

Versatile Native Grasses and a Turf-Alternative Groundcover for the Arid Southwest United States¹

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Abstract

Water use limitations offers new opportunities for utilization of low-input native grasses and groundcovers for the landscapes of southwest USA. Two field studies were conducted with eleven plant species for two years in Scottsdale and Sun City West, AZ to evaluate rate of emergence, ground surface coverage, plant height, and overall plant quality. In the laboratory, *Eragrostis tef* at 86% and *Eragrostis intermedia* at 85% were showing higher percentage of germination compared to other species. Within eight weeks, ten species exhibited an average of 81% emergence at Scottsdale while nine species showed only 58% emergence at Sun City West. *Sporobolus cryptandrus* grew to greater than 76 cm (30 in) in height while kurapia (*Lippia nodiflora*) grew to about 5 cm (2 in). The performances of the groundcover kurapia and the native grasses tested demonstrated excellent potential in the low desert southwest U.S., with low rates of water use, applying fertilizer only at planting, and less frequent mowing requirements. *Lippia nodiflora*, *Sporobolus airoides*, *Bouteloua gracilis*, *Eragrostis intermedia*, and *Muhlenbergia asperifolia* remained green throughout the year when mowed twice a year. *Lippia nodiflora*, *Hilaria rigida*, and *Bouteloua gracilis* exhibited the highest ground surface coverage and uniformity in growth.

Index words: groundcover, landscape, low input, native grasses, plant species.

Species used in this study: Blue grama, *Bouteloua gracilis* (Kunth) Lag. ex Griffiths; buffalograss, *Buchloe dactyloides* (Nutt.) Engelm.; plains lovegrass, *Eragrostis intermedia* A.S. Hitchc.; teff, *Eragrostis tef* (Zucc) Trotter; big galleta, *Hilaria rigida* (Thurb); Kurapia, *Lippia nodiflora* (L.) Greene; alkali muhly, *Muhlenbergia asperifolia* (Nees & Meyen ex Trin.) Parodi; alkali sacaton, *Sporobolus airoides* (Torr.) Torr.; spike dropseed, *Sporobolus contractus* A.S. Hitchc.; sand dropseed, *Sporobolus cryptandrus* (Torr.) A. Gray; and desert zinnia, *Zinnia acerosa* (DC.) A. Gray.

Significance to the Horticulture Industry

Identifying locally acceptable plant species that can be grown and managed with minimum amounts of water, fertilizer and pesticides coupled with low maintenance requirements will help the Arizona green industry, golf courses, and landscape designers to save water, reduce energy, labor, and money. Locally adaptable and versatile native grasses and alternative groundcovers can be important sustainable landscape plants that have aesthetic value and many ecosystem benefits, such as increasing soil organic matter, reducing erosion, capturing pollutants, sequestering CO₂, and removing excessive nitrogen from runoff water. The contributions of these studies will increase awareness and knowledge about the characteristics and performance of the species and potentially be adopted and implemented by golf course superintendents, municipal and school facilities managers, and commercial and residential landscapers. Adoption and installation of these water saving native grasses and a groundcover that are visually pleasing into residential and commercial landscapes can reduce water use while maintaining a sustainable green environment. Implementation of best management practices and technologies will result in reduced fertilizer, irrigation, and pesticides use. It enhances

conservation of resources and increased business opportunities for seed suppliers and sod producers to provide new plant species. Ultimately, landscapes that integrate native grasses and kurapia can contribute to biodiversity and save labor costs by reducing the needs for reseeding, resodding, or replanting.

Introduction

Conventional turfgrasses on golf courses and home lawns generally require intensive management with frequent mowing, fertilizing, and watering. Golf course superintendents, municipal water conservationists, school turf managers, and commercial landscapers have expressed interest in alternative groundcovers and low input native grasses as potential replacements for turfgrass. Major drivers such as water conservation, reducing machinery emissions, and labor costs contribute to designing, creating, and implementing plans and strategies to remove non-functional or undesirable turfgrasses. There are several environmental and economic advantages to utilize ornamental grasses in landscapes; however, aesthetics is perhaps the most popular reason for golf course and landscape architects when selecting plants (Dunning 2014). Golf courses across the United States can have 50 to 70% of the total acreage as non-play areas and can potentially follow Best Management Practices by maintaining native grasses on that area (Dunning 2014). For example, there is about 64% non-play area under a naturalized landscape on the Ambiente Course at the Camelback Golf Club in Scottsdale, AZ that saves 151 to 189 million liters (40 to 50 million gallons) of water per year (Aaron Thomas, Superintendent at Camelback Golf Club, Scottsdale AZ, personal communication 2018). Native grasses are increas-

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Table 1. List of native grasses and groundcovers evaluated in the southwest low desert at Scottsdale and Sun City West, AZ.

