Performance of Garden Roses in North-central Texas under Minimal Input Conditions

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Summary. **One hundred sixteen rose (*Rosa* spp.) cultivars were evaluated under minimal input conditions in north-central Texas for 3 years. Plant quality data included overall plant performance, number of flowers, percentage of bloom coverage, final vigor, and survival. Disease ratings for black spot (*Diplocarpon rosae*), petal blight (*Alternaria alternata*), powdery mildew (*Sphaerotheca pannosa*), and aphid (*Myzus* spp.) infestations were previously reported. Of the original 116 cultivars, 25 had 50% or higher mortality during the trial. Own-root cultivars performed significantly better than the grafted cultivars and had significantly better survival ($P = 0.001$). As a class, the Polyantha cultivars exhibited the best overall performance, mean bloom percentage, final vigor and survival, while cultivars in the Hybrid Tea class had the worst performance in all measures. Foliar nutrient content, bloom number, and mean percentage of bloom were not good predictors of overall performance. Of the diseases monitored, black spot was the most severe and was closely correlated to overall performance and final vigor, but was not the only factor determining overall performance. The top five cultivars in mean overall performance were RADrazz (Knock Out™), Caldwell Pink, Sea Foam, Perle d'Or, and The Fairy, in descending order.**

Roses are among the most popular garden ornamentals in temperate and subtropical zones, but they have a reputation of being very difficult to grow (Manners, 1999). Roses have long been an important landscape plant and there is growing interest in low-maintenance roses that do not require heavy pruning or spraying (Anella et al., 2004). One of the challenges in growing roses is the severe incidence of black spot, which is considered to be the most damaging rose disease in the southern United States (Hagan et al., 2005). However, many of today's gardeners are increasingly sensitive to environmental concerns and are very reluctant to carry out the frequent pesticide applications required during a normal year for most Hybrid Teas in the southern United States. They are also uneasy about the rigorous pruning and regular irrigation required by Hybrid Teas. One of the best ways to avoid the need for pesticides and to minimize other inputs such as labor and water is through the selection of cultivars that will perform well under minimal input conditions. Through cultivar selection, it is possible to reduce or even eliminate the need for fungicidal sprays (Manners, 1999). Other researchers feel that modern shrub roses hold the promise of being better plants for today's landscapes and they identified cultivars best suited for the northern midwestern United States. (Hawke, 1997; Jull, 2004).

The objective of this study was to evaluate the most highly recommended roses, from antique and old garden roses to the very newest shrub roses, and to identify those cultivars that would provide outstanding landscape performance in the southern United States with no fertilizer, pesticides, deadheading or pruning, and with greatly reduced supplemental irrigation, in addition to tolerating poorly aerated, alkaline clay soils, heat, drought, high temperatures, high humidity, rapid changes in temperature, disease (especially black spot), insect, and mite (*Acarina* spp.) pressure.

Materials and methods

Four plants each of 116 rose cultivars were obtained from commercial nurseries and were established in Fall 1998 in replicated field plots at the Texas A&M Research and Extension Center at Dallas. The selection of cultivars included in the study was based on recommendations from experienced rosarians, nursery professionals, and rose enthusiasts for the best rose cultivars in each class. Plant spacing was 5 ft within the rows and 10 ft between the rows. The soil in the plots (described in Table 1), left unamended, was an Austin silty clay (fine-silty, carbonatic, thermic, Udorthentic Haplustoll; Hipp et al., 1992) calcareous in nature with a pH of ≈7.8. The roses were mulched with ≈8 cm of uncomposted shredded hardwood with additional applications made each year to maintain the mulch layer. The plants were irrigated as needed, with a drip irrigation system, in the first 2 years, but received no supplemental irrigation during the remainder of the study. There were no inputs of fertilizer or pesticides during the study.

Twice monthly data collection began in Spring 2000 and continued through 2002, with data collected from April through October each year. Data consisted of flower number, flower size, a visual estimate of flowering percentage, plant vigor, and overall plant performance. Plant performance was determined using a criterion-referenced scale from 1 to 10 with three indices. The three indices were 1) flower quantity and quality; 2) foliage quantity and quality; and 3) plant habit and vigor. The scale

Units

To convert U.S. to SI, multiply by	U.S unit	SI unit	To convert SI to U.S., multiply by
0.3048	ft	m	3.2808
2.54	inch(es)	cm	0.3937
25.4	inch(es)	mm	0.0394
1	mmho/cm	$dS \cdot m^{-1}$	1
0.001	ppm	$g \cdot kg^{-1}$	1000
1	ppm	$mg \cdot kg^{-1}$	1
(°F – 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

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Table 1. Basic soil fertility analysis of the Austin silty clay soil in the rose cultivar evaluation plots.

