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1997 TURFGRASS RESEARCH

Report of Progress 788

Agricultural Experiment Station, Kansas State University, Marc A. Johnson, Director

FOREWORD

Several personnel changes occurred in the K-State turf program in 1996. Joining the program were Dr. Steve Keeley (Extension Turf Specialist), Dr. Bingru Huang (Turfgrass Research and Teaching), and Mr. Alan Zuk (Research Technician). We were fortunate to attract all of these individuals, and all are off to a tremendous start.

As we approach field day, 1997, our thoughts are with Dr. John Pair who is recovering from cancer surgery and treatment. We wish him and his family all the best as they go through this difficult period. We encourage all turf industry members to come to the field day on June 18 to view current research at the Wichita Center.

With our staff at full strength, several new research projects have been initiated for the 1997 season. As always, we are anxious to hear your suggestions for research that can be done to improve our ability to maintain healthy turf in Kansas.

The K-State Turf Team

Personnel Associated with the K-State Turfgrass Program

Mike Daratt	Farmer II, Horticulture Research Center, Wichita
Jack Fry	Associate Professor of Horticulture, Turfgrass Research & Teaching
Bingru Huang	Assistant Professor of Horticulture, Turfgrass Research & Teaching
Hongfei Jiang	Ph.D. candidate - Horticulture
Steve Keeley	Extension Turfgrass Specialist
Larry Leuthold	Professor Emeritus
Christy Nagel	Extension Horticulture Secretary
Kiranmai Nandivada	M.S. Student - Horticulture
John Pair	Professor of Horticulture, Horticulture Research Center, Wichita
Michael Shelton	Plant Research Technician II, Horticulture Research Center, Wichita
Steve Starrett	Assistant Professor, Civil Engineering
Ned Tisserat	Associate Professor of Plant Pathology, Plant Pathology Extension and Research
Ward Upham	Extension Associate - Horticulture
Tom Warner	Professor and Head, Department of Horticulture, Forestry, and Recreation Resources
Henry Wetzel	Ph.D. Candidate, Plant Pathology
Steve Wiest	Associate Professor of Horticulture, Plant Stress Research
Alan Zuk	Research Assistant

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TITLE: Variability in Turfgrass Evapotranspiration on a Golf Course

OBJECTIVE: To quantify the variability in water demand across a single golf course and evaluate the accuracy of weather station-generated evapotranspiration (ET) estimates for determining irrigation needs for one Kansas golf course.

PERSONNEL: Hongfei Jiang, Jack Fry, and Steve Wiest

SPONSORS: Kansas Golf Course Superintendent's Association, Kansas Golf Association, Kansas Turfgrass Foundation

COOPERATOR: Mr. Cliff Dipman, Golf Course Superintendent, Manhattan Country Club

INTRODUCTION:
We generally assume that turf water requirements vary extensively over a golf course, depending upon microclimate. However, the extent of this variability has not been measured. Golf course superintendents often apply a similar amount of water over the entire course, although significant variability in evapotranspiration (ET) may occur. In many cases, irrigation requirements are determined empirically from weather data collected at a single location, without regard to variability in water demand across the site.

MATERIALS AND METHODS:

Evaporation was measured using black Bellani plate atmometers placed on four golf tees and near the weather station at the Manhattan Country Club, Manhattan, KS in 1995 and 1996. Evaporation was measured on a total of 62 precipitation-free summer days for the 2 years. Evaporation for each location on each measurement day was converted to an ET estimate for perennial ryegrass turf mowed at 1.25 cm using an empirical model developed previously by regressing plate evaporation vs. lysimeter ET under well-watered conditions. Evapotranspiration estimates provided by the weather station (Rainbird Irrigation) were compared to ET estimates calculated from atmometer evaporation at each site, using regression analysis.

RESULTS:

In 1995, plate evaporation at the weather station was highest, and that at tee no. 7 was lowest among all locations (Table 1). Evaporation at tees no. 3, 5, and 18 was about 10% lower than that at the weather station.

In 1996, evaporation at tee no. 7 was 21% lower than that at the weather station, and that at tees no. 4 and 18 was about 10% lower than that at the weather station (Table 1). Evaporation at tee no. 3 was similar to that at the weather station.

Evaporation on a north-facing slope was 8% lower than that on a south-facing slope or that on a level surface in 1996 (Table 2). Irrigation applications on north-facing slopes may need to adjusted to account for reduced water requirements.

Weather station-generated ET was consistently higher than atmometer-estimated ET, particularly when ET was higher than 4 mm/day.

Assuming well-watered conditions, using weather station-estimated ET as the sole guide for irrigation would have resulted in excess application of 20 mm water per week on tee no. 7, the tee with lowest water demand. Hence, weather station-estimated ET should not be used exclusively to determine turf water requirements.

Table 1. Atmometer evaporation at the Manhattan Country Club, Manhattan, KS, in 1995 and 1996.

	Evaporation (mm/day)[1]		% of Weather Station	
Location	1995	1996	1995	1996
Weather station	9.6 a [2]	8.3 a	100	100
Tee no. 3	8.5 b	8.4 a	91	101
Tee no. 4	-- [3]	7.7 b	--	90
Tee no. 5	8.8 b	--	94	--
Tee no. 7	7.4 c	6.7 c	78	79
Tee no.18	8.6 b	7.8 b	91	93

[1]Mean of 34 days between 13 June and 30 August, 1995 and 28 days between 10 June and 15 August, 1996.
[2] Means within a column followed by the same letter are not different at $p < 0.05$ by Tukey's HSD.
[3] Evaporation at these tees not evaluated.

Table 2. Evaporation on north- and south-facing slopes at tee no. 18 at the Manhattan Country Club, Manhattan, KS in 1996.

	Evaporation	
Location	(mm/day)[1]	% of Level Surface
Level surface	7.1 a [2]	100
South-facing slope	7.1 a	100
North-facing slope	6.5 b	92

[1]Mean of 28 days between 10 June and 15 August, 1996.
[2] Means within a column followed by the same letter are not different at $P < 0.05$ by Tukey's HSD.

TITLE: Irrigation Management as It Affects Disease and Weed Incidences on a Perennial Ryegrass Golf Course Fairway

OBJECTIVES: To evaluate water savings afforded by monitoring turf ET and adjusting irrigation accordingly; to compare preventive and curative pesticide control measures for control and amount of active ingredient required; and to evaluate effects of two irrigation regimes on turf quality, weed and disease infestations, and pesticide requirements.

PERSONNEL: Hongfei Jiang, Jack Fry, and Ned Tisserat

SPONSORS: Heart of America Golf Course Superintendent's Association, Kansas Golf Course Superintendent's Association, Golf Course Superintendent's Association of America

INTRODUCTION: Golf courses often face public scrutiny because of high summer water usage during peak demand periods in urban areas and fear of potential health and environmental problems posed by pesticide application. The potential influence of irrigation management on environmental issues related to golf course turf is underestimated. Irrigation can influence disease and weed incidence and associated pesticide requirements.

MATERIALS AND METHODS: This study was conducted on perennial ryegrass maintained under golf course fairway conditions in 1995 and 1996. Turf received either daily irrigation of 7.6 mm water regardless of prevailing weather conditions or irrigation on 3 days weekly to replace approximately 80% of atmometer-estimated evapotranspiration (ET). Preventive and curative fungicide and herbicide treatments were arranged within irrigation treatments. Flutolanil (Prostar) and metalaxyl (Subdue) were the fungicides applied at manufacturers' recommended rates for preventive and curative control. Dithiopyr (Dimension) was used as the preventive herbicide for crabgrass control, and fenoxaprop-ethyl (Acclaim) was the curative herbicide.

RESULTS: About 200% more water was applied to daily-irrigated turf compared to turf irrigated based upon atmometer-estimated ET. Similar amounts of active ingredient were used on both fungicide schedules in 1995 (Table 1). In 1996, a preventive fungicide schedule resulted in application of 184% more active ingredient than a curative schedule. Daily irrigation suppressed brown patch injury by 44% in 1995 and 20% in 1996 but increased dollar spot numbers by 248% in 1996 (Table 2). More crabgrass plants were observed in ET-irrigated turf each year.

Table 1. Fungicides and herbicides used for disease and weed control in a perennial ryegrass golf course fairway.

Products	Treatments	Rate (kg ai/ha)	1995 Application dates	Total (kg ai/ha)
Fungicides				
Flutolanil	Preventive	3.0	9 June, 12 July, 4, 27 August	12.0
	Curative	4.5	19 July, 13, 27 August	13.5
Metalaxyl	Preventive	0.2	26 July, 11 August	0.4
Herbicides				
Dithiopyr	Preventive	0.56	4 May	0.56
Fenoxaprop-ethyl	Curative	0.43	20 July	0.43
2,4-D+	Curative	0.94	20 July	0.94
MCPP+		0.50		0.50
Dicamba		0.10		0.10
Fungicides			1996	
Flutolanil	Preventive	3.0	3, 25 June, 18 July, 16 August	12.0
	Curative	4.5	19 June	4.5
Metalaxyl	Preventive	0.2	2, 24 July	0.4
Herbicides				
Dithiopyr	Preventive	0.56	2 May	0.56
Fenoxaprop-ethyl	Curative	0.43	4 July	0.43

Table 2. Influence of irrigation, herbicide, and fungicide treatments on disease and weed infestations and canopy minus air temperature (CMAT) in perennial ryegrass in 1995 and 1996.

	Brown Patch Injury (%)		Dollar Spot (no. /sq m)	Crabgrass (no. /sq m)		Dandelion (no./sq m)		CMAT (°C)
Treatment	1995	1996	1996	1995	1996	1995	1996	1996
Irrigation								
Daily	11.7b[1]	8.8 b	21.3 a	3.7 b	7.1 b	3.8 a	2.8 a	3.9 b
ET	20.9 a	11.0 a	8.6 b	5.6 a	27.3 a	3.0 a	2.6 a	4.5 a
Herbicide								
Preventive	14.0 b	8.5 b	16.5 a	1.4 b	0.8 b	2.8 b	1.6 b	4.3 a
Curative	20.6 a	10.2 ab	16.4 a	0.9 b	2.2 b	0.4 b	2.6 b	4.2 a
Untreated	14.3 b	11.0 a	12.0 a	11.6a	48.7 a	6.1 a	3.9 a	4.2 a
Fungicide								
Preventive	10.0 c	6.7 b	20.8 a	4.6 a	14.1 b	4.6 a	3.8 a	4.2 a
Curative	13.7 b	6.2 b	15.3 b	4.9 a	27.5 a	2.9 b	1.6 b	4.2 a
Untreated	25.0 a	16.8 a	8.7 c	4.4 a	9.9 b	2.7 b	2.6 ab	4.4 a

[1]Within each treatment, means followed by same letter are not significantly different ($P \leq 0.05$)

Table 3. Influence of irrigation, herbicide, and fungicide treatments on turf quality, clipping dry weight, and soil water content in perennial ryegrass in 1995 and 1996.

	Turf Quality			Clipping weight (g sq/m)		Soil Water Content in 1996 (%)		
Treatment	1995	1996(1)[2]	1996(2)	1995	1996	0-15cm	15-30 cm	0-30cm
Irrigation								
Daily	8.3a[3]	7.6 a	6.6 b	1.6 a	4.9 b	36.8 a	37.8 a	37.3 a
ET	7.5 b	7.2 b	7.0 a	1.1 b	6.8 a	30.8 b	33.7 a	32.3 b
Herbicide								
Preventive	8.1 a	7.6 a	7.0 a	1.5 a	6.1 a	34.0 a	36.0 a	35.1 a
Curative	7.5 b	7.4 b	7.0 a	1.0 b	5.1 b	33.7 a	35.3 a	34.5 a
Untreated	8.0 a	7.2 c	6.5 b	1.6 a	6.3 a	33.8 a	35.9 a	34.8 a
Fungicide								
Preventive	8.0 a	7.6 a	6.8 a	1.6 a	6.2 a	33.9 a	36.0 a	35.0 a
Curative	8.0 a	7.5 a	6.8 a	1.3 b	5.8 b	33.9 a	35.6 a	34.7 a
Untreated	7.6 b	7.0 b	6.8 a	1.2 b	5.6 c	33.7 a	35.6 a	34.6 a

[1] Turf quality was rated on a 0 to 9 scale, where 0 = brown , thin, nonuniform turf; 6 = minimum acceptable quality; and 9 = optimum color, density, and uniformity.
[2] Period 1 from 18 June to 30 July, 1996; Period 2 from 13 August to 7 September, 1996.
[x]3Within each treatment, means followed by same letter are not significantly different ($P \leq 0.05$).

TITLE: Drought Responses of Perennial Ryegrass Treated with Plant Growth Regulators

OBJECTIVE: To evaluate perennial ryegrass response to drought stress after application of plant growth regulators.

PERSONNEL: Hongfei Jiang and Jack Fry

SPONSORS: Kansas Golf Course Superintendent's Association, Kansas Turfgrass Foundation

INTRODUCTION:

Lack of water available for irrigation is one of the most important problems facing the turfgrass industry. Development of new management strategies to improve turfgrass drought resistance may include the use of plant growth regulators (PGRs)

METHODS:

Field studies were conducted in 1995 and 1996, and a greenhouse study was done in 1996 on perennial ryegrass maintained under golf course fairway conditions. Plant growth regulators evaluated were ethephon, mefluidide, paclobutrazol, and trinexapac-ethyl. Plant growth regulators were applied at manufacturers' recommended rates (Table 1) with a backpack CO_2-pressurized (242 kPa) sprayer equipped with 8004 flat fan nozzles and calibrated to deliver 560 L/ ha. Application rates were inadvertently doubled on the first application in the field in 1995 (Table 2). Irrigation was applied until PGR application; thereafter, no water was applied. Field plots received intermittent rainfall during study periods.

RESULTS:

All data are presented in Tables 1 to 5. Trinexapac-ethyl (Primo) was the only PGR evaluated that enhanced turfgrass quality during drought, had no deleterious effects on rooting, and suppressed canopy height. Ethephon (Ethrel) enhanced quality during drought in the greenhouse, reduced root length density (RLD) in the field from 0 to 10 and 10 to 20 cm depths, and had no effect on canopy height. Mefluidide (Embark) caused unacceptable chlorosis, reduced rooting at 0 to 40 cm, and suppressed canopy height. Paclobutrazol (Scott's TGR) had negligible effects on ryegrass quality, rooting, and canopy height.

Table 1. Effects of PGRs on perennial ryegrass turf quality in the greenhouse in 1996[1].

PGR	Application Rate (g ai/ha)	Weeks after Treatment in the Greenhouse[2]								
		2	3	4	5	6	7	8	9	11
Trinexapac-ethyl	192	6.9b[3]	7.4 a	7.4 ab	7.6 ab	7.5 a	7.5 a	7.1 a	6.6 a	4.6a
Ethephon	3363	8.1 a	7.9 a	8.1 a	8.3 a	7.8 a	7.6 a	7.1 a	6.3 ab	4.4ab
Mefluidide	134	3.6 c	3.9 b	4.3 b	3.5 c	3.1 c	3.0 c	3.3 b	3.3 c	2.5c
Paclobutrazol	553	7.0b	7.0 a	6.6 b	6.0 b	5.8 b	5.5 b	5.3 ab	4.3 c	2.8bc
Control	--	7.0b	7.0 a	6.8 ab	6.1 b	5.8 b	5.4 b	4.6 b	4.4 bc	2.6c

[1]Turf quality was rated on a 0 to 9 scale, where 0 = brown, thin, nonuniform turf, 6 = minimum acceptable quality; and 9 = optimum color, density, and uniformity.

[2] Irrigation ceased 2 weeks after PGR application.

[3] Means followed by the same letter within a column are not significantly different ($P \leq 0.05$) according to Fisher's protected least significant difference test.

Table 2. Effects of PGRs on perennial ryegrass turf quality in the field in 1995[1].

PGR	Application Rate (g ai/ha)	Weeks After Treatment on 2 June, 1995[2]					
		1	2	3	4	5	
Trinexapac-ethyl	384	7.3b[3]	7.0 c	7.0 c	7.4 a	8.8 a	7.0 a
Ethephon	6726	8.8 a	8.8 a	9.0 a	7.6 a	8.3 a	6.5 a
Mefluidide	268	7.0b	5.3 d	6.0 d	4.8 b	6.8 b	5.3 b
Paclobutrazol	1106	8.8a	8.0 b	8.3 b	7.5 a	9.0 a	7.0 a
Control	--	9.0 a	8.0 b	8.3 b	7.5 a	8.8 a	6.8 a
		Weeks After Treatment on 18 July, 1995					
Trinexapac-ethyl	192	7.8b	8.5 a	8.8 a	8.7 a	8.4 a	5.6 a
Ethephon	3363	9.0 a	8.3 a	7.8 b	8.0 b	6.9 c	4.5 c
Mefluidide	134	6.0 c	4.0 b	4.0 c	4.8 c	5.0 d	2.9 d
Paclobutrazol	553	8.5 a	8.3 a	8.3 ab	8.7 a	8.1 ab	5.3 a
Control	--	8.8 a	8.5 a	8.8 a	8.4 a	8.0 b	4.9 bc

[1] Turf quality was rated on a 0 to 9 scale, where 0 = brown , thin, nonuniform turf, 6 = minimum acceptable quality; and 9 = optimum color, density, and uniformity.

