COOPERATIVE EXTENSION UNIVERSITY OF CALIFORNIA

California Turfgrass Culture

Volume 53, No. 1 - 4, 2003

Zoysiagrass for California

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Zoysiagrasses are warm-season grasses that originated in east Asia and were first introduced into the United States early in the 20th century. In California, there have been only limited use of the grasses for turfgrass sites and as ground covers in landscapes where summers are warm and winters mild. The grasses range from the very fine-leaved Korean velvetgrass (*Zoysia tenuifolia*), used to a limited extent as an unmowed, meadow-like ground cover, to Japanese lawngrass (*Z. japonica*), a relatively coarse bladed turfgrass used in lawns. Other kinds of zoysiagrass include the fine-bladed Manilagrass or Korean lawngrass (*Z. matrella*) that is used for low-input lawns in Asia, and the minor use, highly salt tolerant *Z. sinica* and *Z. machrostaycha*. "Species" of zoysiagrass can be hybridized so the grasses may be considered to be a "family" of related grasses (Brede, 2000). As an example, 'Emerald' zoysiagrass is a hybrid between Korean velvetgrass and Japanese lawngrass.

Interest in zoysiagrass increases

Interest in zoysiagrass improvement programs has increased because they are considered to be resource efficient (low input) or minimum maintenance turfgrasses. As examples, zoysiagrasses are heat tolerant and thrive under high summer temperatures; they have few disease or insect problems, especially under California climatic conditions, and the dense turf is very competitive against weed encroachment; they have a slow growth rate so mowing and edging frequency is reduced; they have high traffic tolerance; they make a satisfactory turf surface with less nitrogen fertilizer than other commonly used turfgrasses; they are moderately salt tolerant; and they grow in light to moderate shade (Youngner, 1980).

Previous California studies have shown that warm-season turfgrasses, including zoysiagrass, require less water supplied as irrigation than the commonly used cool-season turfgrasses (Youngner, 1981; Meyer and Gibeault, 1986). Concerns with zoysiagrass would include their slow establishment rate; thatch accumulation because of the stoloniferous and rhizomatous growth habit; scalping tendency and slow growth/dormancy during winter months.

'El Toro' zoysiagrass used widely

In the mid-1980's 'El Toro' zoysiagrass, a *Z. japonica*, was released from a long term University of California plant improvement program directed by the late Dr. Victor B. Youngner and implemented by Mr. Stanley Spaulding (Gibeault and Cockerham, 1988). 'El Toro' zoysiagrass was shown to have a much faster establishment rate, better late-season color and more rapid spring greenup than other *Z. japonica* grasses, and less thatch production.

'El Toro' zoysiagrass has been used nationally and internationally for various turfgrass purposes since its introduction but to a limited amount in California. A reason 'El Toro' zoysiagrass or other warm-season turfgrasses have not been used more extensively in California, even though they have been shown to be more resource efficient, relates to the dormancy of the grasses during winter months.

Chilling injury to warm-season grasses

Chilling temperatures interacting with high light intensity result in a loss of chlorophyll and dormancy of warm-season

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turfgrasses. The appearance of anthocyanin may be observed as chlorophyll degradation exceeds synthesis; ultimately, the warm-season turfgrasses lose all green color until temperatures increase in late winter or early spring. Normally, the winter temperatures in Southern California are very close to threshold temperatures that cause chlorophyll degradation so plant selection and improvement can influence the presence and degree of dormancy. A continued breeding program at the University of California, Riverside emphasized, among other turfgrass establishment and quality parameters, the ability of experimental lines to retain green color during the winter months. Two zoysiagrass cultivars, 'De Anza' and 'Victoria', resulted from the work.

'De Anza' and 'Victoria' zoysiagrass developed

'De Anza' and 'Victoria' zoysiagrasses were produced by hybridizing 'El Toro' zoysiagrass as the female parent with a zoysia selection that, itself, was a hybrid (*Z. matrella* x (*Z. japonica x Z. tenuifolia*)). Hand pollination was performed and seed was germinated. Seedlings were individually cultured under controlled conditions before being transplanted to the field for evaluation and selection. Several years of field screening demonstrated their superior ability to retain color through the winter months, under conditions in Riverside, California, when compared to other experimental and commercially available zoysia lines. They were also selected because of their competitive turfgrass establishment rate and quality which included color, texture, density, uniformity, and pest resistance. Being siblings, 'De Anza' and 'Victoria' zoysiagrass are similar in overall performance although 'De Anza' has a darker green genetic color and holds color during winter months slightly better than the lighter green; 'Victoria' under Riverside conditions. The cultivars must be vegetatively propagated from sod, stolons or plugs. They are appropriate for applications such as home lawns, parks, golf courses and general purpose lawns. Cultivar performance results from recently completed National Turfgrass Evaluation Program (NTEP) studies show that the two cultivars perform better in regions that have high summer temperatures with moderate winter temperatures. They do not give good performance in regions where low winter temperatures are common. In the greater San Francisco Bay area, a 4-5 month dormancy response is common.

The articles that follow focus on zoysiagrass studies that have been conducted over the past several years, especially with the cultivars 'De Anza', 'Victoria', and 'El Toro' zoysiagrass.

