Evaluating landscape rose performance on reduced irrigation

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Abstract

Water conservation has become a critical issue in urban landscapes in summer-dry climate regions where irrigation must be applied to keep plants healthy. Part of the strategy for reducing landscape water use is incorporating plants with low water needs into the design. To implement this, landscape professionals need information on which available plants can perform acceptably in the landscape on low water, but research-based plant water-use information is often unavailable. Since 2005, University of California researchers have performed trials to evaluate in-ground landscape plant performance on four levels of reduced irrigation, including 10 *Rosa hybrida* cultivars between 2009 and 2016: 'Aushouse', 'Gruss an Aachen', 'KORbin', 'KORelamba', 'KORfloci01', 'KORsixkono', 'KORsteimm', 'Meidrifora', 'Meigalpio', and 'Meijocos'. The irrigation treatments were based on levels of reference evapotranspiration (ET_0) at 20, 40, 60, and 80% of ET_0 in a water budget model using data from a nearby weather station in the California Irrigation Management Information System. After one year of establishment irrigation at 100% of ET_0, irrigation treatments were applied during the second year to six plants of each cultivar on each treatment. Data taken monthly were growth measurements and quality ratings of foliage, flowering, pest tolerance, disease resistance, and overall appearance. Statistical analyses using ANOVA and Tukey's HSD showed no significant differences in growth between treatments at $p \leq 0.05$. For several cultivars, some or all quality parameters were higher on one or more levels of irrigation than others. While some cultivars performed best on the 60% ET_0 treatment, most performed acceptably at 40 and 20% of ET_0 as well. These data have been used to make recommendations for grouping plants by water need in the landscape and in facilitating optimization of landscape water applications.

Keywords: water conservation, reference evapotranspiration, water-use efficiency, plant water use, plant trials, urban landscapes, low-water landscapes, hydrozoning

INTRODUCTION

Urban water use is highly regulated in California where there is competition between the agricultural, ecosystem and urban sectors for the increasingly unstable water supply (California Department of Water Resources, 2009). Because there is no significant warm-season rain, planted landscapes must be irrigated to maintain health, aesthetics, and their important ecosystem services. In 2010, a California state regulation, the Model Water Efficient Landscape Ordinance (MWELO), went into effect whereby new urban landscape and landscape renovation plans during the permitting process are required to provide a water use budget that demonstrates total annual gallons necessary to optimally irrigate the specified plants. This total is derived from the area of the landscape and the water needs of the various plants. After 5 years of drought, the regulation was amended to aggressively address shortages by reducing the allowed water budget to an amount that is equal to or less than 45% of reference evapotranspiration (ET_0) for non-residential landscapes and 55% of ET_0 for residential landscapes (California Department of Water Resources, 2015). The

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reference plant for ET_0 is well-watered fescue turfgrass and daily, monthly, and average ET_0 information is provided for 18 distinct ET_0 zones by the California Irrigation Management Information System (CIMIS) through a network of weather stations across the state (http://wwwcimis.water.ca.gov/). The critical piece of information that landscape architects and irrigation managers need then is the percentage of ET_0 necessary to successfully irrigate the different plants in their plan. Plants are then grouped by water needs (hydrozoned) to optimize irrigation regimes, reduce water-waste, and meet their budget goals.

To address the need for plant water use information, the California Center for Urban Horticulture worked with the Department of Water Resources and the University of California, enlisting the help of over 40 regional horticultural experts to create and refine the Water Use Classification of Landscape Species (WUCOLS), an online database with ET_0-based water use guidelines for over 3,500 taxa of plants used in California landscapes. (http://ucanr.edu/sites/WUCOLS/). The state regulation specifies that WUCOLS be used in the water budget calculation, unless another reliable, research-based source of information can be found. Since 2005, researchers at the University of California have performed trials on perennial landscape plants in the UC Landscape Plant Irrigation Trials©, seeking to evaluate performance on levels of irrigation based on ET_0 (Reid and Oki, 2008, 2013; Oki et al., 2016). This information is used to confirm, alter or supplement the WUCOLS guidelines, especially for new cultivars.

Between 2009 and 2016, ten rose cultivars were evaluated in mixed genera trials (Table 1) on four levels of ET_0-based irrigation. Some of these had been in the trade for years, while others were more recent introductions. There is widespread use of landscape roses in the West, and demand is growing, especially with the introduction of cultivars that purportedly need less water and no chemical inputs. These trials sought to determine which of the evaluated cultivars were disease-resistant, pest-tolerant and provided good landscape aesthetics on reduced levels of irrigation, and to determine the lowest level of irrigation that could produce these results.

Table 1. *Rosa hybrida* cultivars evaluated on 4 reduced levels of irrigation from 2009-2016 in the UC Landscape Plant Irrigation Trials©.