[2] No irrigation was applied after PGR application in the field.

[3] Means followed by the same letter within a column are not significantly different ($P \leq 0.05$) according to Fisher's protected least significant difference test.

Table 3. Effects of PGRs on perennial ryegrass turf quality in the field in 1996[1].

PGR	Application Rate (g ai/ha)	Weeks after Treatment on 2 June, 1996[2]					
		1	2	3	4	5	6
Trinexapac-ethyl	192	9.0a[3]	9.0 a	8.6 a	7.4 b	7.4 a	8.1 a
Ethephon	3363	9.0 a	9.0 a	8.6 a	7.7 a	7.4 a	7.6 bc
Mefluidide	134	8.5 b	8.0 b	7.0 b	5.6 c	5.6 b	6.0 d
Paclobutrazol	553	9.0 a	9.0 a	8.5 a	7.4 b	7.3 a	7.5 c
Control	--	9.0 a	9.0 a	8.6 a	7.4 b	7.2 a	7.9 ab
		Weeks after Treatment on 18 July, 1996					
Trinexapac-ethyl	192	7.5 b	7.0 b	--	6.9 a	6.6 a	7.1 a
Ethephon	3363	7.9 a	7.5 a	--	7.2 a	6.8 a	7.3 a
Mefluidide	134	5.8 c	4.9 c	--	5.9 b	5.8 b	5.9 b
Paclobutrazol	553	7.5b	7.3 ab	--	7.3 a	6.9 a	7.3 a
Control	--	7.8ab	7.0 b	--	7.0 a	6.7 a	7.1 a

[1] Turf quality was rated on a 0 to 9 scale, where 0 = brown , thin, nonuniform turf; 6 = minimum acceptable quality; and 9 = optimum color, density, and uniformity.

[2] No irrigation was applied after PGR application in the field.

[3]Means followed by the same letter within a column are not significantly different ($P \leq 0.05$) according to Fisher's protected least significant difference test.

Table 4. Perennial ryegrass root length density (RLD) and total root length (TRL) as affected by PGRs in 1995[1].

PGR	Application rate (g ai/ha)	RLD (cm/cu cm) at Soil Depths (cm)				TRL (cm)
		0-10	10-20	20-30	30-40	
Trinexapac- ethyl	192	10.4a[2]	3.8 a	2.3 ab	1.9 a	2316 a
Ethephon	3363	10.6 a	3.5 a	3.1 a	2.3 a	2449 a
Mefluidide	134	10.2 a	2.8 a	1.5 b	0.7 b	1912 b
Paclobutrazol	553	8.3 a	4.4 a	2.5 a	1.7 a	2127 ab
Control	--	11.4 a	3.0 a	2.4 ab	1.8 a	2339 a

[1] PGRs were applied on 2 June and 18 July. Roots were sampled on 14 September.
[2]Means followed by the same letter within a column are not significantly different ($P \leq 0.05$) according to Fisher's protected least significant difference test.

Table 5. Perennial ryegrass root length density (RLD) and total root length (TRL) as affected by PGRs in 1996[1].

PGR	Application Rate (g ai/ha)	RLD after 2 June Application at Soil Depths (cm)				TRL (cm)
		0-10	10-20	20-30	30-40	
Trinexapac-ethyl	192	14.0ab[2]	6.0 a	4.0 a	2.6 ab	3346 a
Ethephon	3363	11.5 b	4.3 b	3.7 a	2.2 ab	2713 b
Mefluidide	134	11.7 b	2.9 c	1.7 b	1.1 c	2193 c
Paclobutrazol	553	12.0 b	5.6 a	4.8 a	2.9 a	3184 ab
Control	--	16.0 a	5.7 a	3.5 a	2.1 b	3419 a
		RLD after 18 July Application				
Trinexapac-ethyl	192	16.5 ab	4.8 ab	2.9 ab	2.5 a	3350 ab
Ethephon	3363	16.4 ab	3.4 bc	2.0 b	1.7 ab	2947 bc
Mefluidide	134	15.0 b	2.4 c	1.3 c	0.6 b	2418 c
Paclobutrazol	553	19.2 a	4.7 ab	3.5 a	2.3 a	3715 a
Control	--	20.2 a	5.0 a	2.5 ab	1.9 a	3724 a

[1] PGRs were applied on 2 June and 18 July. Roots were sampled 6 weeks after each application.
[2] Means followed by the same letter within a column are not significantly different ($P \leq 0.05$) according to Fisher's protected least significant difference test.

TITLE: Drought Resistance in Perennial Ryegrass

OBJECTIVES: To compare and evaluate perennial ryegrass cultivars for rooting potential and for drought tolerance and recovery in the greenhouse and in the field

PERSONNEL: Kiranmai Nandivada and Jack Fry

SPONSORS: Kansas Golf Course Superintendent's Association, Kansas Golf Assoc.

INTRODUCTION:

Water scarcity has become an increasing problem in the US. Concern over availability of water has encouraged turfgrass scientists to screen and develop drought-resistant cultivars that provide acceptable turf quality. Under golf course fairway conditions (i.e., mowing heights less than 1cm) rooting potential is reduced. The cultivars that are relatively deeply rooted at low mowing heights and show acceptable turf quality during drought stress and good recovery after drought should be drought resistant.

MATERIALS AND METHODS:

Greenhouse Studies

One study was conducted to determine the rooting potential of perennial ryegrass cultivars under optimum growing conditions. Plugs of 5.0-cm in diameter were sampled from the field and planted in clear polythene tubes (5.0-cm diam by 112-cm deep) filled with a medium-fine sand. These were inserted in PVC tubes (5.2-cm diameter by 112-cm deep) to provide support and set on a wooden frame at a 40 angle to encourage root growth on the lower end of the polythene tube. Irrigation was applied with a mist system at a rate of 1.1cm/day for the duration of the experiment (10 weeks). Mowing was done every other day at 1cm using hand clippers. Fertilizer was applied at 2.5g N/sq m/month. Roots were harvested 3 months after establishment and washed free of sand. Root length density was measured at 0-10, 10-20, 20-30, and 30-40cm depths using a digital image analyzer.

In drought tolerance study, cores measuring 10-cm diam by 15-cm deep were taken from well-watered field plots for dry down in the greenhouse. During dry down, the cultivars were compared for leaf water potential and osmotic potential (using thermocouple psychrometer), turf quality, and drought stress every 2 days. Turf quality and drought ratings in the greenhouse were collected on a 0-9 scale where 0= dead and 9= turf with optimum color, density, and uniformity. Data were subjected to analysis of variance, and means were separated using the least significant difference with $P < 0.05$.

Field Study

This study was conducted on the field plots maintained for the National Perennial Ryegrass Cultivar Trial at the Rocky Ford Turfgrass Research Center in Manhattan. 'Pennfine', 'Nobility', 'Achiever', 'Figaro', and 'Linn' perennial ryegrasses were selected for evaluation. Turf was mowed three times weekly at 1.3 cm and received 150 kg N/ha/yr. Irrigation was applied to prevent stress prior to June 1, 1996; thereafter, no irrigation was applied. Two cores of 1- cm dia x 60- cm deep were taken from each plot to determine the root distribution before and after stress. Data were collected weekly on turf quality, drought ratings, canopy-air temperature difference using an infrared thermometer, soil moisture at 15cm and 30cm using a TDR probe, and clipping weights during the stress period.

RESULTS:

Rooting: In greenhouse study I, Linn had a lower RLD than all cultivars at 0 to 10 cm. Between 30 and 60-cm depths, Figaro, Linn, and Achiever generally had higher RLDs than Pennfine and Nobility (Table 1). Only Figaro produced roots at 70 to 80 cm. In greenhouse study II, Figaro generally had the highest RLD. Only Figaro and Pennfine produced roots deeper than 40 cm (Table 2). No differences were observed among cultivars in rooting in the field (data not shown).

Drought ratings: When ryegrass cores experienced progressive dry down in the greenhouse, Nobility, Achiever, and Figaro generally received the highest drought ratings (Table 3). All cultivars exhibited good recovery after rewatering (data not shown). In the field, Pennfine and Nobility had the highest drought resistance ratings, followed by Figaro and Achiever (data not shown). Linn exhibited poor drought resistance in the field.

Table 1. Root length density (RLD) of ryegrass cultivars in greenhouse study I.

		RLD (cm/cu cm) at Soil Depths (cm)						
Cultivar	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80
Achiever	256 a[1]	206 a	158 a	102 ab	61 a	24 ab	5 a	0 a
Linn	196 b	159 b	130 a	90 ab	41 ab	24 ab	1 a	0 a
Figaro	252 a	190 ab	156 a	112 a	65 a	31 a	7 a	5 a
Pennfine	245 a	174 ab	120 a	65 a	19 b	4 b	0 a	0 a
Nobility	257 a	183 ab	117 a	69 b	26 b	6 b	1 a	0 a

[1]Means followed by the same letter are not significantly different (P<0.05).

Table 2. Root length density (RLD) of ryegrass in greenhouse study II.

	RLD (cm/cu cm) at Soil Depths (cm)				
Cultivar	0-10	10-20	20-30	30-40	40-50
Achiever	752 a[1]	218 b	46 ab	4 b	0 a
Linn	757 a	245 b	62 ab	2 b	0 a
Figaro	925 a	426 a	129 a	31 a	2 a
Pennfine	836 a	241 b	58 ab	6 b	2 a
Nobility	753 a	189 b	40 b	1 b	0 a

[1]Means with same letter are not significantly different (P<0.05).

Table 3. Drought ratings of ryegrass cultivars during progressive dry down in the greenhouse.

	Drought Rating at Weeks into Dry Down [1]				
Cultivar	June 7	June 14	June 21	June 28	Mean
Achiever	8.8 a[2]	7.4 ab	6.0 b	3.1 a	6.6 b
Linn	7.8 c	5.5 c	3.8 c	2.3 b	4.1 d
Figaro	8.6 ab	7.7 a	6.8 a	3.3 a	7.0 a
Pennfine	8.1 bc	6.9 b	5.5 b	3.3 a	6.3 c
Nobility	8.3 a	7.4 ab	6.1 ab	3.3 a	7.1 a

[1]Drought was rated visually on a 0 to 9 scale, 9 = no stress.

[2]Means with the same letter are not significantly different (P<0.05).

TITLE: Effects of High Temperature and Poor Soil Aeration on Creeping Bentgrass

OBJECTIVES: To compare responses of two creeping bentgrass cultivars to high temperature and poor soil aeration stresses and to investigate the physiological mechanisms by which high temperature and poor soil aeration may influence creeping bentgrass.

PERSONNEL: Bingru Huang, Xiaozhong Liu, and Jack Fry

SPONSORS: Alfred Sloan Foundation, Kansas Turfgrass Foundation.

INTRODUCTION:

Creeping bentgrass (Agrostis palustris) is the most widely used cool season turfgrass on golf greens. Turf quality in transitional and warm climate regions often declines during summer months when golf greens receive maximum use. Many factors could be associated with summer bentgrass decline (SBD), including high temperature, high relative humidity, high soil moisture, and poor soil aeration. However, little is known about the genetic variations and physiological mechanisms by which those environmental factors influence bentgrass growth.

MATERIALS AND METHODS:

'Penncross' and 'Crenshaw' were examined. Sods were collected from mature grass stands in field nurseries and planted in a 90% sand and 10% fritted clay (Profile) on November 19, 1996. The soil medium was contained in PVC tubes measuring 4 in. diameter and 30 in. deep. Plants were maintained in growth chambers with a day/night temperature of 25/15 C and a photoperiod of 14 h. Plants were clipped at 1/4 in. height and watered with deionized water every other day. Nutrients were supplied by watering the plants with half-strength Hoagland's solution weekly.

Treatments were imposed 3 months after plants were established. The experiment consisted of two temperature and two soil moisture or aeration treatments. Temperature treatments included an optimum temperature regime (day/night temperature of 25/15C) and a high temperature regime (HT)(day/night temperature of 35/25C). Soil moisture or aeration treatments included a well-watered and well-aerated regime, in which soil oxygen was maintained at a sufficient level (1.5 μg/sq cm/min), and an overwatered and poorly aerated regime (LA), in which soil oxygen was maintained at a hypoxic level (0.1 μg/sq cm/min). In the well-watered and well-aerated treatment, plants were watered on alternate days with drainage occurring from the bottom of the PVC tubes. In LA, soil was saturated completely by daily excessive watering that lead to poor soil aeration.

Leaf chlorophyll content was measured after 14 d of treatment. Canopy photosynthetic rate (Pn) was measured at 12:00 h and whole plant respiration rate (Rn) was measured at 21:00 h after 7 d and 28 d of treatment. A time course of Pn and Rn was measured at 35 d after treatment. Photosynthesis and respiration rates were determined with the LI-6200 gas exchange system. Turf was rated visually based on color, uniformity, and density on a 0 to 9 scale, where 0 = worst quality and 9 = best quality.

RESULTS:

Turfgrass quality: Turf quality declined with HT or LA for both cultivars, beginning 8 d after treatment (Fig. 1). The combination of HT and LA caused further decline of turf quality. High temperature alone had more detrimental effects than LA on turf quality lof Crenshaw, starting at 18 d after treatment. For Penncross, LA had more negative effects on turf quality than HT, beginning at 23 d.

Leaf chlorosis occurred as indicated by the reduction of chlorophyll content under either LA or HT stress conditions (Table 1). The combination of HT and LA reduced leaf chlorophyll content more than either factor alone. The reduction in leaf chlorophyll content was greater with LA than with HT for both Crenshaw and Penncross.

Photosynthesis and respiration rate: Canopy photosynthetic rate (Pn) was reduced for plants grown under HT with LA conditions for both cultivars after 7 d of treatment (Table 2). Pn increased with temperature for both cultivars at 7 d of treatment. Poor aeration alone did not have significant effects on Pn at this time. Respiration rate (Rn) of whole plants including shoots and roots increased with temperature alone or the combination of HT and LA for both cultivars. After 28 d of treatment, Pn declined with HA, LA alone, and the combination of the two treatments for both cultivars. The reduction in Pn was more for Crenshaw than for Penncross under these conditions. Poor soil aeration reduced Rn, whereas HT and the combination of HT and LA caused significant increases in Rn for both cultivars.

Plants of Crenshaw grown under the conditions of LA, HT, or the combination of the two treatments had significant lower Pn during the day (Fig. 2). For Penncross, Pn was reduced only in the afternoon by HT, LA alone, or the combined treatment. For both cultivars, significantly higher Rn at night occurred under HT and the combination treatment compared to the control plants, wherease LA reduced Rn during night.

SUMMARY:

The results indicate that cultivars of creeping bentgrass varied in their responses to HT stress and LA induced by excessive irrigation and poor drainage.

Turf quality declined with HT and LA for both cultivars. The combination of both stresses was more detrimental than either HT or LA alone. High temperature had more severe adverse effects on turf quality than LA for Crenshaw, whereas LA was more detrimental for Penncross.

Turf quality decline under prolonged HT and LA conditions was related to leaf chlorosis, reduced photosynthesis, and increased respiration rate.

Table 1. Leaf chlorophyll content of creeping bentgrass as affected by high temperature and poor aeration after 14 d of treatment.

Cultivar	Treatment	Chlorophyll Content (mg/g)
Crenshaw	Control	1.40 ± 0.11 a
	Low aeration (LA)	0.89 ± 0.01 c
	High temperature(HT)	1.12 ± 0.03 b
	HT-LA	0.63 ± 0.05 d
Penncross	Control	1.25 ± 0.08 a
	Low aeration (LA)	0.86 ± 0.04 c
	High temperature (HT)	1.16 ± 0.07 b
	HT - LA	0.66 ± 0.08 d

Table 2. Canopy photosynthetic rate (Pn, µmol CO_2/sw m/sec) and whole plant respiration rate (Rn, µmol CO_2/sq m/sec) of creeping bentgrass as affected by high temperature and low soil aeration.

		Days after Treatment			
Cultivar	Treatment	Pn	Rn	Pn	Rn
Crenshaw	Control	2.86 b[1]	5.12 b	3.88 a	5.70 b
	Low aeration (LA)	2.52 b	6.87 b	2.34 b	4.94 c
	High temperature(HT)	6.23 a	7.10 a	0.98 c	6.55 a
	HT- LA	1.89 b	7.37 a	0.76 c	6.11 a
Penncross	Control	3.49 b	5.80 b	3.21 a	5.17 b
	Low aeration (LA)	3.11 b	5.60 b	2.05 b	4.05 c
	High temperature(HT)	5.46 a	9.89 a	1.83 bc	5.69 a
	HT-LA	2.72 b	10.03 a	0.95 c	6.16 a

[1]Means follow by the same letter within a column at a given cultivar was not significantly different based on an LSD test (P > 0.05).