Parameter	Units[z]	Mean[y]	SD[x]	Sufficiency level[w]
pH		7.85	0.11	Mildly alkaline
EC	$dS \cdot m^{-1}$	850	85	Slight
Nitrate-N	$mg \cdot kg^{-1}$	7.5	0.9	Very low
Phosphorous	$mg \cdot kg^{-1}$	112	27	Very high
Potassium	$mg \cdot kg^{-1}$	946	67	Very high
Calcium	$mg \cdot kg^{-1}$	64,179	15,228	Very high
Magnesium	$mg \cdot kg^{-1}$	475	38	High
Zinc	$mg \cdot kg^{-1}$	2.12	0.53	High
Iron	$mg \cdot kg^{-1}$	34.9	2.23	High
Manganese	$mg \cdot kg^{-1}$	40.0	4.9	High
Cooper	$mg \cdot kg^{-1}$	1.14	0.04	High
Sodium	$mg \cdot kg^{-1}$	244	27	Low
Sulfur	$mg \cdot kg^{-1}$	56	7	High

[z]1 $dS \cdot m^{-1}$ = 1 mmho/cm, 1 $mg \cdot kg^{-1}$ = 1 ppm.
[y]Each value is the mean of four composite soil samples collected from each field replication (n = 16).
[x]Standard deviation of the mean (n = 4).
[w]Based on Texas Cooperative Extension soil test recommendations.

was as follows: 10 = no deductions for all three indices; 9 = slight deduction for one index; 8 = slight deduction for two indices; 7 = slight deduction for three indices or moderate deduction for one index; 6 = moderate deduction for one index and slight deduction for one index; 5 = moderate deductions for one index and slight deductions for two indices; 4 = moderate deductions for two indices; 3 = severe deductions for one index and moderate deduction for one index; 2 = severe deductions for two indices; 1 = severe deductions for three indices. In addition, a final plant vigor rating was taken at the end of 2003 based on a 1 to 10 scale using the indices of foliage quality and quantity and plant vigor and habit.

In Spring 2003, a subset of rose cultivars was randomly chosen from both the grafted and own-root groups for nutrient analysis. Newly expanded tissue was collected from three locations on each of 33 rose cultivars. At the same time, four composite soil samples were collected from the study area (one composite sample per block). The soil samples were analyzed for pH, salinity, soluble nitrate, and plant-available macro- and micronutrients. Rose leaf tissues were dried at 60 °C and ground to pass a 1-mm sieve. The tissue was analyzed for total nitrogen by using a Kjeldahl digestion followed by steam distillation and titration procedures. Total phosphorus was determined by a colorimetric (ascorbic acid-ammonium molybdate) method, and potassium and iron were determined by atomic absorption spectrometry. The Standard Reference Material Citrus Leaves SRM-1572 (National Institute of Standards and Technology, Gaithersburg, MD) was included in laboratory analyses to ensure accuracy of the results. The overall rank for each rose cultivar was calculated by averaging the four individual nutrient rankings.

The overall rose plant nutrient status was assessed with measurements of relative leaf chlorophyll levels. These measurements, done on a monthly basis in recently matured tissue [leaves in upper portion of current shoots; 20 readings per plant (two readings per leaf); four plants per cultivar], were taken with a SPAD-502 Chlorophyll Meter (Minolta Camera Co., Osaka, Japan).

Disease ratings for petal blight, powdery mildew, and black spot infection occurring by natural inoculation were collected monthly and previously reported (Colbaugh et al., 2005a, 2005b, 2005c). The plants were rated monthly from April through August in 2000 and 2001. The scales each were as follows: 1) petal blight scale 0 to 3, where 0 = no petal blight, 1 = slight petal spots, 2 = moderate number of petal spots, and 3 = severe petal blight symptoms, 2) powdery mildew scale 0 to 3, where 0 = no powdery mildew and 3 = severe powdery mildew, and 3) black spot scale 0 to 5, where 0 = no black spot, 1 = slight defoliation, 2 = minor defoliation, 3 = moderate defoliation, 4 = severe defoliation, and 5 = complete defoliation.

