2)\div 2)\times(\text{difference of days between Rating}_2\text{ and Rating}_1))$; for a total period of 67 weeks and 45 weeks of data.
[z]Mean values followed by the same letters are not significantly different ($P\leq 0.05$) obtained from orthogonal contrasts.

Table 4-2. Mean values of the damage severity index (DSI) caused by chilli thrips in 11 cultivars of Old Garden (OGR) and Modern (MR) roses in central Florida.

		Chilli thrips damage	
Cultivar	Group	DSI	
‘Mrs. B. R. Cant’	OGR	1.01	a[z]
‘Old Blush’	OGR	1.24	ab
‘Bailey Red’	OGR	1.30	ab
‘Belinda's Dream’	MR	1.59	bc
‘BUCbi’ (Carefree Beauty™)	MR	1.59	bc
‘Perle d'Or’	MR	1.61	bc
‘RADrazz’ (Knock Out®)	MR	1.78	cd
‘WEKcisbako’ (Home Run®)	MR	1.85	cd
‘Spice’	OGR	2.14	d
‘Duchesse de Brabant’	OGR	2.86	e
‘Mutabilis’	OGR	3.69	f

[x]Trade name in parenthesis.
[y]DSI=$(\Sigma(\text{Frequency}_1\times\text{Rating value}_1))\div(\text{total of symptomatic readings})$; for a total period of 57 weeks and 37 weeks of data.
[z]Mean values followed by the same letters are not significantly different ($P\leq 0.05$) according to Tukey’s test.

Table 4-3. Weekly statistical significances of flower coverage and plant quality ratings of 11 rose cultivars during a two year evaluation period.

Year 1				Year 2			
Date	Week #	Flower Coverage[z]	Plant quality	Date	Week #	Flower Coverage	Plant quality
3/25/08	8	*	*	3/25/09	60	*	NS
4/24/08	12	*	*	4/1/09	61	*	*
5/8/08	14	NS	*	4/8/09	62	*	*
5/15/08	15	NS	*	4/15/09	63	*	*
5/22/08	16	*	*	4/22/09	64	*	*
5/30/08	17	*	*	4/29/09	65	*	*
6/5/08	18	*	*	5/7/09	66	*	*
6/11/08	19	*	*	5/14/09	67	*	*
6/19/08	20	*	*	5/20/09	68	*	*
6/24/08	21	*	*	5/28/09	69	*	*
7/3/08	22	*	*	6/3/09	70	*	*
7/10/08	23	NS	*	6/10/09	71	*	*
7/17/08	24	*	*	6/17/09	72	*	*
7/24/08	25	*	*	6/24/09	73	*	*
7/31/08	26	*	*	7/1/09	74	*	*
8/7/08	27	*	*	7/8/09	75	*	*
8/15/08	28	NS	*	7/15/09	76	*	*
8/21/08	29	NS	*	7/22/09	77	*	*
8/28/08	30	*	*	7/28/09	78	*	*
9/4/08	31	NS	*	8/5/09	79	*	*
9/11/08	32	*	*	8/12/09	80	*	*
9/18/08	33	*	*	8/18/09	81	*	*
9/25/08	34	*	*	8/25/09	82	*	*
9/30/08	35	*	*	9/1/09	83	*	*
10/9/08	36	NS	*	9/8/09	84	NS	*
10/15/08	37	NS	*	9/15/09	85	*	*
10/22/08	38	*	*	9/23/09	86	NS	*
10/29/08	39	*	*	9/30/09	87	NS	*

[z]NS=Non-significant, *= Significant (Pr≤P =0.05) using Fisher's Exact Test.

Table 4-3. (Continued). Weekly statistical significances of flower coverage and plant quality ratings of 11 rose cultivars during a two year evaluation period.

Year 1				Year 2			
Date	Week #	Flower Coverage[z]	Plant quality	Date	Week #	Flower Coverage	Plant quality
11/6/08	40	*	*	10/6/09	88	*	*
11/13/08	41	NS	*	10/13/09	89	*	*
11/20/08	42	*	*	10/20/09	90	*	*
11/25/08	43	NS	*	10/27/09	91	*	*
12/4/08	44	*	*	11/5/09	92	NS	*
12/11/08	45	NS	*	11/12/09	93	NS	*
12/18/08	46	*	*	11/17/09	94	*	*
1/7/09	49	NS	*	11/24/09	95	*	*
1/14/07	50	*	*	11/30/09	96	*	*
1/21/09	51	NS	*	12/9/09	97	NS	*
1/28/09	52	*	*	12/16/09	98	*	*
2/4/09	53	NS	*	12/30/09	100	*	*
2/11/09	54	NS	*	1/27/10	104	NS	*
2/18/09	55	NS	*				
2/25/09	56	NS	*				

[z]NS=Non-significant, *= Significant (Pr≤P =0.05) using Fisher's Exact Test.

Table 4-4. Differences between initial and final plant size of 11 rose cultivars after the first year of growth in central Florida under low maintenance conditions.

	Initial (1/29/2008)		Final (11/6/2008)		Difference in Growth	
	m		m		m	
Cultivar	Height	Width	Height	Width	Height	Width
‘Bailey Red’	0.23	0.27	0.42	0.48	0.19	0.21
‘Belinda’s Dream’	0.24	0.27	0.50	0.53	0.26	0.26
‘BUCbi’ (Carefree Beauty™)	0.17	0.26	0.55	0.60	0.38	0.34
‘Duchesse de Brabant’	0.33	0.42	0.66	0.77	0.33	0.35
‘WEKcisbako’ (Home Run®)	0.27	0.36	0.51	0.49	0.24	0.13
‘RADrazz’ (Knock Out®)	0.16	0.26	0.68	0.72	0.52	0.46
‘Mrs. B. R. Cant’	0.28	0.50	0.63	0.95	0.35	0.45
‘Mutabilis’	0.40	0.66	0.66	0.79	0.26	0.13
‘Old Blush’	0.34	0.51	0.47	0.52	0.13	0.01
‘Perle d'Or’	0.29	0.44	0.40	0.34	0.11	-0.10
‘Spice’	0.23	0.51	0.42	0.60	0.19	0.09

Table 4-5. Differences between initial and final plant size of 11 rose cultivars after the second year of growth in central Florida under low maintenance conditions.

	Initial (2/25/2009)		Final (1/27/2010)		Difference in Growth	
	m		m		m	
Cultivar	Height	Width	Height	Width	Height	Width
‘Bailey Red’	0.32	0.43	0.34	0.50	0.02	0.07
‘Belinda’s Dream’	0.34	0.41	0.35	0.26	0.01	-0.15
‘BUCbi’ (Carefree Beauty™)	0.34	0.47	0.53	0.71	0.19	0.23
‘Duchesse de Brabant’	0.52	0.68	0.73	1.04	0.21	0.36
‘WEKcisbako’ (Home Run®)	0.34	0.38	0.41	0.23	0.07	-0.15
‘RADrazz’ (Knock Out®)	0.46	0.56	0.77	1.00	0.30	0.44
‘Mrs. B. R. Cant’	0.55	0.89	1.06	1.66	0.50	0.77
‘Mutabilis’	0.47	0.71	0.78	1.18	0.31	0.47
‘Old Blush’	0.38	0.50	0.50	0.64	0.13	0.14
‘Perle d'Or’	0.30	0.34	0.50	0.32	0.21	-0.02
‘Spice’	0.36	0.58	0.55	0.89	0.19	0.32

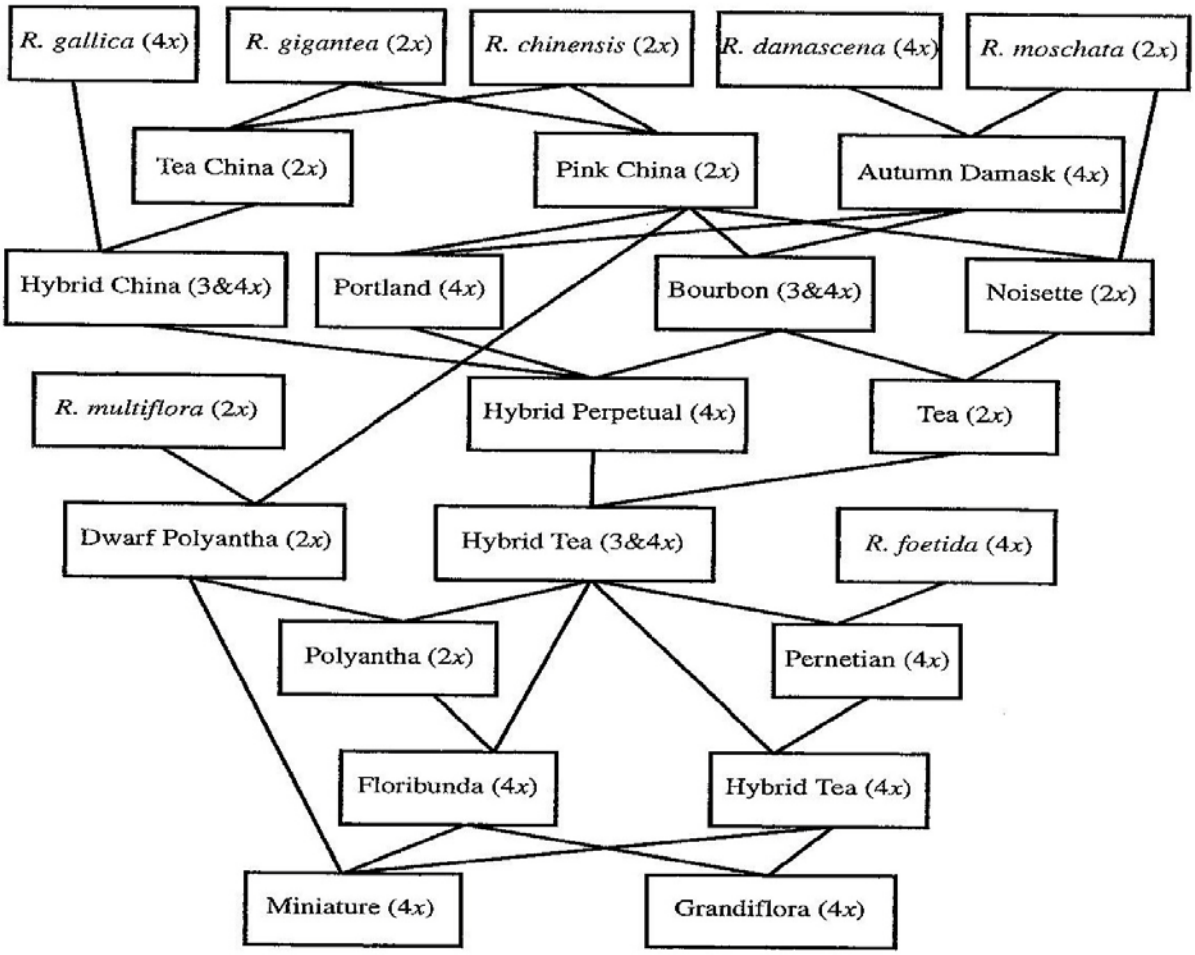


Figure 2-1. Genealogy of roses (Horst and Cloyd, 2007).