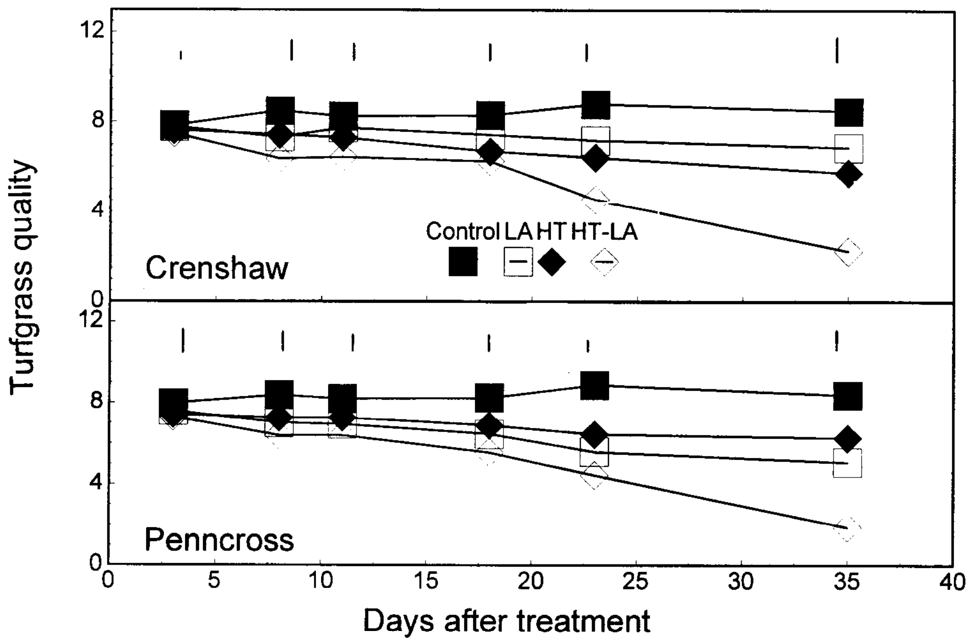

Fig. 1. Turf quality as affected by high temperature (HT), low aeration (LA), and the combination of HT and LA.

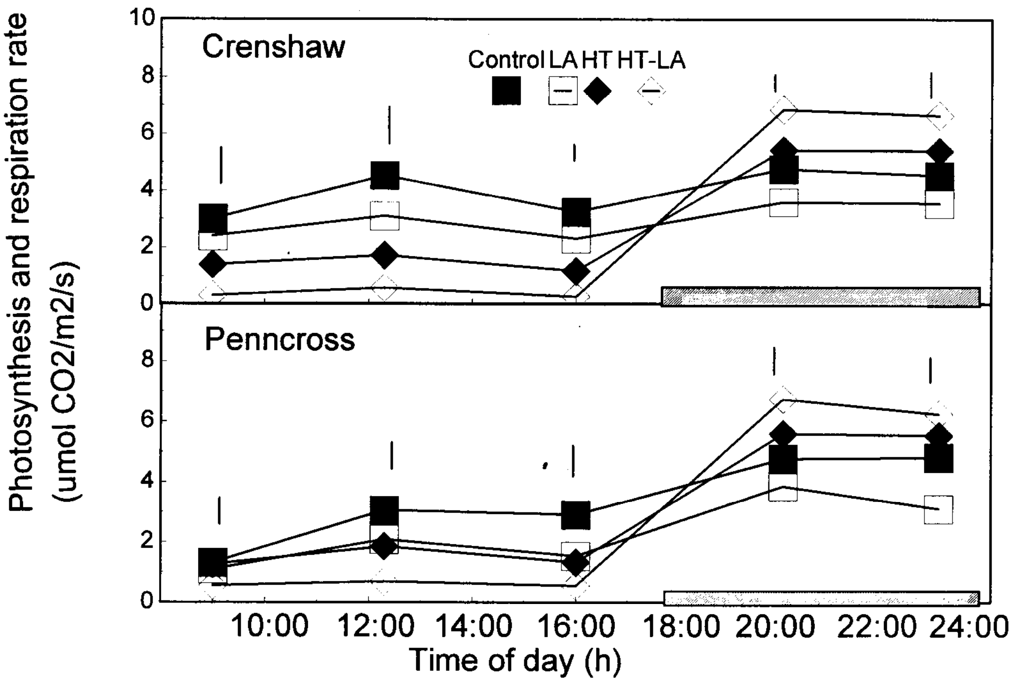

Fig. 2. Time course of photosynthesis and respiration rate as affected by high temperature (HT), low aeration (LA), and the combination of HT and LA.

TITLE: Responses of Forage-Type and Dwarf-Type Tall Fescue Cultivars to Drought Stress and Subsequent Rewatering

OBJECTIVE: To investigate responses of forage-type and dwarf-type tall fescue cultivars to soil drought stress and rewatering drought stress.

PERSONNEL: Bingru Huang, Bin Wang, and Alan Zuk

INTRODUCTION:

Water availability recently has become a major limiting factor in growing turfgrasses in many areas. Studies have shown that tall fescue cultivars vary in drought resistance. Dwarf-type tall fescue has several desirable features, including slow shoot growth rate, darker green color, higher density, and finer texture. Limited available data suggest that these features may negate drought resistance. More detailed information is needed on drought responses of dwarf-type tall fescue in comparison to forage-type cultivars in order to improve drought resistance of tall fescue and to develop better management practices.

MATERIALS AND METHODS:

A forage-type tall fescue cultivar, 'Kentucky-31' and a dwarf-type cultivar, 'MIC-18', were examined. Sod plugs of established turf plants were collected from field plots in October 1996. Sods were washed free of soil before planting in 30-cm diameter and 40-cm deep plastic pots filled with a mixture of coarse river sand and top soil (1:2 v/v).

Plants were grown in a greenhouse, with day/night temperature of 75/60 F and a photoperiod of 14 h. Plants were watered twice a week to soil field capacity until the drying treatment was started. Controlled release fertilizer (N-P-K, 17-6-10) was topdressed twice at 90 g each time in each container during the experiment period. All plants were hand clipped biweekly at 6 cm. Plants were maintained under well-watered conditions for 3 months before the drying treatment was imposed.

The experiment consisted of three soil moisture treatments: a) well-watered control, plants were irrigated every other day until drainage occurred from the bottom of the pots;

b) drought stress, irrigation was withheld allowing soil to dry down for 28 d; and c) recovery, some plants grown under drought stress were resupplied with water to allow recovery for 21 d.

Relative water content (RWC), leaf water potential, leaf chlorophyll fluorescence, and canopy reflectance at eight wavelengths were determined at various times after treatment. Canopy green biomass (normalized vegetation index, ND) and leaf area index (reflectance at 935 nm to 661 nm ratio, IR/R) were calculated based on canopy reflectance.

RESULTS:

Relative water content: Relative leaf water content (RWC) declined with soil drying, starting from 12 d for both cultivars (Fig. 1). RWC returned to the control value after 7 d of rewatering for both cultivars. After 16 d of dry down, K-31 maintained higher RWC than MIC18 with the same level of drying.

Leaf water potential: Decline in leaf water potential (φ_{leaf}) occurred beginning 10 d after dry down for both cultivars (Fig. 2). The reduction in φ_{leaf} under drought stress conditions was greater for MIC18 than Kentucky-31. With the same level of soil drying, K-31 maintained higher φ_{leaf} than MIC18. At 7 d of rewatering following 14 d of drying, φ_{leaf} increased to a larger degree for K-31 than for MIC18 but did not reach the control values for either cultivar. By 14 d of rewatering, φ_{leaf} recovered completely for both cultivars.

Photosynthetic efficiency: Chlorophyll fluorescence as expressed in calculated Fv/Fm ratios is positively proportional to leaf photosynthetic efficiency. Soil drying caused significant declines in the Fv/Fm ratio beginning 16 d after dry-down for MIC18 and 18 d for K-31 (Fig. 3). The decline in Fv/Fm ratios was more dramatic for MIC18 than for K-31. After 7 d of rewatering following 14 d of drought, Fv/Fm ratios recovered somewhat but not to the control values for either cultivar.

Canopy green leaf biomass: Normalized vegetation index (ND) is considered an indicator of canopy green leaf biomass. ND was reduced with soil drying beginning at 11 d for MIC18 and 16 d for K-31 (Fig. 4). The decline in ND was greater for MIC18 than K-31. Recovery in ND after rewatering following 14 d of dry down did not occur until 14 d for MIC18 and 10 d for K-31. ND also increased after 14 d of rewatering following 21 d of dry down but did not reach the control values for either cultivar.

Leaf area index: The ratio of IR/R indicates leaf area index. IR/R was not affected by soil drying until 11 d for MIC18 and 16 d for K-31. IR/R increased after rewatering following 14 d of dry down, but it never reached the control value for either cultivar. However, the recovery was greater for K-31 than for MIC18. Leaf area index did not recover after rewatering following 21 d of dry down for either K-31 or MIC18.

SUMMARY:

Forage-type Kentucky-31 had better drought resistance than dwarf-type MIC18. With soil drying, reductions in canopy green leaf biomass, leaf area index, leaf water status, and photosynthetic efficiency occurred later and were less severe for K-31 than MIC18. After rewatering following soil drying, more and quicker recovery in turf growth and physiological activity also occurred for K-31 than MIC18.

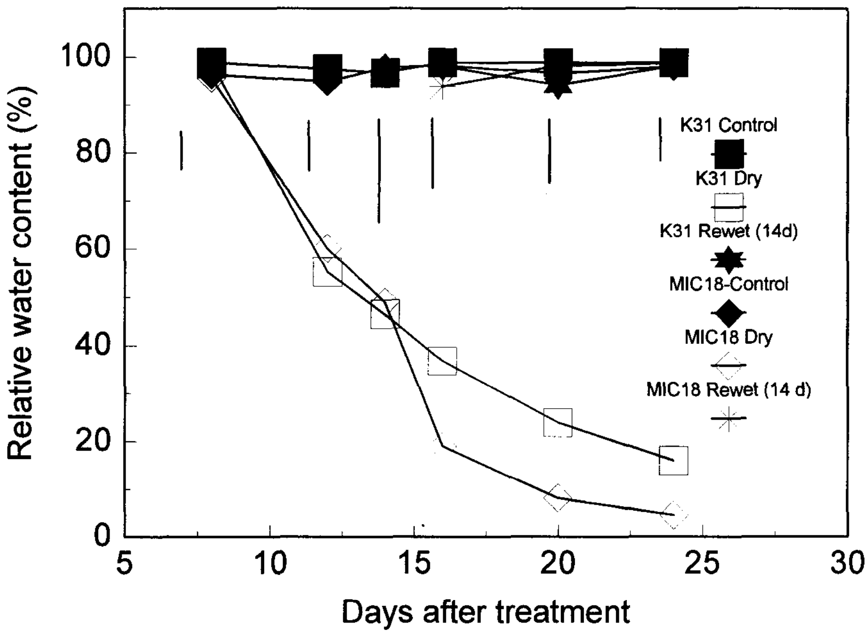

Fig. 1. Relative leaf water content (RWC) in response to soil drying and rewatering following 14 d of drying for Kentucky-31 and MIC18. Bars represent LSD values (P > 0.05).

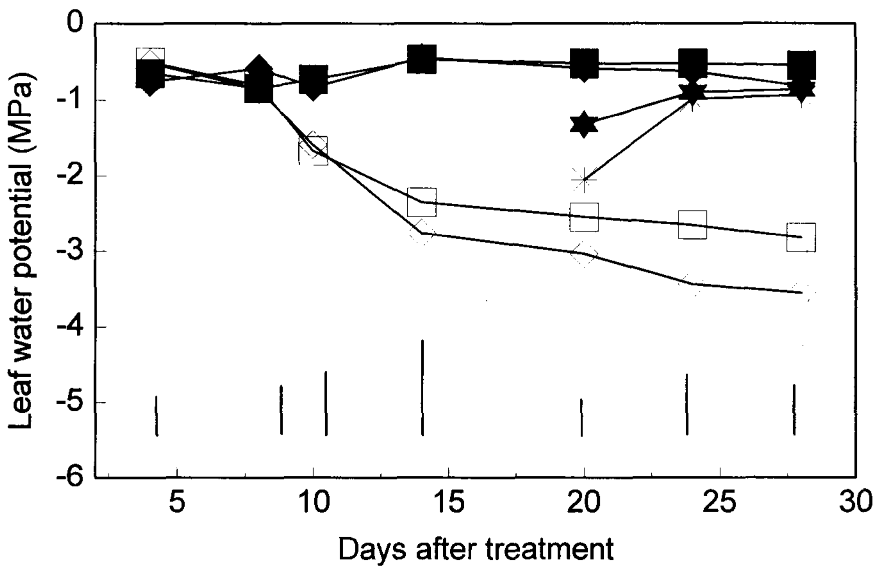

Fig. 2. Leaf water potential in response to soil drying and rewatering following 14 d of drying for Kentucky-31 and MIC18. Bars represent LSD values (P > 0.05).

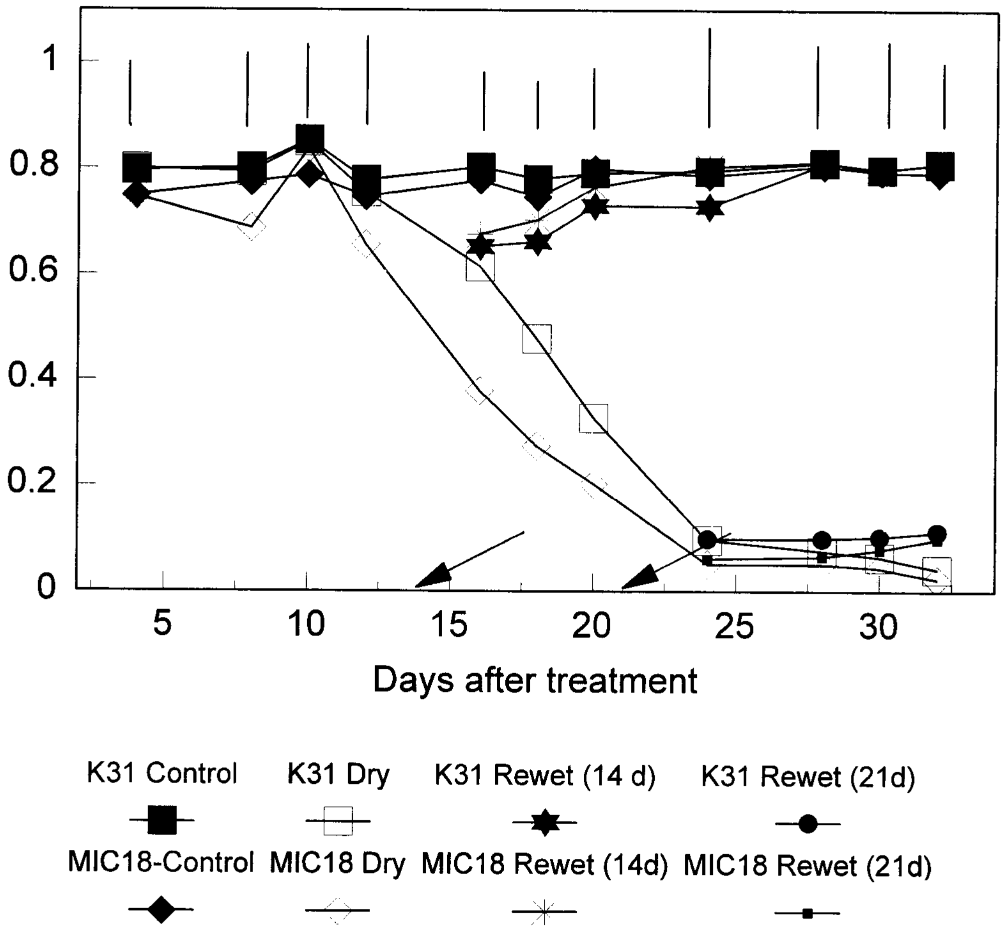

Fig. 3. Chlorophyll fluorescence in response to soil drying and rewatering following 14 and 21 d of drying for Kentucky-31 and MIC18. Bars represent LSD values (P > 0.05).