Years evaluated	Trade name(s)	Patent name	Breeder	Class
2009-2011	Iceberg	KORbin	Kordes	Floribunda
2011-2013	Gruss an Aachen		Hinner-Geduldig	Floribunda
2013-2015	Cream Veranda	KORfloci01	Kordes	Floribunda
	Kardinal Kolorscape	KORsixkono	Kordes	Floribunda
2014-2016	Harlow Carr	Aushouse	David Austin	Shrub
	Bordeaux	KORelamba	Kordes	Floribunda
	Lone Star	KORsteimm	Kordes	Floribunda
	Coral Drift	Meidrifora	Meilland	Groundcover
	Pink Drift	Meijocos	Meilland	Groundcover
	Red Drift	Meigalpio	Meilland	Groundcover

MATERIALS AND METHODS

Field layout and irrigation method

Planting fields were laid out with 1-m wide rows and 1-m wide paths between rows. Four irrigation lines were provided along each row so irrigation treatments could be randomized throughout the field. Plants within the rows were 2 m apart on center. Twenty-four plants of each cultivar were placed according to a randomized complete block pattern with the field blocked north to south: 3 plants on each of 4 irrigation treatments re-randomized in each of the 2 blocks. Rows were covered with 5-7.5 cm of chipped wood mulch.

Irrigation treatments were provided to each plant by two drip emitters delivering a total ≅15 L h^{-1}. During the first 1-1.5 years in the ground, all plants were irrigated at 100% of ET_0 based on local data reported online by CIMIS. Reduced irrigation treatments were imposed during the second year from May to October using the water budget model (CIMIS, 2017). An equal volume of water was applied at each irrigation equivalent to 43% of the soil's water holding capacity in the root zone (an imaginary cylinder 1 m wide and 0.5 m deep). This is the percentage of plant available water in this field soil type, silty clay loam. The frequency of the irrigation was varied with each treatment percentage of ET_0. The average number of days between irrigation events for each treatment can be found in Table 2. The four treatment levels were 80, 60, 40, and 20% of ET_0, corresponding to high, moderate, moderate-low, and low irrigation levels as described in WUCOLS. All plants were pruned during the winter as follows: shrub roses were cut down to ≅45 cm high; groundcover roses were pruned using electric trimmers to ≅25 cm high and 60 cm wide. Debris was removed from under shrubs and between the rows.

Table 2. Average 2nd-year irrigation frequency from May to October on 4 levels of reduced ET_0-based irrigation in the UC landscape plant irrigation trials©.

Treatment ET_0 percentage	No. of days between irrigation events[1]
80	8-14
60	14-21
40	22-30
20	45 (2× during the period)

[1] The smaller number of days is during July only; the larger number is more representative of the average.

Data collection and analysis

Plant width, length, and height measurements were taken monthly. An average plant growth index (PGI) was calculated for each irrigation level using the formula $[(l+w)/2+h]/2$, where l, w, and h represent length, width, and height of the plant (Irmak et al., 2004). To account for differences in plant size not related to irrigation treatments, a relative PGI (rPGI) was calculated for each plant each month during the deficit irrigation treatments using the formula PGIm/PGIi, where PGIm stands for the monthly PGI and PGIi stands for the initial PGI. Mean rPGIs across treatments were compared using ANOVA and Tukey's HSD test.

Qualitative performance ratings (on a scale of 1-5) were taken monthly in the following categories: foliage appearance, flowering abundance, pest tolerance, disease resistance, vigor, and overall appearance (Plant Trials Database, 2017). Foliage ratings were based on fullness, color, uniformity, and "cleanness" of leaves (i.e., no holes, edge burn, curling, necrosis, etc.); flowering ratings were based on percentage of plant covered in open blooms; pest and disease ratings were a percentage of leaves damaged, if any; and vigor was based on percentage of plant actively growing and pushing new buds. Overall appearance was a combined rating that looks at how all the other factors worked together to affect the overall landscape aesthetic of the plant. Ratings were therefore based on the overall impression the individual specimen made as a landscape component. Therefore, a plant receiving a '5' overall appearance rating would be excellent: eye-catching, uniform, healthy, and any damage from environmental or biological factors was overridden by beautiful form, good foliage color, abundant blooms and other similar factors. A '4' rating was a very good plant, but perhaps not at its peak or quite excellent. A '3' rating was acceptable performance, but not up to '4' standards, while '2' is unacceptable for several reasons, and '1' is close to death. Recommendations for irrigation level were based on the treatments that produced the combination of best average quality ratings across the categories during the growing season and uncompromised growth.

RESULTS AND DISCUSSION

Growth

The most interesting thing about the results is that there were no differences between any treatments in relative plant growth index for any cultivar in any year. Some small differences seem to appear, but these were statistically insignificant at $p \leq 0.5$ (Table 3). Clearly these roses have retained a natural adaptability to infrequent irrigation, most likely through the development of an extensive root system which gives the plants access to available water in a large volume of soil. Other adaptations are tough leaves with a waxy cuticle (the 'Kordes' cultivars) and reduced leaf size (the 'Meilland' cultivars), both of which reduce evapotranspiration. These roses also seem to be genetically delimited to a certain amount of growth within a year, regardless of the availability of water.