Literature Cited

Brede, D. 2000. Turfgrass Maintenance Reduction Handbook: Sports, Lawns, and Golf. Ann Arbor Press: Chelsea, MI. 374 pages.

Gibeault, V.A. and S.T. Cockerham. 1988. 'El Toro' Zoysiagrass. Calif. Turfgrass Culture. 38 (1&2):1.

Meyer, J.L. and V.A. Gibeault. 1986. Turfgrass Irrigation Under reduced Irrigation. Calif. Agriculture. 40(7,8): 19-20.

Youngner, V.B. 1980. Zoysiagrasses in California. Calif. Turfgrass Culture. 30(1): 1,2.

Youngner, V.B., A.W. Marsh, R.A. Strohman, V.A. Gibeault, and S. Spaulding. 1981. Water Use and Turf Quality of Warm Season and Cool Season Turfgrasses. *In*: Proceedings of the Fourth International Turf Research Conference Vol 4. (Ed. R.W. Sheard). Pp 251-257. (University of Guelph, Guelph, Ontario, Canada).

Enhancement of Zoysiagrass Winter Color with Fertilization

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One of the reasons warm-season turfgrasses are not more widely used in California is due to their characteristic winter dormancy. Two cultivars of zoysiagrass, 'De Anza' and 'Victoria', were developed in part because of their ability to retain green color during winter months and low temperature conditions in Riverside, CA. It was the objective of a study reported here to evaluate the effect of nitrogen and iron fertilization on the enhancement of 'De Anza' and 'Victoria' winter color.

Methods

The same nitrogen and iron treatments were applied to mature 'De Anza' and 'Victoria' zoysiagrass stands, with treatments initiated on November 4, 1993, at the University of California, Riverside, Turfgrass Research Facility. Ammonium sulfate and calcium nitrate at 0.5 lb N/1000 ft^2 every two weeks and the same materials at 1.0 lb N/1000 ft^2 every four weeks were applied as granular materials with and without ferrous sulfate

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at the rate of 1.0 oz/1000 ft^2 every two weeks and 2.0 oz/1000 ft^2 every month. Isobutylidene diurea, IBDU, was applied at 2.0 lb N/1000 ft^2 every eight weeks, also with and without iron. The control treatments received no nitrogen with iron and no nitrogen without iron. Treatments were applied four times, at approximately monthly intervals during the winter months of November, December, January and February, 1993/1994. The experimental design was a split-block with three blocks. Turfgrass culture during the study consisted of irrigation based on an automated weather station determination of evapotranspiration and mowing at 0.75 in. with a reel mower. Treatments were rated approximately weekly from mid-November 1993 through the end of January 1994 and in February, March, and April, using a visual rating scale of 1-9, with 1 representing complete dormancy and 9 representing deep green color. (In addition to analysis of variance to test main effects of nitrogen and iron fertilizers and the interaction, contrasts were used for mean comparisons. Contrasts for nitrogen fertilizer were nitrogen versus control, soluble nitrogen versus slow release, ammonium sulfate versus calcium nitrate, frequency of application for the soluble nitrogen sources, and interaction of material by frequency. Contrasts for iron fertilizer were iron versus control and frequency of application. The dependent variable was the average color rating over the interval December 7, 1993 though March 3, 1994, with each month weighted equally.)

Table 1. Color ratings[1] of zoysiagrass by nitrogen source and timing.

Source	Frequency	'De Anza'	'Victoria'
Ammonium sulfate	2 weeks	6.3	5.0
	4 weeks	6.5	5.0
Calcium nitrate	2 weeks	6.2	4.9
	4 weeks	6.0	5.1
IBDU	8 weeks	5.5	5.1
Control	----	3.4	3.7
LSD (P = 0.05)		*0.8*	*0.6*
<u>Significance of Contrasts</u>			
Nitrogen vs. Control		***[2]	***
Soluble Nitrogen vs. Slow Release		*	NS
Ammonium sulfate vs. Calcium nitrate		NS	NS
Soluble Nitrate Frequency		NS	NS
Soluble Nitrate, Materials x Frequency		NS	NS

[1]Average 7 Dec. 1993 - 3 Mar. 1994, each month weighted equally.
[2]NS not significant; * P=0.05; *** P=0.001.

Results and Discussion

Color ratings, averaged for December 1993 through March 1994, by nitrogen fertilization treatments are shown in Table 1. Color ratings were significantly higher with nitrogen fertilizer than without for both cultivars of zoysiagrass. Soluble nitrogen provided somewhat higher ratings than slow release nitrogen for 'De Anza' zoysiagrass but not for 'Victoria' zoysiagrass. There were no significant differences between ammonium sulfate and calcium nitrate nor between applications once every two weeks and once every four weeks for either variety. The magnitude of the nitrogen effect was approximately 2.7 units (rating scale of 1 to 9) for 'De Anza' but only 1.3 for 'Victoria'.

Effects of iron fertilizer are shown in Table 2. Color ratings for treatments with iron fertilizer were significantly higher than for the control for both cultivars (P=0.05 and 0.01) for 'De Anza' and 'Victoria', respectively. The interaction of nitrogen treatment and iron treatment was not significant for either cultivar.

