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Seeded Bermudagrass Fall Color Retention

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Introduction

Seeded and vegetative turfgrass bermudagrasses (*Cynodon* spp) are commonly used in Southern California because they are well adapted to the region. They are tough grasses that recover from traffic injury quickly during the seasons of their growth. Growth slows and ultimately stops in late fall and winter and plant dormancy results in most locations. If used intensely for recreational purposes during the winter season, bermudagrass fields are worn and can be severely damaged due to the lack of recuperative ability.

Chilling temperatures that characterize Southern California during the late fall and winter interact with high light intensity and result in a loss of chlorophyll causing the dormancy. 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, when they once again regreen. Normally, the winter temperatures in Southern California are very close to threshold temperatures that cause chlorophyll degradation so plant selection and culture can influence the presence and degree of dormancy.

It was the objective of this project to examine cultural programs that reduce/postpone dormancy, or turfgrass color loss, of three seeded bermudagrasses during the late fall and winter in Riverside, California.

Methods

The two-year study was initiated on August 21, 1998, on well-established swards of three seeded bermudagrass (*Cynodon dactylon* (L.) Pers.) cultivars, Princess, FMC 6 (Sultan brand), and NuMex Sahara. NuMex Sahara and FMC 6 (Sultan brand) are multiclone synthetic cultivars, while Princess is a F1 intraspecific hybrid. One morphological difference among these cultivars is turf density: Numex Sahara is least dense, FMC6 (Sultan brand) is intermediate, and Princess is most dense.

The location of the trial was the University of California Riverside Turfgrass Research Facility. Studied were two nutrients, N and Fe, and a cultivation treatment of vertical mowing. The treatments, as detailed in the accompanying tables, were arranged in a split-block design with the nutritional treatments being main plots. Each treatment was replicated three times. The same treatments were applied to each grass.

Vertical mowing treatments were accomplished with a single pass of a Ryan Ren-O-Thin set to cultivate to the soil surface, but not into the soil profile. Vertical mowing was performed on August 19 or October 5, 1998, and August 11 or October 12, 1999. A control plot received no cultivation treatment. Fertility treatments were applied with a Gandy drop spreader.

Throughout the study, the test area was irrigated to prevent plant stress, with moisture being replaced based on water use determined by the California Irrigation Management Information System (CIMIS) adjusted by monthly crop coefficients for warm-season turfgrasses. The grasses were mowed twice each week (until growth slowed in October, when weekly mowing was performed) at 1.6 cm with a Jacobsen Greens King three-reel mower.

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Data collected that is presented here included visual ratings of turfgrass color and quality. Color and quality ratings were on a 1 – 9 scale with 9 being the deepest green color and best quality. Quality ratings would be a turf score that would account for color, texture, density, uniformity, and presence or absence of pest activity. Color and quality data were taken on a weekly basis throughout the summer/fall/early winter in both years. All data were subjected to an ANOVA with significant differences indicated in the tables presented.

Results

The results are presented in Tables 1-6. Table 7 provides weekly soil temperatures for each year, August through December.

For reporting periods within the fall/early winter seasons for both years, the results are presented based on a study of the SAS printout shown as scatter plots over time. It was then

Table 1. Princess bermudagrass *color* (1-9, 9 = deep green) at three time periods for 1998 and 1999, and for the overall average (1998 and 1999).

Treatments			1998			1999			Average		
$CaNO_3$	Fe	Mow	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.
		a	7.4	6.3a	3.5	5.8	5.0	3.0	6.6	5.6	3.2
		b	7.4	5.5 b	2.8	5.8	5.0	3.0	6.6	5.2	2.9
		c	7.4	6.1ab	3.1	5.7	4.9	2.9	6.6	5.5	3.0
			ns	*	ns	ns	ns	ns	ns	ns	ns
	0		7.4	5.8 b	3.0	5.8	4.9	3.0	6.6	5.3 b	3.0
	3		7.4	5.8 b	3.0	5.7	4.9	2.9	6.5	5.4 b	3.0
	4		7.4	6.3a	3.4	5.8	5.0	3.0	6.6	5.7a	3.2
			ns	**	ns	ns	ns	ns	ns	**	ns
0			7.0 c	4.9 c	2.2 b	4.2 c	3.1 c	1.0 c	5.6 c	4.0 c	1.6 c
1			7.9a	7.1a	4.5a	7.0a	6.6a	4.7a	7.4a	6.8a	4.6a
2			7.3 b	5.9 b	2.7 b	6.0 b	5.3 b	3.2 b	6.7 b	5.6 b	3.0 b
			***	***	***	***	***	***	***	***	***
Interaction $CaNO_3$ x Mow											
0		a	7.0	5.3a	2.4	4.2	3.1	1.0	5.6	4.2	1.7
0		b	7.0	4.4 b	1.9	4.3	3.0	1.0	5.6	3.7	1.5
0		c	7.0	5.0a	2.1	4.2	3.1	1.0	5.6	4.0	1.6
1		a	7.9	7.2a	4.8	7.0	6.6	4.8	7.4	6.9	4.8
1		b	7.9	6.8a	4.2	7.0	6.6	4.7	7.4	6.7	4.4
1		c	7.9	7.1a	4.5	7.0	6.5	4.7	7.4	6.8	4.6
2		a	7.3	6.4a	3.2	6.1	5.3	3.2	6.7	5.8	3.2
2		b	7.3	5.2 b	2.1	6.0	5.3	3.3	6.7	5.3	2.7
2		c	7.3	6.1a	2.8	6.0	5.3	3.2	6.7	5.7	3.0
			ns	*	ns	ns	ns	ns	ns	ns	ns

Treatments:

$CaNO_3$	Fe	Mow
0 = no calcium nitrate	0 = no iron	a = vertical mow summer
1 = calcium nitrate 1#N/M/mo.	3 = 2 oz. Fe/M/mo.	b = vertical mow fall
2 = calcium nitrate 1#N/M/2 mo.	4 = 4 oz. Fe/M/mo.	c = no vertical mow

ns, *, **, *** = not significant, $P \leq 0.05$, 0.01, 0.001, respectively.
Main effect means with no letter(s) in common are significantly different on Fisher's Protected LSD Test at P = 0.05. Mowing effects for each level of calcium nitrate tested only if the interaction was significant. LSD test of mowing at each level of calcium nitrate.

Table 2. NuMex Sahara bermudagrass *color* (1-9, 9 = deep green) at three time periods for 1998 and 1999, and for the overall average (1998 and 1999).

Treatments			1998			1999			Average		
$CaNO_3$	Fe	Mow	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.
		a	7.2	6.2	2.3	5.9	4.7	2.4	6.6	5.5	2.4
		b	7.1	5.7	2.3	5.8	4.6	2.2	6.5	5.2	2.3
		c	7.2	5.9	2.2	5.9	4.6	2.1	6.6	5.3	2.2
			ns	ns	ns	ns	ns	ns	ns	ns	ns
	0		7.2	5.8	2.1	6.0	4.7	2.4	6.6	5.2	2.2
	3		7.2	5.9	2.5	5.8	4.5	2.1	6.6	5.3	2.4
	4		7.2	6.1	2.3	5.8	4.6	2.2	6.6	5.4	2.3
			ns	ns	ns	ns	ns	ns	ns	ns	ns
0			6.9 c	4.5 c	1.4 c	4.7 c	3.0 b	1.1 b	5.7 c	3.7 c	1.3 c
1			7.5 a	7.0a	3.5a	6.8a	5.4a	2.9a	7.1a	6.2a	3.2a
2			7.1 b	5.9 b	1.8 b	6.1 b	5.4a	2.7a	6.6 b	5.6 b	2.2 b
			***	***	***	***	***	***	***	***	***
Interaction $CaNO_3$ x Mow											
0		a	6.9	4.9	1.4	4.8	3.0a	1.1a	5.8	4.0	1.3a
0		b	6.8	4.0	1.4	4.7	3.0a	1.1a	5.7	3.5	1.3a
0		c	6.9	4.4	1.4	4.7	3.0a	1.1a	5.7	3.7	1.3a
1		a	7.5	7.1	3.5	6.8	5.6a	3.2a	7.2	6.3	3.3a
1		b	7.5	6.9	3.5	6.6	5.3 b	2.8 b	7.1	6.1	3.1 b
1		c	7.5	7.0	3.4	6.8	5.4 b	2.8 b	7.1	6.2	3.1 b
2		a	7.1	6.2	1.9	6.2	5.4a	2.9a	6.7	5.8	2.4a
2		b	7.0	5.7	1.8	6.1	5.4a	2.7a	6.6	5.6	2.3a
2		c	7.1	5.9	1.7	6.1	5.3a	2.4 b	6.6	5.6	2.1 b
			ns	ns	ns	ns	*	**	ns	ns	***