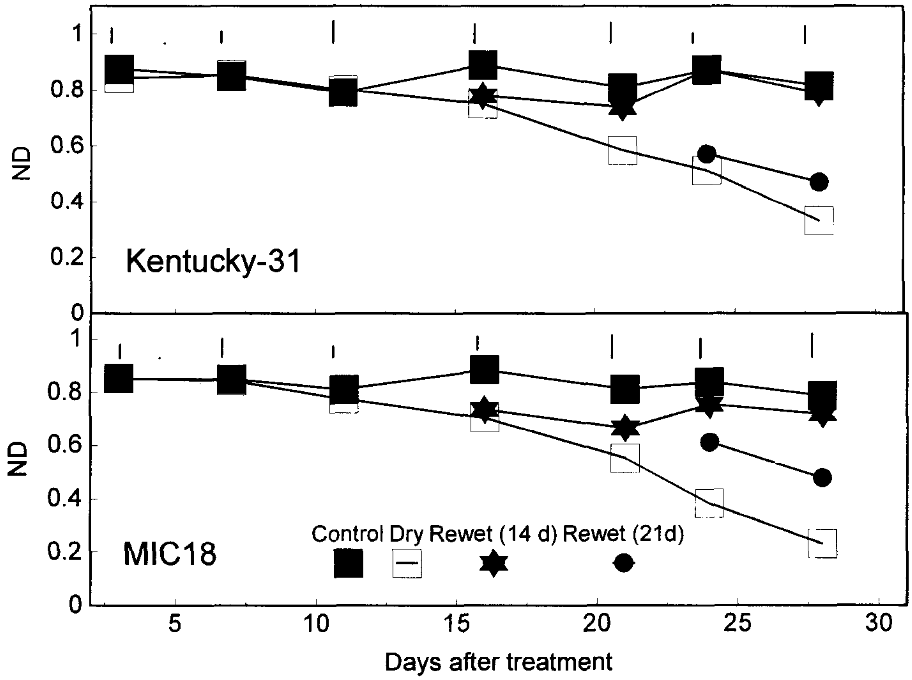

Fig. 4. Canopy green leaf biomass as indicated by normalized vegetation index (ND) in response to soil drying and rewatering following 14 and 21 d of drying for Kentucky-31 and MIC18. Bars represent LSD values (P > 0.05).

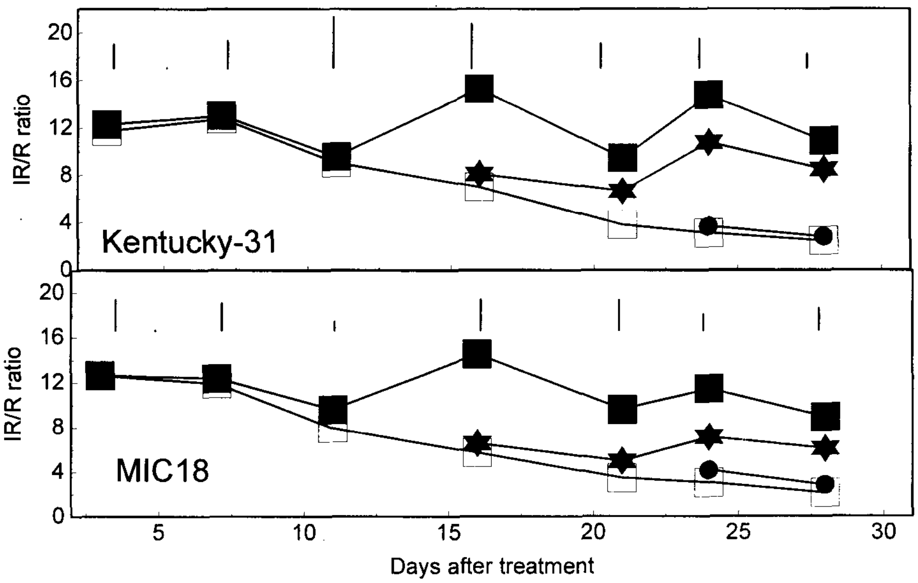

Fig. 5. Canopy leaf area index as indicated by IR/R ratio in response to soil drying and rewatering following 14 and 21 d of drying for Kentucky-31 and MIC18. Bars represent LSD values (P > 0.05).

TITLE: Effects of Cultivar, Fungicide Applications, and Clipping Removal on Development of Rhizoctonia Brown Patch on Tall Fescue.

OBJECTIVE: To evaluate management options for control of Rhizoctonia brown patch of tall fescue.

PERSONNEL: Ned Tisserat and John Pair

SPONSORS: Kansas Turfgrass Foundation

MATERIALS AND METHODS:
Tall fescue plots were established at the Horticulture Research Center, Wichita, in the spring of 1996. The experimental design was a split-split plot. The cultivars (main plots) AFA, Houndog V, Jaguar 3, and Kentucky 31 were seeded in early April at a rate of 6 lb/1000 sq feet. Cultivars were mowed (subplots) twice a week at a height of 2 1/2 inches with 1) a mulching mower in which the clippings were returned to the turf or 2)with a mower in which clippings were collected and removed from the plots. Each subplot received 1) no fungicide treatment; 2) a preventive application of Prostar at 3 oz/1000 sq ft on 4 Jun, 2 Jul, and 1 Aug; or 3) a curative application of Daconil Weather Stik at 6 oz/1000 sq ft on 18 Jun, 2 Jul, and 1 Aug. Individual plots were 8 X 4 ft and were replicated three times. Fungicides were applied in water equivalent to 4 gal/1000 sq ft at 30 psi with 8004 flat-fan nozzles using a CO_2-powered backpack sprayer. Plots were rated for % plot area damaged.

RESULTS:
The effects of fungicide applications, mowing techniques and cultivars are shown in Figures 1-3. Plot damage in July and early August was a combination of Pythium blight and Rhizoctonia brown patch, whereas damage at later sampling times was a result of brown patch. No significant interactions occurred among treatments except a cultivar X fungicide interaction on 1 Aug. This interaction apparently was due to enhanced development of Pythium blight in late June and July in Houndog V cultivar plots treated with the fungicide Prostar. The reason for this interaction is unclear, but perhaps the early spring seeding (hence more juvenile, and susceptible turf growth), cultivar susceptibility, and predisposition by the fungicide treatment increased Pythium blight. Prostar is effective in controlling brown patch but not Pythium blight.

Both preventive monthly fungicide treatments with Prostar and curative treatments with Daconil (three applications) were effective in reducing brown patch in late summer (Figure 1). Although the curative treatments were effective, they did not result in a reduction in the number of fungicide applications. All treatments, including the untreated plots, had very low levels of damaged turf by late September. This suggests that tall fescue can recover from brown patch injury after several weeks (i.e., the turfgrass is not noticeably thinned or killed by the disease).

The cultivar Houndog V showed significant damage from Pythium blight on 1 Aug (Figure 2). This disease is not common in Kansas and may have been the result of spring seeding and wet conditions in late June. No significant differences occurred among cultivars in the amount of brown patch at the other sampling dates. This is in contrast to previous reports indicating that KY 31 is more tolerant to brown patch.

Returning clippings to the turf (mulching mower) did not significantly increase the incidence of brown patch at any of the sampling dates (Figure 3). This suggests that diseased clippings are not significant sources of inoculum.

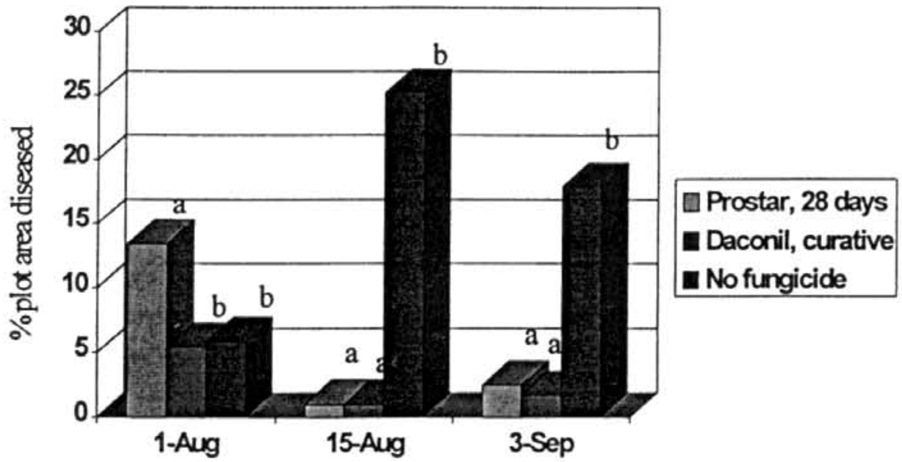

Figure 1. Effect of fungicide applications on disease development. Disease severity ratings on 1 Aug are for Pythium blight and brown patch. Ratings at the other dates are for brown patch only.

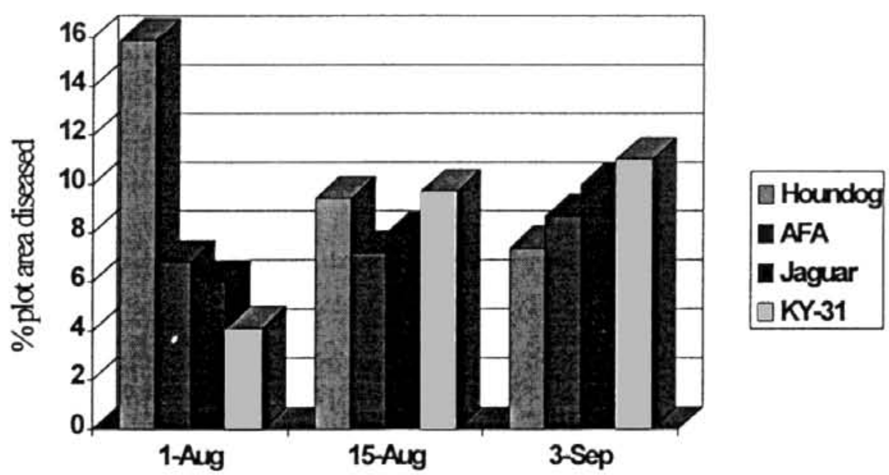

Figure 2. Effect of tall fescue cultivar on disease development. Disease severity ratings on 1 Aug are for Pythium blight and brown patch. Ratings at the other dates are for brown patch only.

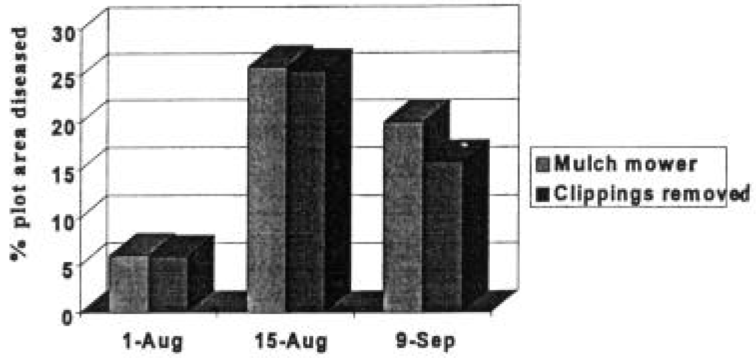

Figure 3. Effect of returning grass clippings to the turfgrass on the severity of disease on tall fescue. Disease severity ratings on 1 Aug are for Pythium blight and brown patch. Ratings at the other dates are for brown patch only.

TITLE: Preventive Fungicide Applications for Control of Rhizoctonia Brown Patch of Tall Fescue.

OBJECTIVE: To evaluate the effectiveness of a preventive fungicide spray program to control brown patch disease.

PERSONNEL: Ned Tisserat and John Pair

SPONSORS: Novartis, PBI Gordon, Rhone Poulenc, AgrEvo, Bayer, Zeneca, ISK, and the Kansas Turfgrass Foundation.

MATERIALS AND METHODS:

Fungicides were evaluated on an established stand of tall fescue (blend of three unidentified cultivars) at the Horticulture Research Center, Wichita, KS. Applications were made on 18 Jun 1996 and continued at 2- or 4-week intervals through 1 Aug. Fungicides were applied with a CO_2-powered backpack sprayer with 8003 TeeJet nozzles at 30 psi in water equivalent to 2.9 gal/1000 sq ft. Plots were not irrigated after applications. Plots were 6 ft X 10 ft and arranged in a randomized complete-block design with three replications. Plots were rated every 2 weeks for the percent area damaged.

RESULTS:

Brown patch severity was low throughout June and July (data not presented) but then increased in August and September because of relatively hot, humid conditions. All fungicide treatments suppressed brown patch severity on 1 Aug. (Table 1). Applications of Heritage 50WP and Prostar 50WP at 28-day intervals were as effective in controlling brown patch as any fungicide treatment applied at 14-day intervals. Applications of Prostar at 2 oz/1000 sq ft at 14-day intervals resulted in significant (9.0%) plot discoloration from Pythium blight (*Pythium* sp.) on 1 Aug. Pythium blight was not observed in other fungicide-treated plots in this study but did occur in adjacent, spring-seeded, tall fescue plots treated with Prostar at similar rates. This suggests that Prostar predisposed tall fescue to Pythium blight. Applications of Daconil Ultrex and Daconil 2787 resulted in a yellowing of the turfgrass beginning in late June and continuing until 1 Aug. All fungicide treatments gave excellent control of brown patch 2 weeks (16 Aug) after the last application date (1 Aug). However, only Bayleton at 2 oz, both formulations of Daconil, the 3 oz rate of Prostar, and both rates of Heritage gave aesthetically acceptable (<15%) levels of brown patch control 4 wk after the last fungicide application.

Table 1. Control of Rizoctonia brown patch of tall fescue by preventive fungicide applications, 1996.

Treatment and Rate/1000 sq ft	Spray Interval[1] (days)	% Plot Area Damaged[2]		
		1 Aug	16 Aug	2 Sept
Daconil Weather Stik 6.0SC 6 fl oz	14	3.3cde	0.7ab	3.3a
Heritage 50WP 0.2 oz	14	3.7cde	1.7ab	3.3a
Heritage 50WP 0.4 oz	28	1.0abc	0.7ab	4.7a
Prostar 50WP 2 oz	14	9.0f[3]	1.7ab	31.3bcd
Daconil Ultrex 82WG 4 oz	14	3.0bcde	0.7ab	5.7a
Bayleton 25DF 2 oz	14	2.3bcd	1.3ab	12.3ab
Banner Maxx 1.2MC 2 fl oz	14	0.7abc	0.0a	26.7bc
Sentinel 40WG 0.25 oz	28	6.7ef	3.3bc	30.0bcd
Prostar 50WP 3 oz	28	2.0bcd	0.0a	5.0a
CGA 173506 75WG 0.5 oz	14	1.0abc	2.3abc	38.3cde
Chipco 26019 2SC 4 fl oz	14	1.0abc	2.0abc	51.7def
Rizolex 75WP 2 oz	14	5.0def	7.0c	60.0ef
Chipco 26019 50WG 2 oz	14	0.0a	2.7abc	71.7fg
Polyoxorim 2.2WP 4 oz	14	3.7cde	1.7ab	73.3fg
No fungicide	--	20.0g	28.3d	83.3g

[1]Fungicide treatments on the 14-day schedule were applied on 4 Jun, 18 Jun, 2 Jul, 16 Jul, and 1 Aug; fungicide treatments on the 28-day schedule were applied on 4 Jun, 2 Jul, and 1 Aug. No fungicide applications were made after 1 Aug.

[2]Treatment means not followed by the same letter are significantly different ($P = 0.05$) by FLSD test. Data arcsine/square root transformed for analysis and backtransformed for presentation.

[3] Damage in plot caused by Pythium blight and not Rhizoctonia brown patch.

TITLE: Evaluation of Biocontrol Products for Suppression of Parasitic Nematodes on a Bentgrass Putting Green

OBJECTIVE: To evaluate the effectiveness of biocontrol products to suppress parasitic nematodes.

PERSONNEL: Ned Tisserat and Tim Todd

SPONSORS: Kansas Turfgrass Foundation, Heart of America Golf Course Superintendents Assocation, and the Kansas Golf Course Superintendents Association

MATERIALS AND METHODS:

Products were evaluated on a bentgrass putting green at the Prairie Dunes Country Club, Hutchinson, KS. The turfgrass had a history of summer thinning and decline that was associated with relatively high populations of plant parasitic nematodes. Products were applied to the turf with a CO_2-powered backpack sprayer at 30 psi using 8003 nozzles in water equivalent to 3.6 gal/1000 sq ft. Plots were 6X6 ft and arranged in a randomized complete-block design with four replicates. All treatments with the exception of ABG 9017 F were applied on 24 Jun and 22 Jul. The ABG 9017 F treatments were applied only on 24 Jun. On 24 Jun (pretreatment), 22 Jul, and 26 Aug, four soil cores, 1 in. diameter and 3 in. deep, were removed from each plot and bulked. Nematodes and microbivores were extracted from the samples by sucrose density centrifugation and enumerated.