A strong response of 1 lb N/1000 ft^2 per month was found on color retention by both cultivars, but especially with 'De Anza'; also, the positive influence of iron alone can be noted, especially with 'Victoria' zoysiagrass. Nitrogen and iron treatments resulted in better color retention than nitrogen or iron alone with both grasses. While both nutrients positively affect color retention, 'De Anza' was much more influenced by nitrogen and 'Victoria' was more influenced by iron. Overall, the color retention by 'De Anza' zoysiagrass with nitrogen and iron fertilization treatments was very good. The intensity of color qualitatively was similar to nearby cool-season turfgrasses that were not in this study but located on the research facility. The overall color retention by 'Victoria' zoysiagrass was good, displaying a lighter-green winter color in contrast to the deep green color of 'De Anza' zoysiagrass.

Table 2. Color ratings[1] of zoysiagrass by iron timing.

Source	Frequency	'De Anza'	'Victoria'
Iron sulfate	2 weeks	5.7	5.2
	4 weeks	5.9	5.2
Control		5.4	4.1
LSD (P = 0.05)		*0.3*	*0.5*
<u>Significance of Contrasts</u>			
Iron sulfate vs. Control		*[2]	**
Iron sulfate Frequency		NS	NS

[1]Average 7 Dec. 1993 - 3 Mar. 1994, each month weighted equally.
[2]NS not significant; * P=0.05; *** P=0.001.

Mowing Height and Verticutting Frequency Evaluations on 'De Anza' and 'Victoria' Zoysiagrasses

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Zoysiagrasses are well adapted to Southern California and can be grown in all areas of California where the summers are warm and the winters mild. Considered to be a grass with maintenance requirements that are lower than those of most other turfgrasses, zoysiagrasses are tolerant of heat, drought, salinity, heavy traffic and not commonly susceptible to disease, insect, or weed invasion problems. It was the objective of this study to evaluate mowing heights and vertical mowing frequencies as cultural practices for 'De Anza' and 'Victoria' zoysiagrass.

Methods

Mowing was done twice weekly at 0.4, 0.5, 0.75, and 1.25 in using individual 7-blade walk-behind reel mowers for each mowing height. Verticutting was applied using a Ryan Renothin or a Ryan Mataway with the blades just above the soil surface. Vertical mowing frequencies were none, 1x, and 3x (every 6 weeks) in 1995 and none, 1x, and 4x (every 5 weeks) in 1996. All plots received 1.0 lb N/1000 ft^2 as 16-6-8 every 6 weeks in 1995 and monthly in 1996. Irrigation was non-limiting.

Clipping yields were taken after 5 days growth, with clippings oven dried at 60°C for 48 hours. Visual turf ratings were made monthly on a 1-9 scoring system with 9 being genetically perfect expression of color, texture, uniformity and density. Thatch measurements were taken from three measurements each of three cores per replication. Surface hardness data was made using the Clegg Impact Tester with a 5.0 lb missile. First drop readings were recorded for 3 areas per replication. Data were analyzed using ANOVA or GLM. Significant differences of means were determined at the 95% confidence level using LSD.

Results and Discussion

'De Anza' ZOYSIAGRASS

Visual turf quality of 'De Anza' zoysiagrass was generally indistinguishable between treatments throughout the study. They were generally rated at 7.3 to 7.5 on a 1 to 9 scale with 9 best. Vertical mowing treatments were apparent for one to three weeks.

'De Anza' clipping yields the first year indicated that the mowing height of 0.5 in. was the optimum level in terms of most clippings in the warm summer months with the range extending to 0.4 and 0.75 in. the rest of the year (Table 1). In the second year, the trend was repeated though less pronounced with only the yields of the 1.25 in. mowing height treatment significantly lower (Table 2).

Table 1. Clipping yields of 'De Anza' zoysiagrass by mowing heights and vertical mowing frequency (1995).

	Dry wt oz/10 ft^2				
Treatment	Jul	Aug	Sep	Oct	mean
Mow Ht.(in)					
0.4	3.2	5.3	6.8	3.2	4.6
0.5	5.0	6.3	6.1	2.8	5.2
0.75	3.7	5.2	6.6	3.4	4.8
1.25	2.5	4.4	5.0	1.9	3.5
LSD	*0.6*	*0.6*	*0.8*	*0.4*	*0.5*
Vert. Mow*					
V0	4.1	6.3	6.9	3.3	5.2
V1	3.4	5.6	6.5	3.1	4.7
V2	3.3	4.0	5.0	2.2	3.7
LSD	*1.2*	*1.7*	*1.4*	*0.6*	*1.1*

* VO = No vertical mowing;
V1 = One vertical mowing in June;
V2 = Three vertical mowings @ 6 week intervals.

Table 2. Clipping yields of 'De Anza' zoysiagrass by mowing heights and vertical mowing frequency (1996).