Common name	Scientific name	Seed rate (kg ha ⁻¹)	Type
Alkali sacaton	<i>Sporobolus airoides</i>	3.40	Native grass
Alkali muhly	<i>Muhlenbergia asperifolia</i>	1.40	Native grass
Blue grama	<i>Bouteloua gracilis</i>	4.50	Native grass
Buffalograss	<i>Bouteloua dactyloides</i>	244.0	Native grass
Teff	<i>Eragrostis tef</i>	5.60	Annual grass
Plains Lovegrass	<i>Eragrostis intermedia</i>	1.1	Native grass
Big galleta	<i>Hilaria rigida</i>	195	Native grass
Sand dropseed	<i>Sporobolus cryptandrus</i>	1.1	Native grass
Spike dropseed	<i>Sporobolus contractus</i>	1.1	Native grass
Desert zinnia	<i>Zinnia acerosa</i>	2.5	Native forb
Kurapia	<i>Lippia nodiflora</i>	43,560 plugs	Groundcover

ing in popularity in southern United States landscapes as exemplified by assessments in Florida (Wilson and Knox 2006), Georgia (Corley and Reynolds 1994, Ruter and Carter 2000), and South Carolina (Aitken 1995). Plant species from natural settings are generally regarded as a low maintenance alternative (Dana 2002). Moreover, severe droughts over recent past years in the southwest United States have increased the public's awareness about water conservation and the demand for low input native grasses and alternative groundcovers. Goals are to find appropriate horticultural plant species, and install and grow the most attractive, least water-consuming replacement plant species in areas where turfgrasses are removed. The demand is increasing for readily available, low maintenance, attractive plants for these naturalized areas. However, there is an information gap in which plant species meet these needs. One way to enhance landscapes while conserving water is to identify and establish low input native grasses and multi-use groundcover plant species to achieve and maintain desirable aesthetic landscapes. The objectives of these experiments were: (1)

to evaluate and compare the adaptation, performance, and ornamental and functional potential of native grasses and groundcovers when grown under low-input landscape maintenance conditions; (2) to identify native grasses with potential for use in high stress environments such as rough areas of golf courses, roadsides and rights-of-way, or landscapes in schools, parks, or large-scale commercial plantings; (3) to generate local research-based information on the feasibility of growing alternative groundcovers and low-input native grasses; and (4) to increase the awareness and knowledge of stakeholders about the characteristics of the native grasses and alternative groundcovers for low water use requirements and potential water saving capacity.

Materials and Methods

Plant species. Both laboratory and field experiments were conducted with eleven plant species including eight native grasses, an introduced annual forage grass, a native forb, and an introduced landscape groundcover. United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Plant Materials Program fact sheet publications (<https://www.nrcs.usda.gov/wps/portal/nrcs/main/plantmaterials/technical/>) were used for descriptions of each native plant species. Plant species tested are listed in Table 1.

Laboratory germination trial. Prior to the field study, a laboratory experiment was conducted using a completely randomized design (CRD) to determine the viability and germination rate of the seeds of native grasses. Ten seeds were placed on a paper towel moistened with tap water in a petri dish replicated four times for up to 2 weeks. The petri dishes were kept at room temperature and seed germination was monitored daily and expressed as germination percentage (Fig. 1).

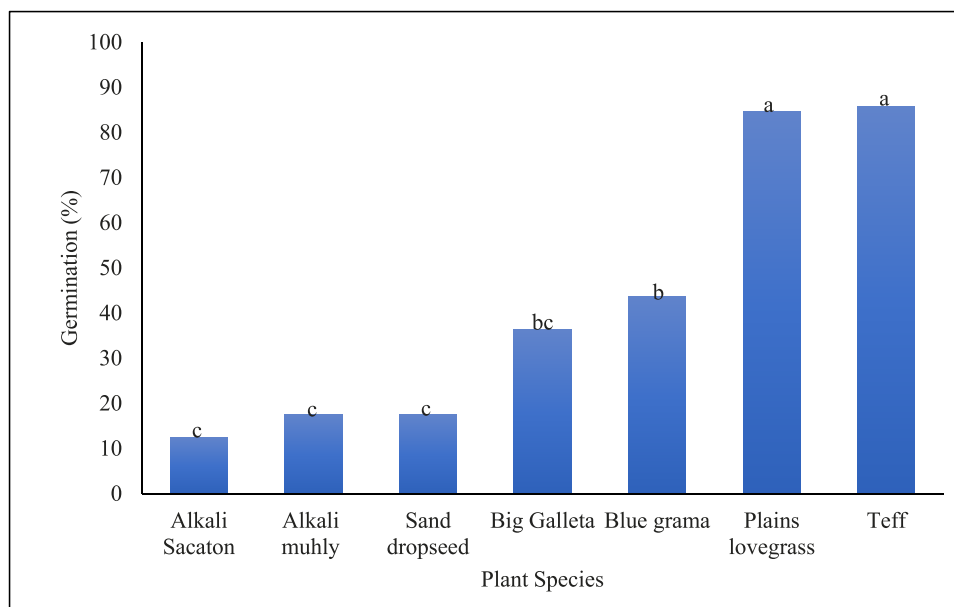


Fig. 1. Germination in the laboratory at seven days after seeding (average of two years). Bars not connected by the same letter are significantly different at alpha 0.05.