RESULTS:

Nematode populations tended to decrease from 24 Jun to 26 Aug in nontreated plots (data not shown). Application of Precep, Vector, Zap, ABG 9008, and ABG 9017 did not further reduce populations of parasitic nematodes or microbivores during the summer months. Application of Nemacur in Jun reduced *Tylenchorhynchus clayton* but not other parasitic nematode populations by Jul. No differences in nematode populations were observed in Nemacur-treated plots in Aug. Summer thinning of the bentgrass, observed in previous years, did not occur in 1996, no correlations occurred between bentgrass quality ratings (data not shown) and nematode populations. Application of both rates of ABG 9017 F caused phytotoxicity and thinning of bentgrass 10 days after application. Plots treated with the ABG 9017 at 2.3 pt/1000 ft^2 continued to show damage 2 mo after application.

Table 1. Suppression of parasitic nematodes on a bentgrass putting green by biocontrol products, 1996.

	Nematodes/100 cu cm Soil									
Treatment and Rate/1000 sq ft	*Hoplolaimus galeatus*		*Criconemella xenoplax*		*Hemicycliophora* sp.		*Tylenchorhynchus claytoni*		Nematode Microbivores	
	Jul	Aug	Jul	Aug	Jul	Aug	Jul[1]	Aug	Jul	Aug
Control	160	75	285	40	80	50	425[a]	190	2090	1130
Nemacur 3E, 9.7 fl oz	190	80	190	160	10	30	60[b]	50	1640	1120
Precep, 0.7 fl oz	80	50	300	250	40	40	510[a]	190	1790	1670
Vector MC, 4.5 oz	150	40	440	50	120	50	440[a]	300	2020	1350
Zap 8-0-0, 2.9 fl oz	160	10	170	170	30	50	480[a]	310	2480	2140
ABG 9008 WP, 1.1 lb	250	80	300	120	70	60	600[a]	320	2160	1470
ABG 9008 WP, 2.3 lb	160	40	300	60	60	50	660[a]	130	2890	1550
ABG 9017 F, 1.1pt	260	50	110	60	20	50	840[a]	250	1730	840
ABG 9017 F, 2.3 pt	350	180	250	170	40	90	600[a]	250	2030	1690

[1] *T. claytoni* populations in the Nemacur-treated plots were significantly different in Jul but not Aug (*P*=.10) based on least squares means of $\log_{10}$ - transformed data. None of the other treatments significantly altered (*P*=.10) nematode populations at either sampling date.

TITLE: Assessing Genetic Diversity in *Ophiosphaerella herpotricha* and *O. korrae*, Two Agents that Cause Spring Dead Spot of Bermudagrass

OBJECTIVE: To assess the genetic diversity of these fungi through the use of molecular biology techniques.

PERSONNEL: Henry Wetzel and Ned Tisserat

SPONSORS: Golf Course Superintendent's Association of America, Heart of

America Golf Course Superintendent's Association

INTRODUCTION:

Spring dead spot (SDS) of bermudagrass is caused by the fungi *Ophiosphaerella herpotricha*, *O. korrae,* and *Leptosphaeria narmari*. *Ophiosphaerella herpotricha* is the agent that has been associated with SDS throughout the mid-west region of the transition zone, whereas *O. korrae* has been associated with SDS throughout the east and west coast regions of the transition zone. *Leptosphaeria narmari* is the primary cause of SDS in Australia. We reported the first detection of *L. narmari* from colonized bermudagrass obtained from the Shangri-La Golf Course in Afton, Oklahoma at the 1996 American Phytopathological Meetings. Classical microbiological methods have failed to reveal the reproductive biology of these organisms. This study is using molecular biology techniques to determine whether or not populations of these fungi are clonal (i.e., identical) or variable on a spatial scale such as from fairway to fairway on the same golf course or from golf course to golf course within a region.

MATERIALS AND METHODS:

Numerous turfgrass samples were collected in May of 1994 from three golf courses: Independence Golf Course in Southeast Kansas and South Lakes Golf Course and Shangri-La Golf Course in Northeast Oklahoma. An additional 272 isolates were collected from Shangri-La G.C. in May of 1996 to confirm previous results on the possibility of all three SDS agents coinciding on the same fairway. Bermudagrass roots exhibiting the presence of darkly pigmented ectotrophic runner hyphae were washed, surface sterilized, and plated on selective medium. Cultures exhibiting *O. herpotricha* colony morphology then were transferred to liquid media in preparation for the isolation of deoxyribonucleic acid (DNA). The DNA then was extracted, and isolate identity was confirmed with specific polymerase chain reaction (PCR) primers for *O. herpotricha* and *O. korrae*. Once isolates are identified through PCR, an additional set of PCR primers, developed from a DNA library of *O. herpotricha*, then are implemented to assess the similarities and differences among the *O. herpotricha* isolates. A technique known as Random Amplified Polymorphic DNA (RAPD) PCR also will be used to assess and verify genetic diversity among *O. herpotricha* and *O.korrae* isolates.

RESULTS:

Isolates collected in May 1994 from Independence, South Lakes, and Shangri-La golf course have been identified to species. All isolates from Independence and South Lakes appear to be *O. herpotricha*. The majority of the isolates from Shangri-La are *O. herpotricha*; however, five isolates of *O. korrae* and one isolate of *Leptosphaeria narmari* were recovered from this course. Results of the resampling of Shangri-La in May 1996 are as follows: 143 *O. herpotricha*, 72 *O. korrae*, and 57 unidentified isolates. Twenty of the 57 unidentified isolates have been identified putatively as *L. narmari* based on ribosomal DNA evidence. Currently, we are in the process of sequencing the ribosomal DNA of a selected few of these 20 unidentified isolates in order to compare DNA sequences with *L. narmari* isolates from an Australian collection. This should give us additional evidence that *L. narmari* is present in North America.

Preliminary data have been assessed for genetic diversity among Shangri-La, *O. herpotricha* isolates collected in 1994. Results indicate that many genotypes coexist within an individual fairway. This suggests that sexual recombination is occurring frequently among the populations of *O. herpotricha*. These initial results need to be repeated along with genetic diversity assessment of the remaining two golf course samples. With the more frequent occurrence of *O. korrae* from the second sampling trip to Shangri-La in May of 1996, we will begin to assess the genetic diversity of this species with the RAPD PCR assay and also use this assay to verify genetic diversity in *O. herpotricha* isolates.

TITLE: The Effects of Aerification and Fungicide Application on the Development of Summer Patch Disease in Mystic Kentucky Bluegrass

OBJECTIVE: To determine the efficacy of aerification in combination with a fungicide application to suppress summer patch disease in Kentucky bluegrass maintained under golf course fairway conditions.

PERSONNEL: Henry Wetzel

SPONSORS: Bayer, ISK Biosciences, Novartis, Rohm & Haas, and Zeneca

MATERIALS AND METHODS:

An experiment to test the effects of fungicide application and aerification was established on a Kentucky bluegrass cv. 'Mystic' plot at the Rocky Ford KSU Turfgrass Research Center. The experimental design was a split plot, with fungicide treatments as main plots and aerification treatments as subplots. The main plots were 120 ft^2, replicated four times and assembled into a randomized complete block design. Aerification occurred on 26 April and 18 October with a Ryan Greensair equipped with hollow tines. The aerification cores were verticut to amend the soil back into the plots, and remaining thatch was raked and discarded. Fungicides (Table 1) were applied on 15 May and 19 June in 2.3 gal H_2O/1000 sq ft with a backpack CO_2 powered sprayer equipped with TeeJet 8003 nozzles. Fungicides were not watered in following treatment. The turfgrass was reel mowed three times per week at 3/4 in. to mimic a golf course fairway situation. Irrigation was applied deeply and infrequently to maintain adequate soil moisture. Preemergent crabgrass control (Dimension) was applied in mid-April followed up with a preventative white grub control (Merit) application in mid-May.

Disease ratings were assessed weekly as a percent area of turfgrass blighted beginning on 26 June when disease symptoms were first observed. Turfgrass quality was assessed on a 0 to 10 scale, where 0 = completely brown or dead turf and 10 = optimum turf density with no disease. A rating of 8 is considered the minimal acceptable quality for a golf course fairway. Data were analyzed using SAS PROC MIXED procedures, and significant differences were separated at the P=0.05 level.

RESULTS:

Environmental conditions this past spring were ideal for grass growing in northeast Kansas. Very little precipitation occurred, and temperatures were in the mid-80's. However, high temperatures in mid-June resulted in symptoms of summer patch. Disease severity was light in all plots. Preventative fungicide applications and spring aerification failed to reduce summer patch severity (Tables 2 & 3). Initial symptoms of summer patch were evident 1 week after the second fungicide application was made on 19 June. This probably explains why no significant differences occurred among treatments in turfgrass quality (Table 2) and summer patch disease severity (Table 3), because these products had very little curative efficacy on summer patch disease.

This experiment will be carried out through the growing season of 1998. An isolate of *Magnaporthe poae*, the causal agent of summer patch, was isolated from the Kentucky bluegrass cv. 'Mystic' plots in 1996 and was used to prepare inoculum. Plots were amended with the fungal inoculum on 31 March 1997 in hopes of distributing the pathogen more evenly throughout the experimental area for the following season. I plan to move my first application up to mid-April and then make two additional applications in mid-May and mid-June.

Table 1. Fungicide treatments applied to Kentucky bluegrass cv. 'Mystic' at the Rocky Ford KSU Turfgrass Research Center in Manhattan, KS, 1996.

Treatment	Rate	Application Dates
	oz/1000 sq ft	
1. Eagle 40 WP	1.2	15 May, 19 June
2. Fluazinam 500F	1.5	15 May, 19 June
3. Sentinel 40WG	0.25	15 May, 19 June
4. Heritage 50WG	0.2	15 May, 19 June
5. Banner MC	4.0	15 May, 19 June
6. Control	- -	- -

Table 2. Turfgrass quality ratings on Kentucky bluegrass cv. 'Mystic' at the Rocky Ford KSU Turfgrass Research Center in Manhattan, KS, 1996.

Treatment	Turfgrass Quality (0 -10)[1]			
	26 June	3 July	10 July	18 July
Main Effects:				
1. Eagle 40 WP	7.5[2]	5.7[2]	5.7[2]	5.4[2]
2. Fluazinam 500F	7.2	6.2	6.6	6.2
3. Sentinel 40WG	7.3	6.1	6.5	5.1
4. Heritage 50WG	7.6	7.1	7.2	7.1
5. Banner MC	7.0	5.6	6.1	5.7
6. Control	7.2	6.5	6.7	6.2
Sub-plots:				
Aerification	7.2	6.5	6.7	6.4
Without aerification	7.4	5.9	6.2	5.4

[1]Turfgrass quality was assessed on a 0 to 10 scale, with 8 being minimal acceptable quality for a golf course fairway. A rating of 0 being completely brown or dead turf and 10 being optimum density and greenness.
[2] No significant differences among treatments at the P=0.05 level.

Table 3. Summer patch disease severity[1] on Kentucky bluegrass cv. 'Mystic' at the Rocky Ford KSU turfgrass research center in Manhattan, KS, 1996.

Treatment	26 June	3 July	10 July	18 July
(Main Effects)	------------------Percent Disease (0-100)------------------			
1. Eagle 40 WP	3.2[2]	21.7[2]	20.3[2]	32.3[2]
2. Fluazinam 500F	5.8	20.0	14.3	20.7
3. Sentinel 40WG	3.8	17.8	12.0	28.7
4. Heritage 50WG	2.4	12.8	5.8	9.0
5. Banner MC	6.5	21.2	15.0	22.8
6. Control	4.9	12.8	8.3	17.2
(Sub Plots)				
Aerification	4.6	14.7	9.6	16.2
Without Aerification	4.3	20.8	15.7	27.2

[1]Summer patch disease severity expressed as percent plot area of the turfgrass stand blighted.
[2] No significant differences among treatments at the P=0.05 level.

TITLE: Evaluation of Flowering Ornamentals to Guide Timing of Preemergence Herbicide Application for Crabgrass

OBJECTIVE: To survey ornamental bloom times and determine which are the best indicators for determining time of preemergence herbicide application.

PERSONNEL: Jack Fry, Ward Upham, and Alan Zuk

INTRODUCTION:

Optimum application times for herbicides vary, and some should be coordinated with crabgrass germination time to maximize effectiveness. Prodiamine (Barricade) and dithiopyr (Dimension) are herbicides that have a relatively long residual and can provide effective crabgrass control when applied as a single application in early spring or even in the previous fall. Therefore, coordinating application time of these herbicides with crabgrass germination is not critical.

The initial application of other herbicides that have a shorter residual, such as pendimethalin (Pre-M, Pendulum, Scott's Turf Weedgrass Control); benefin (Balan); benefin + trifluralin (Team); bensulide (Betasan, Scott's Weedgrass Preventer); DCPA (Dacthal); and oxadiazon (Ronstar) is best coordinated with crabgrass germination time to maximize longevity of control.

Rather than using a standard calendar date to determine preemergence herbicide application time, some have recommended basing application time upon flowering of commonly used ornamentals. Some recommendations have been to apply the herbicide "when forsythia blooms wither" or "when the redbud begins to bloom." However, the accuracy of these recommendations has never been established.

MATERIALS AND METHODS:

We worked with researchers at the University of Nebraska, Lincoln to survey 21 flowering ornamentals and determine which were the best "indicators" for crabgrass germination. The period from bloom start to end was recorded for each ornamental. Crabgrass germination date also was recorded.

RESULTS:

In Manhattan, crabgrass in bare soil germinated on April 15, 1995 and May 9, 1996. In thin turf, it germinated on May 22, 1995 and May 16, 1996.

Several ornamentals started or ended bloom before crabgrass germination (Table 1).

Table 1. Flowering ornamentals that ended (E) or started (S) bloom 1 to 3 weeks prior to crabgrass germination in thin turf.

Ornamental	1995	1996
Bridal wreath spirea		E
Flowering quince		E
Lantana viburnum	E	
Lilac	E	
Redbud		E
Sand plum		E
Saucer magnolia		E
Tatarian honeysuckle	E	S
Tulip		E
Vanhoutte spirea		S
Winter honeysuckle		E

Lilac and lantana viburnum blooms withered 1 to 3 weeks prior to crabgrass germination in both years. Lilac was also a reliable indicator in Lincoln, Nebraska in both years. This survey will continue during spring, 1997. In addition, we're conducting an experiment to determine the effectiveness of several preemergence herbicides applied based upon bloom time of these ornamental indicators.

TITLE: Selective and Nonselective Bermudagrass Control

OBJECTIVE: To evaluate herbicides for nonselective bermudagrass control and selective control in tall fescue and zoysiagrass

PERSONNEL: Ward Upham and Jack Fry

INTRODUCTION:
Bermudagrass can be an invasive weed, and nonselective control is usually required. However, some herbicides have demonstrated activity on bermudagrass that could be used selectively in established turf.

MATERIALS AND METHODS:

Three separate studies were conducted: 1) nonselective bermudagrass control; 2) selective bermudagrass control in tall fescue; and 3) selective bermudagrass control in zoysiagrass. Treatments and application rates for all studies are presented in Tables 1 to 3. Herbicides were applied with a CO_2 backpack sprayer calibrated to deliver 60 GPA (1.4 gal/1,000 sq ft) at 35 psi. Plot size was 1 by 2 m, and experimental designs were randomized complete blocks with four replications. Data were subjected to analysis of variance, and means were separated using the Waller-Duncan Bayesian k ratio t test (K = 100, P = 0.05).

Nonselective control: Treatments were applied to a mature stand of S-16 bermudagrass. Data were collected in September on percent bermudagrass control.

Selective control in tall fescue: S-16 bermudagrass plugs were transplanted into K-31 tall fescue (2 per plot), and bermudagrass and zoysiagrass colors were rated 7 weeks after treatment.

Selective control in zoysiagrass: A natural infestation of common bermudagrass was used in an existing stand of 'Meyer' zoysiagrass. Bermudagrass control was evaluated in September. Phytotoxicity was rated up to 4 weeks after treatment (WAT). Acclaim was tank mixed with Ferromec or a colorant to evaluate these materials for potential to reduce phytotoxicity.

RESULTS:

Nonselective control: The best control was achieved with Roundup and Finale treatments. Roundup was as effective at 3 oz/gal as at 5 oz/gal. There was no advantage to mixing Roundup and Finale. Bermudagrass control with Acclaim plus Turflon Ester was inferior to that observed in plots treated with Roundup or Finale but superior to that in plots treated with Acclaim plus Super Trimec. Fusilade II provided a level of control statistically similar to that with Roundup and Finale, but it was less than 90%. All plots will be observed in 1997 for bermudagrass recovery.

Selective control:

Tall fescue. The only treatment that did not reduce tall fescue quality to an unacceptable level; and caused severe injury to bermudagrass was Fusilade II. Acclaim caused slight bermudagrass discoloration; Finale and Roundup caused severe injury to both tall fescue and bermudagrass.