	Dry wt oz/10 ft^2							
Treatment	Apr	May	Jun	Jul	Aug	Sep	Oct	mean
Mow Ht.(in)								
0.4	4.7	5.7	5.4	7.0	5.4	6.2	5.5	5.7
0.5	4.4	6.2	6.1	6.6	6.4	6.4	6.0	6.0
0.75	3.8	6.6	6.5	5.8	6.1	5.9	5.5	5.7
1.24	4.4	5.6	3.9	4.8	5.0	5.1	4.6	4.8
LSD	*0.6*	*0.9*	*0.8*	*1.3*	*2.2*	*1.3*	*0.8*	*0.8*
Vert. Mow*								
V0	4.6	6.2	5.6	6.9	6.7	6.5	5.8	6.1
V1	4.6	6.7	5.0	6.2	6.4	6.2	5.5	5.8
V2	3.8	5.2	4.1	5.0	4.3	4.7	4.9	4.8
LSD	*0.6*	*0.5*	*1.7*	*1.0*	*1.3*	*1.0*	*0.6*	*0.5*

* VO = No vertical mowing;
V1 = One vertical mowing in May;
V2 = Four vertical mowings @ 5 week intervals

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Vertical mowing treatments reduced 'De Anza' zoysiagrass clipping yields in each year. As vertical mowing frequency increased, clipping yield decreased (Table 1 and Table 2). Thatch thickness increased with increased mowing height (Table 3). Vertical mowing once per season did not significantly reduce thatch. Repeated vertical mowing reduced thatch of 'De Anza' by 11%. Sponginess as measured by Clegg Impact Tester was not significantly affected by mowing height in July, decreasing by 11% in October with 0.4 in. mowing height compared to 1.25 in. (Table 4). Repeated vertical mowing reduced sponginess and increased firmness by 16% in the summer and by 34% in the fall.

Table 3. Thatch thickness of 'De Anza' zoysiagrass by mowing height and vertical mowing frequency (summer 1996).

Treatment	Thatch (in)
Mow Ht.(in)	
0.4	1.0
0.5	1.1
0.75	1.2
1.25	1.3
LSD	*0.1*
Vert. Mow*	
V0	1.2
V1	1.2
V2	1.1
LSD	*0.1*

* VO = No vertical mowing;
V1 = One vertical mowing in May;
V2 = Four vertical mowings @ 5 week intervals.

Table 4. Clegg Impact Test of 'De Anza' zoysiagrass by mowing height and vertical mowing frequency (1996).

	gMax	
Treatment	July	Oct
Mow Ht.(in)		
0.4	19.6	18.9
0.5	20.3	18.8
0.75	18.8	17.0
1.25	19.3	17.1
LSD	*1.5*	*1.7*
Vert. Mow*		
V0	17.9	15.9
V1	19.9	16.7
V2	20.7	21.3
LSD	*1.5*	*1.4*

* VO = No vertical mowing;
V1 = One vertical mowing in May;
V2 = Four vertical mowings @ 5 week intervals.

'Victoria' ZOYSIAGRASS

Visual turf quality of 'Victoria' zoysiagrass was generally indistinguishable between treatments throughout generally rated at 7.3 to 7.5 on a 1 to 9 scale with 9 best. Vertical mowing treatments were apparent for one to three weeks. 'Victoria' zoysiagrass clipping yields the first year indicated that the mowing height range of 0.5 in to 0.75 in. was the optimum level for clipping yield in the warm summer months with the range extending in the fall (Table 5). In the second year, the 0.75 in. mowing height tended to yield highest (Table 6).

Vertical mowing treatments reduced 'Victoria' zoysiagrass clipping yields in each year. As vertical mowing frequency increased, clipping yield decreased (Table 5 and Table 6). Thatch thickness decreased 26 % as mowing height decreased from 1.25 in. to 0.4 in. (Table 7). Vertical mowing once per season did not significantly reduce thatch. Repeated vertical

Table 5. Clipping yields of 'Victoria' zoysiagrass by mowing heights and vertical mowing frequency (1995).

	Dry wt oz/10 ft^2				
Treatment	Jul	Aug	Sep	Oct	mean
Mow Ht.(in)					
0.4	3.5	5.9	6.4	2.6	4.7
0.5	6.7	7.8	6.8	2.2	6.2
0.75	6.1	6.7	6.4	2.8	5.7
1.25	4.1	6.4	6.2	1.8	4.8
LSD	*0.7*	*0.6*	*0.7*	*0.4*	*0.4*
Vert. Mow*					
V0	6.7	8.5	7.5	3.0	6.8
V1	5.6	6.3	6.4	2.3	4.9
V2	4.6	5.3	5.4	1.8	4.4
LSD	*1.1*	*2.0*	*1.1*	*0.7*	*1.2*

* VO = No vertical mowing;
V1 = One vertical mowing in June;
V2 = Three vertical mowings @ 6 week intervals.

Table 6. Clipping yields of Victoria zoysiagrass mowing heights and vertical mowing frequency (1996).

	Dry wt oz/10 ft^2							
Treatment	Apr	May	Jun	Jul	Aug	Sep	Oct	mean
Mow Ht.(in)								
0.4	4.8	5.0	6.2	8.4	7.8	7.2	3.7	6.0
0.5	4.5	5.8	6.4	7.9	8.0	7.5	3.8	6.1
0.75	4.8	5.5	7.0	7.9	9.4	7.8	4.3	6.3
1.25	4.5	6.2	4.6	7.1	8.2	7.2	4.3	5.9
LSD	*0.8*	*0.8*	*0.8*	*0.9*	*2.2*	*1.6*	*0.8*	*0.6*
Vert. Mow*								
V0	5.2	6.2	7.2	9.1	9.9	8.8	4.8	7.0
V1	4.8	5.9	5.3	7.6	8.8	7.5	4.1	6.1
V2	4.0	4.7	5.6	6.8	6.3	6.0	3.2	5.1
LSD	*1.0*	*0.8*	*1.9*	*2.4*	*2.4*	*1.5*	*1.1*	*1.2*

* VO = No vertical mowing;
V1 = One vertical mowing in May;
V2 = Four vertical mowings @ 5 week intervals.

mowing reduced thatch of 'Victoria' by 10%. Sponginess as measured by Clegg Impact Tester was not significantly affected by mowing height in July with a decrease in sponginess and an increase in firmness of 11% in October (Table 8). Repeated vertical mowing reduced sponginess and increased firmness 8% in summer to 19% by fall.