Table 2. Soil analysis for experimental sites at Scottsdale and Sun City West, AZ.^Z

Soil Standard Test	Method	Sites		Units
		Scottsdale	Sun City	
pH	1:1	8.1 (H)	8.0 (M)	SU
Electrical Conductivity (EC)	1:1	1.3 (M)	2.1 (M)	dS/m
Calcium (Ca)	NH ₄ Oac (pH8.5)	2,900 (H)	3,500 (VH)	ppm
Magnesium (Mg)	NH ₄ Oac (pH8.5)	800 (VH)	1,300 (VH)	ppm
Sodium (Na)	NH ₄ Oac (pH8.5)	330 (VH)	430 (VH)	ppm
Potassium (K)	NH ₄ Oac (pH8.5)	680 (VH)	550 (VH)	ppm
Nitrate-N (NO ₃ -N)	cd-Reduction	110 (VH)	150 (VH)	ppm
Phosphate-P (PO ₄ -P)	Olsen	31 (H)	16 (M)	ppm
Free Lime (FL)	Acid Test	medium	High	
ESP	Calculated	5.9	5.9	%
CEC	Calculated	24.3	31.6	Meq/100g
Sand	Hydrometer	42	62	%
Silt	Hydrometer	44	26	%
Clay	Hydrometer	14	12	%
Classification	Hydrometer	Loam	SL	

^ZNote: H- high, M-medium, VH-very high, SL-Sandy Loam.

Field experimental site. The experiments were established on two golf courses, at the Camelback Golf Club in Scottsdale, AZ [elevation: 398 m (1306 ft); latitude: 33.55634, longitude: 111.93809] in May 2016 and at the Briarwood Country Club [elevation: 381 m (1250 ft); latitude: 33.67230, longitude: 112.35214] in Sun City West, AZ in June 2017. The USDA NRCS Plant Material Center in Tucson, AZ provided seeds and information on seeding rates for most of the native grasses and the native forb; the University of Arizona Karsten Turfgrass Research Facility provided seeds and seeding rates information for *Hilaria rigida*, and *Sporobolus cryptandrus*. Experiments at both sites consisted of treatment plots for each species that measured 1.8 m by 1.8 m (6 ft by 6 ft) in a randomized complete block design with four replications. Both golf course sites were in non-play areas; Camelback Golf Club had a loamy soil and Briarwood Country Club had a sandy loam soil (Table 2) as analyzed and determined by Motzz Laboratory Inc., in Phoenix, AZ. At Camelback GC, in May 2016, the seedbed was prepared with a backhoe to scratch and loosen the bare ground soil to 15 cm (6 in) depth and then leveled with a dragmat. The study site at Briarwood CC in May 2017 had remnants of bermudagrass turf that was sprayed with glyphosate three times at ten days intervals before seedbed preparation and planting. The seedbed was prepared by using a core aerifier to scratch and loosen the soil to a 10 cm (4 in) depth and then leveled and smoothed with a dragmat. Grasses and the forb were seeded by hand scattering and then followed with a push lawn roller to firm the soil. Approximately 17,628 kurapia plugs per ha (43,560 per acre) were hand-planted.

At Camelback Golf Club, a pop-up sprinkler irrigation system was installed to irrigate the site while an existing irrigation system was utilized at Briarwood Country Club. The amount of irrigation water applied, and rainfall received as compared to reference evapotranspiration rate (ET_o) during the establishment period for the native grasses and groundcovers and during the four seasons of the year are described in Figures 2, 3 and 4. At Camelback Golf Club in Scottsdale, AZ, approximately 6.6 mm (0.26 in) water was applied daily during the first month after

sowing to aid uniform germination and establishment. The plots received an average of 5.0 mm (0.2 in) daily during July and August and there was additional rainfall of 0.51 mm (0.02 in) and 3.3 mm (0.13 in) during July and August, respectively. Irrigation was reduced to 3.3 mm (0.13 in) daily during September and October and then terminated from November 2016 to April 2017. In Sun City West at Briarwood CC, plant species were grown under more deficit irrigation. Only 1.02 mm (0.04 in) irrigation daily was provided during the first month after sowing, which was reduced to 0.51 mm (0.02 in) in July and August. Total rainfall was 0.51 mm (0.02 in) and 3.3 mm (0.13 in) in July, and August, respectively. Irrigation was reduced to 0.33 mm (0.013 in) in September and October and terminated from November 2017 to the end of March 2018. Grasses were mowed two times per year at Camelback GC on 02 August and 12 October 2016, 08 May and 13 September 2017, and 21 June and December 2018 while Briarwood CC was mowed once per year on 20 September 2017 and on 15 November 2018.