Zoysiagrass. All herbicide treatments provided statistically similar levels of bermudagrass control. Less discoloration was observed on turf treated with Acclaim + Ferrmoec compared to Acclaim alone at 2, 3, and 4 WAT. Acclaim + Colorant and Acclaim + Ferrmoec never exhibited unacceptable levels of phytotoxicity.

Table 1. Nonselective bermudagrass control at Manhattan, KS in Sept., 1996.

Treatment	Rate (product/a)	Control (%)[1]
Finale	6.4 qts.	96 d[2]
Roundup	4.8 qts.	99 d
Finale	6.4 qts.	96 d
Roundup	4.8 qts.	100 d
Roundup +	4.8 qts.	
Finale	6.4 qts.	97 d
Acclaim +	23 fl. oz.	
Turflon Ester	1 qt.	67 c
Acclaim +	23 fl. oz.	
Super Trimec	3 pts.	22 b
Fusilade II	20 fl. oz.	89 d
Roundup	3 gal.	100 d
Untreated	--	0 a

[1]Rated on a 0 to 100% scale.
[2]Means followed by the same letter in a column are not significantly different (P < 0.05).

Table 2. Tall fescue and bermudagrass discoloration after herbicide application at Manhattan, KS in 1996. Tall fescue was the desired species, bermuda the weed.

		Discoloration [2]	
Treatment	Rate (product/a)	Tall fescue	Bermuda
Untreated	--	9.0 a[3]	9.0 a
Finale	6.4 qts.	0.0 c	0.0 d
Roundup	4.8 qts.	0.0 c	0.0 d
Fusilade II	6 fl. oz.	7.4 b	1.7 c
Acclaim	22 fl. oz.	9.0 a	6.3 b

[1]All treatments applied on 15 July and 15 August.
[2]Turf discoloration (indicates phytotoxicity) rated on a 0 to 9 scale, 9 = least discoloration.
[3]Means followed by the same letter in a column are not significantly different (P < 0.05).

Table 3. Selective bermudagrass control in 'Meyer' zoysiagrass and zoysiagrass discoloration at Manhattan, KS in 1996.

				Discoloration[3]			
		Control[2]		1	2	3	4
Treatment[1]	Rate (product/a)			WAT[4]	WAT	WAT	WAT
Untreated	--	0	b	9.0 a[5]	9.0 a	9.0 a	9.0 a
Acclaim	22 fl. oz.	46	a	6.7 c	6.3 c	7.0 b	6.7 c
Fusilade II	6 oz.	73	a	9.0 a	6.0 c	5.3 c	5.3 c
Acclaim plus	22 fl. oz.	66	a	6.7 c	7.7 b	8.3 a	8.0 b
Ferromec	5 qts.						
Acclaim plus	22 fl. oz.	59	a	8.0 a	8.0 b	8.3 a	8.0 b
Colorant	6 qts.						

[1]All Acclaim treatments applied on 3 June, 1 July, and 1 August. Fusilade applied on 10 June, 1 July, and 1 August.
[2]Control rated visually on a 0 to 100% scale in September.
[3]Turf discoloration (indicates phytotoxicity) rated on a 0 to 9 scale, 9 = least discoloration.
[4]WAT = weeks after treatment.
[5]Means followed by the same letter in a column are not significantly different ($P < 0.05$).

TITLE: Preemergence Herbicide Evaluation

OBJECTIVE: To assess the efficacy of Barricade 65WG for control of crabgrass at various rates and in comparison to three other preemergence herbicides.

PERSONNEL: Ward Upham and Alan Zuk

SPONSOR: Sandoz Co.

MATERIALS AND METHODS:

A bluegrass turf, located at the KSU Rocky Ford Turfgrass Research Center near Manhattan, KS, was used for this study. Treatments, application rates, and results are presented in Table 1. Treatments were applied on 8 April, 1996. At the time of treatment, the sky was mostly cloudy, wind speed was 7 mph, and the temperature was 61° F. Liquid treatments were applied with a backpack CO_2 sprayer equipped with 8004 flat-fan nozzles and calibrated to deliver 60 GPA (1.4 gal/1000 sq ft) at 35 psi. Granular treatments were applied using a shaker bottle. Plot size was 1 by 2 meters, and the experimental design was a randomized complete block with three replications. Plots were examined for phytotoxicity at 1, 2, and 4 weeks after treatment and for percent crabgrass coverage at 10, 12, 14, 16, 18, and 20 weeks after treatment. Crabgrass coverage data were converted to percent crabgrass control based upon crabgrass levels in the nontreated plots. Data were subjected to analysis of variance, and means were separated using the Waller Duncan Bayesian k ratio t test (k = 100, P = 0.05).

RESULTS:

No significant differences occurred in phytotoxicity on any rating dates through 4 weeks after treatment. Crabgrass was not observed until 14 weeks after treatment. Therefore, no ratings were available for the scheduled dates of 10 and 12 weeks after treatment. Ratings were not taken 20 weeks after treatment because the crabgrass showed signs of decline from frost.

At 14 and 16 weeks after treatment, Barricade 65WG at 0.32 lbs. ai/a and Pendulum 60WG at 3.0 ai/a were the only preemergent treatments that provided < 90% crabgrass control (Table 1). At 18 weeks after treatment, Pendulum 60WG at 3.0 lbs. ai/a and Ronstar 2G at 4.0 lbs. ai/a were the only treatments that provided < 90% crabgrass control.

Table 1. Crabgrass control after treatment with Barricade, Pendulum, Ronstar, or Dimension preemergence herbicides at Manhattan, KS in 1996.

Treatment[1]	Rate (lbs ai/a)	14 WAT[2]	16 WAT	18 WAT
Untreated	---	0.00 c[3]	0.00 c	0.00 d
Barricade 65 WG	0.32	82.53 ab	84.93 ab	95.57 ab
Barricade 65 WG	0.48	95.90 a	95.20 ab	94.53 ab
Barricade 65 WG	0.65	99.60 a	98.67 a	100.00 a
Barricade 65 WG	0.75	96.20 a	100.00 a	99.57 a
Barricade 65 WG	0.97	99.60 a	100.00 a	100.00 a
Pendulum 60 WG	3.0	73.33 b	80.07 b	80.50 c
Ronstar 2G	4.0	95.90 a/	94.87 ab	89.27 bc
Dimension 1EC	0.5	97.97 a	95.13 ab	94.03 ab

[1]All treatments were applied on April 8, 1996.

[2]WAT = weeks after treatment

[3]Means followed by the same letter in a column are not significantly different (P < 0.05).

TITLE: KTURF: A Pesticide and Nitrogen Leaching Model Available on the World Wide Web

INVESTIGATOR: Steve Starrett

SPONSOR: United States Golf Association

Models were developed at KSU and funded by the USGA to estimate the percentage of applied nitrogen or pesticide that leaches through 50 cm (20 in.) of turfgrass-covered soil. KTURF was developed to allow golf course superintendents to use these models on the Internet. Access to the KTURF models is available via the Internet and the World Wide Web at the following URL: http://www.eece.ksu.edu/starret/KTURF/

The KTURF models were developed using artificial neural networks (ANNs), a form of artificial intelligence. ANNs are trained using experimental data from experimental tests. The ANN "learns" the relationships between the inputs and the output. Once the models are developed (trained), those relationships can be applied to other situations to make predictions about the output, which is the percentage of nitrogen or pesticide that leaches. Two interactive models are currently available at the KTURF website. The nitrogen model predicts the percentage of applied nitrogen leaching through 50 cm of turfgrass-covered soil. It is applicable to both fairway and greens conditions. The user must supply four input variables to compute the predicted result: the sand content of the soil, the irrigation applied to the soil, the form of nitrogen applied, and the time after the nitrogen application that the leached output is desired. The pesticide model that is currently available is applicable only to fairway conditions. It predicts the percentage of applied pesticide that leaches through 50 cm of turfgrass-covered soil. The irrigation rate and the time (in days after pesticide application) are necessary input variables. In addition, two characteristics of the pesticide, the water solubility and the sorption coefficient, must be inputted. Because these characteristics may be unknown, a menu of common pesticides used is provided. However, if a pesticide used is not listed, your pesticide sales representative can provide this information. The output forms also display the variables entered to ensure that submitted data were correct. The output value provided is an estimated percentage of how much of the applied pesticide leached. KTURF can help to reduce pesticide leaching by allowing users to experiment with different pesticide/irrigation schemes. Thus, they can optimize their practices to reduce the likelihood of pesticide leaching beyond the root zone.

An article about KTURF was published recently in the USGA Greens Section Record. A technical article about the KTURF nitrogen model is being published in *Communications in Soil Science and Plant Analysis*. A technical article about the KTURF pesticide model is under review by *Advancements in Environmental Research*.

TITLE: The Color of Turfgrass. I. Differences between Species.

OBJECTIVE: To determine whether computers can distinguish between turfgrass species based on their color.

PERSONNEL: Steven Wiest

INTRODUCTION:

Turfgrass scientists have long used a subjective visual rating system in almost all of their studies — for instance, the chemical trials reported elsewhere in this report. This rating system has always been highly subjective, because different people would come up with different ratings on the same treatment plot. This report presents part of a study designed to replace subjective ratings with a computerized quantitative analysis of turf stand color.

MATERIALS AND METHODS:

Four year old plots of Mustang tall fescue *(Festuca arundinacea)* and Meyer zoysiagrass *(Zoysia japonica)* were used as the study material. Pictures were taken with a camera held horizontal to the ground at a height of 1.3 m, with ASA 100 film and a 28 mm wide-angle lens. Prints (10 x 13 cm) were scanned using an Epson ES-600 flatbed scanner, and the digitized images were stored in the computer using lossless compression techniques.

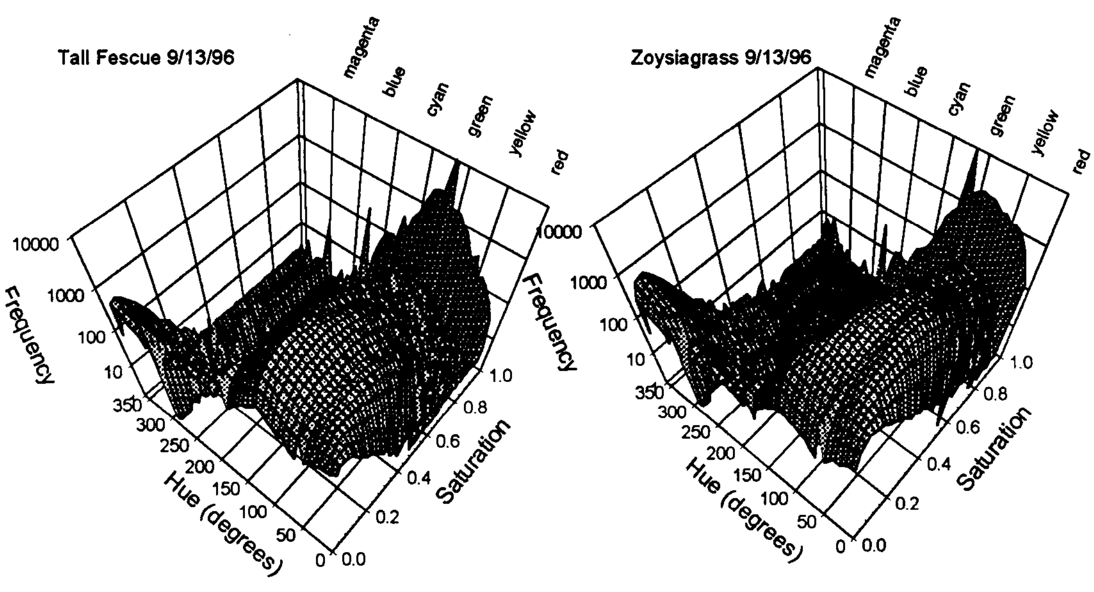

Figure 1. Three-dimensional representation of pixel frequencies of hue and saturation components from tall fescue and zoysiagrass on 13 September 1996.

Color spectra of the digitized images were obtained by first separating the red, green, and blue components of the photo into separate files, then converting them into hue (tint), saturation (purity), and intensity (darkness). These three components then were used to compare photos of tall fescue vs. zoysiagrass. The spectra of four replicates were averaged.

RESULTS:

The most reliable results can be obtained from the hue vs. saturation data (Figure 1). This is because slight differences, such as inconsistent exposures during the taking of the picture and/or during processing, can lead to differences in intensity (i.e., light vs. dark or specifically the magnitude of the light reflected off the photograph), but should not affect hue or saturation.

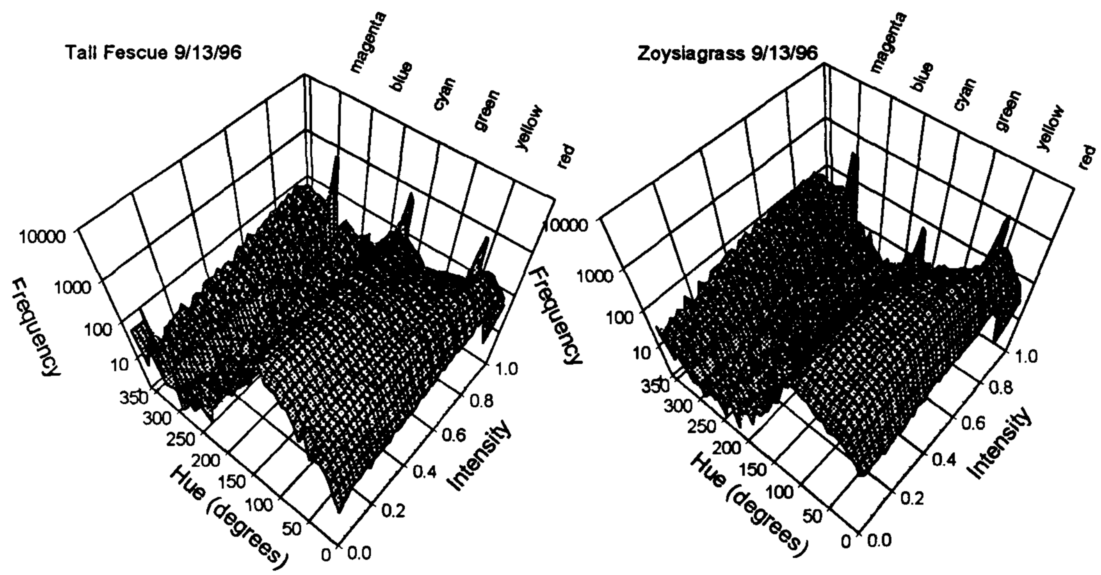

Figure 2. Three-dimensional representation of pixel frequencies of hue and intensity components from tall fescue and zoysiagrass on 13 September 1996.

It is readily apparent from Figure 1 that differences in the color of the two species in mid-September can be seen and quantified. Green occurs at a hue of about 100°, whereas yellow is represented by a hue of about 50°. Tall fescue is a darker green color than zoysiagrass in mid-September, and this exemplified by a higher spectral peak around 100° (green) and a lower spectral shoulder around 50° (yellow) in tall fescue than in zoysiagrass.

The results shown in Figure 2 show that the same differences can be seen when comparing hue vs. intensity. This can be taken as a confirmation of the conclusions drawn from Figure 1.

These results demonstrate that computer-based analysis of photographs has the potential to quantify color differences between plots of turfgrass. However, color is only one aspect of the rating process, and further work is needed before subjective ratings can be replaced by computers.

TITLE: The Color of Turfgrass. II. Spring Green-up of Warm-Season Turfgrasses

OBJECTIVE: To determine whether computers can quantify differences between warm-season turfgrass species during spring green-up.

PERSONNEL: Steven Wiest

INTRODUCTION:

Rating systems have always been highly subjective, because different people come up with different ratings on the same treatment plot. This report presents another part of a study designed to replace subjective ratings with a computerized quantitative analysis of turf stand color.

MATERIALS AND METHODS:

Four-year-old plots of Midlawn bermudagrass *(Cynodon dactylon x transvaalensis)* and Prairie buffalograss *(Buchloe dactyloides)* were used as the study material. Pictures were taken with a camera held horizontal to the ground at a height of 1.3 m, with ASA 100 film and a 28 mm wide-angle lens. Prints (10 x 13 cm) were scanned using an Epson ES-600 flatbed scanner, and the digitized images were stored in the computer using lossless compression techniques. Photographs were taken on 1 and 28 May, 1996.