Conclusions

'De Anza' zoysiagrass performed well at a mowing height range of 0.4 to 1.25 in. Maximum clipping yields were at the mowing height range of 0.4 to 0.75 in. 'De Anza' thatch and sponginess is controlled by mowing height and vertical mowing, with vertical mowing having the greater effect. 'Victoria' zoysiagrass performs well at a mowing height range of 0.4 to 1.25 in. Maximum clipping yields were at the mowing height range of 0.5 to 0.75 in. Lower mowing height and vertical mowing act to control thatch with mowing height having more effect than vertical mowing.

Table 7. Thatch thickness of 'Victoria' zoysiagrass by mowing height and vertical mowing frequency (Summer, 1996).

Treatment	Thatch (in)
Mow Ht.(in)	
0.4	1.0
0.5	1.1
0.75	1.2
1.25	1.3
LSD	*0.1*
Vert. Mow*	
V0	1.2
V1	1.1
V2	1.1
LSD	*0.1*

* VO = No vertical mowing;
V1 = One vertical mowing in May
V2 = Four vertical mowings @ 5 week intervals.

Table 8. Clegg Impact Tester of 'Victoria' zoysiagrass by mowing height and vertical mowing frequency (1996).

	gMax	
Treatment	July	Oct
Mow Ht.(in)		
0.4	5.7	6.8
0.5	5.3	6.2
0.75	5.4	6.3
1.25	5.9	6.2
LSD	*0.4*	*0.4*
Vert. Mow*		
V0	5.4	6.0
V1	5.6	6.1
V2	5.8	7.1
LSD	*0.3*	*0.4*

* VO = No vertical mowing;
V1= One vertical mowing in May;
V2 = Four vertical mowings @ 5 week intervals.

Zoysiagrass Cultivar and Experimental Line Dry-Down as a Method of Water Conservation

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Because of the long-term California issue of water availability, one aspect of turfgrass species selection relates to plant water requirement/irrigation management, and possible water conservation opportunities that may exist through species and cultivar selection (Sifers et al., 1990). In that regard, it was the objective of this study to evaluate the tolerance of zoysiagrass cultivars and experimental lines to a summer dry-down treatment as a possible emergency water conservation practice

Methods

The study was conducted at the University of California South Coast Research and Extension Center in Irvine, California. The site has a maritime climate. The 24 cultivars and experimental lines of zoysiagrass, as given in the Tables, were vegetatively established in June 1992, to plots 36 ft^2 in size. Each grass was replicated three times and arranged in a randomized complete block design. The research area was

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Table 1. Rate of green color loss for zoysiagrass in 1996 and 1997 (July 1 – Sept. 30). Presented as regression analysis of color scores during dry-down (no irrigation).

Cultivar / Line	1996* Color Loss (Slowest To Quickest)		1997* Color Loss	
Diamond	-0.9	a**	-2.6	abcd
Emerald	-1.3	ab	-2.4	abc
DALZ 8701	-2.1	abc	-3.0	bcde
Palisades	-3.0	bcd	-4.4	fghij
Crowne	-3.1	bcd	-2.4	ab
El Toro	-3.9	cde	-3.3	bcdef
Cavalier	-4.6	def	-2.9	abcd
TGS-B10	-5.1	ef	-5.4	j
DALZ 8516	-5.2	efg	-3.1	bcde
Z88-3	-5.7	efgh	-1.9	a
TGS-W10	-5.9	fghi	-5.1	ij
JZ-1	-7.1	ghij	-4.3	fghi
CD 259-13	-7.3	hij	-7.2	k
Victoria	-7.4	hijk	-2.5	abc
TC 5018	-7.5	hijk	-5.1	hij
DALZ 8501	-7.6	hijk	-4.6	ghij
DALZ 8508	-7.7	ijk	-3.5	cdef
Royal	-8.8	jk	-3.6	defg
Marquis	-9.3	k	-4.0	efgh
Sunburst	-11.3	l	-5.1	ij
GT 2047	-12.0	l	-8.2	k
Meyer	-12.2	l	-5.2	ij
GT 2004	-14.2	m	-7.4	k
Omni	-18.3	n	-7.3	k

*Correlation between years r = 0.727.
**Fisher's protected LSD, P = 0.05; regression coefficients with no letter(s) in common are significantly different.

mowed twice weekly, when needed, at 0.75 in. with a reel mower; it was fertilized with 3.0 lb N/1000 ft^2 per year, with applications of 0.5 lb N/1000 ft^2 per month in February, April, June, August, October and December. During the dry-down period, the area was mowed as needed and no N was applied for the August treatment.