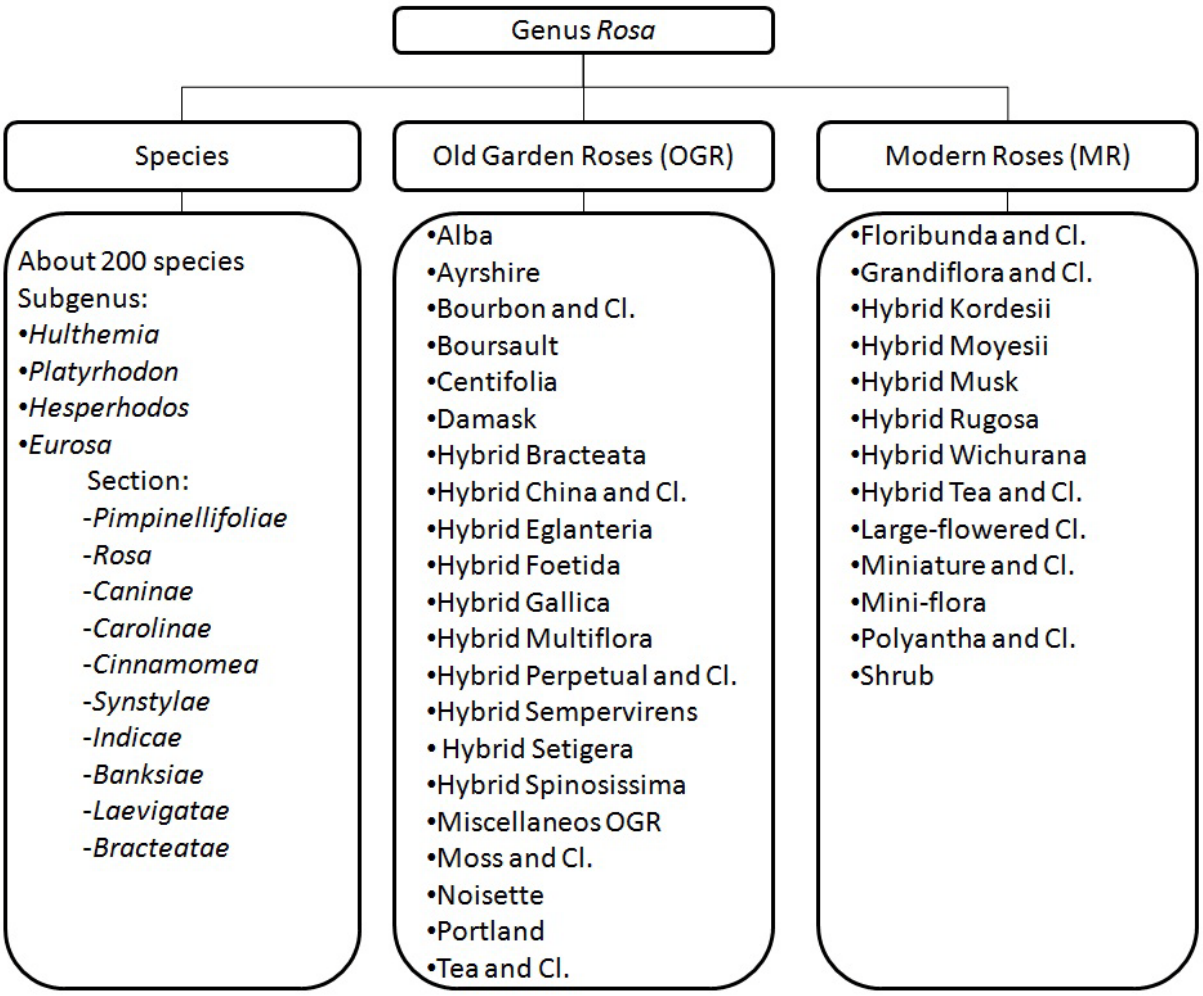


Figure 2-2. Rose family tree (Horst and Cloyd, 2007). Modified by Mangandi, 2010. (Cl. refers to climbing cultivars of the corresponding horticultural class)

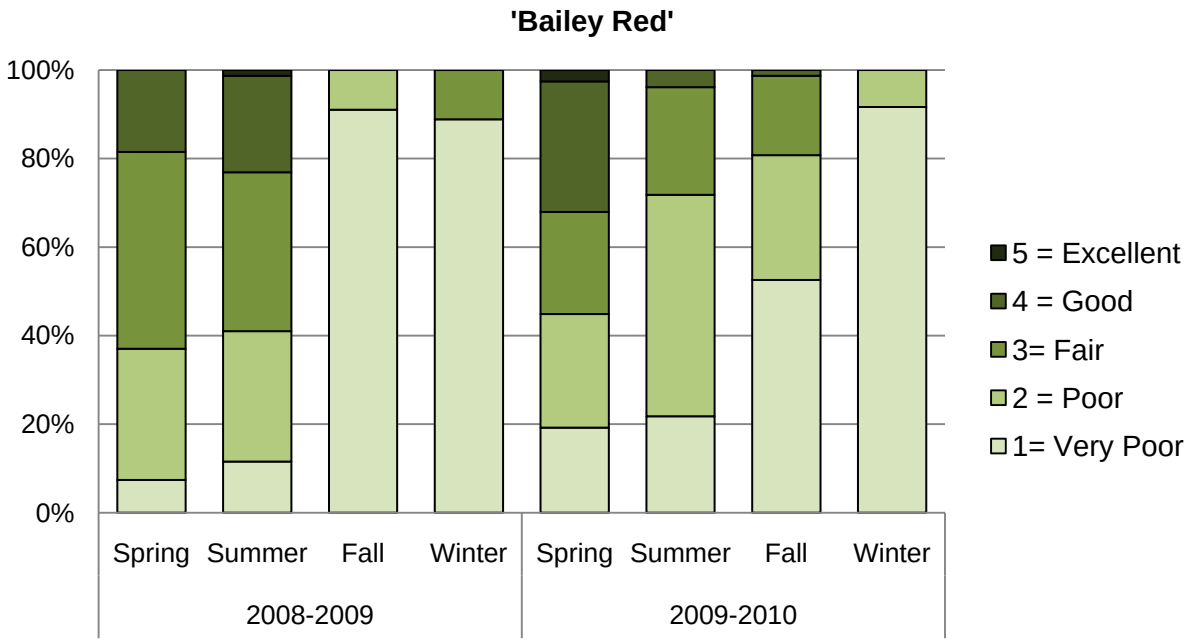


Figure 4-1. Seasonal frequency of plant quality ratings for the rose cultivar 'Bailey Red' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

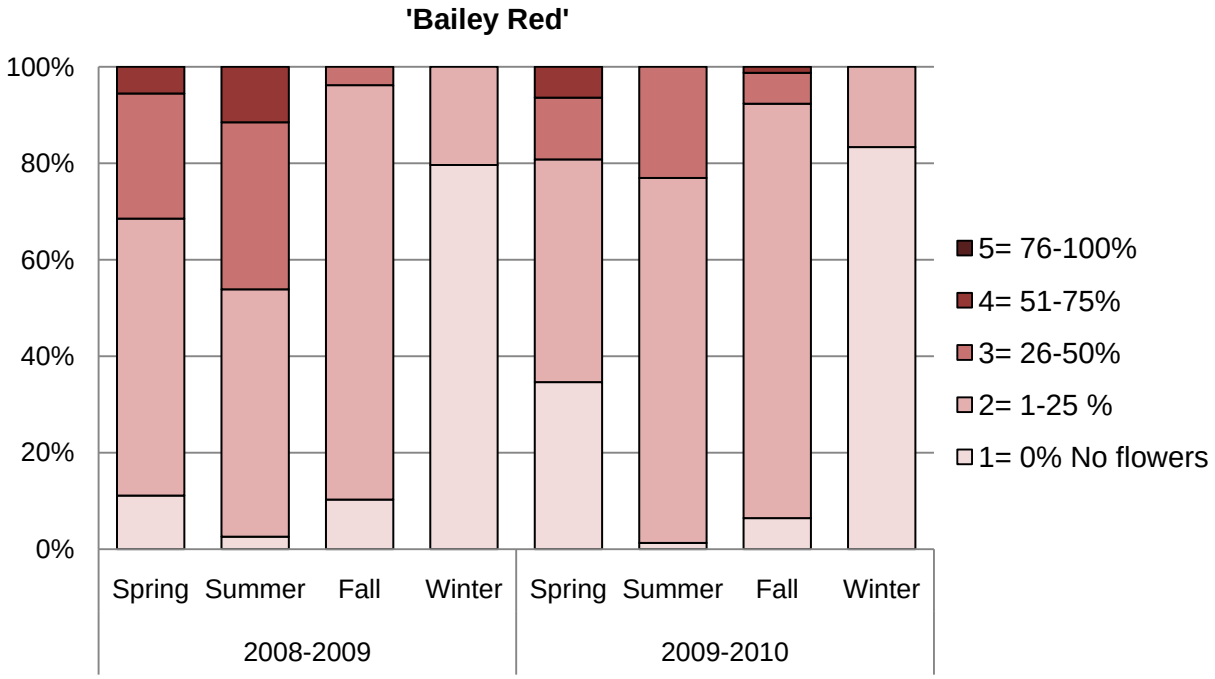


Figure 4-2. Seasonal frequency of flower coverage ratings for the rose cultivar 'Bailey Red' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

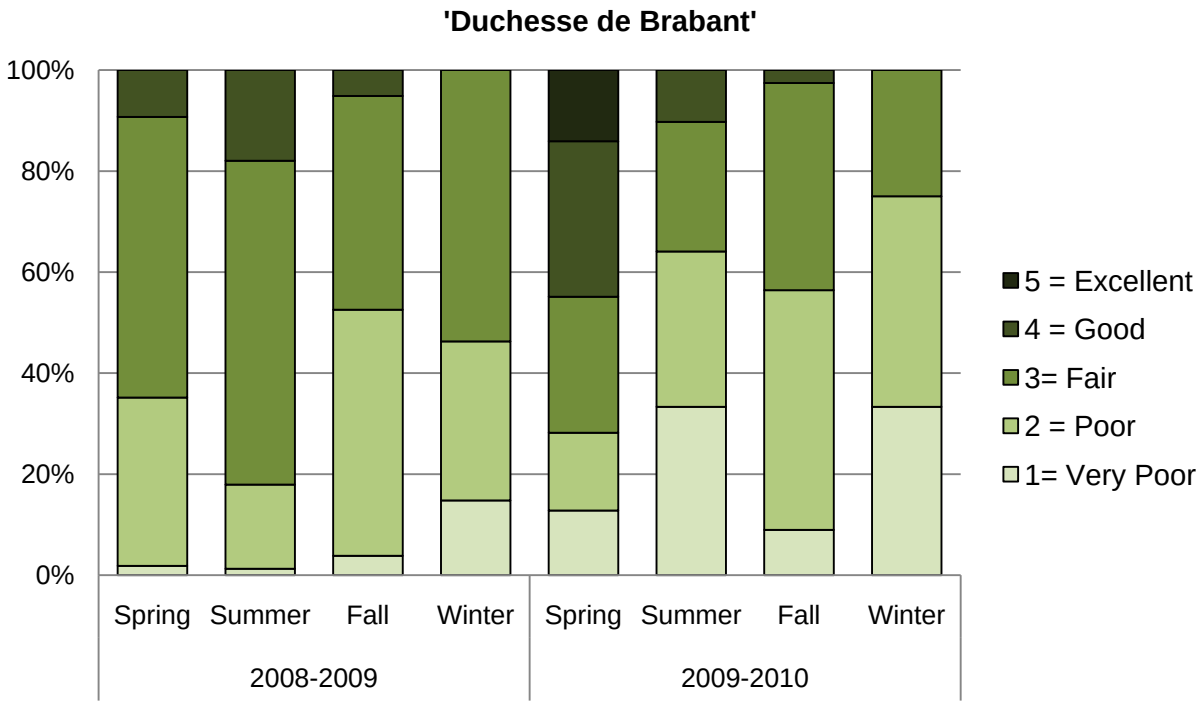


Figure 4-3. Seasonal frequency of plant quality ratings for the rose cultivar 'Duchesse de Brabant' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