Data collection. Data were collected for rate of emergence, plant height, and overall plant quality ratings at intervals after installation of the two field experiments. Seedling counts were initiated as soon as emergence began and continued until it appeared that the number of seedlings had plateaued at approximately 8 weeks after sowing. The plant growth in height (cm) was measured from ground level to the tip of plants before flowering. An overall visual quality rating was evaluated each week for the collective qualities of greenness, surface coverage, and stand uniformity following the National Turfgrass Evaluation Guidelines (Kevin and Shearman 1998), where 1 = the poorest or lowest, 5 = acceptable, 9 = the best or highest rating. Individual ratings for plant greenness were rated from 1 to 9 similarly with 1 = brown, 5 = light green, and 9 = dark green. Surface coverage ratings from 1 to 9 were taken visually, with plots with almost no vegetative cover = 1 and complete coverage of the area with no visible soil = 9. For these studies, native grasses and groundcovers with promising qualities were determined as those that

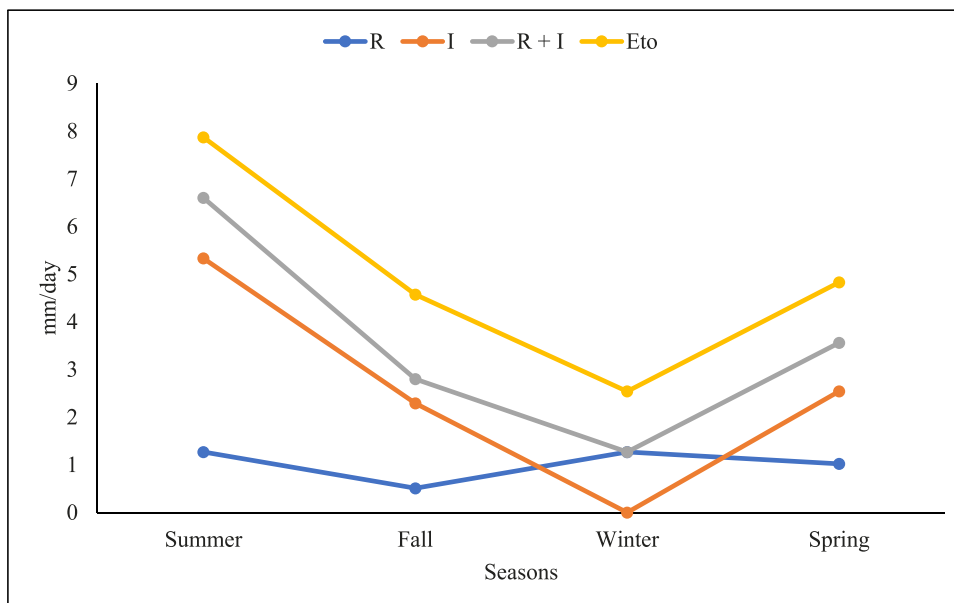


Fig. 2. Amount of irrigation applied, and rainfall received as compared to reference Eto (Bermudagrass) during four seasons for the establishment and maintenance of native grasses and groundcovers at Scottsdale, AZ in 2016-2017. Code: (I = Irrigation, R = Rainfall, Eto = reference evapotranspiration).

showed moderate (average quality ratings > 5 to high quality (average ratings > 7) across the years and seasons. Data were analyzed using JMP ver. 14.5 statistical software and means compared using the student's t-test.

Results and Discussion

Germination. The laboratory seed germination test indicated that most of the native grasses completed germinating within 1 week. There were no significant differences in seed germination between the two years; therefore, the means for the two years were pooled for comparisons among species. *Kurapia* (*Lippia nodiflora*)

was grown from plugs and not included in the laboratory tests. A week after seed test initiation, there were significant differences ($p= 0.05$) among the ten species for their rates of germination (Fig. 1). Two species, *Eragrostis tef* (teff) and *E. intermedia* (plains lovegrass) exhibited significantly higher percentage seed germination of 86 and 85%, respectively compared to other species. *Bouteloua gracilis* (blue grama) and *Hilaria rigida* (big galleta) seeds exhibited 44 and 36% germination, respectively. Three species, *Sporobolus cryptandrus* (sand dropseed), *S. airoides* (alkali sacaton), and *Muhlenbergia asperifolia* (alkali muhly) had less than 20% germination.