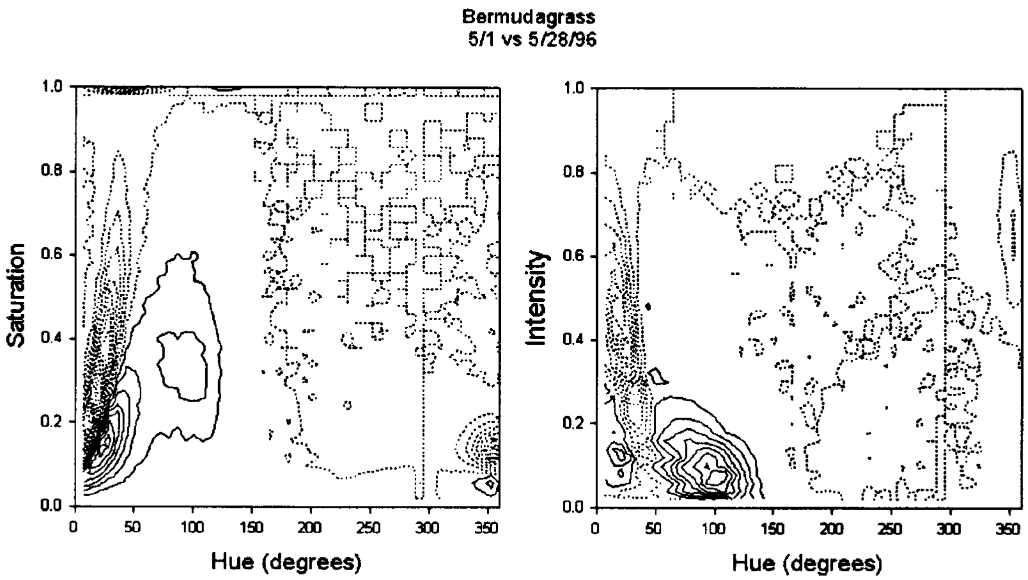

Figure 1. Contour plot of spectral differences in bermudagrass canopies between 1 and 28 May, 1996. Solid lines indicate increased frequencies. Dashed lines indicate decreased frequencies. Contour lines are present at frequency intervals of 500.

Color spectra of the digitized images were obtained by first separating the red, green, and blue components of the photo into separate files, then converting them into hue (tint), saturation (purity), and intensity (darkness). These three components then were used to compare photos of bermudagrass vs buffalograss. The spectra of four replicates were averaged.

RESULTS:

Both bermudagrass (Figure 1) and buffalograss (Figure 2) showed obvious greening between 1 and 28 May, 1996. This is seen on the figures as a decrease in the frequency of hues between 0-50° (the range of reds, browns, and yellows) and an increase in the frequency of hues between 50-100° (yellows, yellow-greens, and greens).

During May, 1996 bermudagrass color decreased in a rather narrow hue range of about 20-40° (Figure 1). Saturations and intensities of this decrease both were spread from about 0.2 to 0.5. The decreased frequencies of yellowish colors were replaced with increased levels of green, as expected, and also decreased saturations and intensities. Thus, this technique picks up the increased leaf chlorophyll (i.e., the hue increase to around 100°) and also quantifies the fact that bermudagrass has a sort of washed-out, darker appearance (represented by the low values of saturation and intensity, respectively).

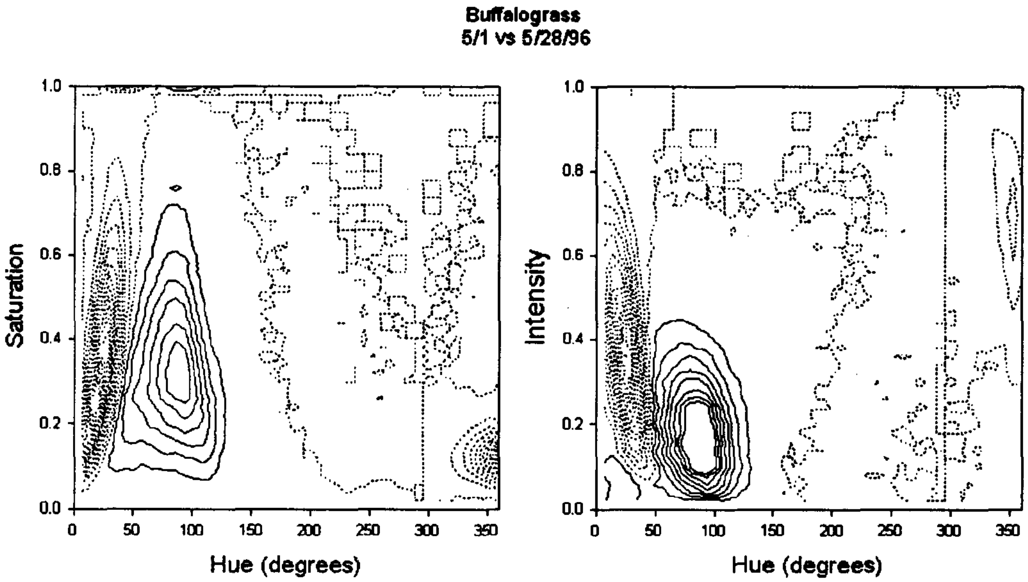

Figure 2. Contour plot of spectral differences in buffalograss canopies between 1 and 28 May, 1996. Solid lines indicate increased frequencies. Dashed lines indicate decreased frequencies. Contour lines are present at frequency intervals of 500.

Green-up in buffalograss was quite distinguishable from that of bermudagrass (Figure 2). Although color decreased at hues between about 20-40° and at both saturations and intensities between 0.1 to 0.6, similar to that observed in bermudagrass, the color increases were different than those observed in bermudagrass. Hue increased much more strongly and clearly between 50 and 125°. Saturation values remained at about 0.1 to 0.6 at all increased hues. Intensity decreased in range from 0.1 to 0.6 to 0.05 to 0.3. These results are consistent with a change in the canopy where the purity of the color remains the same, although the hue changes to a more green color and the overall color becomes darker (decreased intensity) Thus, the computer analysis of these turfgrass canopies can provide more quantitative information than simple visual evaluation of the plots. Supplementing visual observations of turfgrass plots with computerized analyses will provide researchers with much more information than they currently have available.

TITLE: Creeping Bentgrass Cultivar Evaluation

OBJECTIVE: To evaluate the performance of standard and experimental cultivars of creeping bentgrass in the Kansas climate

PERSONNEL: Jack Fry

SPONSOR: National Turfgrass Evaluation Program

INTRODUCTION

For a long time, Penncross creeping bentgrass was the only choice for golf putting greens. However, several new creeping bentgrass cultivars have been released in the past several years, and many are under evaluation. Cultivars that have seen increased use in the Midwest are Crenshaw, Cato, L-93, Providence, and SR1020.

MATERIALS AND METHODS

Cultivars were seeded in fall 1993 on a putting green constructed to USGA specifications at the Rocky Ford Turfgrass Research Center. All cultivars are creeping bentgrasses except 'Tendenz', which is a colonial bent. Turf was mowed 6 days weekly at 5/32 inch. A total of 5 lbs. N/1,000 sq. ft. was applied in 1996. Irrigation was applied to prevent stress. No fungicides were applied, so that differences among cultivars in disease susceptibility could be evaluated. Turf quality was rated visually, where 0 = dead turf; 7 = acceptable quality; and 9 = optimum color, density, and uniformity. Other parameters were rated on a 0 to 9 scale, where 0 = worst and 9 = best.

RESULTS

The best genetic color ratings were observed for Cato, Providence, and Crenshaw. The finest leaf texture was rated on G-2 and Century. Most other grasses had statistically similar leaf texture ratings but Pro/Cup, Lopez, Pennlinks, ISI-AP-89150, Penncross, Imperial, and Tendenz, were significantly coarser.

Turf quality was relatively poor throughout the growing season, because no fungicides were applied. This resulted in significant infestations of dollar spot and brown patch. Black turfgrass ataenius also caused significant damage but was treated with a curative insecticide application. Significant differences in quality were observed only in May and September. In May, the highest quality was rated for Bar WS 42102, which was not significantly different from any other cultivars except SR1020 and A-4. In September, L-93 and A-1 were rated highest for quality, but these were not different from Southshore, MSUEB, Providence, ISI-AP-89150, G-2, G-6, or Seaside.

Table 1. Performance of bentgrass cultivars under putting green conditions at Manhattan, KS in 1996.[1]

			Turf Quality					
Cultivar[2]	Color	Leaf Texture	May	Jun	Jul	Aug	Sep	Mean[3]
Lofts L-93*	7.0	8.0	7.0	6.3	6.3	5.3	6.3	6.3
Bar AS 492	7.0	8.3	7.7	6.7	5.7	6.0	4.3	6.1
Bar WS 42102	7.0	8.3	8.0	7.0	5.0	5.7	4.7	6.1
Cato*	7.7	8.3	7.3	6.7	6.0	5.7	5.0	6.1
Pro/Cup*	7.0	7.3	7.3	6.7	6.3	5.7	4.7	6.1
Regent*	7.0	8.0	7.0	6.7	6.3	5.7	4.7	6.1
Southshore*	7.0	8.3	7.3	6.7	5.0	6.0	5.3	6.1
Trueline*	7.3	8.0	7.0	7.0	6.0	5.7	5.0	6.1
DG-P	7.3	8.0	7.0	6.3	5.0	6.0	5.3	5.9
Lopez*	7.0	7.7	6.7	6.3	5.7	6.0	5.0	5.9
Pennlinks*	7.0	7.7	7.3	6.7	5.0	5.3	5.0	5.9
MSUEB	7.0	8.0	7.0	5.7	5.7	5.0	5.7	5.8
Providence*	7.7	8.0	7.0	6.0	4.0	6.0	6.0	5.8
ISI-AP-89150	7.0	7.3	6.7	6.3	4.3	6.0	5.3	5.7
Penn A-1 (A-1)*	7.3	8.3	6.0	6.0	4.7	5.3	6.3	5.7
Penn G-2 (G-2)*	7.0	8.7	6.7	6.3	4.7	5.0	5.7	5.7
Backspin (SYN 92-5)*	7.0	8.0	6.7	6.3	5.3	6.0	4.0	5.7
Crenshaw*	7.7	8.3	6.7	6.7	4.7	6.0	4.0	5.6
Penncross*	7.0	7.3	7.0	5.7	5.3	5.0	5.0	5.6
18th Green*	7.0	8.0	7.3	6.0	4.3	6.3	3.3	5.5
Century (SYN 92-1)*	7.0	8.7	6.7	6.3	5.0	5.7	4.0	5.5
Imperial (SYN 92-5)*	7.0	7.7	6.7	5.7	5.0	5.3	4.7	5.5
Penn G-6 (G-6)*	7.0	8.3	6.0	6.3	4.7	5.0	5.3	5.5
Seaside*	7.0	8.3	6.7	6.0	4.3	5.3	5.3	5.5
Tendenz*	7.0	7.7	7.0	5.7	4.7	5.3	5.0	5.5
SR 1020*	7.0	8.0	6.3	5.7	4.0	6.3	4.7	5.4
Mariner (SYN-1-88)*	7.0	8.0	6.7	6.0	4.7	4.3	4.7	5.3
Penn A-4 (A-4)*	7.0	8.3	5.7	5.3	4.7	6.0	4.7	5.3
LSD Value**	0.5	0.9	1.6	NS	NS	NS`	1.2	NS

[1]All characteristics were rated on a 0 to 9 scale, 9 = best.
[2]Cultivar names followed by an asterisk are commercially available in the U.S.
[3]Average of monthly ratings taken from May through September.
[4]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when this value is larger than the corresponding LSD value. NS - no significant difference among cultivars.

TITLE: High-Maintenance Kentucky Bluegrass Trial

OBJECTIVE: To evaluate Kentucky bluegrass cultivars under golf course fairway conditions in the transition zone.

PERSONNEL: Steve Keeley

SPONSOR: National Turfgrass Evaluation Program

INTRODUCTION:

Turfgrass breeders recently have been directing efforts toward developing Kentucky bluegrass cultivars with improved tolerance to low mowing heights. Successful cultivars must form a dense playing surface at low mowing heights (5/8 inch or less) and must have resistance to summer patch. If such cultivars can be identified, they would provide a viable alternative to perennial ryegrass for cool-season fairway turf in the transition zone.

MATERIALS AND METHODS:

One-hundred and five Kentucky bluegrass cultivars were seeded in September of 1995 at the Rocky Ford Turfgrass Research Field in Manhattan. The trial was mowed at 0.6 in and was fertilized with 4 lb N/1000 sq ft per year. The turf was irrigated to prevent stress, except for a period in September during which irrigation was withheld in order to evaluate the cultivars for drought resistance. No fungicides or insecticides were applied.

Turf quality was rated monthly from April to October on a visual scale of 0 to 9, where 0=dead turf and 9=optimum color, density, and uniformity. A rating of six would be considered minimum acceptable quality for a fairway. The cultivars also were rated for color, spring green-up, leaf texture, seedling vigor, dormancy in response to drought, and billbug damage.

RESULTS:

Cultivars with an average rating of 6.0 or above included Midnight, Blacksburg, Award, NuGlade, Wildwood, Glade, SR2000, Bartitia, Jefferson, and Limousine, along with several experimental releases. Summer patch did not occur in the plot area during 1996. We will continue to evaluate these cultivars over the next several years.

Table 1. Performance of Kentucky bluegrass cultivars under golf course fairway conditions at Manhattan, KS in 1996.[1]

							Turf Quality							
Cultivar	Color	Greenup	Leaf texture	Seedling vigor	Dormancy	Billbugs	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean
Midnight	8.0	6.7	6.3	6.3	4.3	9.0	6.3	7.0	7.3	7.3	7.3	7.0	7.0	7.0
PST-B3-180	6.3	7.0	6.3	6.7	5.7	9.0	7.0	7.7	7.0	7.0	7.0	6.7	6.3	7.0
PST-P46	6.7	7.0	5.7	6.3	4.7	9.0	7.3	7.7	7.7	7.3	6.3	5.7	6.0	6.9
ZPS-2572	7.7	6.3	6.7	6.0	4.3	9.0	6.0	7.3	7.3	7.3	7.0	6.3	6.0	6.8
Blacksburg	8.0	6.3	6.3	6.3	4.3	9.0	6.7	7.3	7.3	6.7	7.3	6.0	5.3	6.7
TCR-1738	7.3	6.7	6.7	5.7	4.0	9.0	6.0	7.7	7.0	7.0	6.7	6.3	6.0	6.7
Award	7.0	6.7	6.3	6.0	3.7	9.0	5.3	7.7	7.7	6.7	7.0	5.0	5.3	6.4
J-1567	8.0	6.0	6.3	5.3	3.3	8.7	5.3	7.3	7.3	6.7	7.0	5.3	5.7	6.4
NuGlade	7.7	5.3	6.3	5.3	4.0	8.7	5.3	7.0	6.7	7.0	6.3	6.3	6.3.	6.4
J-1561	6.3	6.3	6.7	5.3	4.0	9.0	5.7	7.0	6.7	6.3	6.0	6.0	6.3	6.3
J-1576	7.3	6.0	6.3	5.3	3.3	8.7	5.0	7.7	6.3	7.0	6.7	5.7	5.7	6.3
PST-B2-42	6.3	6.3	6.0	5.7	6.3	9.0	6.0	7.0	6.3	6.0	6.3	6.7	5.7	6.3
Wildwood	6.0	7.3	6.3	7.0	4.0	9.0	7.0	7.7	6.7	6.3	5.7	5.7	5.3	6.3
Glade	6.7	6.3	7.0	6.7	3.3	9.0	6.0	7.0	6.3	6.3	6.7	5.3	5.7	6.2
MED-18	7.7	5.7	6.3	5.7	4.7	9.0	5.0	7.0	6.0	6.3	7.0	5.7	6.7	6.2
PST-638	7.7	6.7	5.7	6.0	4.0	9.0	6.3	7.0	5.7	6.7	6.7	5.3	5.7	6.2
SR 2000	7.7	6.3	4.7	6.0	5.7	9.0	5.3	6.0	6.7	6.7	6.7	6.0	6.3	6.2
VB 16015	8.3	6.0	5.3	6.0	3.3	9.0	5.7	7.3	7.0	6.7	7.0	4.3	5.3	6.2
Ba 75-490	6.7	6.3	5.3	6.7	5.3	9.0	6.7	5.7	6.7	6.0	5.7	6.0	6.0	6.1
BA 81-058	7.0	6.0	5.7	7.0	4.7	9.0	6.3	6.7	6.0	6.3	6.0	5.3	6.0	6.1
J-1936	7.3	6.0	6.3	6.0	3.7	9.0	5.3	7.3	6.3	6.3	5.7	5.7	6.0	6.1
PST-BO-141	6.0	6.3	6.0	6.0	5.7	9.0	5.7	7.0	5.7	6.0	5.7	7.0	6.0	6.1
Bartitia	6.7	6.0	7.7	7.0	2.7	9.0	5.7	7.3	6.0	6.0	6.0	5.0	6.0	6.0
Jefferson	6.3	7.0	6.3	7.3	5.3	9.0	6.0	6.0	5.7	6.0	5.7	6.3	6.7	6.0
LTP-621	6.7	6.3	5.7	7.3	4.0	8.3	6.3	6.3	6.0	5.7	5.7	5.7	6.3	6.0
Limousine	6.3	6.3	8.0	5.7	2.7	8.7	5.7	7.0	7.0	6.7	6.0	4.7	5.0	6.0
J-2582	6.7	6.3	6.0	5.7	3.7	9.0	6.0	5.7	6.0	6.0	5.7	5.7	6.0	5.9
America	6.0	6.3	6.0	6.3	4.3	9.0	5.3	6.7	5.7	5.7	5.3	6.7	5.3	5.8
Ba 73-373	5.3	5.7	6.7	7.3	3.3	9.0	6.7	6.0	5.7	6.0	5.3	5.0	6.0	5.8
Baronie	5.3	7.3	6.0	7.7	4.7	9.0	7.3	5.7	4.7	5.7	5.0	6.0	6.3	5.8
Coventry	5.7	6.3	5.3	6.3	3.7	9.0	6.7	5.7	6.0	5.7	5.3	4.3	6.7	5.8