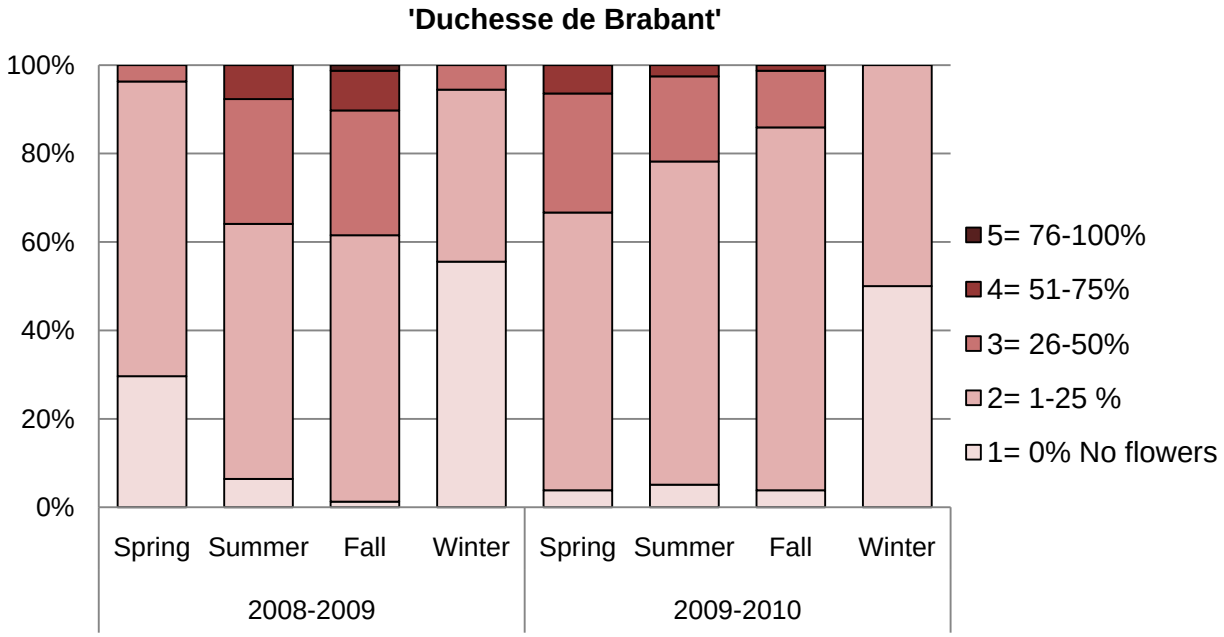


Figure 4-4. Seasonal frequency of flower coverage ratings for the rose cultivar 'Duchesse de Brabant' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

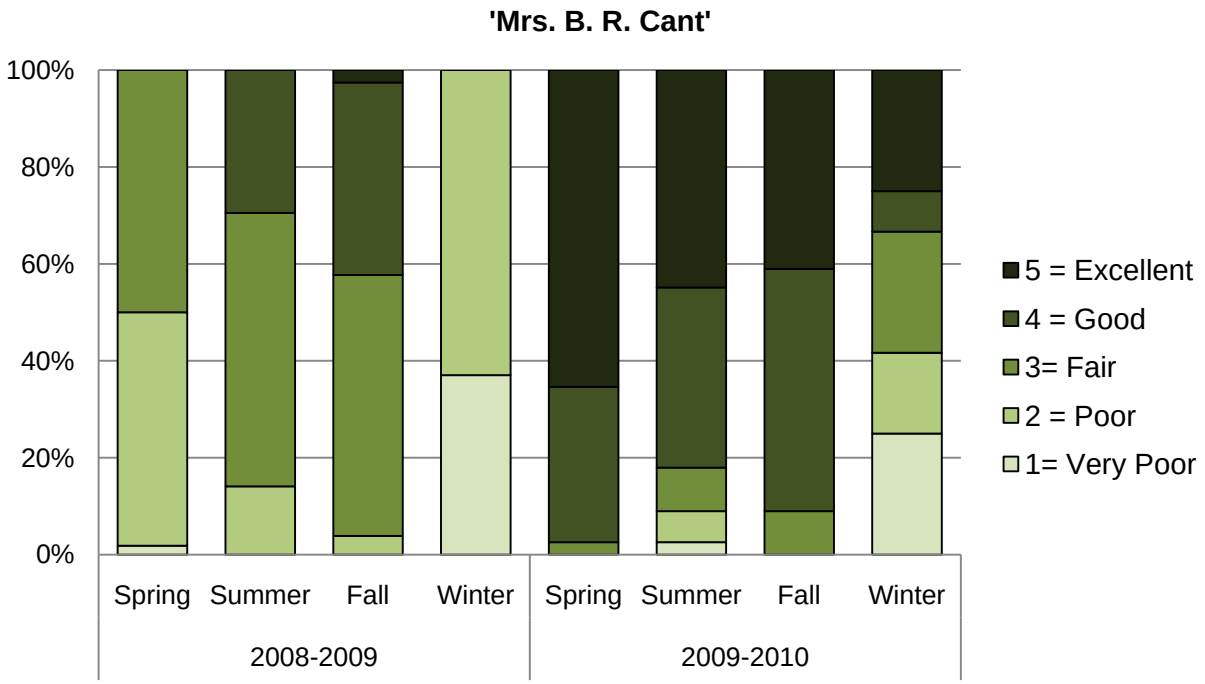


Figure 4-5. Seasonal frequency of plant quality ratings for the rose cultivar 'Mrs. B. R. Cant' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

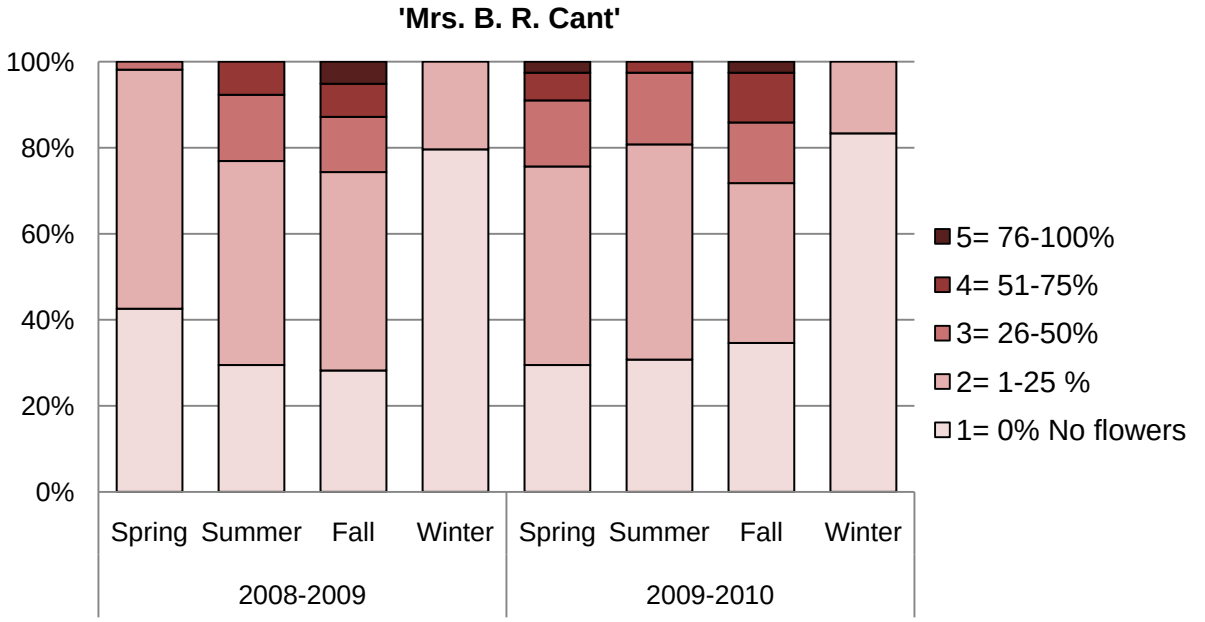


Figure 4-6. Seasonal frequency of flower coverage ratings for the rose cultivar 'Mr. B. R. Cant' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

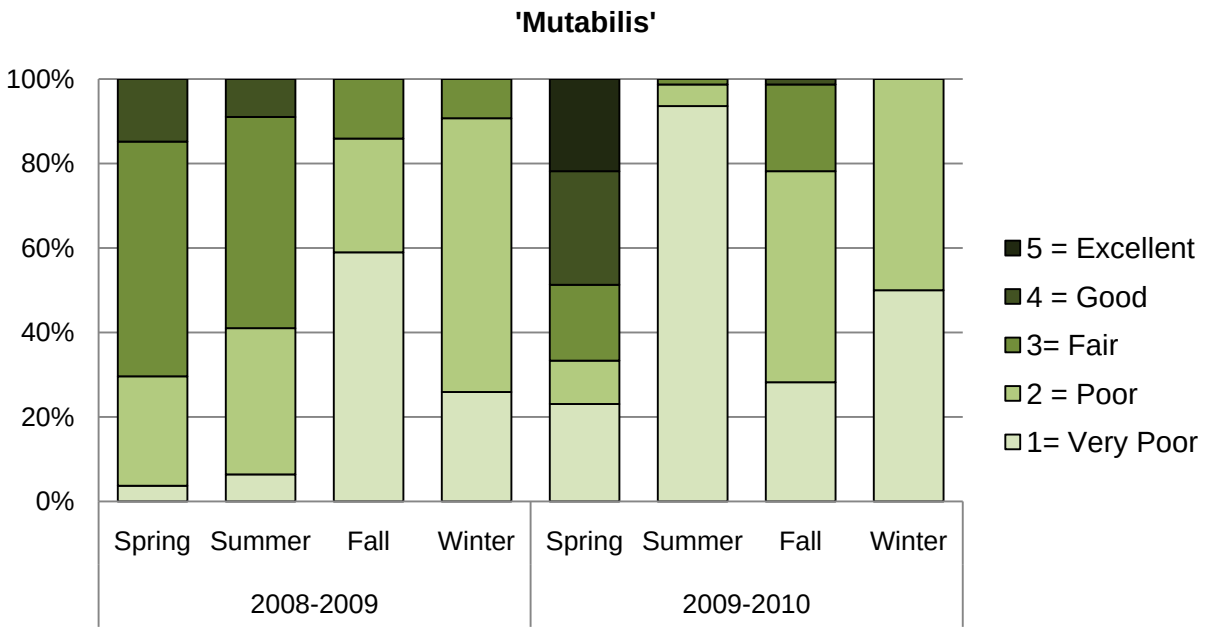


Figure 4-7. Seasonal frequency of plant quality ratings for the rose cultivar 'Mutabilis' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