Treatments:

$CaNO_3$	Fe	Mow
0 = no calcium nitrate	0 = no iron	a = vertical mow summer
1 = calcium nitrate 1#N/M/mo.	3 = 2 oz. Fe/M/mo.	b = vertical mow fall
2 = calcium nitrate 1#N/M/2 mo.	4 = 4 oz. Fe/M/mo.	c = no vertical mow

ns, *, **, *** = not significant, $P \leq 0.05$, 0.01, 0.001, respectively.
Main effect means with no letter(s) in common are significantly different on Fisher's Protected LSD Test at P = 0.05. Mowing effects for each level of calcium nitrate tested only if the interaction was significant. LSD test of mowing at each level of calcium nitrate.

decided to use September 2 - October 27 for the high plateau time (best color); November 3 - December 8 for the decline time; and December 15 and 23 for the low (greatest color loss at a plateau) time. There was also a statistical and graphical examination of the feasibility of averaging results across the two study years by the statistician. It was determined that averaging could be validated. The two years and the average across the two years results are given based on this format of analysis and reporting times.

The color of the three bermudagrass cultivars for the duration of the study are presented in Tables 1, 2, and 3. The cultivar color closely tracked the late fall soil temperatures at Riverside as presented in Table 7. Color declined for all grasses starting in early November through the first week of December. As soil temperatures moved to the 50-52°F level, the greatest color loss was observed. Because of the plot layout, statistical comparisons among the three grasses regarding color loss or retention cannot be made, but the

Table 3. FMC 6 (Sultan brand) bermudagrass *color* (1-9, 9 = deep green) at three time periods for 1998 and 1999, and for the overall average (1998 and 1999).

Treatments			1998			1999			Average		
$CaNO_3$	Fe	Mow	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.
		a	7.2a	4.5a	1.8a	5.4	4.1	1.9	6.3	4.3a	1.9
		b	6.9 b	3.1 b	1.4 b	5.3	4.1	1.9	6.1	3.6 b	1.7
		c	7.1a	4.3a	1.8a	5.4	4.1	1.9	6.3	4.2a	1.8
			*	*	*	ns	ns	ns	ns	*	ns
	0		7.0	3.9	1.6	5.4	4.2	1.9	6.2	4.0	1.8
	3		7.1	4.0	1.7	5.3	4.0	1.9	6.2	4.0	1.8
	4		7.1	4.1	1.7	5.3	4.2	1.9	6.2	4.1	1.8
			ns	ns	ns	ns	ns	ns	ns	ns	ns
0			6.4 c	2.7 c	1.1 b	4.0 c	2.5 b	1.0 b	5.2 c	2.6 c	1.1 c
1			7.8a	5.6a	2.6a	6.3a	4.9a	2.4a	7.1a	5.3a	2.5a
2			7.0 b	3.6 b	1.3 b	5.7 b	4.9a	2.3a	6.3 b	4.3 b	1.8 b
			***	***	***	***	***	***	***	***	***
Interaction $CaNO_3$ x Mow											
0		a	6.5a	3.0a	1.2	4.0a	2.5	1.0	5.2 b	2.8a	1.1
0		b	6.2 b	2.1 b	1.0	3.8 b	2.5	1.0	5.0 c	2.3 b	1.0
0		c	6.4a	2.9a	1.2	4.1a	2.6	1.0	5.3a	2.7a	1.1
1		a	7.8a	6.1a	2.8	6.4a	4.9	2.4	7.1a	5.5a	2.6
1		b	7.7a	4.9 b	2.3	6.3 b	4.9	2.4	7.0 b	4.9 b	2.4
1		c	7.8a	5.9a	2.7	6.3 b	4.9	2.4	7.1a	5.4a	2.5
2		a	7.1a	4.4a	1.4	5.7a	5.0	2.3	6.4a	4.7a	1.9
2		b	6.7 b	2.4 b	1.0	5.7a	4.9	2.3	6.2 b	3.7 b	1.6
2		c	7.1a	4.1a	1.4	5.7a	5.0	2.3	6.4a	4.5a	1.9
			***	**	ns	***	ns	ns	**	**	ns

Treatments:

$CaNO_3$	Fe	Mow
0 = no calcium nitrate	0 = no iron	a = vertical mow summer
1 = calcium nitrate 1#N/M/mo.	3 = 2 oz. Fe/M/mo.	b = vertical mow fall
2 = calcium nitrate 1#N/M/2 mo.	4 = 4 oz. Fe/M/mo.	c = no vertical mow

ns, *, **, *** = not significant, $P \leq 0.05$, 0.01, 0.001, respectively.
Main effect means with no letter(s) in common are significantly different on Fisher's Protected LSD Test at P = 0.05. Mowing effects for each level of calcium nitrate tested only if the interaction was significant. LSD test of mowing at each level of calcium nitrate.

Table 4. Princess bermudagrass *quality* (1-9, 9 = best) at three time periods for 1998 and 1999, and for the overall average (1998 and 1999).

Treatments			1998			1999			Average		
$CaNO_3$	Fe	Mow	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.
		a	6.2a	4.6a	4.3	5.3	5.1	4.5	5.7a	4.8	4.4
		b	4.0 b	3.4 b	3.5	5.2	5.1	4.5	4.6 b	4.2	4.0
		c	5.8a	4.1ab	3.9	5.2	5.1	4.5	5.5a	4.6	4.2
			**	*	ns	ns	ns	ns	**	ns	ns
	0		5.2	4.0	3.9	5.2	5.1	4.5	5.2	4.6	4.2
	3		5.4	3.9	3.8	5.2	5.2	4.5	5.3	4.5	4.1
	4		5.4	4.1	3.9	5.3	5.1	4.5	5.3	4.6	4.2
			ns	ns	ns	ns	ns	ns	ns	ns	ns
0			5.0 b	3.6 c	3.4 c	4.1 c	4.0 c	4.0 c	4.6 c	3.8 c	3.7 c
1			5.9a	4.4a	4.5a	6.4a	6.2a	4.9a	6.2a	5.3a	4.7a
2			5.1 b	4.0 b	3.7 b	5.2 b	5.1 b	4.5 b	5.1 b	4.6 b	4.1 b
			***	***	***	***	***	***	***	***	***
Interaction $CaNO_3$ x Mow											
0		a	5.9	4.3	3.8	4.0a	4.0	4.0	5.0	4.1	3.9
0		b	3.7	2.9	2.9	4.1a	4.0	4.0	3.9	3.5	3.4
0		c	5.5	3.7	3.4	4.0a	4.0	4.0	4.8	3.8	3.7
1		a	6.7	4.8	5.0	6.5a	6.2	5.0	6.6	5.5	5.0
1		b	4.5	3.9	4.2	6.4a	6.2	4.9	5.5	5.0	4.6
1		c	6.4	4.3	4.4	6.4a	6.2	4.9	6.4	5.3	4.7
2		a	6.1	4.7	4.1	5.2a	5.1	4.5	5.7	4.9	4.3
2		b	3.9	3.3	3.3	5.1a	5.1	4.6	4.5	4.2	3.9
2		c	5.4	4.1	3.8	5.1a	5.1	4.5	5.2	4.6	4.2
			ns	ns	ns	ns	ns	ns	ns	ns	ns