The experimental design was a randomized complete block with one plant per cultivar per replication with four replications. Only cultivars with three or more surviving plants (replications) were included in the statistical analysis. The own-root cultivars and grafted cultivars were analyzed separately. A significance level of $P \leq 0.05$ was maintained for all analyses within the study. The Kolmogorov-Smirnov test was used to determine that the data were normally distributed ($P = 0.001$). The statistical analyses for grafted versus own-root, and cultivars by class, were performed as a one-way analysis of variance [ANOVA (SAS Institute, Cary NC)]. Correlation analyses (PROC CORR) were also performed for the leaf nutrient concentrations and chlorophyll (SPAD) readings (SAS Institute). Rose cultivar names and horticultural classes are reported according to the standards and descriptions of the American Rose Society as the Official International Registration Authority for Roses (Cairns et al., 2000).

Results and discussion

The results of the mean overall performance, mean percentage of bloom coverage, and final vigor ratings of the 91 cultivars that had plants surviving in at least three of the four replications at the end of the 4-year study are contained in Table 2 (64 own-root cultivars) and Table 3 (27 grafted cultivars). Cultivars were significantly different for all measurements within both groups ($P = 0.01$). Observed survival percentages are similar to other studies in which not all of the cultivars survived (Hawke, 1997; Jull, 2004). As a group, own-root had significantly better mean overall appearance ratings than the grafted cultivars ($P = 0.001$). Of the cultivars not included in the analysis, no plants of Dorothe®, Iceberg (KORbin), Pascali®, Seguin, and Sunbright® survived to the end of the study. Cultivars in which three of the four replicate plants died were Angel Face, First Prize, Gold Glow, Maman Cochet, Raspberry Twist, and Sun Flare (JACjem). The following cultivars had plants that died in two of the replications: Consuelo, Crimson Glory, Fragrant Cloud,

Table 2. Performance of own-root rose cultivars evaluated over 3 years under minimal input conditions in north-central Texas.