Table 3. Final relative plant growth index[1] for 10 *Rosa hybrida* cultivars grown on 4 levels of ET_0-based irrigation their 2nd year in the UC Landscape Plant Irrigation Trials©.

Cultivar	Treatment % of ET_0			
	80	60	40	20
Aushouse	1.7	1.8	1.9	1.7
Gruss an Aachen	1.9	1.9	2.0	1.9
KORbin	3.1	2.8	2.8	2.4
KORelamba	1.3	1.7	1.3	1.5
KORfloci01	3.1	3.0	2.4	2.5
KORsixkono	3.3	3.2	3.4	2.2
KORsteimm	1.4	1.5	1.6	1.5
Meidrifora	1.2	1.3	1.3	1.3
Meijocos	1.4	1.4	1.4	1.5
Meigalpio	1.4	1.6	1.5	1.4

[1] No significant differences on any irrigation level for any species using ANOVA and Tukey's HSD at $p \leq 0.5$.

Plant quality

With one exception, these cultivars all performed acceptably on all irrigation levels during the second growing season (Table 4). Only 'Aushouse' ('Harlow Carr') proved marginally acceptable on any irrigation level. Its non-uniform habit of long, spreading canes and an open center, discoloration of the leaves from the sun and thrips damage, and the tendency of the leaves to wilt in the heat made it unacceptable most of the year. In fact, if the month of April with its heavy spring bloom had not been factored in, the overall appearance rating for the growing season would not have reached the acceptable level of '3' on any treatment. The 60%-ET_0 treatment was the only irrigation level to produce average foliage ratings of '3', and it also produced the highest rating in each of the other categories as well. Overall, this plant would not be recommended for hot, interior urban landscapes.

The best performers in these trials on the lowest irrigation treatment were 'KORbin', 'KORsixkono', and 'Meijocos'. Even when not in full bloom, they had good form and were vigorous growers. Another feature that made each of these outstanding was a high level of repeat blooming throughout the season on all irrigation rates. Other strong repeat bloomers were 'KORelamba', 'Meidrifora', 'Meigalpio', and 'KORsteimm'. 'Meidrifora' showed damage from powdery mildew during the wet, cool spring, but quickly outgrew it in the summer. The main drawback of 'KORsteimm' was its foliage quality which began declining early in September, sooner than most roses in this climate zone, USDA Zone 9b.

Recommendations for the optimal irrigation percentage of ET_0 yielding the best landscape performance are given along with the average overall appearance rating in Table 4. Where there was no difference in the growth and other quality ratings (not shown), a range of recommended irrigation levels is suggested.

Table 4. Average overall appearance ratings (on a scale of 1-5) from April to October for 10 *Rosa hybrida* cultivars grown on 4 levels of ET_0-based irrigation their 2nd year in the UC Landscape Plant Irrigation Trials©.

Cultivar	Treatment % of ET_0				Recommended rate[1]
	80	60	40	20	
Aushouse	2.9	3.1	2.9	3.0	60
Gruss an Aachen	3.8	3.1	4.0	3.4	40
KORbin	4.1	4.3	4.3	4.1	40-60
KORelamba	3.8	3.5	3.9	3.7	40
KORfloci01	3.3	3.1	3.7	3.4	40
KORsixkono	4.2	4.3	3.9	4.1	60
KORsteimm	3.5	3.6	3.7	3.4	40
Meidrifora	3.9	4.0	4.0	3.7	40-80
Meijocos	4.0	3.9	3.9	3.9	20-80
Meigalpio	4.0	3.8	3.9	3.5	40-80

[1]Some quality parameters not shown here, such as flowering or foliage quality, may be factored into the recommended rate.

CONCLUSIONS

Rose breeding is clearly yielding cultivars that can be incorporated into gardens that do not require a high level of irrigation in summer-dry regions. Most of the cultivars above can be irrigated at 40-60% of ET_0 without compromising health or appearance. Many of these are also pest-tolerant, disease-resistant, and strong bloomers throughout the warm months, making them assets to an attractive urban landscape. With the data generated by these trials, landscape professionals can efficiently hydrozone and irrigate using the best roses available.

The potential for adding high visual impact to the low-water landscape with roses is high. These researchers are currently evaluating seven additional cultivars with plans to install additional fields designated just for roses. In the summer-arid regions of the world like the American West and Southwest, water use efficiency in urban areas is the most important factor in landscape design and maintenance. If the most suitable roses can be identified and evaluated for water needs, then landscapers can use them with confidence of success while reducing the water use of the landscapes they manage.

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