Treatments:

$CaNO_3$	Fe	Mow
0 = no calcium nitrate	0 = no iron	a = vertical mow summer
1 = calcium nitrate 1#N/M/mo.	3 = 2 oz. Fe/M/mo.	b = vertical mow fall
2 = calcium nitrate 1#N/M/2 mo.	4 = 4 oz. Fe/M/mo.	c = no vertical mow

ns, *, **, *** = not significant, $P \leq 0.05$, 0.01, 0.001, respectively.
Main effect means with no letter(s) in common are significantly different on Fisher's Protected LSD Test at P = 0.05. Mowing effects for each level of calcium nitrate tested only if the interaction was significant. LSD test of mowing at each level of calcium nitrate.

relative differences can be noted from the first three tables. N treatments had the most significant impact and most consistent impact on color at all time periods with all grasses, with the results being rate dependent. More N resulted in higher color response during the growing season and, in general, better color retention in the fall. Fe, in contrast, had very little influence on color retention as can be seen by the lack of statistical difference among Fe treatments. An exception is a response of Princess during the fall to the high Fe treatment (see Table 1). The vertical mowing treatments tested did not have a serious influence on color retention, with the October vertical mowing yielding reduced color, especially on FMC 6 (Sultan brand), because of the loss of leaves and the poor recovery from that treatment.

Turfgrass quality results are presented by cultivar in Tables 4, 5, and 6. Like color, quality was primarily influenced by N, with increasing quality noted with the higher N rate. Those

Table 5. NuMex Sahara bermudagrass *quality* (1-9, 9 = best) at three time periods for 1998 and 1999, and for the overall average (1998 and 1999).

Treatments			1998			1999			Average		
$CaNO_3$	Fe	Mow	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.
		a	5.6a	5.3	4.3	5.2	4.7	4.0	5.5a	5.0	4.1
		b	4.1 c	4.6	4.1	5.1	4.6	4.0	4.6 b	4.6	4.1
		c	5.2 b	4.9	4.2	5.2	4.6	4.0	5.2a	4.8	4.1
			***	ns	ns	ns	ns		**	ns	ns
	0		5.0	4.9	4.2	5.3	4.8	4.0	5.1	4.8	4.1
	3		5.1	5.0	4.3	5.1	4.6	4.0	5.1	4.8	4.1
	4		4.8	5.0	4.1	5.1	4.5	4.0	5.1	4.8	4.1
			ns	ns	ns	ns	ns		ns	ns	ns
0			4.8 b	4.0 c	3.8 c	4.2 c	3.9 b	4.0	4.5 c	4.0 c	3.9 c
1			5.3a	5.7a	4.7a	5.9a	5.1a	4.0	5.6a	5.4a	4.4a
2			4.7 b	4.9 b	4.0 b	5.4 b	4.9a	4.0	5.0 b	4.9 b	4.0 b
			***	***	***	***	***		***	***	***
Interaction $CaNO_3$ x Mow											
0		a	5.5	4.5	4.0	4.3	3.9a	4.0	4.9	4.2	4.0
0		b	3.9	3.5	3.6	4.2	3.9a	4.0	4.0	3.7	3.8
0		c	4.9	4.1	3.9	4.2	3.9a	4.0	4.6	4.0	3.9
1		a	6.0	6.0	4.7	6.0	5.2a	4.0	6.0	5.6	4.4
1		b	4.4	5.5	4.7	5.8	5.0 b	4.0	5.1	5.2	4.4
1		c	5.6	5.7	4.7	6.0	5.0 b	4.0	5.8	5.3	4.4
2		a	5.3	5.3	4.1	5.5	4.9a	4.0	5.4	5.1	4.0
2		b	3.9	4.6	3.9	5.3	4.8a	4.0	4.6	4.7	4.0
2		c	4.9	4.8	3.9	5.3	4.8a	4.0	5.1	4.8	4.0
			ns	ns	ns	ns	*		ns	ns	ns

Treatments:

$CaNO_3$	Fe	Mow
0 = no calcium nitrate	0 = no iron	a = vertical mow summer
1 = calcium nitrate 1#N/M/mo.	3 = 2 oz. Fe/M/mo.	b = vertical mow fall
2 = calcium nitrate 1#N/M/2 mo.	4 = 4 oz. Fe/M/mo.	c = no vertical mow

ns, *, **, *** = not significant, P ≤ 0.05, 0.01, 0.001, respectively.
Main effect means with no letter(s) in common are significantly different on Fisher's Protected LSD Test at P = 0.05. Mowing effects for each level of calcium nitrate tested only if the interaction was significant. LSD test of mowing at each level of calcium nitrate.

Table 6. FMC 6 (Sultan brand) bermudagrass *quality* (1-9, 9 = best) at three time periods for 1998 and 1999, and for the overall average (1998 and 1999).

Treatments			1998			1999			Average		
$CaNO_3$	Fe	Mow	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.	Sept.-Oct.	Nov.-early Dec.	Late Dec.
		a	5.4a	4.4a	4.0a	4.8	4.4	3.8	5.1a	4.4a	3.9a
		b	3.9 b	3.3 b	3.3 b	4.7	4.4	3.8	4.3 b	3.9 b	3.5 b
		c	5.1a	4.2a	4.0a	4.8	4.5	3.9	4.9a	4.4a	4.0a
			**	*	**	ns	ns	ns	**	*	**
	0		4.8	3.9	3.8	4.8	4.6	3.9	4.8	4.2	3.8
	3		4.8	4.0	3.8	4.7	4.3	3.8	4.8	4.1	3.8
	4		4.7	4.0	3.8	4.8	4.5	3.8	4.8	4.2	3.8
			ns	ns	ns	ns	ns	ns	ns		ns
0			4.3 c	3.4 c	3.6 b	4.0 c	3.7 b	3.5 b	4.2 c	3.5 c	3.6 c
1			5.5a	4.8a	4.2a	5.5a	4.9a	4.0a	5.5a	4.9a	4.1a
2			4.6 b	3.7 b	3.6 b	4.9 b	4.8a	3.9a	4.7 b	4.2 b	3.8 b
			***	***	***	***	***	***	***	***	***
Interaction $CaNO_3$ x Mow											
0		a	4.7a	3.7	3.8a	4.0	3.6	3.4	4.3a	3.6a	3.6 b
0		b	3.7 b	2.8	3.1 b	4.0	3.7	3.5	3.8 b	3.2 b	3.3 c
0		c	4.6a	3.7	3.8a	4.0	3.9	3.7	4.3a	3.8a	3.8a
1		a	6.4a	5.3	4.4a	5.5	4.9	4.0	5.9a	5.1a	4.2a
1		b	4.4 c	4.3	3.9 b	5.4	4.9	4.0	4.9 c	4.6 c	3.9 b
1		c	5.8 b	4.9	4.3a	5.5	4.9	4.0	5.6 b	4.9a	4.1a
2		a	5.0a	4.2	3.9a	4.8	4.8	3.9	4.9a	4.5a	3.9a
2		b	3.7 b	3.0	3.0 b	4.8	4.6	3.8	4.3 b	3.8 b	3.4 b
2		c	4.9a	3.9	3.9a	4.9	4.9	4.0	4.9a	4.4a	4.0a
			***	ns	***	ns	ns	ns	***	*	**