Cultivar	Class[z]	Mean bloom [±SE (%)]	Mean overall rating [±SE (1–10 scale)][y]	Final vigor rating [±SE (1–10 scale)][x]	Survival (%)
Archduke Charles	Ch	5.3 ± 0.7	3.6 ± 0.2	4.3 ± 0.6	100
Arethusa	Ch	7.3 ± 0.7	5.3 ± 0.1	8.1 ± 0.7	100
Baronne Prevost	HP	3.8 ± 0.5	3.2 ± 0.1	2.9 ± 0.5	100
Baty's Pink Pillar	LCl	2.2 ± 0.5	5.2 ± 0.1	6.3 ± 1.2	100
Belinda	HMsk	8.8 ± 1.2	4.1 ± 0.2	2.8 ± 1.1	75
Belinda's Dream	S	10.0 ± 1.0	4.9 ± 0.1	6.1 ± 1.4	100
Blush Noisette	N	15.7 ± 1.3	5.7 ± 0.1	6.0 ± 1.0	100
Bon Silene	T	4.7 ± 0.5	5.2 ± 0.1	8.9 ± 0.3	100
Buff Beauty	HMsk	4.7 ± 0.6	4.4 ± 0.1	5.6 ± 0.9	100
Cadenza	LCl	14.6 ± 1.3	4.7 ± 0.1	4.7 ± 0.2	100
Caldwell Pink	Fo	17.9 ± 1.5	6.7 ± 0.1	7.6 ± 0.2	100
Carefree Beauty™ (BUCbi)	S	9.7 ± 1.7	6.1 ± 0.1	7.8 ± 0.8	100
Cecile Brunner	Pol	17.2 ± 1.0	6.0 ± 0.1	7.5 ± 0.4	100
Celine Forestier	N	4.1 ± 0.4	3.4 ± 0.1	2.8 ± 0.3	100
Clotilde Soupert	Pol	8.1 ± 1.0	4.5 ± 0.2	7.0 ± 2.4	75
Comtesse du Cayla	Ch	4.7 ± 0.6	4.7 ± 0.2	6.1 ± 2.1	75
Cramoisi Superieur	Ch	5.7 ± 0.7	4.9 ± 0.1	4.9 ± 0.2	100
Dortmund	H Kor	10.1 ± 1.6	4.4 ± 0.2	4.9 ± 0.9	100
Ducher	LCh	4.0 ± 0.6	4.7 ± 0.3	6.8 ± 2.3	75
Duchesse de Brabant	T	10.1 ± 0.9	5.1 ± 0.1	7.7 ± 0.9	100
Else Poulsen	F	20.4 ± 1.4	5.4 ± 0.1	5.8 ± 0.7	100
Gartendirektor Otto Linne	S	20.2 ± 1.3	5.5 ± 0.1	4.6 ± 0.2	100
Georgetown Tea	T	4.3 ± 0.4	5.1 ± 0.1	8.8 ± 0.4	100
Heritage® (AUSblush)	S	4.5 ± 0.6	4.4 ± 0.1	3.7 ± 0.4	100
Hermosa	Ch	5.6 ± 0.7	3.9 ± 0.1	3.9 ± 0.2	100
Isabella Sprunt	T	3.5 ± 0.4	3.8 ± 0.2	5.8 ± 1.9	75
Jaune Desprez	N	2.6 ± 0.4	3.9 ± 0.2	6.1 ± 2.0	75
Knock Out™ (RADrazz)	S	19.6 ± 1.9	7.5 ± 0.1	9.2 ± 0.1	100
Kronprincessin Viktoria	B	4.9 ± 0.8	3.3 ± 0.2	3.1 ± 1.1	75
La France	HT	3.0 ± 0.5	3.3 ± 0.1	3.4 ± 0.9	100
Lafter	HT	2.5 ± 0.5	5.4 ± 0.1	8.4 ± 0.4	100
La Marne	Pol	23.0 ± 1.8	5.6 ± 0.1	8.2 ± 0.3	100
Lamarque	N	9.6 ± 0.1	4.4 ± 0.1	6.4 ± 1.0	100
Lindee	Fo	9.7 ± 1.0	4.0 ± 0.1	4.8 ± 1.2	100
Louis Philippe	Ch	8.6 ± 0.8	4.9 ± 0.1	6.3 ± 0.6	100
Madame Alfred Carriere	N	7.0 ± 0.9	4.8 ± 0.1	6.1 ± 0.8	100
Madame Antoine Mari	T	6.3 ± 0.9	4.3 ± 0.2	6.4 ± 2.2	75
Madame Joseph Schwartz	T	5.2 ± 0.8	4.0 ± 0.2	4.2 ± 1.8	75
Maggie	Fo	9.8 ± 1.0	4.3 ± 0.1	6.0 ± 0.8	100
Marchesa Boccella	HP	5.5 ± 0.6	4.4 ± 0.1	3.7 ± 0.4	100
Maréchal Niel	N	1.0 ± 0.2	3.0 ± 0.2	3.5 ± 1.2	75
Marie Daly	Pol	10.5 ± 1.0	5.2 ± 0.1	5.6 ± 1.2	100
Monsieur Tillier	T	10.5 ± 1.1	6.1 ± 0.1	9.0 ± 0.2	100
Mrs. Dudley Cross	T	4.0 ± 0.6	3.7 ± 0.2	6.6 ± 2.2	75
Mutabilis	Ch	15.0 ± 1.0	6.2 ± 0.1	8.3 ± 0.5	100
Nearly Wild	F	11.7 ± 1.4	4.3 ± 0.2	4.0 ± 0.7	100
New Dawn	LCl	5.6 ± 1.3	6.2 ± 0.1	8.6 ± 0.6	100
Old Blush	Ch	8.0 ± 1.3	3.7 ± 0.2	4.1 ± 2.3	75
Paul Neyron	HP	3.3 ± 0.5	3.1 ± 0.1	3.3 ± 0.4	100
Perle d'Or	Pol	18.1 ± 1.4	6.6 ± 0.1	9.4 ± 0.1	100
Pinkie, Climbing	Pol	18.5 ± 1.7	5.9 ± 0.1	8.4 ± 0.3	100
Puerto Rico	Fo	6.1 ± 0.6	4.5 ± 0.1	6.3 ± 0.7	100
Red Cascade	Cl Min	12.4 ± 1.6	5.7 ± 0.1	6.3 ± 1.3	100
Reve d'Or	N	4.7 ± 0.5	5.8 ± 0.1	9.5 ± 0.2	100
Sarah Van Fleet	HRg	6.4 ± 0.7	5.3 ± 0.1	4.9 ± 0.4	100
Sea Foam	S	18.9 ± 1.5	6.6 ± 0.1	7.6 ± 0.7	100

(*Continued on next page*)

Table 2. (*Continued*) Performance of own-root rose cultivars evaluated over 3 years under minimal input conditions in north-central Texas.