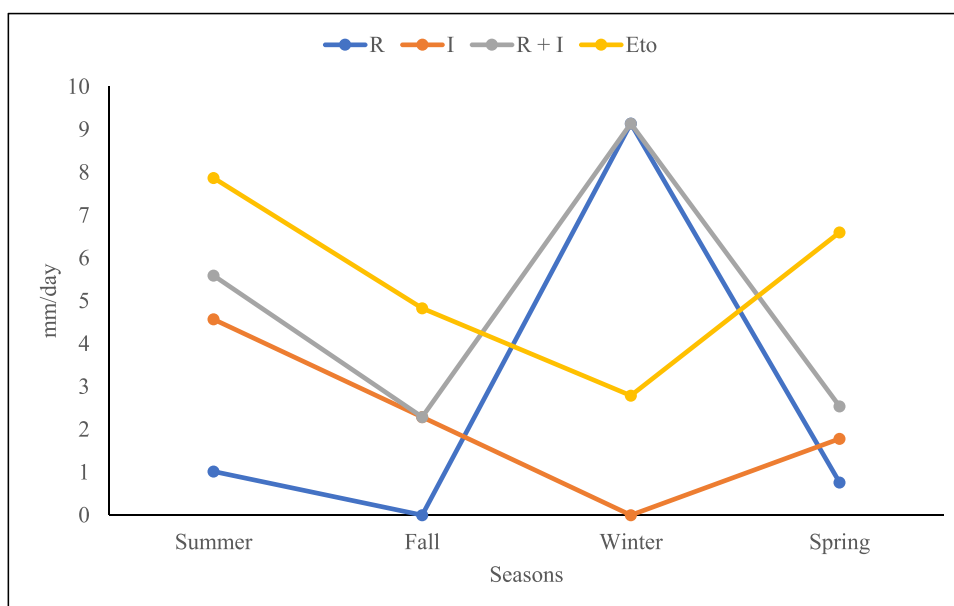


Fig. 3. Amount of irrigation applied, and rainfall received as compared to reference Eto (Bermudagrass) in the four seasons for the establishment of native grasses and groundcovers at Scottsdale, AZ in 2017-2018. Code: (I = Irrigation, R = Rainfall, Eto = Evapotranspiration reference).

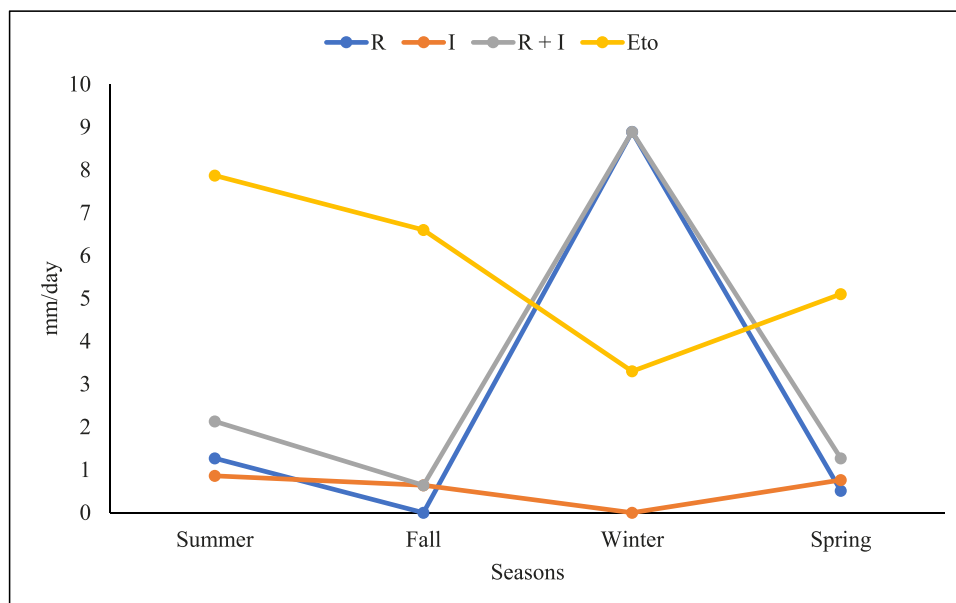


Fig. 4. Amount of irrigation applied, and rainfall received as compared to ETo (Bermudagrass) reference for the establishment of native grasses and groundcovers at Sun City West, AZ in 2017-2018. Code: (I = Irrigation, R = Rainfall, Eto = Evapotranspiration reference).

Seeds of *B. dactyloides* (buffalograss), *S. contractus* (spike dropseed), and the forb, *Zinnia acerosa* (desert zinnia) failed to germinate by 14 days in the laboratory.