Treatments:

$CaNO_3$	Fe	Mow
0 = no calcium nitrate	0 = no iron	a = vertical mow summer
1 = calcium nitrate 1#N/M/mo.	3 = 2 oz. Fe/M/mo.	b = vertical mow fall
2 = calcium nitrate 1#N/M/2 mo.	4 = 4 oz. Fe/M/mo.	c = no vertical mow

ns, *, **, *** = not significant, P ≤ 0.05, 0.01, 0.001, respectively.
Main effect means with no letter(s) in common are significantly different on Fisher's Protected LSD Test at P = 0.05. Mowing effects for each level of calcium nitrate tested only if the interaction was significant. LSD test of mowing at each level of calcium nitrate.

observations were consistent across the three time periods (Sept./Oct.; Nov./Dec. and late Dec.). Significance in quality with N was noted at practically every observation date for the two-year study. In contrast, Fe treatments did not influence turfgrass quality of the three cultivars at any recording date. There was no improvement in turfgrass quality with the August or October vertical mowing treatments, however, there was a decrease in quality noted with the October treatment. This was most noteworthy with the FMC 6 (Sultan brand) bermudagrass, but was also observed with Princess and NuMex Sahara in 1998. The bermudagrasses were not able to recover from the October cultivation, especially the FMC 6 (Sultan brand) and Princess.

Table 7. Average weekly soil temperatures at UC Riverside for the study period 1998-1999, (soil temperature at 15 cm.).

1998			1999		
Week	Temperature °F	Temperature °C	Week	Temperature °F	Temperature °C
08/02 – 08/08	87.8	31	08/01 – 08/07	91.4	33
08/09 – 08/15	89.6	32	08/08 – 08/14	89.6	32
08/16 – 08/22	87.8	31	08/15 – 08/21	89.6	32
08/23 – 08/29	87.8	31	08/22 – 08/28	80.6	27
08/30 – 09/05	87.8	31	08/29 – 09/04	75.2	24
09/06 – 09/12	86	30	09/05 – 09/11	73.4	23
09/13 – 09/19	82.4	28	09/12 – 09/18	73.4	23
09/20 – 09/26	78.8	26	09/19 – 09/25	73.4	23
09/27 – 10/03	77	25	09/26 – 10/02	73.4	23
10/04 – 10/10	73.4	23	10/03 – 10/09	69.8	21
10/11 – 10/17	69.8	21	10/10 – 10/16	69.8	21
10/18 – 10/24	68	20	10/17 – 10/23	66.2	19
10/25 – 10/31	68	20	10/24 – 10/30	66.2	19
11/01 – 11/07	64.4	18	10/31 – 11/06	62.6	17
11/08 – 11/14	60.8	16	11/07 – 11/13	62.6	17
11/15 – 11/21	59	15	11/14 – 11/20	62.6	17
11/22 – 11/28	59	15	11/21 – 11/27	57.2	14
11/29 – 12/05	59	15	11/28 – 12/04	55	13
12/06 – 12/12	52	11	12/05 – 12/11	52	11
12/13 – 12/19	55	13	12/12 – 12/18	50	10
12/20 – 12/26	50	10	12/19 – 12/25	52	11
12/27 – 12/31	52	11	12/26 – 12/31	52	11

Conclusions

Under climatic conditions at UC Riverside, the rapid loss of most or all color in the three cultivars was associated with the drop in temperature, as recorded by soil temperatures, starting in early December of the two test years.

The results showed that N was the most important variable examined regarding opportunities for extending color of bermudagrass cultivars into the late fall and early winter in Southern California. Fe fertilization and vertical mowing either showed no effect on winter color retention or very minimal influence, with the October vertical mowing being too late in the season for satisfactory regrowth to occur.

Distribution of Phenolic Acids and Allelopathic Potential in Cool-season and Warm-season Turfgrass Species

Lin L. Wu[1], M. Ali Harivandi[2], and Xun Guo[1]

Allelopathy is any indirect, beneficial or harmful, effect by one plant on another through release of chemicals into the environment. The term “allelochemical” refers to compounds identified in chemical interactions between plant species. Although most plant phenolic compounds are secondary metabolites and do not appear to play a role in basic metabolism, there is a great deal of evidence indicating that phenolics play a significant role as allelochemicals (Levin, 1971; Kuiters, 1990; Waterman and Mole, 1994; Inderjit, 1996). Allelochemicals may be released into the environment through leaching of living plant tissue, root exudates, residue decomposition, volatilization, microbial activity, and agricultural practices such as plowing of plant residues into the soil. This study looked at differential distribution of

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phenolic acids and allelopathic potential in turfgrass species (Wu et al., 1998) as a potentially useful trait for turfgrass breeding and management.

Phenolic acids and allelopathy in Buffalograss turf

Buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] turf plots were established in the experimental field of the Department of Environmental Horticulture, University of California, Davis campus. Buffalograss variety 'UCHL-1'was seeded at a rate of 20 g m^{-2}. Vegetatively propagated varieties 'Prairie' and 'NE609' were planted as 2.5 cm diameter plugs at 30 cm intervals. Buffalograss turf was established 12 months after seeding and plugging. Turf plots were fertilized with 16-6-6 fertilizer at a rate of 30.5 g m^{-2} once in May, once in July, and once in September. During the dry season, from May to October, the turf plots were irrigated once a week and mowed weekly at 5 cm high. No herbicide was used during the experiment.

Phenolic acids extracted from buffalograss clippings were identified and tested for their effects on seed germination and seedling growth of annual bluegrass and buffalograss. Seeds of annual bluegrass (*Poa annua* L.), a golf green perennial biotype that came from golf greens of the Davis municipal golf course, were produced in the greenhouse. Seeds of the UCHL-1 buffalograss were harvested from the experimental field of the Department of Environmental Horticulture at UC Davis and were dehulled.

Fourteen different phenolic acid compounds were identified from the buffalograss clipping extracts. Of the 14 phenolic acids, 10 phenolic acids were tested for effects on annual bluegrass and buffalograss seedling growth (Table 1). All 10 phenolic acids produced various degrees of shoot and root growth inhibition in annual bluegrass seedlings. In distilled water (control), after 14 days growth, the mean shoot length of annual bluegrass was about 32 mm. Under the treatment using the buffalograss extract, the mean shoot length was 66% of the control. For seedlings in 100 mg L^{-1} phenolic acid, the shoot length ranged between 63% of control for those treated with p-coumaric acid and 90% of control for those treated with p-hydroxybenzoic acid. Root growth of annual bluegrass was more severely inhibited by buffalograss extract and the phenolic acids than shoot growth. Root length in the control treatment was about 25 mm, while root length was reduced to 56% of the control in the p-hydroxybenzoic acid and 4% of control in the p-coumaric acid. Buffalograss shoot growth was not inhibited by the buffalograss extract or the phenolic acids. However, buffalograss seedling root growth was inhibited to varying degrees. Mean root length in the control treatment was 32 mm; root length declined to 56% of control in seedlings treated with buffalograss clipping extract, and to 13% treated with caffeic and ferulic acid. Root length of the buffalograss seedlings was only slightly affected by p-hydroxybenzoic acid treatment. Between treatment's differences in buffalograss shoot length were not significant. The effects of the phenolic acids on both shoot growth and root growth between the two grass species were significantly different at the 1% level (Table 1).