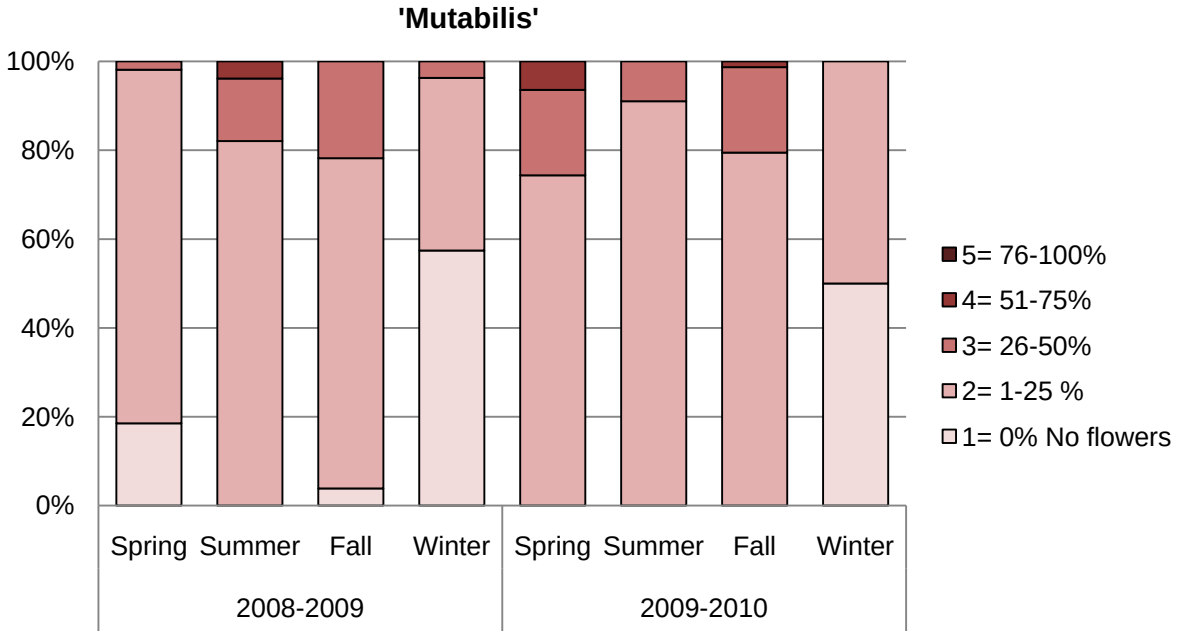


Figure 4-8. Seasonal frequency of flower coverage ratings for the rose cultivar 'Mutabilis' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

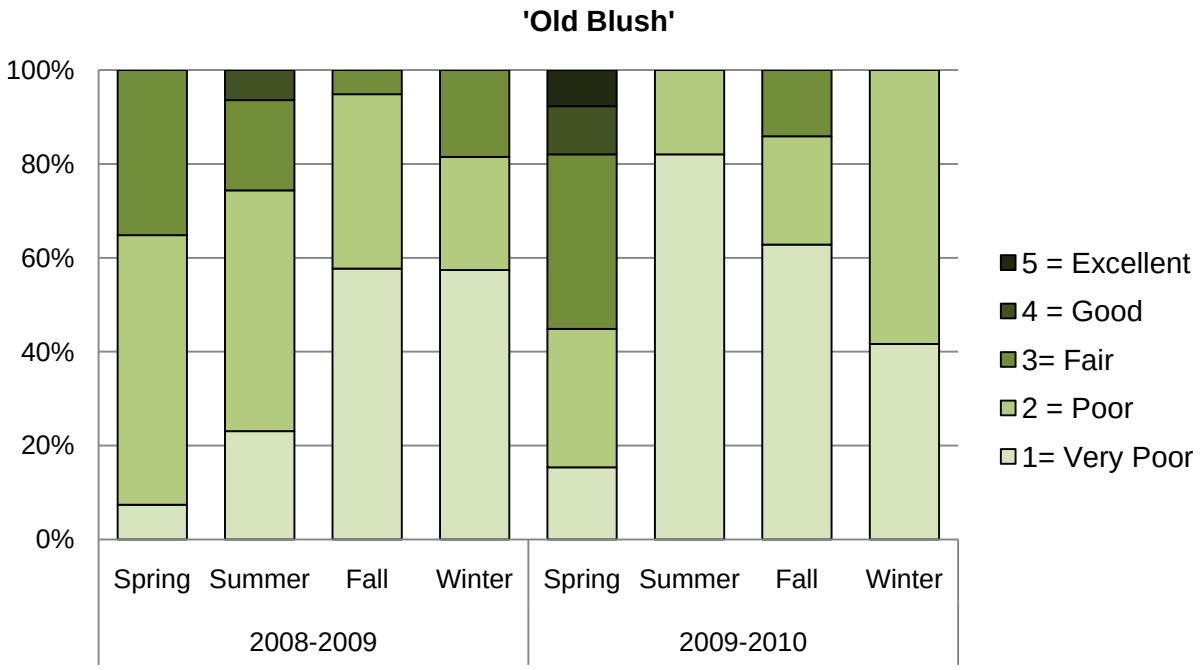


Figure 4-9. Seasonal frequency of plant quality ratings for the rose cultivar 'Old Blush' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

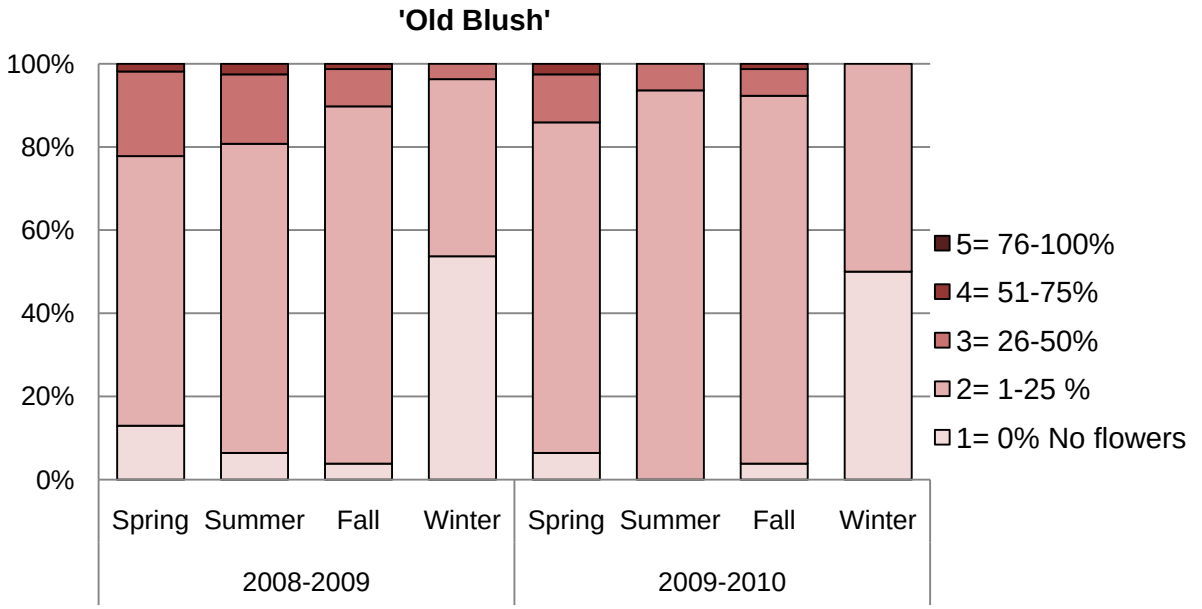


Figure 4-10. Seasonal frequency of flower coverage ratings for the rose cultivar 'Old Blush' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

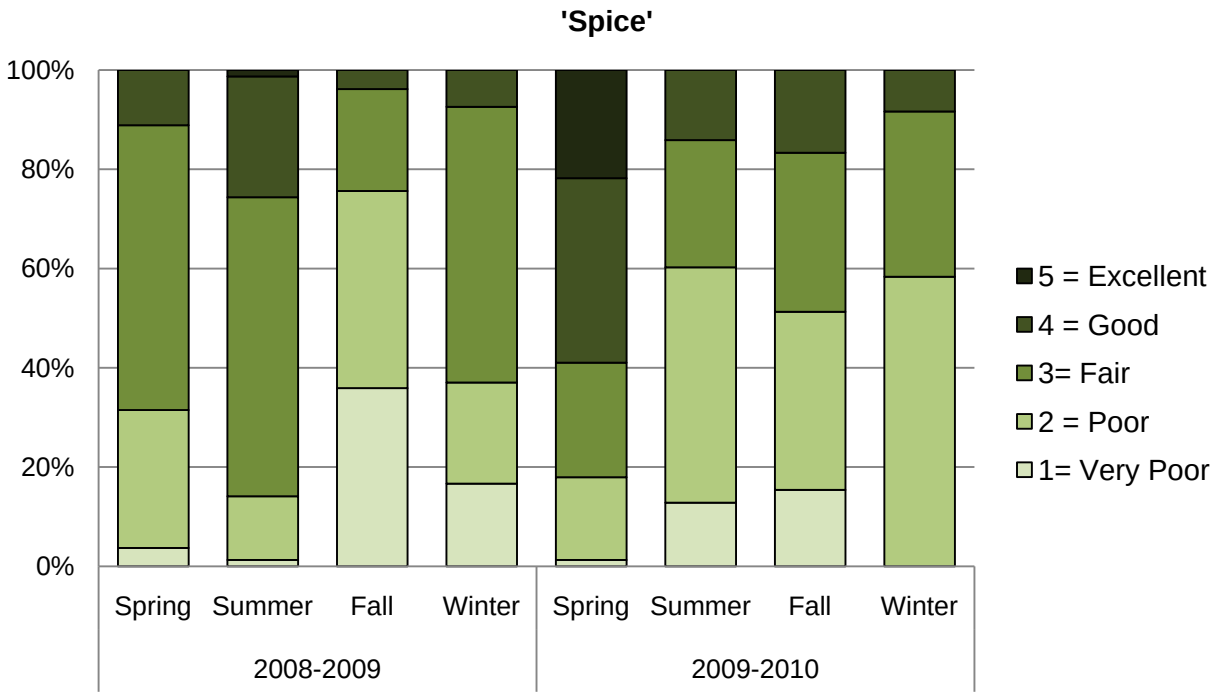


Figure 4-11. Seasonal frequency of plant quality ratings for the rose cultivar 'Spice' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

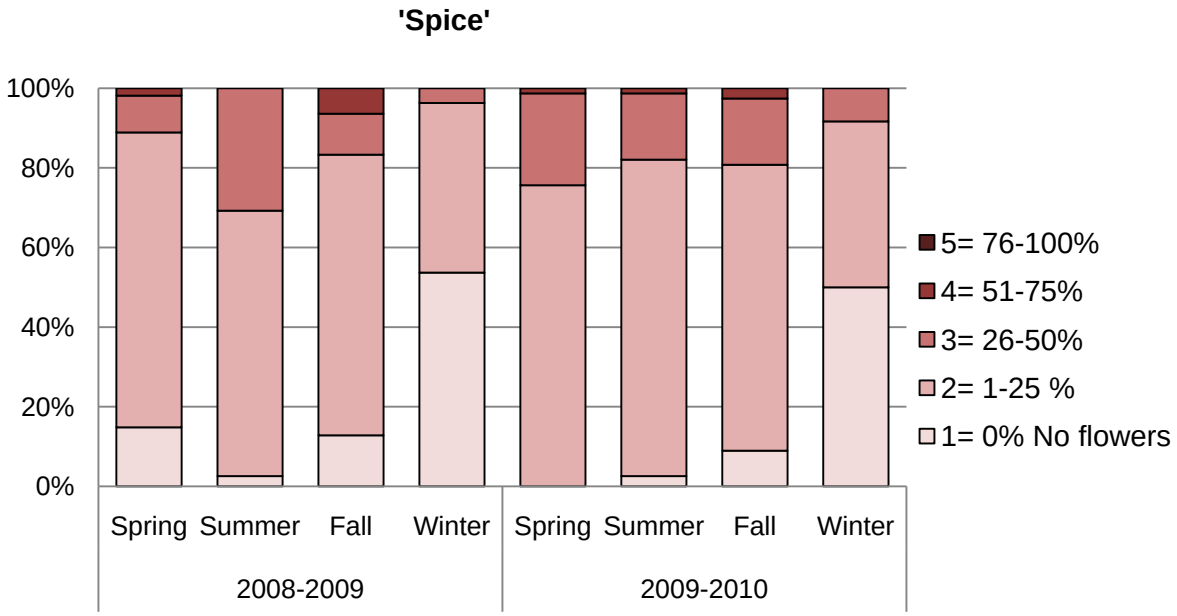


Figure 4-12. Seasonal frequency of flower coverage ratings for the rose cultivar 'Spice' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