Cultivar	Class[z]	Mean bloom [±SE (%)]	Mean overall rating [±SE (1–10 scale)][y]	Final vigor rating [±SE (1–10 scale)][x]	Survival (%)
Sir Thomas Lipton	HRg	5.0 ± 0.6	5.9 ± 0.1	6.3 ± 0.9	100
Sombreuil	Cl T	2.6 ± 0.6	3.6 ± 0.1	3.9 ± 0.3	100
Souvenir de St. Anne's	B	7.3 ± 0.7	4.8 ± 0.1	7.2 ± 1.1	100
Spice	Fo	11.9 ± 0.9	6.2 ± 0.1	9.0 ± 0.2	100
The Fairy	Pol	23.5 ± 1.7	6.5 ± 0.1	7.5 ± 0.7	100
Trumpeter® (MACtrum)	F	9.7 ± 1.2	2.9 ± 0.2	1.6 ± 0.6	100
Westerland® (KORlawe)	S	2.5 ± 0.5	3.0 ± 0.2	2.4 ± 0.5	100
Zephirine Drouhin	B	5.5 ± 0.9	4.7 ± 0.1	4.1 ± 0.3	100

[z]B = Bourbon, Ch = China, Cl Min = Climbing Miniature, Cl T = Climbing Tea, F = Floribunda, Fo = Found, Hkor = Hybrid Kordesii, HMsk = Hybrid Musk, HP = Hybrid Perpetual, HRg = Hybrid Rugosa, HT = Hybrid Tea, LCl = Large-flowered Climber, N = Noisette, Pol = Polyantha, S = Shrub, T = Tea.
[y]Criterion-referenced scale from 1 to 10 with three indices (flower quantity and quality, foliage quantity and quality, and plant habit and vigor): 10 = no deductions for all three indices, 9 = slight deduction for one index, 8 = slight deduction for two indices, 7 = slight deduction for three indices or moderate deduction for one index, 6 = moderate deduction for one index and slight deduction for one index, 5 = moderate deductions for one index and slight deductions for two indices, 4 = moderate deductions for two indices, 3 = severe deductions for one index and moderate deduction for one index, 2 = severe deductions for two indices, 1 = severe deductions for three indices.
[x]Criterion-referenced scale from 1 to 10 using the indices of foliage quality and quantity and plant vigor and habit.

Table 3. Performance of 27 grafted rose cultivars evaluated over 3 years under minimal input conditions in north-central Texas.