Inhibition of seedling establishment in buffalograss turf

To test the allelopathic effects of established buffalograss turf on seedling establishment of annual bluegrass and buffalograss, 30 cm x 30 cm quadrants were marked in the established buffalograss plots (described before) by punching 2.5 cm diameter wood sticks into the ground at four corners

Table 1. Seed germination, shoot length, and root length measured as percentage of the control treatment (distilled water) for seedlings of annual bluegrass (*Poa annua*) and buffalograss (*Buchloe dactyloides*) after two weeks incubation in extracts of buffalograss clippings and in solutions of the ten phenolic acids (100 mg L^{-1}).

Treatment	Annual bluegrass			Buffalograss		
	Germination (%)	Shoot length (% control)	Root length (% control)	Germination (%)	Shoot length (% control)	Root length (% control)
Distilled water	89†	100	100	81	100	100
Buffalograss extract	90	65	25	82	111	56
Caffeic acid	90	62	20	80	80	13
p-Coumaric acid	87	62	4	85	80	16
Ferulic acid	89	75	20	87	85	13
Gentisic acid	85	88	20	86	111	75
Homoveratric acid	82	78	32	80	105	34
p-Hydroxybenzoic acid	90	90	56	82	116	71
Protocatechuic acid	92	50	8	80	80	55
Salicylic acid	90	61	31	85	80	33
3,4,5-trimethoxybenzoic acid	85	61	31	80	81	33
Vanillic acid	86	75	28	87	116	59
ANOVA						
Between phenolic acid treatments	NS	***	***	NS	**	***
Between turfgrass species						
Shoot growth	***					
Root growth	***					

†: Mean of 20 measurements.

Table 2. Seedling establishment of annual bluegrass (*Poa annua* L.) and buffalograss [*Buchloe dactyloids* (Nutt.) Emgelm.] in established buffalograss.

Seeds of plant species	Field	Number seeds sown in the field	Seedlings found in turf	Number of seedlings became established	Rate of establishment (%)
Annual bluegrass	Buffalograss turf	300	142 ± 18	0	0
Annual bluegrass	Bare field	300	203 ± 25	128 ± 18	63 ± 6
Buffalograss	Buffalograss turf	300	165 ± 15	1.3 ± 0.5	1 ± 0
Buffalograss	Bare field	300	191 ± 16	97 ± 13	50 ± 12

Note: Annual bluegrass establishment (produced three or more tillers) was tested in December in dormant buffalograss turf, and buffalograss establishment was tested in June in actively growing buffalograss turf.

of each quadrant. Quadrants layed out in bare ground adjacent to the turf plots were used as control plots. Testing of annual bluegrass (a cool-season winter weed) seedling establishment was conducted in dormant buffalograss turf in November of 1994. Buffalograss (a warm-season turfgrass species) seedling establishment was conducted in June of 1995 on actively growing buffalograss turf. Three hundred seeds of annual bluegrass or buffalograss were sown into each quadrant and pressed down to the ground surface by hand. Irrigation was sufficient to ensure germination. Three weeks after seeding, the number of seedlings found in each quadrant was recorded. After an additional 4 weeks, the number of seedlings having produced three or more tillers was recorded. Buffalograss turf reduced seedling (in November) establishment of annual bluegrass and buffalograss (Table 2). Seven weeks after seeding, no annual bluegrass was established in the buffalograss turf, while 62% of seedlings were established and had produced more than three tillers in the bare soil plots. By June, 1995, only 0.9% of buffalograss seedlings were established in the buffalograss turf, while 50.3% seedling establishment occurred in the bare soil plots.

To test for genetic variation in the distribution of phenolic acid among the three buffalograss cultivars, phenolic acids were extracted from clippings using either deionized water (pH 6.8, EC = 0.05) or 0.2% (weight/volume) of $NaHNO_3$ (pH 8.0, EC = 1.7). The base solution was chosen for phenolic acid extraction because under field management conditions in arid and semi-arid regions of the western United States and California high salinity and high pH irrigation waters are common. Base extraction of phenolic acids may provide additional information for extractable concentrations of phenolic acids under high pH conditions.

Concentrations of the six phenolic acids detected in the water and base extracts of the three buffalograss varieties are presented in Table 3. The results revealed several patterns in the distribution of these phenolic acids: (1) higher concentrations of p-coumaric acid and gentisic acid were found in the base extracts than in water extracts in all three buffalograss varieties; (2) higher ferulic acid concentrations were found in the base than in the water extracts for UCHL-1 and NE609, while concentrations were the same in both base and water extracts for Prairie; (3) homoveratric acid occurred at lower concentrations in base extracts than in water extracts for all three varieties; (4) p-hydroxybenzoic acid concentration was higher in the water than in the base extract for UCHL-1, but the higher concentration was found in the base extract for Prairie, while there was very little difference between the water and base extracts for NE609; and (5) vanillic acid concentrations were considerably higher in the water extracts than in the base extracts for UCHL-1 and NE609, while the opposite result was found for Prairie.

The extractable phenolic acid concentrations, expressed on the basis of tissue dry weight (Table 3), were quite different among the three buffalograss varieties. The highest

Table 3. Concentrations of the six phenolic acids detected in distilled water and in sodium bicarbonate extracts from clippings of three buffalograss varieties.

Phenolic acids	UCHL-1 ($\mu g\ g^{-1}$ clipping dry weight)		Prairie ($\mu g\ g^{-1}$ clipping dry weight)		NE609 ($\mu g\ g^{-1}$ clipping dry weight)	
	Water extract	Base extract	Water extract	Base extract	Water extract	Base extract
p-Coumaric acid	22 ± 4*	35 ± 1	299 ± 40	399 ± 5	25 ± 7	38 ± 2
Ferulic acid	0 ± 0	8 ± 0	0 ± 0	0 ± 0	1 ± 10	4 ± 0
Gentisic acid	16 ± 1	27 ± 8	79 ± 7	337 ± 4	33 ± 14	34 ± 1
Homoveratric acid	21 ± 5	6 ± 0	63 ± 3	0 ± 0	14 ± 3	6 ± 0
p-Hydroxybenzoic acid	34 ± 4	3 ± 0	32 ± 1	48 ± 1	9 ± 1	6 ± 2
Vanillic acid	101 ± 5	0 ± 0	329 ± 17	424 ± 27	50 ± 12	0 ± 0
Total	202	82	804	1208	135	89
ANOVA						
Between extracts	F = 4.91, P < 0.05		F = 1.44, P > 0.05		F = 5.50, P < 0.05	
Between varieties	F = 26.04, P < 0.001					
Variety x Extract interaction	F = 2.10, P > 0.05					

*: mean and standard deviation of three samples.

concentrations of gentisic acid (337 μg g^{-1}) in the base, and 79 μg g^{-1} in the water extracts, and high concentrations of vanillic acid in both the water and base extracts (329 μg g^{-1} and 424 μg g^{-1}, respectively) were detected in the Prairie variety. Overall, Prairie had the highest tissue phenolic acid concentrations for both base extract and water extracts.

Analysis of variance indicates (Table 3) that overall, within variety, phenolic acid concentrations detected in water and base extracts were significantly different (at 5%) for UCHL-1 and NE609, but not for Prairie. Phenolic acid concentrations between buffalograss varieties were significantly different at 1%.