Emergence. There were significant ($p < 0.05$) differences in the seedling emergence and survival rate among native grasses and groundcovers (Table 3). When averaged over locations (8 weeks after planting) the survival rate was 92% for kurapia plugs. The average emergence was 90% for big galleta, and 88% for teff and these were significantly different from other species, except for blue grama at 77%. The emergence of sand dropseed, alkali sacaton, and plains lovegrass ranged from 60 to 67%. The least emergence was observed for spike dropseed at 41% and alkali muhly at 48%. The emergence, survival, and establishment of the species were affected by locations. Of the 11 species seeded or planted in the field, 10 and 9 species were emerged and

Table 3. Percent emergence of plant species (eight weeks after seeding/planting) in Scottsdale and Sun City West, Arizona in the 2016-2017 season.^Z

Common name	Locations		Average
	Scottsdale	Sun City West	
Kurapia	98a	85abc	92a
Big galleta	97ab	83abc	90a
Teff	97ab	80abc	88a
Blue grama	83abc	70bc	77ab
Alkali sacaton	93ab	40de	67bc
Sand dropseed	63cd	70bc	67bc
Plains lovegrass	93ab	23e	60bcd
Alkali muhly	63cd	33e	48cd
Spike dropseed	42de	40de	41d
Average	81A	58B	

^ZLevels not connected by the same letter are significantly different within locations of the different species and between locations of the same species, within column for the average over locations, and within the same row for average over the species.

established at Scottsdale and Sun City West, respectively. When averaged over all the species, percent emergence was significantly higher at Scottsdale with 81% compared to Sun City West at 58%. In establishing a stand, kurapia covered the surface area of the plots within 8 weeks at Scottsdale and 12 weeks at Sun City West. All plant species, except desert zinnia, emerged and established well at Scottsdale. Both desert zinnia and buffalograss failed to emerge at Sun City West. The most emerged species at Scottsdale were kurapia at 98%, teff at 97% and big galleta at 97% followed by plains lovegrass at 93% and alkali sacaton at 93%. Kurapia, teff and big galleta also demonstrated good emergence and had more than 80% emergence at Sun City West. At Scottsdale, buffalograss was slow to emerge and spread slowly to establish a stand covering 35% of the plot area in 8 weeks and covered the entire plot in 12 weeks, but it failed to emerge in Sun City West. Most species, except alkali sacaton, alkali muhly and plains lovegrass, exhibited similar emergence patterns with no significant differences between both locations. It appeared that plains lovegrass, alkali sacaton, and alkali muhly performed better in a slightly heavier loamy soil compared to a sandy loam soil.

Plant height. Height of seedlings through maturing plants varied amongst the species (Fig. 5). When averaged over two locations, height for sand dropseed measuring 76 cm (30 in) and plain lovegrass at 66 cm (26 in) were significantly ($p < 0.05$) greater than the height for all other native grasses. The plant heights of kurapia, buffalograss and alkali muhly were significantly shorter than all other species. At Scottsdale, where optimal irrigation was given, plants grew fast and required more mowing (twice each year), compared to where plants were exposed to the more deficient moisture at Sun City West (only once each year). Bermudagrass invasion resulted in competition in some of

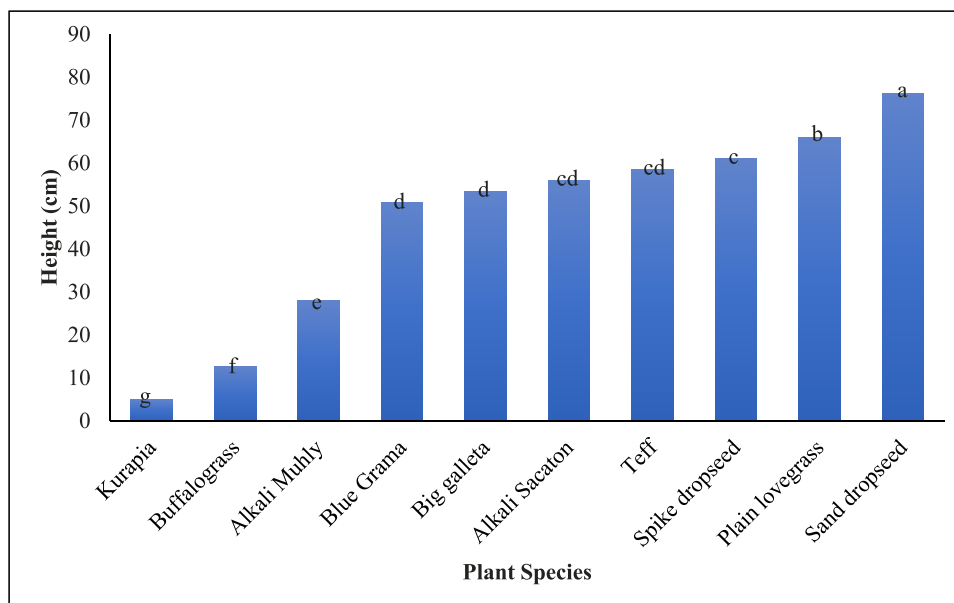


Fig. 5. Plant heights in centimeters averaged over locations at eight weeks after planting. Levels not connected by the same letter are significantly different at alpha 0.05.

the plots, where it was difficult to control, resulting in slower growth rates for some of the desired grasses.