Cultivar	Class[z]	Mean bloom [±SE (%)]	Mean overall rating [±SE (1–10 scale)] [y]	Final vigor rating [±SE (1–10 scale)][x]	Survival (%)
American Beauty	HP	0.5 ± 0.1	2.9 ± 0.1	3.3 ± 0.2	100
Blaze	LCl	8.5 ± 1.4	2.1 ± 0.2	1.6 ± 1.0	75
Bonica®	F	4.9 ± 1.2	2.3 ± 0.2	1.6 ± 0.6	100
Chrysler Imperial	HT	2.8 ± 0.5	3.3 ± 0.1	3.2 ± 0.4	100
Dame de Cour	HT	6.0 ± 0.9	2.6 ± 0.2	2.6 ± 0.9	75
Don Juan	LCl	5.2 ± 0.7	2.5 ± 0.1	2.0 ± 0.5	100
Double Delight™ (ANDeli)	HT	2.3 ± 0.5	1.5 ± 0.1	1.0 ± 0.3	100
Easy Going™ (HARflow)	F	7.0 ± 0.9	3.4 ± 0.2	1.4 ± 0.8	75
Europeana®	F	8.6 ± 1.3	3.0 ± 0.2	1.1 ± 0.5	75
Eutin	F	12.1 ± 1.3	3.6 ± 0.1	3.3 ± 0.3	100
Fragrant Cloud	HT	2.4 ± 0.5	2.2 ± 0.1	1.1 ± 0.9	50
Gene Boerner	F	12.2 ± 1.1	3.6 ± 0.1	3.5 ± 0.2	100
Gold Medal® (AROyqueli)	Gr	4.4 ± 0.7	2.4 ± 0.1	1.4 ± 0.7	100
Graham Thomas® (AUSmas)	S	5.2 ± 0.5	4.3 ± 0.1	4.1 ± 0.1	100
Granada	HT	5.5 ± 1.0	2.9 ± 0.2	1.4 ± 1.0	75
Iceberg (climbing)	Cl F	4.5 ± 0.8	3.4 ± 0.2	2.9 ± 1.0	75
Livin' Easy™ (HARwelcome)	F	11.7 ± 1.1	4.4 ± 0.2	1.1 ± 0.3	75
Margaret Merril® (HARkuly)	F	3.0 ± 0.6	2.7 ± 0.2	1.9 ± 1.0	100
Mister Lincoln	HT	0.8 ± 0.3	1.5 ± 0.1	0.5 ± 0.4	75
Oklahoma	HT	2.9 ± 0.5	2.3 ± 0.1	1.2 ± 0.4	75
Queen Elizabeth	Gr	3.4 ± 0.6	2.2 ± 0.1	1.9 ± 0.8	75
Radiance	HT	2.4 ± 0.4	3.5 ± 0.1	3.7 ± 0.3	100
Red Radiance	HT	4.6 ± 0.6	4.5 ± 0.5	4.7 ± 0.5	100
Red Ribbons (KORtemma)	S	16.3 ± 1.6	5.1 ± 0.2	4.6 ± 0.7	100
Showbiz (TANweieke)	F	4.9 ± 1.1	1.7 ± 0.1	0.6 ± 0.4	75
Tournament of Roses (JACient)	Gr	6.5 ± 1.0	2.7 ± 0.1	2.6 ± 1.2	75
Tropicana (TANorstar)	HT	5.6 ± 0.7	2.7 ± 0.1	2.8 ± 0.5	100

[z]Cl F = Climbing Floribunda, F = Floribunda, Gr = Grandiflora, HP = Hybrid Perpetual, HT = Hybrid Tea, LCl = Large-flowered Climber, S = Shrub.
[y]Criterion-referenced scale from 1 to 10 with three indices (flower quantity and quality, foliage quantity and quality, and plant habit and vigor): 10 = no deductions for all three indices, 9 = slight deduction for one index, 8 = slight deduction for two indices, 7 = slight deduction for three indices or moderate deduction for one index, 6 = moderate deduction for one index and slight deduction for one index, 5 = moderate deductions for one index and slight deductions for two indices, 4 = moderate deductions for two indices, 3 = severe deductions for one index and moderate deduction for one index, 2 = severe deductions for two indices, 1 = severe deductions for three indices.
[x]Criterion-referenced scale from 1 to 10 using the indices of foliage quality and quantity and plant vigor and habit.

Francis Dubreuil, Gruss an Aachen, Madame Gregory, Mrs. B.R. Cant, Natchitoches Noisette, Pam's Pink, Peace, Perle des Jardins, Safrano, Souvenir de la Malmaison, Sunsprite (KORresia), and Valentine. Of the cultivars in which plants died in two or more of the replications, 10 were on their own roots and 16 were grafted. Manners (1999) reported that only a few own-root rose cultivars performed well in the sandy soils of central Florida, but, similar to our findings, recommended own-root roses for the clay soils of northern

Florida. A comparison of grafted-to-own-root cultivars indicates that the own-root cultivars had significantly ($P = 0.001$) better mean overall performance and survival percentage than the grafted cultivars under the minimal input conditions of the study. However, these results need to be further examined using grafted and own-root plants of the same cultivars to determine whether this is an artifact of the cultivars in the study or if the rootstock(s) was not suited to the soil or care conditions of the study.