Distribution of phenolic acids in cool-season and warm-season turfgrasses

Clippings were collected from four cool-season turfgrass species, perennial ryegrass (*Lolium perenne* L., var. Mahatton), Kentucky bluegrass (*Poa pratensis* L. var. A34), creeping bentgrass (*Agrosyis palustris* Huds. var. Panncross), and tall fescue (*Festuca arundinacea* Schreb. var. Olympic) and four warm-season turfgrasses including buffalograss, zoysiagrass (*Zoysia japonica* Stued., var. El Toro), bahiagrass (*Paspalum notatum* Flugge.), and kikuyugrass (*Pennisetum clandestinum* Hochst ex Chiov.), and St. Augustinegrass (Stenotaphrum secundatum [Walt.] Kuntze.). Crude extracts made with 500 ml deionized water were used for the phenolic acid analysis. Figure 2 presents the distribution of the 12 phenolic acids in the extracts of the four warm-season turfgrass species. Gallic acid was not detected in any of the four warm-season turfgrass species. Salicylic acid was not detected in the four cool-season species, but occurred in all the five warm-season species. Zoysiagrass contained P-comaric, syrnigic, and salicylic acids. Bahiagrass contained P-comaric, Syrnigic, p-hydroxy-benzioc, trans-cinnamic, and 3,4,5-trimethoxybenzoic acids. Caffeic, ferulic, gentisic, syringic, vanillic, salicylic, and 3,4,5-trimethoxybenzoic acids were detected in St. Augustinegrass. Protocatechuic, syringic, vanillic, salicylic, trans-cinnamic, and 3,4,5-trimethoxybenzoic acids were detected in kikuyagrass. Ferulic, Protocatechuic, syringic, and 3,4,5-trimethoxybenzoic acids occurred in relatively high tissue concentration ranging from 50 μg g^{-1} to 80 μg g^{-1} dry weight in the turfgrass species tested, while the concentrations of the rest of the phenolic acids occurred only from less than 5 μg g^{-1} to 30 μg g^{-1}.

Conclusions

These studies demonstrate that root growth of annual bluegrass seedlings was severely inhibited by phenolic compounds. Growth of buffalograss seedlings was significantly, although less severely, inhibited. The allelopathic effects of the phenolic compounds studied seem not to be species specific, but to act like a broad-spectrum, preemergence growth inhibitor. Since seedlings with impaired root growth are unlikely to survive in a well-established sward, this finding has practical significance. Infrequent irrigation and drying of the soil common for buffalograss would accentuate this effect, and may partially explain the commonly observed lack of *Poa annua* invasion in most buffalograss stands.

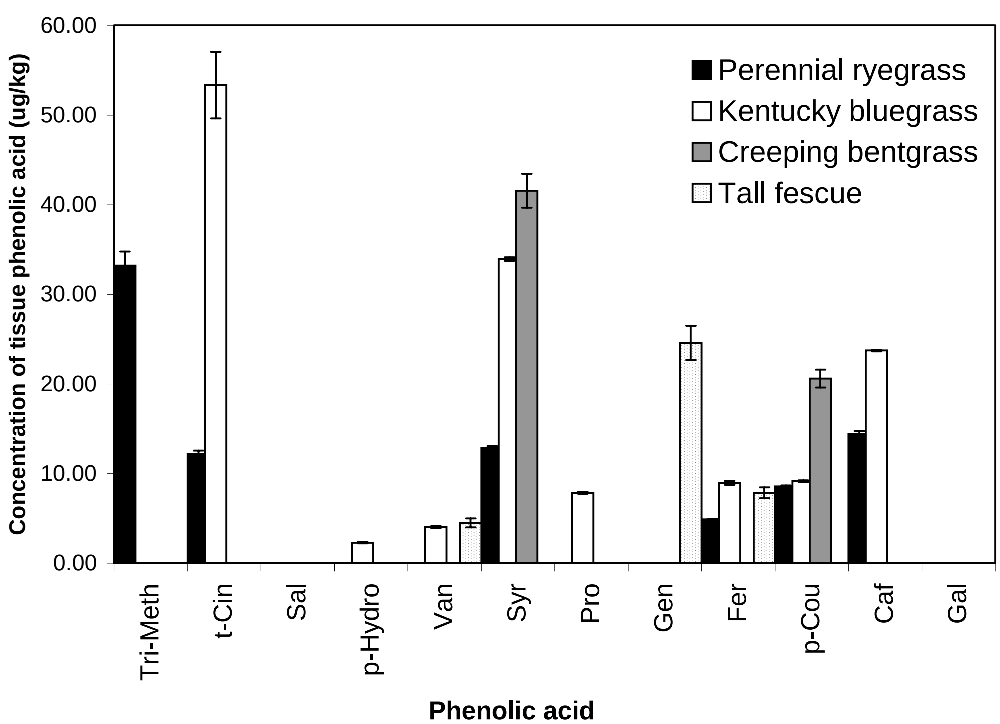

Figure 1. Distribution of phenolic acids in clipping extracts made from four cool-season turfgrass species. Abbreviations as follows: Trim = 3,4,5-trimethoxybenzoic acid; t-Cin = trans-cinnamic acid; Sal = salicylic acid; p-Hydro = p-hydroxy-benzoic acid; Van = vanillic acid; Syr = syringic acid; Pro = protocatechuic acid; Gen = gentisic acid; Fer = ferulic acid; Cou = p-coumaric acid; Caf = caffeic acid; Gal = garlic acid. Each column represents mean of three replications and bars represent standard deviations of the means.

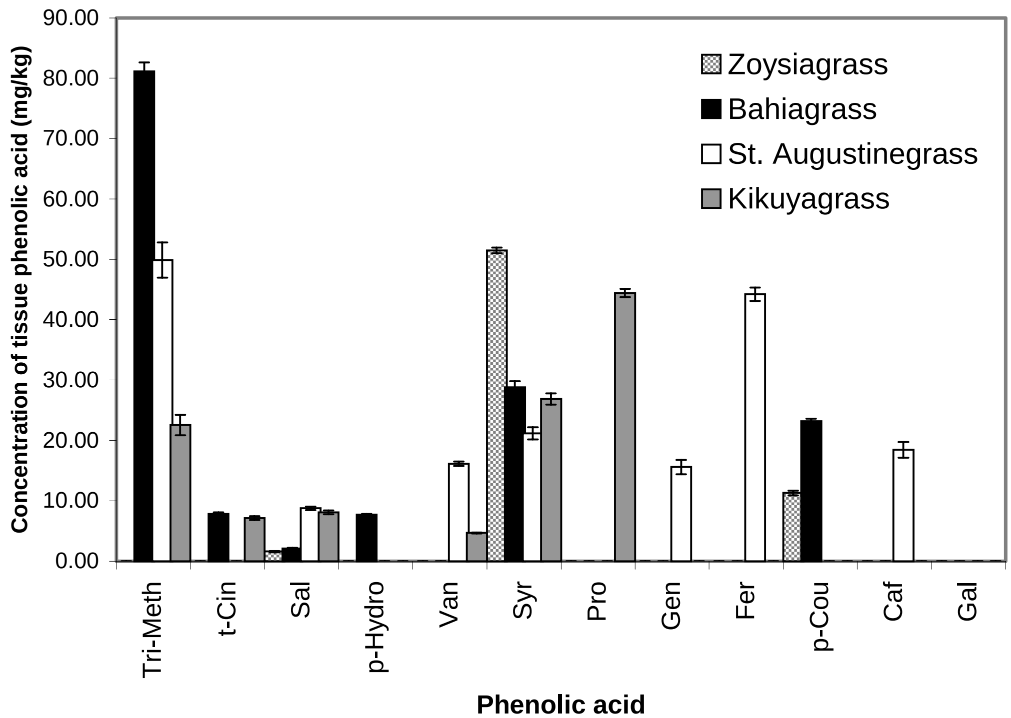

Figure 2. Distribution of phenolic acids in clipping extracts from four warm-season turfgrass species. Abbreviations as follows: Trim = 3,4,5-trimethoxybenzoic acid; t-Cin = trans-cinnamic acid; Sal = salicylic acid; p-Hydro = p-hydroxy-benzoic acid; Van = vanillic acid; Syr = syringic acid; Pro = protocatechuic acid; Gen = gentisic acid; Fer = ferulic acid; Cou = p-coumaric acid; Caf = caffeic acid; Gal = garlic acid. Each column represents mean value of three replications and bars represent standard deviations of the means.