Greenness. The variation among the species in greenness were highly significant ($p < 0.0001$) only during the winter at both Scottsdale and Sun City West (Fig. 6). Locations had no significant effect on greenness of the species and means were pooled for comparison purposes. In the winter, sand dropseed, spike dropseed, and big galleta did not remain green. Kurapia, plains lovegrass, alkali sacaton, alkali muhly and blue grama maintained greater greenness (the quality values of > 7). During summer, spring and into the fall all species exhibited acceptable green color (quality values of > 5).

Coverage. All the native grasses established and provided surface area coverage throughout the experimental period at various levels to (Fig. 6). Surface area coverage for seven of nine species in Scottsdale and four of eight in Sun City West were observed to be acceptable (quality values of > 5) during all seasons over two years. Spike dropseed and sand dropseed in Scottsdale and spike dropseed, plains lovegrass, alkali sacaton, and alkali muhly in Sun City West performed at an unacceptable level in ground surface coverage (quality values of < 5). Kurapia showed excellent surface coverage in Scottsdale followed by plains lovegrass, buffalograss, big galleta, blue grama, and alkali sacaton. Big galleta, blue grama, and kurapia provided good surface coverage at Sun City West. Alkali muhly at Scottsdale and sand dropseed at Sun City West gave moderate surface coverage (quality level of > 6). Averaged over both locations, big galleta, kurapia, blue grama, and alkali muhly provided adequate surface coverage (quality level of > 5).

Uniformity. Assessment of growth uniformity encompassed evenly covering the plot area and uniform height of the plants of the species. Averaged over both locations, big

galleta, kurapia, and blue grama performed acceptably over the duration of the two years (Fig. 6).

Overall results. An overall comparison of the experiments indicated that the species performed better for emergence, area coverage, and greater growth in height at Scottsdale than at the Sun City West. Between the two sites, a major difference was the irrigation application rate and frequency during the establishment period. The amount of water that was applied and the frequency intervals were significantly lower at Sun City West. At Scottsdale, irrigation was applied at 65% ETo during germination, emergence, and early establishment in the first summer and then followed by 53, 50, and 0% of the ETo in spring, fall and winter, respectively, for 2016-2017. Irrigation was reduced to 58, 53, 50, and 0% for the summer, spring, fall and winter, respectively, for 2017-2018. At Sun City West, species were grown almost under natural rainfall settings where only 53% of the total ETo was met and sprinkler irrigation contributed only 9%. The sandy loam soil texture at Sun City West along with minimal irrigation during seed germination and stand establishment might have contributed to a higher percolation rate of irrigation water, causing deficient moisture levels at the critical time of establishment, resulting in poor emergence and establishment of the species.

Most of the native grasses planted at both Scottsdale and Sun City West demonstrated very good stand establishment characteristics, survival, and aesthetic qualities. Kurapia and teff were non-native species that exhibited excellent survival and very good overall growth qualities. All the species were perennial except teff, an annual forage. The new groundcover, kurapia, performed exceptionally well at both sites and showed the potential for adoption and long-term performance for overall quality in a low-input landscape. Buffalograss was very slow to establish but by