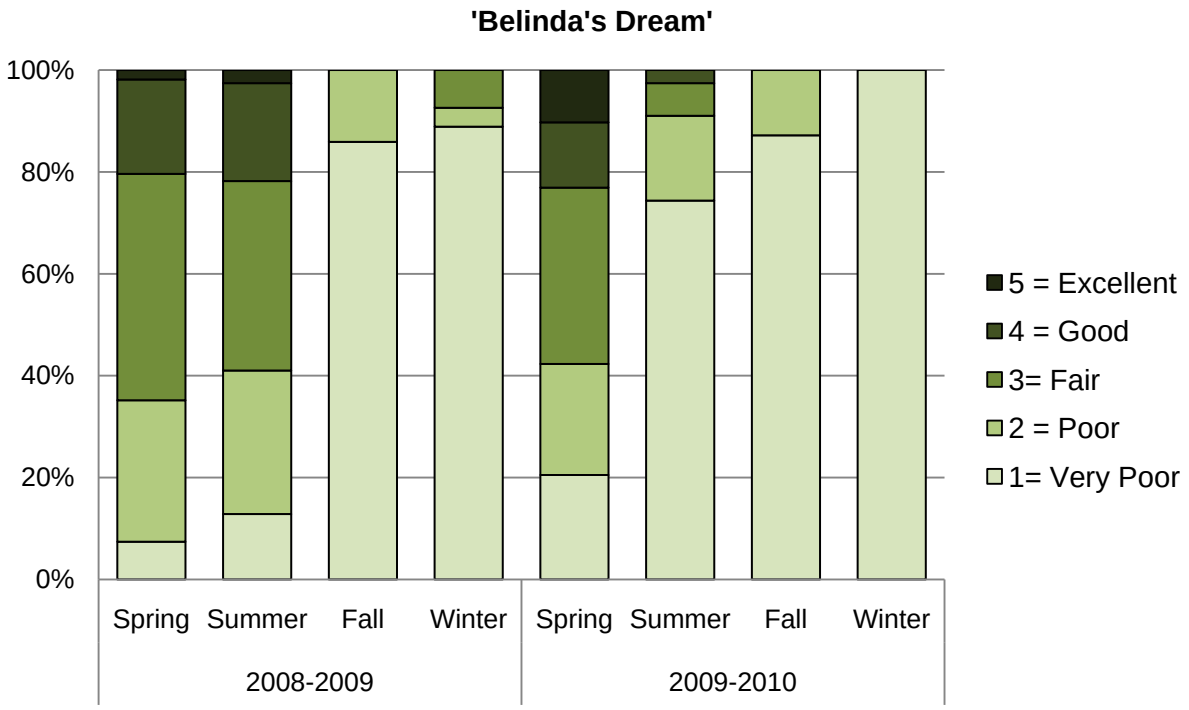


Figure 4-13. Seasonal frequency of plant quality ratings for the rose cultivar 'Belinda's Dream' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

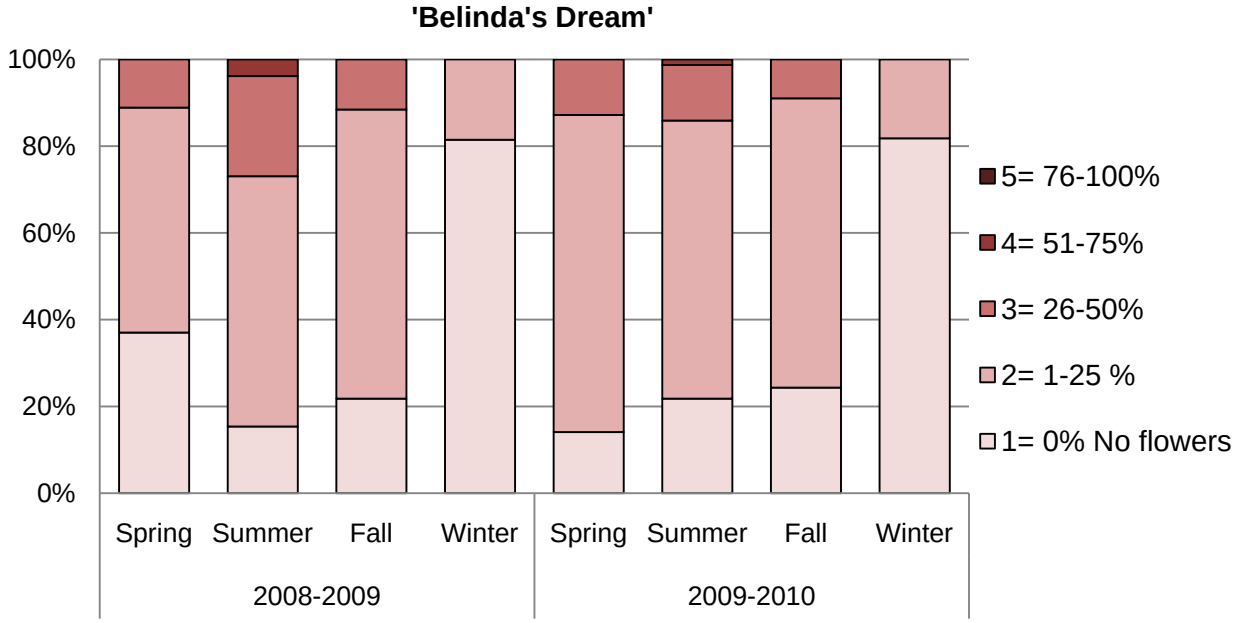


Figure 4-14. Seasonal frequency of flower coverage ratings for the rose cultivar 'Belinda's Dream' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

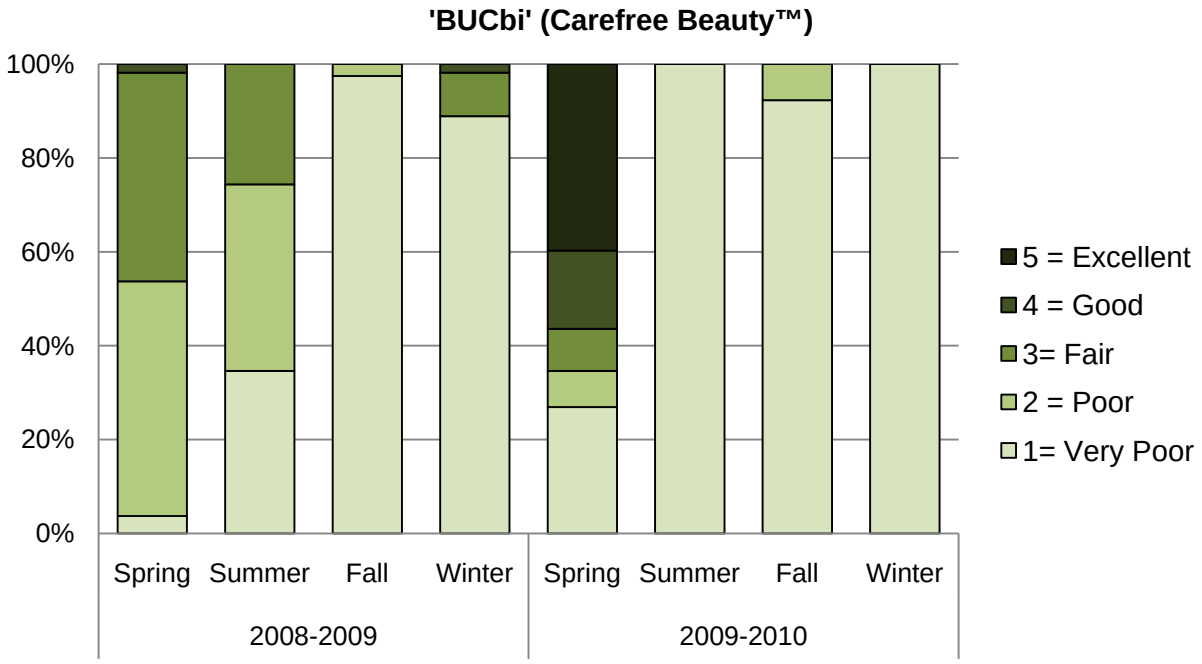


Figure 4-15. Seasonal frequency of plant quality ratings for the rose cultivar 'BUCbi' (Carefree Beauty™) (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

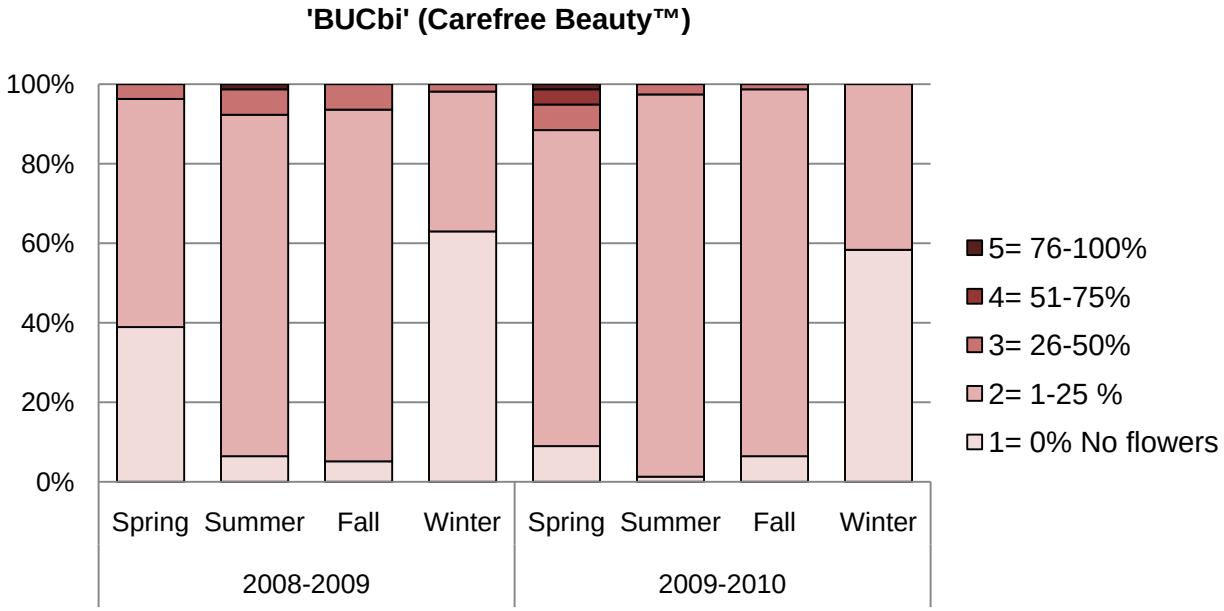


Figure 4-16. Seasonal frequency of flower coverage ratings for the rose cultivar 'BUCbi' (Carefree Beauty™) (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