To identify the major factors determining field performance of the 64 own-root cultivars, the top and bottom five cultivars were further analyzed and combined with data from previously published papers (Colbaugh et al., 2005a, 2005b, 2005c). 'RADrazz' (Knock Out™) was the best-performing cultivar with a mean overall rating of 7.48, whereas Trumpeter® was the worst-performing rose overall with a mean overall rating of 2.92 (Table 4). Hagan et al. (2005) reported that 'RADrazz' did not appear to be seriously damaged by black spot, which is confirmed by this study. When comparing the results of the overall bloom coverage, 'The Fairy' was the top performing cultivar. 'RADrazz', which was rated as the best overall in appearance, was not the cultivar with the greatest mean coverage of blooms. However, we did note a predominance of the cultivars that rated high in one category also rated similarly high in the second category. In the case of 'RADrazz', its vigorous growth and attractive foliage contributed to its high overall rating. The discrepancy of these two distributions indicates that appearance of a landscape shrub is not simply limited to coverage of bloom. Fifteen of the cultivars that performed well in this study are recommended as low-maintenance cultivars for Florida gardens (Manners, 1999).

Leaf chlorophyll content and nutrient status in the foliage as determined by tissue analysis and SPAD readings were not good indicators of mean overall performance. Nitrogen (2.1–8.2 g kg^{-1}) and phosphorus (1.5–2.4 g kg^{-1}) content did not

Table 4. Performance and disease ratings of the top and bottom five own-root rose cultivars evaluated over 3 years under minimal input conditions in north-central Texas.

Cultivar	Mean overall rating [±SE (1–10 scale)][z]	Final vigor rating [±SE (1–10 scale)][y]	Black spot (0–5 scale)[x]	Powdery mildew (0–3 scale)[w]	Alternaria petal blight (0–3 scale)[v]
Knock Out™ (RADrazz)	7.5 ± 0.1	9.2 ± 0.1	0.23	0	0.05
Caldwell Pink	6.7 ± 0.1	7.6 ± 0.2	0.51	0	0
Sea Foam	6.6 ± 0.1	7.6 ± 0.7	0.46	0	0.14
Perle d'Or	6.6 ± 0.1	9.4 ± 0.1	0.93	0	0
The Fairy	6.5 ± 0.1	7.5 ± 0.7	0.68	0	0.09
Baronne Prevost	3.2 ± 0.1	2.9 ± 0.5	3.55	0	0.07
Paul Neyron	3.1 ± 0.1	3.3 ± 0.4	3.61	0.05	0.12
Maréchal Niel	3.0 ± 0.2	3.5 ± 1.2	1.13	0	0.04
Westerland® (KORlawe)	3.0 ± 0.2	2.4 ± 0.5	1.84	0	0
Trumpeter® (MACtrum)	2.9 ± 0.2	1.6 ± 0.6	1.75	0	0.08

[z]Criterion-referenced scale from 1 to 10 with three indices (flower quantity and quality, foliage quantity and quality, and plant habit and vigor): 10 = no deductions for all three indices, 9 = slight deduction for one index, 8 = slight deduction for two indices, 7 = slight deduction for three indices or moderate deduction for one index, 6 = moderate deduction for one index and slight deduction for one index, 5 = moderate deductions for one index and slight deductions for two indices, 4 = moderate deductions for two indices, 3 = severe deductions for one index and moderate deduction for one index, 2 = severe deductions for two indices, 1 = severe deductions for three indices.
[y]Criterion-referenced scale from 1 to 10 using the indices of foliage quality and quantity and plant vigor and habit.
[x]0 = no black spot, 1 = slight defoliation, 2 = minor defoliation, 3 = moderate defoliation, 4 = severe defoliation, and 5 = complete defoliation.
[w]0 = no powdery mildew and 3 = severe powdery mildew.
[v]0 = no petal blight, 1 = slight petal spots, 2 = moderate number of petal spots, and 3 = severe petal blight symptoms.

Table 5. Comparison of the performance of eight rose cultivar classes evaluated over 3 years under minimal input conditions in north-central Texas.