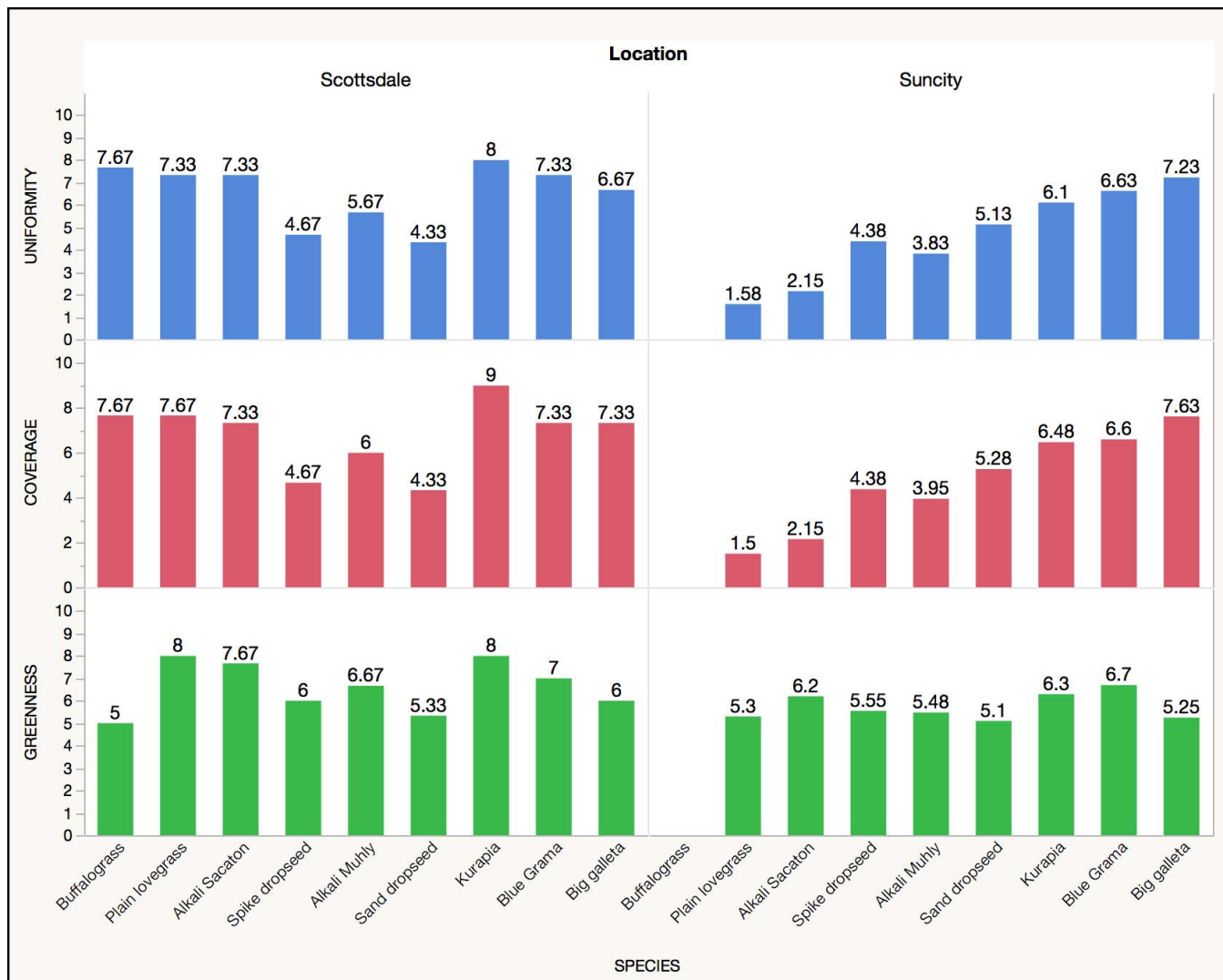


Fig. 6. Evaluation of native grasses and groundcovers for greenness, surface coverage, and uniformity averaged over the four seasons (summer, fall, winter and spring) at Scottsdale and Sun City West, AZ. Note the quality values of > 5 is acceptable quality for each parameter.

the end of the growing season exhibited excellent coverage of the surface area of the plots.

All the species exhibited growth characteristics and habits that ranged from very low growing such as kurapia and buffalograss to intermediate grasses such as alkali muhly, blue grama, and big galleta to taller species such as alkali sacaton and dropseeds. These observed characteristics of the native grasses and kurapia in the field exhibiting differential growth between tall and short statured plants and densities provide information when selecting plants for potential sites where each type of species can be utilized. Spatially, the taller bunch forming grasses such as dropseeds, alkali sacaton, and plains lovegrass provide different perspectives of ground covers as they grow in compact tufts with more exposed bare ground compared to shorter statured stoloniferous species. The shorter statured and spreading buffalograss, alkali muhly, big galleta, and kurapia offer more complete ground surface covering. Additionally, plants such as buffalograss and kurapia can be grown as a lawn where there are low amounts of traffic. In our present study,

native grasses such as alkali muhly, blue grama, buffalograss and big galleta had the characteristics that did not require frequent mowing and maintenance. They can be used in the landscape as perennial plants covering the surface areas for erosion control and providing aesthetic value. These grasses are adaptable to the desert environment and can be grown under low input conditions. Once established, they should only require minimal inputs of fertilizers, irrigation, pesticides, and mowing labor.

The experiments at two locations over two years yielded results that exhibited promising year-around green grasses such as alkali sacaton, alkali muhly, plains lovegrass, and blue grama, and kurapia. In comparison to intensely managed turfgrasses, the major appealing benefits of these native grasses and kurapia were the low input features of less frequent mowing, low water, fertilizers, and pesticides requirements. The potential for the utility of native grasses and alternative groundcovers such as kurapia in sites where turfgrasses are removed is ever-increasing as water availability and quality dimin-

ishes with frequent and prolonged droughts in the southwest USA. The choices of native grass species and ground covers provide a range of aesthetic qualities as well as functionality. Incorporating native grasses can offer transitions between manicured turfs on golf course fairways, tees, and greens to more native wildlands or to landscaped residential and commercial communities. Native grasses in a naturalized landscape can benefit biodiversity, and save costs on inputs for water, fertilizers, pesticides, and labor for golf courses and other landscapes. As observed in the present study, once established, some perennial native grasses and kurapia can offer year-round greenness under frost-free mild winters. Tall and short statured plants can spatially provide surface ground cover to alleviate soil erosion due to water runoff or monsoon winds. The benefits of environmentally friendly and aesthetically pleasing native grasses and kurapia can significantly and successfully contribute to desert landscapes.

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