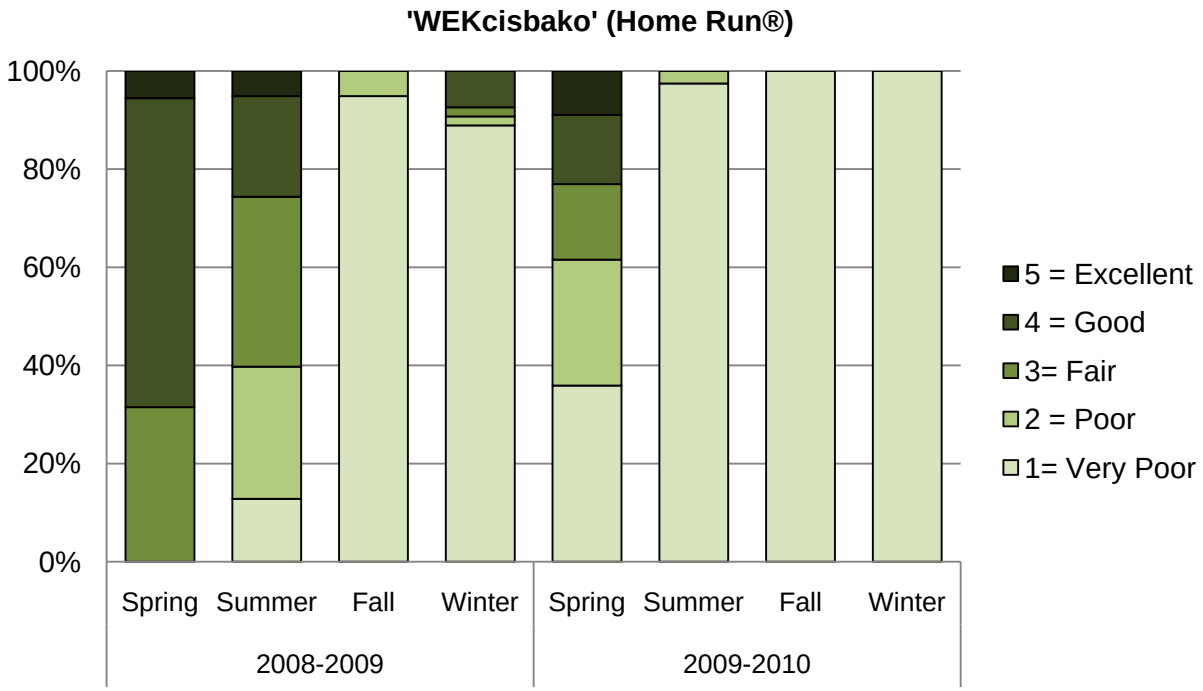


Figure 4-17. Seasonal frequency of plant quality ratings for the rose cultivar 'WEKcisbako' (Home Run®) (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

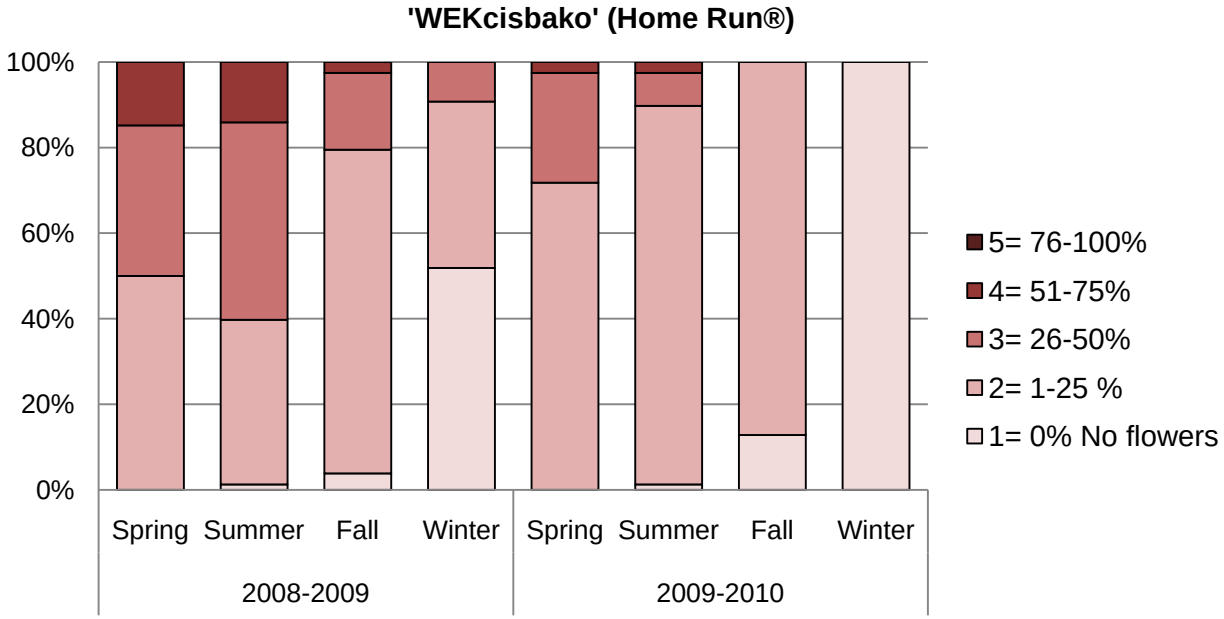


Figure 4-18. Seasonal frequency of flower coverage ratings for the rose cultivar 'WEKcisbako' (Home Run®) (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

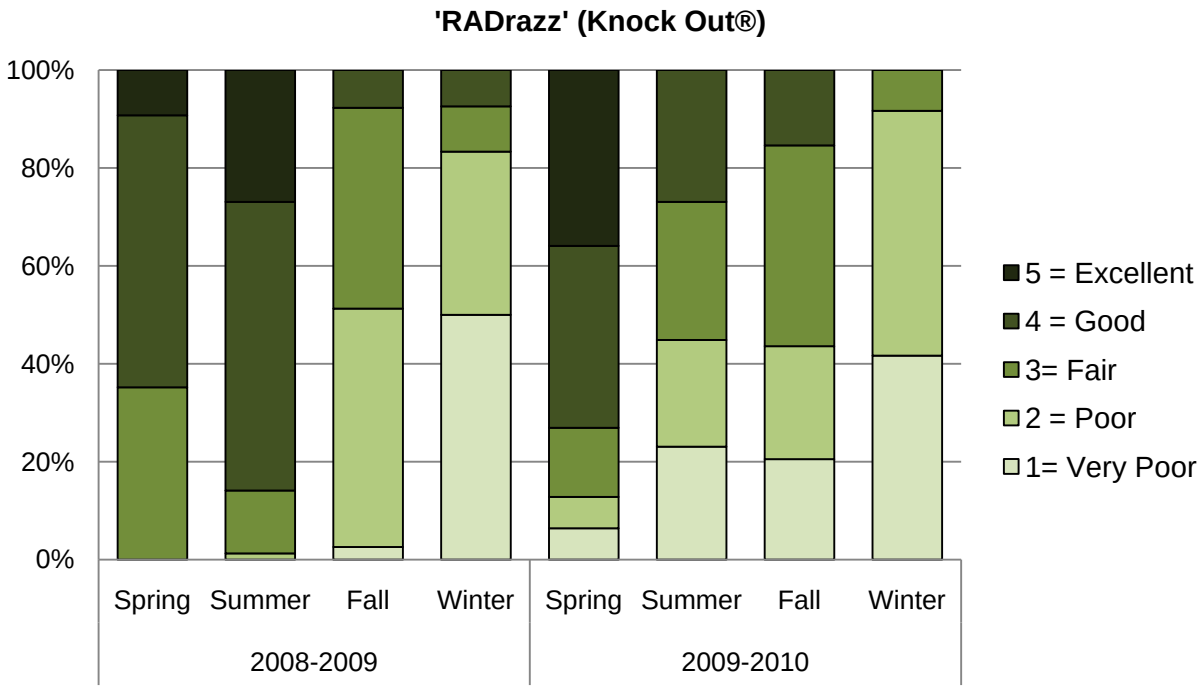


Figure 4-19. Seasonal frequency of plant quality ratings for the rose cultivar 'RADrazz' (Knock Out®) (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

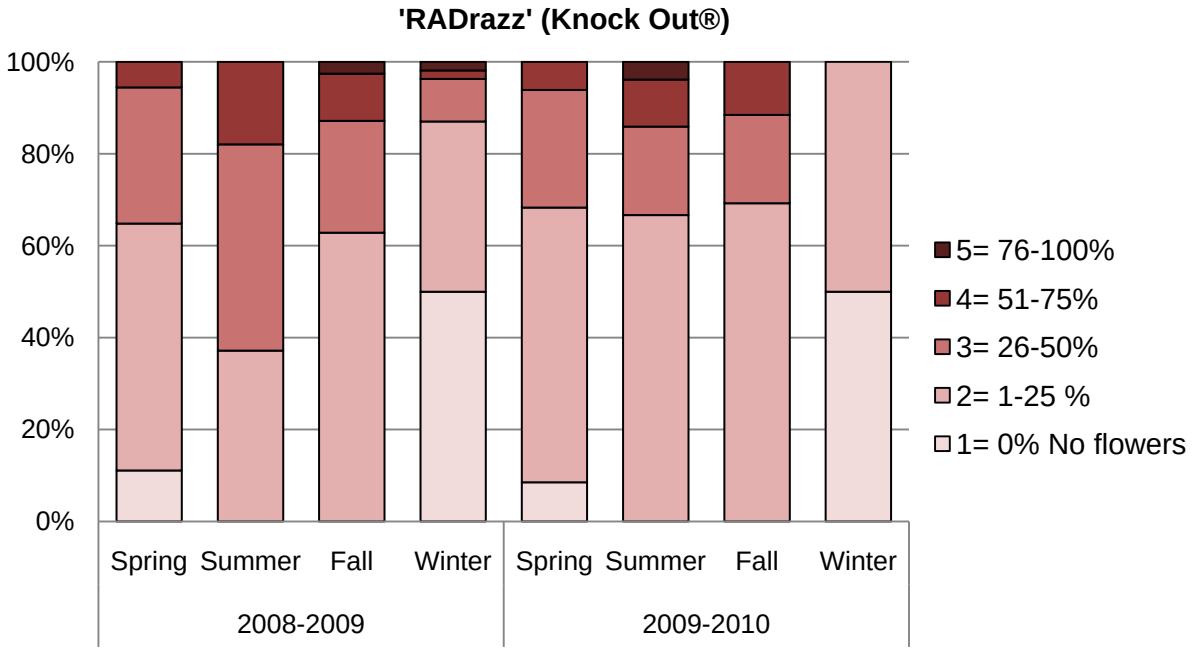


Figure 4-20. Seasonal frequency of flower coverage ratings for the rose cultivar 'RADrazz' (Knock Out®) (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