Concentrations of the phenolic acids differed significantly among buffalograss varieties. Concentrations of six of the phenolic compounds were similar in the diploid buffalograss variety 'UCHL-1' and the hexaploid buffalograss variety 'NE609', while the tetraploid variety 'Prairie' had much higher concentrations of p-coumaric, gentisic, and vanillic acids.

There were substantial differences, both quantitative and qualitative, in the distribution of phenolic acids among the cool-season and among the warm-season turfgrass species. These are potentially useful traits for turfgrass breeding and management. One interesting finding was that salicylic-acid was found in all the warm-season turfgrass species tested, but not detected in the cool-season turfgrass species tested. It has been reported that infection of tobacco-necrosis-virus can cause accumulation of salicylic acid in leaves of tobacco (*Nicotiana tabacum* L.) and cucumber (*Cucumis sativus* L.) plants, and it is known for systemic acquired disease resistance (Malamy et al., 1990; Shulaev et al., 1995; Molders et al., 1996). Whether the distribution of salicylic acid in turfgrasses has any relation to disease resistance is an interesting question for further research.

It should be noted that the amount and type of phenolic compounds released by plants as well as the allelopathic activity of these compounds may be profoundly affected by seasonal changes, soil physical and chemical conditions, soil nutrients, and biotic factors such as plant density, growth conditions, stress of plants, and soil microbial activities. Therefore, allelopathic response and effect of a turfgrass can differ under different turfgrass management conditions. Nevertheless, allelopathic relations in turfgrass species and cultivars could be a valuable genetic trait for turfgrass breeding and management.

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Tall Fescue Cultivars Performance in California's Central Coast (1997-2000)

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Tall fescue *(Festuca arundinacea* schreb.) is a bunch-type perennial turfgrass species adapted to a wide range of soils and climates. A cool-season grass, it tolerates heat better than all other cool-season turfgrass species, although it will not tolerate temperatures at either extremes. It does particularly well along the California Coast (from the San Francisco Bay Area south) and in California's Central Valley. It is not generally recommended for the northernmost and southernmost portions of California, or the highest mountain altitudes, because of its relative intolerance to temperature extremes.

Tall fescue, commonly referred to as either "turf-type" or "dwarf" fescue is propagated by seed at seeding rates of 7-10 lbs./1,000 ft^2 where a dense, uniform stand is desired. It is also widely available as sod. Recommended mowing height for tall fescue ranges from 1.5 to 3 inches. The species does not tolerate cutting closer than 1.5 inches.

Tall fescue has good drought and shade resistance and is moderately tolerant of submergence, water-logged condition and salinity. It does not produce stolons and, although some strains may produce very short rhizomes, grass will not spread significantly.

Due to its considerable adaptability, tall fescue is used for a variety of turf purposes, including athletic fields, parks, cemeteries, playgrounds, roadsides, airfields, waterways, slopes, and home lawns. With the introduction of improved cultivars in the mid-1970's, use of this grass has expanded rapidly in California and elsewhere.

Evaluations

In October 1996, a trial was initiated at the U.C. Bay Area Research and Extension Center in Santa Clara, CA, to evaluate newly developed tall fescue cultivars. Cultivars were evaluated for turfgrass suitability along the central coast of California, a "transition zone" climate. The study was financially supported by the Northern California Turf and Landscape Council, Golf Course Superintendents Association of Northern California, and the University of California Cooperative Extension. The National Turfgrass Evaluation Program (NTEP) contributed both financial support and all grass seed.

The 131 varieties were seeded in October 1996, at a rate of 9 lbs./1,000 ft^2 in 25-ft^2 plots, replicated three times in a randomized, complete block design. Analysis of the soil, a silt loam, at the beginning of the study indicated favorable pH, a safe salinity level, and adequate phosphorus and potassium.

All plots were in full sun and mowed at 2 inches, with clippings returned, and were fertilized with 4 lbs. N/1,000 ft^2 per year. Annual fertilization consisted of 1-2 pounds of each of phosphorus and potassium. Irrigation was based on 80% reference ET (Evapotranspiration). No dethatching, or disease and insect control were practiced during the study. To prevent annual bluegrass *(Poa annua* L.) invasion, the preemergent herbicide oxadiazon (Ronstar G) was applied each fall. The trial ran for 4 years, ending in December 2000.

During the evaluation period, plots were visually rated, monthly or seasonally as relevant, for color, texture, and overall quality. Table 1 summarizes combined data for the four-year evaluations.

At the trial site, average monthly soil temperatures ranged from a low of 51°F in December to a high of 74°F in July-August, with measurements taken at a depth of 4 inches. Average monthly air temperatures also were lowest in December at 39.5°F; the highest average monthly air temperature was 80°F in August-September. According to temperatures given in Table 2, this is a moderate temperature area. Average monthly ET and precipitation are also summarized in Table 2 (see pg. 12). Overall quality ratings are based on evaluation of all turfgrass quality components combined into one turf score. As indicated by the overall ratings, most of the newly developed cultivars produced significantly higher quality turf than did older cultivars. The same conclusion emerges from review of individual quality components. New cultivars were darker green and produced denser stands of grass.

No disease or insect activity was detected on any of the cultivars during this study. Minor weed invasion occurred on a few plots. Virtually no thatch developed on any of the plots over the term of this study, indicating that, at least within a few years after planting, thatch should not be a problem in tall fescue stands.

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Results of this study supported our previous findings that newly developed tall fescue cultivars are well suited for use as turf under the California's Central Coast conditions, characterized as a "transition zone" climate. New cultivars perform significantly better under such conditions than do old cultivars. Since all tall fescue cultivars competed well with weeds, and the area's common diseases and insects affected none, this grass may also be considered a low maintenance species in regard to pest control.

Table 1. Turf quality and quality components ratings for turf-type tall fescue cultivars grown in Santa Clara, California (1997-2000)*.