Rose type	Cultivars within class (no.)	Mean overall rating [±SE (1–10 scale)] [z]	Mean Bloom [±SE (%)]	Final vigor rating [±SE (1–10 scale)] [y]	Survival [±SE (%)]
Polyantha	7	5.8 ± 0.3	17.0 ± 2.2	7.7 ± 0.5	96.4 ± 3.6
Shrub	10	4.8 ± 0.6	10.7 ± 2.4	5.0 ± 0.9	87.5 ± 8.5
China	10	4.5 ± 0.3	6.7 ± 1.1	5.5 ± 0.7	87.5 ± 5.6
Noisette	8	4.3 ± 0.4	6.3 ± 1.6	5.4 ± 0.8	87.5 ± 6.7
Found	7	4.2 ± 0.7	8.4 ± 2.2	5.0 ± 1.2	78.6 ± 14.9
Climber	5	4.1 ± 0.8	7.2 ± 2.1	4.7 ± 1.3	95.0 ± 5.0
Tea	14	3.7 ± 0.4	4.2 ± 0.8	5.5 ± 0.8	73.2 ± 6.7
Floribunda	19	2.9 ± 0.3	7.2 ± 1.1	1.9 ± 0.4	72.4 ± 7.1
Hybrid Tea	19	2.4 ± 0.3	2.7 ± 0.4	1.9 ± 0.5	63.2 ± 8.6

[z]Criterion-referenced scale from 1 to 10 with three indices (flower quantity and quality, foliage quantity and quality, and plant habit and vigor): 10 = no deductions for all three indices, 9 = slight deduction for one index, 8 = slight deduction for two indices, 7 = slight deduction for three indices or moderate deduction for one index, 6 = moderate deduction for one index and slight deduction for one index, 5 = moderate deductions for one index and slight deductions for two indices, 4 = moderate deductions for two indices, 3 = severe deductions for one index and moderate deduction for one index, 2 = severe deductions for two indices, 1 = severe deductions for three indices.
[y]Criterion-referenced scale from 1 to 10 using the indices of foliage quality and quantity and plant vigor and habit.

correlate with leaf chlorophyll SPAD readings, whereas potassium (7.8–15.4 g kg^{-1}) and iron (13.6–62.1 mg kg^{-1}) concentrations were correlated with leaf chlorophyll SPAD readings (r^2 = 0.378, P = 0.004 and r^2 = 0.380, P = 0.004, respectively). Nitrogen and potassium content were low compared with the levels reported for garden roses and landscape woody plants (Cabrera 2002, 2003; Peters and Knauss, 1984). The content of phosphorus (P) in the leaf tissue confirmed the inherently high soil P sufficiency levels of the soil at the study site (Table 1). The soil analysis also indicated high levels of iron (Table 1), but given their calcareous nature, Austin silty-clay soils are known for their limitations to supply adequate plant available iron (Hipp et al., 1992). This was confirmed by the low iron content in the rose leaf tissues.

Within the top five cultivars, other factors are equally if not more important in determining overall performance (Table 4). Similarly, although very important, final vigor rating alone does not fully reflect the overall performance for the top or bottom five performing cultivars. Several authors have reported that black spot was the most significant rose disease, whereas powdery mildew had much less impact (Hagan et al., 2005; Hawke, 1997; Manners, 1999). Thus, an analysis combining mean overall performance with the disease ratings for the top and bottom five cultivars shows a good correlation between the mean overall performance and black spot susceptibility. In our trials, powdery mildew and petal blight, although disfiguring nuisances, did not impact the overall survival, performance, or bloom of the plants.

The results of the analysis of cultivars by class are listed in Table 5. Similar to the recommendations by Manners (1999), there were clear differences among classes with the Polyantha, Shrub, China, Noisette, Found, Climbers, and Tea classes superior to the Floribunda and Hybrid Tea classes in mean overall performance. The mean overall performance of the Polyantha cultivars was twice that of the Hybrid Tea cultivars. Polyanthas were the best in overall performance, mean percentage of bloom, final vigor, and survival, whereas Hybrid Teas were the worst in all categories. As noted previously, mean percentage of bloom was not a good predictor of overall performance (value) when comparing roses by class. For example, the Floribunda cultivars ranked fourth in mean percentage of bloom, but were next to last in all the other categories. Manners (1999) reported that Tea roses are usually highly resistant to black spot and powdery mildew and are well adapted to high temperatures, humidity, and rain. Found rose cultivars ranked in the middle for mean overall performance, final vigor, and percentage of survival. In conclusion, although some classes as a whole performed better than others, there were good individual cultivars identified even in mediocre or poor classes (for example 'Else Poulson', which is a Floribunda). Based on the results of this study, cultivars were selected for inclusion in an expanded statewide study to develop the EarthKind™ collection of roses.

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