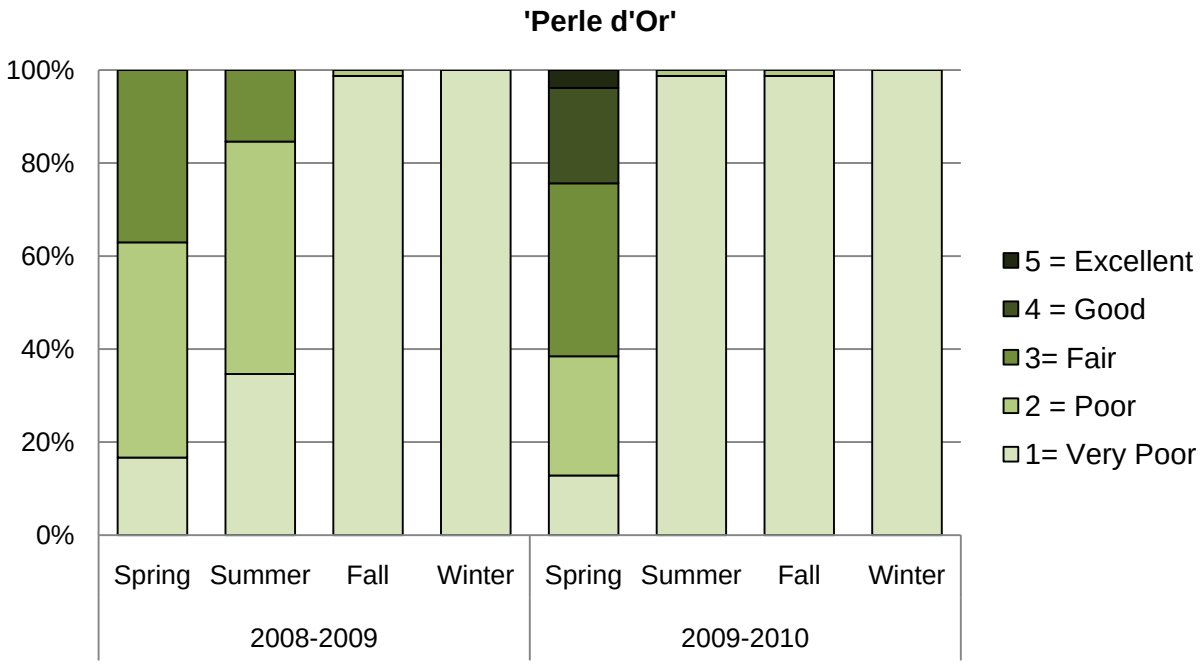


Figure 4-21. Seasonal frequency of plant quality ratings for the rose cultivar 'Perle d'Or' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

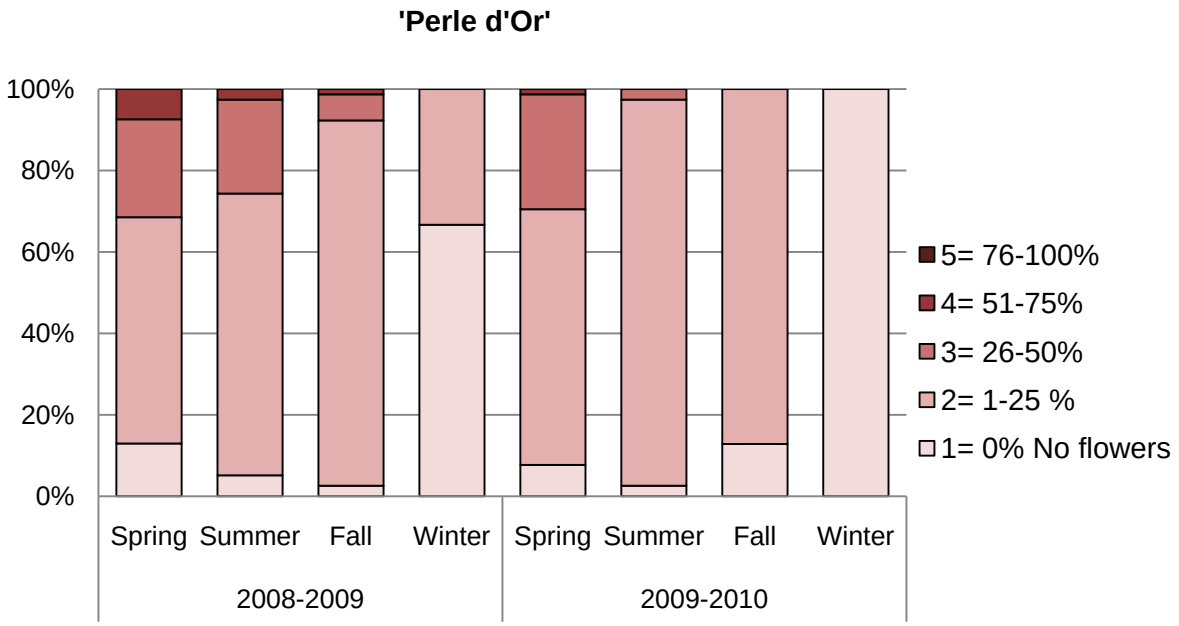


Figure 4-22. Seasonal frequency of flower coverage ratings for the rose cultivar 'Perle d'Or' (Spring: 21 Mar.-20 June; Summer: 21June-22 Sept.; Fall: 23 Sept.-20 Dec; Winter: 21 Dec-20 Mar.).

CHAPTER 5
SUMMARY AND CONCLUSIONS

This study evaluated the performance of 11 OGR and MR rose cultivars in central Florida under low maintenance conditions. Initially, twelve cultivars were selected for evaluation, but 'Louis Philippe' was eliminated from analysis after it was realized that three of the six replicates were actually a look-alike cultivar ('Cramoisi Superieur'). The objective of this research was to develop recommendations of shrub rose cultivars that will perform well in central Florida with minimal inputs of water and fertilizer and no pruning or pest control. All cultivars were evaluated for two years (Feb. 2008- Jan. 2010) to determine plant quality and flower coverage. Additionally, susceptibility to black spot, Cercospora leaf spot and chilli thrips damage was analyzed for all cultivars from Sept. 2008 through Dec. 2009.

Plant quality was variable among the cultivars 82 weeks and flower coverage was variable during 60 weeks of the evaluation period. Variability of plant quality ratings were related principally to the severity of damage from black spot, Cercospora leaf spot, and chilli thrips. These factors caused different levels of defoliation on plants, decreasing plant growth and vigor on some cultivars which also reduced flower production. Since these were the most detrimental factors affecting the roses overall performance and appearance, they will be used to develop our recommendations of cultivars for central Florida.

The cultivar 'Mrs. B. R. Cant' appeared to be the most suited for central Florida conditions when grown on its own roots, with low inputs of water and fertilizer and no pruning or pesticide applications. This cultivar had low susceptibility to chilli thrips damage and was moderately susceptible to black spot and Cercospora leaf spot. Plant

quality of this cultivar improved greatly during the second year of evaluation and flower production was fairly constant.

‘Duchesse de Brabant’ and ‘RADrazz’ (Knock Out®) although susceptible to some yellowing from Cercospora leaf spot, were less prone to defoliation than the worst cultivars. ‘RADrazz’ (Knock Out®) also was moderately susceptible to chilli thrips damage whereas ‘Duchesse de Brabant’ was highly susceptible. Despite these problems, plants of these cultivars formed well-structured shrubs. Similarly, the cultivar ‘Spice’ had an overall fair quality rating, maintained a well-rounded plant structure, and defoliated less even though it was highly susceptible to chilli thrips damage and moderately susceptible to black spot and Cercospora leaf spot. Flower production on all of these cultivars did not appear to be greatly reduced. These cultivars are cautiously recommended as low maintenance, own-root cultivars in central Florida, particularly where flower production is valued over foliage appearance.

The OGR ‘Bailey Red’ and ‘Old Blush’ and the MR ‘Belinda’s Dream’ were highly susceptible cultivars to black spot. Cultivars ‘Perle d’Or’, ‘BUCbi’ (Carefree Beauty™), and ‘WEKcisbako’ (Home Run®), all MR, were highly susceptible to Cercospora leaf spot. All these cultivars had severe defoliation, poor growth and reduced vigor and therefore failed to form well-structured bushes. Additionally ‘Perle d’Or’, ‘WEKcisbako’ (Home Run®) and ‘Belinda’s Dream’ were also prone to die back. Although plants of these cultivars received high flowering ratings, this was due to the small size of the plant in comparison to the large clusters of flowers produced. ‘Mutabilis’ was the cultivar most susceptible to chilli thrips damage showing damaged foliage throughout the year. Chilli thrips damage and high susceptibility to black spot caused severe defoliation on all

plants of this cultivar. By the end of the second year of the evaluation, ‘BUCbi’ (Carefree Beauty™), ‘Bailey Red’, ‘Perle d’Or’, ‘WEKcisbako’ (Home Run®), and ‘Belinda’s Dream’ had deteriorated so badly that they were removed from the trial. Consequently, these cultivars are not recommended as low maintenance, own-root shrub roses for central Florida. ‘Old Blush’ and ‘Mutabilis’ remain and continue to grow and bloom. Both have the reputation of being reliable, low-maintenance roses in Florida and it is possible their poor performance was due to either the initial low quality of the plants (in the case of ‘Old Blush’) or the effects of chilli thrips– a new pest for Florida (in the case of ‘Mutabilis’). Both cultivars will be evaluated for another year along with the remaining cultivars and five additional ones. Various rose cultivars designated as Earth-Kind® due to their outstanding performance in Texas showed poor performance and were not reliable under low maintenance in central Florida.

It is worth noting that the cultivars studied have different growth habits and, like all plants, should be selected according to their placement and purpose in the garden. ‘RADrazz’ (Knock Out®) and ‘Duchesse de Brabant’ formed more upright, medium-sized bushes whereas plants of ‘Spice’ were more compact and shorter. In contrast, ‘Mrs. B. R. Cant’ formed large, sprawling bushes more typical of Tea roses. Since all cultivars were planted on their own roots, it is also important to mention that they may grow larger and perform better if grafted onto *R. fortuniana* rootstock.

APPENDIX A
SYMPTOMS OF BLACK SPOT, CERCOSPORA LEAF SPOT AND CHILLI THRIPS DAMAGE ON ROSE CULTIVARS

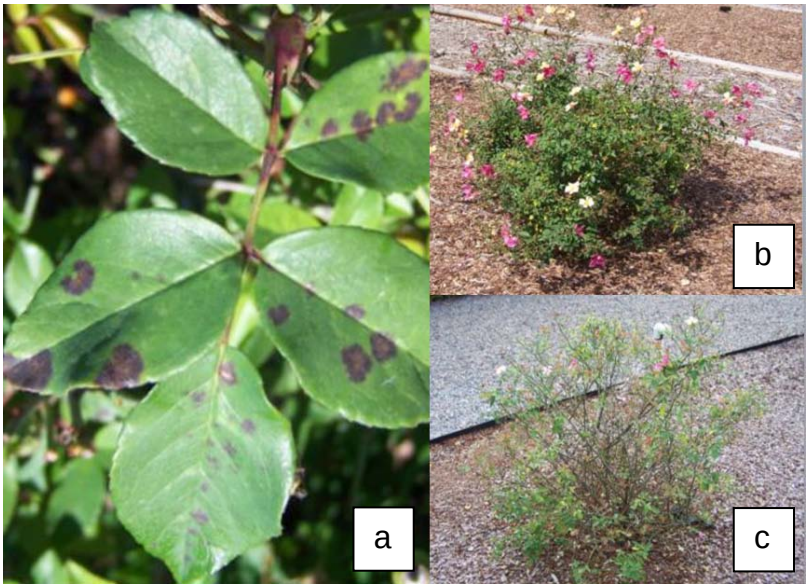


Figure A-1. Typical symptoms of black spot (*Diplocarpon rosae*) on a rose leaf (a) and a plant of the cultivar 'Mutabilis' showing healthy leaves (b) and severe defoliation (c).