Name	Overall Quality	Genetic Color	Leaf Texture	Winter Color	Name	Overall Quality	Genetic Color	Leaf Texture	Winter Color
Plantation	7.1	7.5	6.9	7.3	DP 50-9011	6.6	7.3	6.6	7.0
Bandana	7.0	7.3	7.0	7.0	Durana	6.6	7.1	6.3	7.0
Bonsai 2000	7.0	7.3	7.3	7.0	Duster	6.6	7.2	6.3	6.3
Crossfire II	7.0	7.4	7.0	7.3	EA 41	6.6	7.3	6.8	7.0
CU9502T	7.0	7.3	7.2	7.0	Equinox	6.6	7.2	6.6	7.0
Jaguar 3	7.0	7.3	7.1	7.0	MB 213	6.6	7.2	6.0	7.0
Masterpiece	7.0	7.3	7.3	7.0	MB 29	6.6	7.3	6.1	7.0
Millennium	7.0	7.0	6.8	7.3	OFI-96-31	6.6	7.3	6.5	7.0
Shenandoah II	7.0	7.3	6.8	7.0	OFI-FWY	6.6	7.3	6.3	7.0
Tulsa	7.0	7.4	6.8	7.0	Pick FA N-93	6.6	7.3	6.7	7.0
Anthem II	6.9	7.0	7.3	7.0	Pick FA UT-93	6.6	7.3	6.5	7.0
Aztec II	6.9	7.5	7.4	6.7	Pixie E+	6.6	7.2	6.0	7.0
Brandy	6.9	7.3	6.8	7.0	Sunpro	6.6	7.3	6.7	7.0
Empress	6.9	7.3	6.8	7.3	Watchdog	6.6	7.3	6.8	7.0
Gazelle	6.9	7.5	7.5	7.3	WX3-275	6.6	7.1	6.3	7.0
MB 212	6.9	7.3	7.1	7.0	ATF-020	6.5	7.2	6.6	6.7
MB 26	6.9	7.2	6.8	7.0	ATF-022	6.5	7.3	6.2	7.0
Pick RT-95	6.9	7.3	7.0	7.0	BAR FA6 US2U	6.5	7.1	6.5	6.7
Rembrandt	6.9	7.4	7.3	7.0	Coronado Gold	6.5	7.3	6.3	7.0
Scorpio	6.9	7.6	7.3	7.3	Dominion	6.5	7.3	6.3	7.0
BAR-FA 6LV	6.8	7.2	7.2	7.0	Glen Eagle	6.5	7.2	6.0	7.0
Coronado	6.8	7.3	6.5	7.0	ISI-TF11	6.5	7.2	6.3	7.0
Coyote	6.8	7.3	6.8	7.0	MB 214	6.5	7.4	6.6	7.3
CU9501T	6.8	7.3	6.7	7.0	Pro 8430	6.5	7.2	6.6	7.0
Finelawn 5LZ	6.8	7.5	6.7	7.3	Rebel 2000	6.5	7.2	6.0	7.0
Olympic Gold	6.8	7.4	6.6	7.0	Renegade	6.5	7.0	5.8	7.0
Oncue	6.8	7.3	6.8	7.0	Reserve	6.5	7.3	6.9	7.0
Pick FA 20-92	6.8	7.3	6.3	7.0	Safari	6.5	7.2	6.2	7.0
Pick FA XK-95	6.8	7.3	7.0	7.0	Tomahawk-E	6.5	7.2	6.1	7.0
R5 AU	6.8	7.3	6.5	7.0	Falcon II	6.4	7.2	6.0	6.7
Rebel Sentry	6.8	7.3	6.6	7.0	Finelawn Petite	6.4	7.0	6.1	7.0
Red Coat	6.8	7.3	7.1	7.0	Genesis	6.4	7.3	5.8	7.0
SRX 8500	6.8	7.4	6.8	7.0	Helix	6.4	7.1	5.9	6.3
Tar Heel	6.8	7.2	6.5	7.0	Leprechaun	6.4	7.1	5.8	7.0
Wildfire	6.8	7.3	7.0	6.7	Lion	6.4	7.4	6.3	7.0
Wyatt	6.8	7.3	6.8	7.0	MB 28	6.4	7.3	5.9	7.0
Apache II	6.7	7.3	6.6	7.0	OFI-931	6.4	7.2	6.3	7.0
Arabia	6.7	7.2	6.7	6.7	OFI-96-32	6.4	7.3	6.0	7.3
Arid 3	6.7	7.0	6.6	6.7	Pedestal	6.4	7.0	5.8	7.0
ATF-253	6.7	7.1	6.4	7.0	Axiom	6.3	7.2	6.5	6.7
ATF-257	6.7	7.2	6.8	7.0	Comstock	6.3	7.0	6.0	6.3
BAR-FA 6D	6.7	7.3	6.5	7.0	Onyx	6.3	7.2	6.1	7.0
Barrera	6.7	7.3	7.0	7.0	ISI-TF10	6.3	7.3	5.7	7.0
Barrington	6.7	7.3	6.8	7.0	JTTFC-91	6.3	7.1	6.1	6.7
Bravo	6.7	7.3	6.6	7.0	Kitty Hawk S.S.T.	6.3	7.3	6.3	6.7
Bulldawg	6.7	7.2	6.9	7.0	PSII-TF-I0	6.3	7.2	5.4	6.7
Cochise II	6.7	7.2	6.3	7.0	PSII-TF-9	6.3	7.1	5.5	6.7
MA 25	6.7	7.2	6.9	7.3	Velocity	6.3	7.2	6.3	6.7
ISI-TF9	6.7	7.2	6.6	7.0	WVPB-1B	6.3	7.2	5.5	6.7
Mustang II	6.7	7.3	6.8	7.0	Bonsai	6.2	7.2	6.2	6.7
OF1-951	6.7	7.3	6.8	7.0	Chapel Hill	6.2	7.2	5.8	6.7
Pick FA 15-92	6.7	7.2	6.6	7.0	Good-En	6.2	7.3	5.8	6.7
PST-5TO	6.7	7.3	7.2	7.0	JSC-1	6.2	7.2	5.8	6.7
Regiment	6.7	7.3	6.4	7.0	JTTFA-96	6.2	7.0	6.9	6.7
Shortstop II	6.7	7.3	6.9	7.0	Marksman	6.2	7.2	6.2	6.7
Southern Choice	6.7	7.3	6.6	7.0	MB 215	6.2	7.2	6.1	6.7
SR 8210	6.7	7.3	6.5	7.0	MB 216	6.2	7.3	5.6	6.7
SRX 8084	6.7	7.4	6.7	7.0	Shenandoah	6.2	6.9	6.1	6.7
TF6	6.7	7.2	6.3	7.0	WPEZE	6.2	7.1	6.1	6.7
Tracer	6.7	7.3	7.0	7.0	Titan 2	6.1	6.8	5.8	6.7
Twilight II	6.7	7.3	6.6	7.0	DLF-1	5.9	6.9	5.7	6.7
Wolfpack	6.7	7.3	7.2	7.0	Arid	5.5	6.8	5.8	6.7
Airlie	6.6	7.3	6.4	7.0	DP 7952	5.5	6.8	5.8	6.7
Alamo E	6.6	7.3	6.7	7.0	AV-1	5.3	7.2	5.8	6.3
Arid II	6.6	7.2	6.1	7.0	Kentucky-31W/Endophyte	3.5	4.5	2.6	5.3
Arizona	6.6	7.1	6.3	7.0	LSD Value**	0.4	0.5	0.6	0.6

*The values are averages of monthly and quarterly ratings from 1997 through 2000. The rating scales are:
-Overall Quality (turfscore): 1-9: 9=Ideal turf.
-Genetic Color: 1-9: 9=Darkest color.
-Leaf Texture 1-9: 9=The narrowest leaf blades.
-Winter Color: 1-9: 9=Least dormancy.
**LSD Value: To determine statistical differences among cultivars, subtract one cultivar's mean from another cultivar's mean. Statistical differences occur when this value is larger than the corresponding LSD value. If the difference between the mean values for two cultivars within the same column is not greater than the corresponding LSD, then the two cultivars are statistically the same for that specific quality component.

Table 2. Average monthly air and soil temperature, precipitation and evapotranspiration in Santa Clara, California (1997-2000).

Month	Air Temperature °F			Soil Temperature °F*	Precipitation (Inches)	Evapotranspiration (Inches)
	Maximum	Minimum	Mean			
January	60	44	51	52	4.7	1.2
February	61	44	52	51	4.5	1.8
March	65	45	55	57	1.6	3.6
April	69	48	58	61	1.0	5.1
May	72	51	61	66	0.6	5.7
June	76	55	65	71	0.2	6.4
July	79	57	67	74	0.1	6.8
August	80	58	68	74	0.9	5.1
September	80	57	67	72	0.1	4.7
October	74	50	61	65	0.6	3.5
November	64	46	55	59	1.8	1.7
December	60	39	49	51	0.5	1.6

*Soil temperature measured 4 inches below surface.

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.

CALIFORNIA TURFGRASS CULTURE EDITORIAL COMMITTEE

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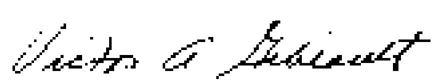

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