From the time of sward maturation, the study area was irrigated based on calculated evapotranspiration from an automated weather station, adjusted for monthly warm-season turfgrass crop coefficients and for the distribution uniformity of the study area. In June 1996 and 1997, the study area was irrigated at 125% of irrigation requirement to ensure uniform soil moisture throughout the profile. Irrigation was withheld between July 1 and October 1 for 1996 and 1997.

On at least a weekly basis, visual color ratings were taken as an indication of dehydration response. A 1-9 scale was used with 1 representing no green color and 9 representing maximum green color of the desired grass. Quality ratings, which is a visual summary of color, texture, density, uniformity and pest activity, used a 1-9 scale, with 1 representing dead turf and 9 representing the best performance for the grass. Percent weed encroachment was

Table 2. Final ranking on Dec. 1, 1997, (after two summers of imposed drought) of zoysiagrass cultivars/ experimental lines for color[1], quality[2], and percent weeds[3].

Cultivar / Line	Color	Quality	Percent Weeds
Crowne	7.0	5.7 a	1.7 e
Z88-3	7.0	5.0 ab	24.0 cde
El Toro	7.0	4.8 abc	1.7 e
Palisades	7.0	4.2 abc	7.3 de
Cavalier	6.3	4.2 abc	20.7 cde
Diamond	6.2	4.2 abc	12.7 de
Victoria	7.0	3.8 bc	48.3 bc
DALZ 8701	6.3	3.5 bcd	4.7 e
Emerald	6.5	3.3 cd	21.7 cde
DALZ 8516	7.0	3.3 cd	36.7 cd
Marquis	6.7	2.0 de	73.3 ab
TGS W-10	7.0	2.0 de	67.7 ab
TC 5018	7.0	1.7 e	83.3 a
CD 259-13	7.0	1.7 e	88.3 a
TGS B-10	7.0	1.7 e	81.7 a
DALZ 8501	6.7	1.7 e	80.0 a
DALZ 8508	7.0	1.3 e	81.7 a
Royal	7.0	1.3 e	71.7 ab
QT 2047	7.0	1.0 e	93.3 a
Omni	7.0	1.0 e	90.0 a
QT 2004	5.0	1.0 e	95.0 a
JZ-1	7.0	1.0 e	87.7 a
Meyer	5.0	1.0 e	93.3 a
Sunburst	7.0	1.0 e	95.0 a
	N.S.[4]		

[1] Color: 1 – 9 Visual Rating; 9 = Dark Green.
[2] Quality: 1 – 9 Visual Rating; 1 = Dead, 9 = Excellent Grass Color, Texture, Density, Uniformity.
[3] Percent Weeds: Percent Area Covered.
[4] N.S.: Not Significantly Different.

recorded as percent area covered with creeping woodsorrel (*Oxalis corniculata* L.) and annual bluegrass (*Poa annua* L.) being the weeds present.

Data were separated into three phases: (1) spring recovery (19 Feb. - 27 June 1997); (2) dry-down (5 July -30 Sept., 1996, and 3 July - 26 Sept., 1997); and (3) fall recovery (1 Oct. -14 Dec., 1996, and Oct. 3 - 1 Dec., 1997). A split block analysis of variance was run for each phase, each year, with grass and date as the treatment factors. Color scores were analyzed each year. Quality score and percent weeds were analyzed for 1997. To study patterns over time, the mean color score, quality score, and percent weeds on each date were regressed against day for each variety within each phase, each year. Regressions with an exponential term were fitted using non-linear regression in SAS, while others were fitted with multiple regression. Additionally, final color and quality scores as well as percent weeds, all recorded December 1, 1997, were analyzed by randomized complete block analysis of variance (Fisher's Protected LSD Test).

Results

The results are presented in Tables 1 and 2.

It was found that:

- Those grasses that lost color the slowest (or avoided dehydration the best) the first year were those grasses that recovered the quickest (or resisted drought the best) when irrigation was reinstated on October 1. See Table 1. Slow color loss was noted with 'Diamond', 'Emerald', DALZ 8701, 'Palisades', 'Crowne', and 'El Toro'. In contrast, grasses that did not avoid dehydration and lost color very rapidly included 'Omni', GT 2004, 'Meyer', GT 2047, and 'Marquis'.
- Grass color loss in 1997 was moderately correlated to the color loss noted in 1996 (r = 0.727). See Table 1.
- Those grasses that recovered quickly following the first year dry-down resulted in the highest quality and lowest percent weeds on July 3, 1997, at the time of initiation of the second dry-down treatment. Those grasses that were slow to recover were invaded by creeping woodsorrel and annual bluegrass and were of varying degrees of poor quality at the commencement of the second dry-down cycle.

- Following the second dry-down cycle and reinstatement of irrigation on October 1, 1997, ratings from December 1, 1997 are presented in Table 2 and give the final grass color, sward quality and percent weeds. 'Crowne' zoysiagrass was highest ranked for quality, followed by Z 88-3, 'El Toro', 'Palisades', 'Cavalier', and 'Diamond'. Many of the other cultivars were highly dominated by unwanted vegetation at the conclusion of this study.

Conclusions

Those grasses that had the best ability to avoid or postpone dehydration were those grasses that showed the best recovery and resisted the severe drought regime imposed in this study. Also, reduced sward quality and weed presence were highly associated with the poor dehydration avoidance.