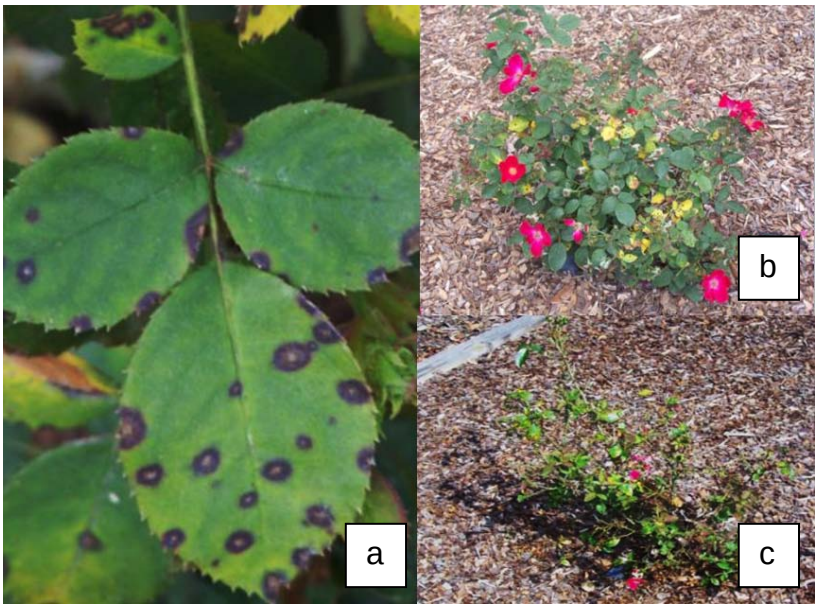
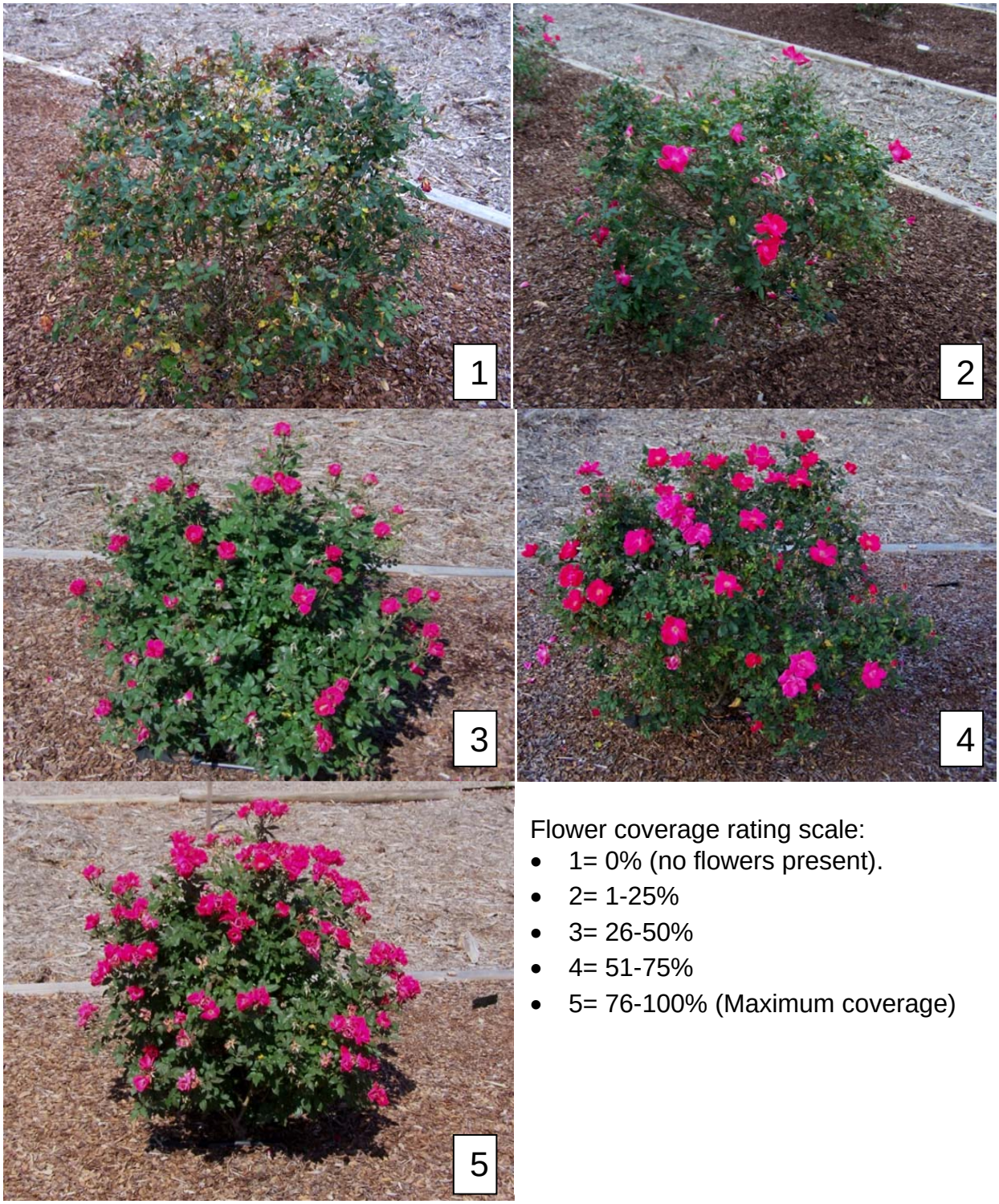


Figure A-2. Typical symptoms of Cercospora leaf spot (*Cercospora rosicola*) on a rose leaf (a) and a plant of the cultivar 'WEKcisbako' (Home Run®) showing early infection (b) and severe defoliation (c).

Figure A-3. Foliar damage caused by chilli thrips (*Schirtothrips dorsalis*) on rose leaves

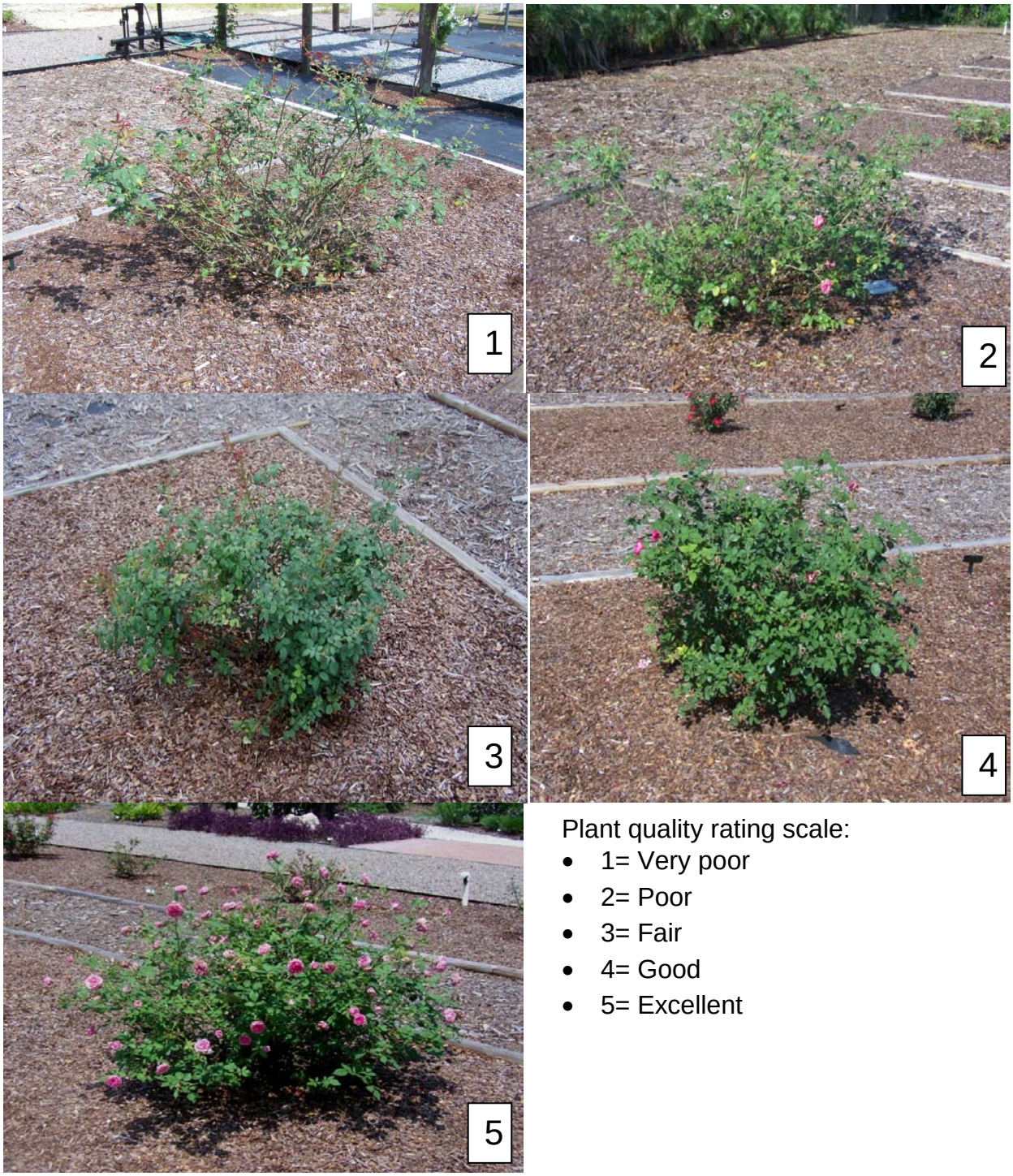
APPENDIX B
EVALUATION RATINGS FOR PLANT QUALITY AND FLOWER COVERAGE



Flower coverage rating scale:

- 1= 0% (no flowers present).
- 2= 1-25%
- 3= 26-50%
- 4= 51-75%
- 5= 76-100% (Maximum coverage)

Figure B-1. Rating scale used to quantify flower coverage. Cultivar 'RADrazz' (Knock Out®) used as example



Plant quality rating scale:

- 1= Very poor
- 2= Poor
- 3= Fair
- 4= Good
- 5= Excellent

Figure B-2. Rating scale used to quantify plant quality. Cultivar ‘Mrs. B. R. Cant’ used as example

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BIOGRAPHICAL SKETCH

Jozer A. Mangandi is originally from San Salvador, El Salvador. He became interested in agriculture since early years obtaining a specialization in agriculture in high school. He moved to Honduras in 2001 were he obtained a bachelor's degree in Agricultural Science and Production at the Pan-American School of Agriculture, "Zamorano" in 2005. He evaluated the incidence of the disease Lethal Yellowing of Coconut palms on replanted populations in Honduras. In 2006 he moved to Florida to work as an intern at the Gulf Coast Research and Education Center (Wimauma, Fl). As an assistant in the plant pathology lab, he was involved in the isolation and identification of pathogens in the diagnostic clinic. He also assisted in laboratory and field experiments for control of diseases on strawberries.

In 2008, he started a master's program under the guidance of Dr. Sydney Park Brown. He worked at University of Florida's-Plant City campus as a research student evaluating rose cultivars under low maintenance conditions.