This study confirmed that there is a large variation in drought resistance within the zoysiagrass genus, as represented by the grasses in this study. Future work should continue to focus on the plant mechanisms involved in this resistance, on plant improvement that incorporates those mechanisms, and on further understanding of cultural practices for resource conservation and economic savings.

Literature Cited

S.I. Sifers, J.B. Beard, and M.H. Hall. 1990. Comparative Dehydration Avoidance and Drought Resistance Among Major Warm-Season Turfgrass Species and Cultivars. Texas Turfgrass Research PR 4749: 37-40.

Zoysiagrass Cultivar Performance

Victor A. Gibeault[1], Stephen T. Cockerham[2], and Richard Autio[1]

The selection of the turfgrass species, or the mix of species and the selection of the cultivar or blend of cultivars, to be established is one of the most important decisions that must be made for a new or reestablished turfed site. Strongly influencing the decision are issues such as the use the facility will receive, the environmental conditions of the site, and the level of maintenance that will be practiced. Characteristics such as heat and drought tolerance, recovery from wear, shade and salinity tolerance, as well as mowing height adaptation, establishment rate and leaf blade texture are examples of considerations leading to the selection of a grass for a given site. Cultivar selection of the chosen species is based on the grass performance in an area, with performance including characteristics such as color, texture, density, uniformity and pest resistance.

Reported in this article are the performance characteristics of zoysiagrass cultivars and experimental lines from a cooperative study with the National Turfgrass Evaluation Program (NTEP) and the University of California Riverside Turfgrass Project. NTEP provides leadership in turfgrass evaluation and improvement by linking the public and private sectors of the industry through their common goals of grass development, improvement and evaluation. In California,

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Table 1. Zoysiagrass quality, genetic color, winter color, and winter kill at UC Riverside (UCR) and the NTEP National summary means, 1997-2000. Ratings are based on a 1-9 scale with 9 best. Winter kill is percentage of plot affected.

Grass	Quality		Genetic Color		Winter Color		Winter Kill (%)	
Seeded	UCR	Mean	UCR	Mean	UCR	Mean	UCR	Mean
ZEN-500	5.2	5.2	7.2	6.3	1.0	2.3	--	6.7
Zemth	5.1	5.3	7.3	6.5	1.0	2.2	--	16.7
J-37	4.8	5.5	7.0	6.1	1.0	2.2	--	26.7
ZEN-400	4.8	5.5	6.8	5.9	1.0	1.8	--	8.3
I-36	--	5.3	--	6.1	--	2.3	--	18.3
Chinese Common	4.6	5.1	7.0	6.1	1.0	1.7	--	0.0
Z-18	4.2	4.0	5.9	5.1	4.2	2.4	--	99.0
Korean Common	4.0	4.2	6.4	5.8	1.0	1.7	--	75.0
LSD	*0.4*	*0.2*	*0.7*	*0.2*	*0.2*	*0.4*	--	
Vegetative								
Victoria	6.6	5.6	7.3	5.7	5.7	4.1	--	99.0
De Anza	6.4	5.5	7.4	5.8	6.0	3.9	--	99.0
Zorro	6.1	6.4	7.4	6.3	4.6	3.6	--	99.0
Zeon	5.9	6.2	7.2	6.1	4.8	3.8	--	99.0
Emerald	5.8	6.4	7.6	6.5	2.0	3.5	--	99.0
El Toro	5.6	6.1	7.2	6.3	1.8	2.7	--	86.3
Jamur	5.6	6.0	7.4	6.2	1.4	2.5	--	99.0
Miyako	4.9	5.4	6.8	5.3	4.3	3.7	--	99.0
HT-210	4.9	5.1	7.1	5.6	5.4	3.3	--	99.0
J-14	4.7	5.6	6.6	6.1	1.0	2.3	--	48.3
Meyer	4.4	5.4	7.8	6.7	1.0	2.4	--	65.7
LSD	*0.5*	*0.2*	*0.6*	*0.3*	*0.7*	*0.5*	--	*9.2*

NTEP studies of the commonly used warm- and cool-season turfgrass species are conducted at the UC Riverside Turfgrass Research Facility, at the UC South Coast Research and Extension Center in Irvine, and in the greater San Francisco Bay area.

Methods

The zoysiagrass study was established on July 29, 1996, at UC Riverside. The same grasses were established at a total of 17 locations in southern and transitional states. At Riverside, the 5ft x 6ft plots were arranged in a randomized complete block design and there were three replications for each grass. Vegetative cultivars were planted from 2-inch plugs on 1 ft centers. Seeded cultivars were seeded at the rate of 1 lb/1000 ft^2. When mature, the grasses were mowed at 5/8 inch with a reel mower twice weekly during the growing season and once a week after that. Nitrogen was applied at the rate of 4 lb N/1000 ft^2 per year, with individual applications being made at 1 lb N/1000 ft^2 for the months of March, May, July, and September. Irrigation was supplied throughout the study according to calculated water use from the California Irrigation Management Information System (CIMIS), to prevent stress.

Ratings were made on a monthly basis following NTEP protocol. Quality, which integrated all aspects of turfgrass quality, was on a 1-9 scale, with 9 best. This single measurement included the desirability of color, texture, density, uniformity and pest activity or resistance. Genetic color reflected inherent color of the genotype when not under stress, with a 1-9 scale, 9 being dark green. Winter color ratings, taken at 10 test locations in southern states, was also rated on a 1-9 scale with 9 being dark green. Percent winter kill was recorded at the Kentucky test location. Data was collected monthly for the calendar years of 1997-2000. Cultivar differences are based on use of Least Significant Difference (LSD) statistics for mean separation. The LSD value is located at the bottom of the tables. To determine whether a cultivar's performance is different from another, subtract one entry's mean from another entry's mean. If this value is larger that the LSD value, the observed difference in cultivar performance is significant and did not happen by chance.

Results

The results in Table 1, which are averages from four years of data collected, are presented based on quality performance in California. Both California and national mean averages are given for each of the four characteristics of interest. The quality and genetic color are descriptive of cultivar/experimental line performance. Note that winter color varies considerably, among the grasses, with some holding color during winter months better than others. Also, many grasses had serious winter kill in Kentucky where that data was collected. While not a consideration for California turfgrass selection and use, it is a limiting factor regarding the use of some zoysiagrass cultivars/experimental lines in areas with low winter temperatures.

For more detailed information on the results of this study visit the NTEP website at: www.ntep.org.

U C T U R F C O R N E R

UC Turf Corner contains summaries of recently reported research result, abstracts of certain conference presentations and announcements of new turf management publications.

Turf Protects the Environment, Benefits Health

(From "Better Turf Thru Agronomics", December 2002)

Turf has a multifacted story that we need to tell. The scientific research finding in the literature are compelling. As examples, turf reduces runoff and soil erosion, protects groundwater and surface water quality, and is linked to decomposition of polluting organic chemicals, benefiting human health. Other functional benefits of turf include heat dissipation (which reduces energy required to cool nearby homes and buildings), noise abatement and glare reduction, and fire hazard reduction.

Turfgrasses can offer a low-cost, safe surface for outdoor leisure activities and recreational sports. Recreation on turf surfaces improves physical and mental health, relieves stress, and contributes to enjoyment of life, all of which are vital to the quality of life in contempory society.

Lastly, it is being shown that a beautiful lawn or golf course enhances the quality of life because of its aesthetic appeal and verifiable health benefits. Views of open green space promote quicker recovery from experimentally induced stress when compared to busy mall scenes. Hospital patients who were provided an outdoor view of nature recovered more quickly and required fewer, less potent analgesics than patients whose rooms viewed a hospital wing. Also, it has been shown that attention to roadside aesthetics can reduce commuter stress.

A New Publication Available

"Turfgrass Traffic and Compaction: Problems and Solutions" has recently been released by the University of California Division of Agriculture and Natural Resources. Written by Dr. Ali Harivandi, UC Cooperative Extension Environmental Horticulture Advisor in Alameda, Contra Costa and Santa Clara Counties, the new release, Publication 8080, can be ordered from the UC publication catalogue or visit the online catalogue at http://anrcatalog.ucdavis.edu. An electronic version is available at the DANR Communication Services website at the same address.

UC Riverside Turf Website Launched

The UCR Turfgrass Research Program has unveiled its new website: http://ucrturf.ucr.edu It's loaded with meaty information strategically organized for turf professionals and the general public. The website was designed as a multi-linked, user-friendly communication vehicle.

Last Issue of California Turfgrass Culture in Present Format

California Turfgrass Culture was first issued on January 1, 1951, with Volume 1, Number 1. A four page newsletter, it was designed "for the dissemination of information on turf culture. We hope it will contribute to the development of better turf in Southern California." In its 53 years of distribution we, at the University of California, hope that it has been successful in its purpose. This issue will be the last in the present format of "The Culture." While the future of the publication and its format is uncertain at the present time, all past issues can be accessed at the UCR Turf Webside at http://ucrturf.ucr.edu and also at the Ornamental Horticulture Research and Information Center at UC Davis. The site address is http://ohric.ucdavis.edu.

V.A. Gibeault, September 19, 2003

WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in their original labeled containers in a locked cabinet or shed, away from food or feeds and out of the reach of children, unauthorized persons, pets, and livestock.

Recommendations are based on the best information currently available, and treatments based on them should not leave residues exceeding the tolerance established for any particular chemical. Confine chemicals to the area being treated. THE GROWER IS LEGALLY RESPONSIBLE for residues on his crops as well as for problems caused by drift from his property to other properties or crops.

Consult your County Agricultural Commissioner for correct methods of disposing of leftover spray material and empty containers. **Never burn pesticide containers.**

PHYTOTOXICITY: Certain Chemicals may cause plant injury if used at the wrong stage of plant development or when temperatures are too high. Injury may also result from excessive amounts of the wrong formulation or from mixing incompatible materials. Inert ingredients, such as wetters, spreaders, emulsifiers, diluents and solvents, can cause plant injury. Since formulations are often changed by manufacturers, it is possible that plant injury may occur, even though no injury was noted in previous seasons.

NOTE: Progress reports give experimental data that should not be considered as recommendations for use. Until the products and the uses given appear on a registered pesticide label or other legal, supplementary direction for use, it is illegal to use the chemicals as described.

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