							Bluegrass Turf Quality							
Cultivar	Color	Greenup	Leaf texture	Seedling vigor	Dormancy	Billbugs	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean
NJ 1190	5.3	6.7	6.7	6.0	2.7	9.0	6.3	6.0	5.7	5.3	5.3	6.0	6.0	5.8
PST A418	8.0	5.0	5.3	5.7	4.0	9.0	5.3	7.0	6.3	6.0	6.3	4.3	5.0	5.8
Unique	5.7	5.7	6.3	6.0	5.7	9.0	5.7	6.7	5.0	5.7	5.7	6.3	5.7	5.8
ZPS-2183	7.7	6.3	5.7	6.3	3.0	9.0	4.0	7.0	6.0	6.3	7.0	5.7	4.7	5.8
ZPS-309	7.3	5.7	6.0	5.3	3.3	9.0	5.7	6.3	6.3	6.3	6.0	4.7	5.0	5.8
A88-744	6.3	6.0	5.3	5.7	4.7	9.0	4.7	6.7	5.7	5.3	6.0	5.3	6.0	5.7
Allure	5.7	6.7	5.0	6.0	4.0	9.0	5.7	6.3	5.7	6.0	5.3	5.0	6.0	5.7
Ascot	7.7	4.7	6.3	6.7	3.7	9.0	5.0	7.0	5.7	6.0	6.0	4.3	6.0	5.7
Caliber	6.3	6.7	6.0	6.7	4.0	9.0	6.0	5.7	5.7	6..0	5.7	5.0	5.7	5.7
Classic	5.0	7.7	6.0	7.3	5.3	9.0	7.0	5.3	4.7	5.7	5.0	5.7	6.7	5.7
Fortuna	6.3	5.7	6.0	7.0	4.0	9.0	5.7	5.7	5.7	6.3	5.3	5.0	6.0	5.7
H86-690	7.0	7.3	6.3	6.7	2.3	9.0	6.0	6.0	6.0	6.3	6.0	4.7	4.7	5.7
Haga	5.0	8.0	6.3	7.7	4.7	9.0	7.3	5.3	4.7	5.7	4.7	5.7	6.7	5.7
J-1555	7.0	6.0	6.0	5.3	3.0	8.0	5.3	6.3	5.7	5.7	5.3	5.3	6.0	5.7
Kenblue	5.0	8.0	7.7	7.7	2.7	9.0	7.0	4.7	4.0	5.0	5.0	4.3	5.0	5.0
Sidekick	6.0	4.7	5.3	6.7	3.7	9.0	5.3	5.3	4.7	4.7	5.0	5.0	5.3	5.0
NJ-54	7.3	5.7	4.7	4.0	5.0	9.0	4.3	4.3	4.7	5.7	5.7	5.3	4.3	4.9
PST-A7-245A	5.7	6.0	6.0	4.7	3.0	8.0	4.7	5.7	4.7	4.7	4.7	4.0	5.3	4.8
Ba 81-113	5.7	6.0	6.0	6.3	2.7	8.7	5.0	5.0	5.0	5.0	4.3	3.3	4.0	4.5
MED-1991	5.3	5.3	6.7	5.3	2.0	8.3	4.7	5.3	4.7	5.0	4.3	3.3	4.3	4.5
Ba 76-197	5.0	5.0	5.7	5.7	3.3	8.7	4.7	4.7	4.3	4.7	4.7	3.7	4.0	4.4
Sodnet	5.7	5.7	7.3	4.3	1.0	4.7	3.3	6.7	6.0	5.3	3.7	1.7	2.7	4.2
Ba 76-372	5.7	5.7	5.7	5.7	1.7	9.0	3.7	4.3	4.3	4.0	4.3	3.3	4.3	4.0
DP 37-192	5.7	5.7	6.3	5.0	1.0	5.3	4.0	4.3	4.7	4.0	3.3	2.0	3.0	3.9
BAR VB 6820	6.3	6.3	6.3	3.7	1.0	6.3	2.7	4.3	3.7	3.7	3.3	2.7	3.0	3.3
LSD Value[2]	1.0	1.1	1.3	1.2	1.2	1.6	1.6	0.9	1.6	1.8	1.3	1.7	1.3	0.9

[1]All characteristics were rated on a 0 to 9 scale, 9 = best.

[2]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when this value is larger than the corresponding LSD value.

TITLE : High Maintenance Perennial Ryegrass Cultivar Trial

OBJECTIVE : To evaluate the performance of perennial ryegrass cultivars for adaptability under Kansas conditions.

PERSONNEL: Kiranmai Nandivada and Jack Fry

SPONSOR: National Turfgrass Evaluation Program

INTRODUCTION :

Perennial ryegrass is used widely in the U. S. and is known for quick germination, rapid coverage, good wear tolerance, and rich green color. Ryegrass is widely used in Kansas on golf course fairways and tees. Efforts have been made to improve the mowing, quality, disease resistance, and stress tolerance of ryegrass cultivars.

MATERIALS AND METHODS :

Ninety-six ryegrass cultivars were seeded at the Rocky Ford Turfgrass Research Center in Manhattan during the fall of 1994. The turf was mowed at a height of 1 inch to simulate fairway conditions on a golf course. Fertilizers were applied at the rate of 4 lbs N / 1000 sq ft/ yr. Irrigation ceased on June 1, so we could evaluate drought response for the remainder of the summer. Turf quality was rated visually on a 0-9 scale where 0 = dead turf and 9 = optimum color, uniformity, and density. Leaf texture and color, wilting, and subsequent green-up (after wilt) also were evalutated on a 0 to 9 scale where 9 = best.

RESULTS:

Cultivars with the highest spring green-up ratings were Saturn, Precision, Elf, Stallion Select, and Edge. Twenty cultivars had genetic color ratings above 7.0, including Laredo, CalypsoII, Advantage, Divine, Cutter, Esquire, Top Hat, Night Hawk, Brightstar, Imagine, Nine-O-One, Elf, Edge, Achiever, Riviera II, Accent, Vivid, Omni, Manhattan 3, and RPBD.

Cultivars with the finest leaf texture were Quickstart, Divine, Nine-O-One, and Calypso II.

When evaluated for wilting during drought, cultivars that exhibited the best wilting resistance were Navajo, Assure, Williamsburg, Night Hawk, Stallion Select, Saturn, and Quickstart.

Considering overall quality, cultivars with an average rating of 6.5 and above were Divine, Laredo, Imagine, Brightstar, Precision, CalypsoII, Esquire, Manhattan3, Advantage, Riviera II, and Night Hawk. Ten cultivars had average quality ratings of less than 6.0, including Vivid, Achiever, Elf, Pegasus, Express, Nobility, Morning Star, Figaro, Pennfine, and Linn.

Table 1. Performance of perennial ryegrass cultivars under golf course fairway conditions at Manhattan, KS in 1996.[1]

					Turf quality					
Cultivar[2]	Color	Green-up	Leaf Texture	Wilting	April	May	June	July	Aug	Mean
LRF-94-B6	8.0	6.0	6.3	4.3	7.0	7.3	8.0	6.3	7.7	7.3
MB46	7.7	5.3	6.3	4.7	7.0	8.0	8.0	6.0	7.0	7.2
Divine	7.3	6.3	6.7	5.3	6.3	6.7	8.0	5.3	8.0	6.9
LRF-94-C7	7.7	6.0	6.0	5.3	6.3	6.3	8.0	6.3	7.3	6.9
MB44	7.7	5.0	6.7	5.3	6.0	7.0	8.0	5.7	7.7	6.9
Excel (MB 1-5)*	7.7	6.3	6.0	4.0	7.0	7.0	7.7	5.7	6.7	6.8
LRF-94-C8	7.7	6.7	6.3	4.3	7.0	7.0	7.7	6.0	6.3	6.8
Brightstar*	7.3	6.0	6.3	5.0	5.7	7.0	7.3	6.0	7.3	6.7
Brightstar II (PST-2M3)*	8.0	5.7	6.7	6.3	6.3	7.7	8.0	4.3	7.3	6.7
Citation III (PST-2DGR)*	7.7	6.3	7.0	5.7	6.3	7.0	7.7	5.3	7.0	6.7
Imagine*	7.3	4.7	6.3	5.7	5.7	7.7	8.0	5.0	7.3	6.7
Laredo*	7.7	6.7	6.0	5.3	6.3	6.7	7.0	6.3	7.3	6.7
MB45	8.0	5.7	6.3	4.7	6.7	7.0	7.3	6.0	6.7	6.7
Omega3 (ZPS-2DR-94)*	7.0	6.7	5.7	5.3	7.0	6.3	7.7	5.0	7.3	6.7
Precision*	6.7	7.0	6.3	5.7	7.3	5.7	7.0	5.3	8.0	6.7
Saturn II (ZPS-2ST)*	7.0	6.7	6.7	5.0	6.3	5.7	7.7	5.7	8.0	6.7
ZPS-2NV	6.7	5.7	6.0	5.3	6.0	6.3	7.7	5.7	7.7	6.7
BAR USA 94-II	7.7	6.0	6.3	5.0	6.0	6.7	8.0	5.3	7.0	6.6
Blazer III (Pick 298)	6.3	6.0	6.0	4.0	6.3	6.3	7.3	5.7	7.3	6.6
Calypso II*	7.7	6.3	6.7	4.7	6.3	6.3	7.7	5.3	7.3	6.6
Esquire*	7.3	6.3	6.0	5.0	6.3	6.3	7.3	5.7	7.3	6.6
Manhattan 3*	7.0	6.0	6.3	5.0	6.7	6.3	7.3	5.7	7.0	6.6
PST-2FE	7.0	6.0	6.0	6.3	7.0	6.0	7.0	6.0	7.0	6.6
Advantage*	7.3	5.7	6.0	4.3	7.0	6.7	7.3	5.3	6.3	6.5
Line Drive (MB 47)*	7.7	6.0	6.3	5.3	6.0	6.0	7.3	5.7	7.7	6.5
Majesty (MB 43)*	7.7	6.0	6.7	5.0	6.7	6.3	7.3	5.0	7.0	6.5
Night Hawk*	7.3	6.3	6.0	6.0	6.7	6.7	7.7	5.0	6.7	6.5
Nine-O-One*	7.3	6.0	6.7	5.0	6.3	6.3	7.0	5.3	7.3	6.5
Panther (ZPS-PR1)*	7.7	5.7	6.3	4.7	6.0	6.7	7.3	6.0	6.7	6.5
Pennant II (MB-42)*	8.0	6.0	6.7	5.7	6.3	6.7	7.7	4.7	7.3	6.5
PSI-E-1	6.7	6.7	6.0	6.3	6.7	5.7	7.0	5.7	7.3	6.5
PST-2DLM	7.7	6.0	6.0	4.7	6.7	7.0	8.0	5.0	6.0	6.5
Riviera II*	7.0	6.3	6.0	5.0	7.0	6.0	7.0	5.3	7.3	6.5
Saturn*	6.3	7.7	6.3	6.3	7.3	5.7	6.7	5.7	7.0	6.5
Wind Star (PST-28M)*	7.0	6.7	6.0	4.3	6.3	6.0	7.0	5.7	7.3	6.5
Edge*	7.0	7.0	6.3	5.7	7.0	5.7	7.0	5.0	7.3	6.4
Legacy II (Lesco-TWF)*	7.7	5.7	6.7	5.0	6.0	6.7	7.0	6.3	6.0	6.4
LRF-94-MPRH	7.7	5.7	6.0	4.7	6.0	7.0	7.3	5.3	6.3	6.4
Passport (PST-2FF)*	7.0	6.0	6.0	4.7	6.7	6.3	6.7	5.3	7.0	6.4

Perennial Ryegrass Turf Quality

Cultivar	Color	Greenup	Leaf Texture	Wilting	April	May	June	July	Aug	Mean
SR 4010 (SRX 4010)	6.3	6.7	6.0	5.7	6.7	5.7	7.0	5.7	7.0	6.4
Academy (PC-93-1)*	6.7	6.3	6.0	5.7	6.3	5.3	7.0	5.3	7.3	6.3
Accent*	7.0	6.0	6.3	5.0	5.7	6.3	6.3	5.7	7.3	6.3
APR 106	6.0	6.3	6.0	5.7	6.3	5.0	6.3	5.7	8.0	6.3
CAS-LP23	7.0	5.3	6.0	5.3	5.7	6.3	7.0	5.3	7.0	6.3
MVF-4-1	6.3	6.3	6.3	5.7	6.7	5.7	7.0	5.3	7.0	6.3
Navajo*	6.3	6.0	6.0	6.0	6.3	5.3	6.7	5.7	7.3	6.3
Omni*	7.0	5.7	6.0	5.0	5.7	7.0	7.3	4.3	7.0	6.3
PICK LP 102-92	8.0	6.0	6.3	5.0	6.0	6.7	7.3	4.3	7.0	6.3
PICK PR 84-91	6.7	5.7	6.0	6.3	6.0	6.7	7.3	4.7	7.0	6.3
Prizm*	7.0	6.0	6.0	5.0	6.3	6.3	7.3	4.7	6.7	6.3
PST-GH-94	7.7	5.7	6.3	5.7	5.7	6.3	7.7	4.7	7.3	6.3
RPBD	7.0	6.0	6.3	5.0	6.3	6.0	7.3	5.3	6.3	6.3
Stallion Select*	6.0	7.0	6.0	6.0	7.0	5.7	6.0	6.0	7.0	6.3
WVPB-93-KFK	6.3	6.3	6.0	5.7	6.3	5.7	7.0	5.7	6.7	6.3
WX3-91	7.0	6.7	6.0	5.7	6.3	6.0	6.7	5.7	6.7	6.3
APR 12	6.7	6.7	6.0	5.7	6.7	5.7	6.7	4.7	7.3	6.2
Cutter*	7.3	6.0	5.7	4.3	6.3	5.7	7.0	5.3	6.7	6.2
ISI-MHB	7.0	6.3	6.3	5.0	5.7	6.0	6.7	5.3	7.3	6.2
Quickstart*	6.3	6.3	6.7	7.0	6.7	5.7	7.0	4.7	7.0	6.2
WVPB 92-4	6.0	6.3	6.0	6.3	6.3	5.0	6.7	5.7	7.3	6.2
DLP 1305	6.0	6.3	6.0	4.7	5.7	5.7	6.3	5.7	7.0	6.1
DSV NA 9401	5.0	6.7	5.7	6.0	7.7	4.7	5.7	6.3	6.0	6.1
J-1703	6.7	6.3	6.0	5.0	6.3	5.7	7.0	5.7	6.0	6.1
KOOS 93-3	6.3	6.3	6.0	5.0	6.7	5.7	6.3	5.0	7.0	6.1
KOOS 93-6	6.3	6.0	6.0	5.3	6.3	5.3	6.7	5.7	6.3	6.1
MED 5071	6.7	6.3	6.3	5.0	6.0	6.7	6.3	5.0	6.7	6.1
PST-2R3	7.3	6.0	6.0	4.7	6.3	6.0	6.7	5.0	6.7	6.1
SR 4200	6.7	6.0	6.0	5.0	6.3	5.3	6.7	5.0	7.0	6.1
SR 4400 (SRX 4400)	6.0	6.3	6.0	6.3	6.0	5.3	6.3	5.0	7.7	6.1
Top Hat*	7.3	6.7	6.0	4.7	6.7	6.3	6.7	5.0	6.0	6.1
WVPB-PR-C-2	6.3	6.3	6.0	5.7	6.7	5.7	6.7	5.0	6.7	6.1
WX3-93	7.0	6.7	6.0	5.0	6.3	6.3	7.3	5.0	5.7	6.1
APR 131	6.0	6.3	4.0	6.0	6.0	4.7	6.0	6.0	7.3	6.0
Assure*	6.3	6.0	6.0	6.0	6.0	5.3	6.7	5.0	7.0	6.0
Dancer*	6.0	6.3	5.7	4.7	6.0	5.7	6.0	5.7	6.7	6.0
J-1706	6.7	6.0	6.7	4.3	5.7	5.0	6.7	6.0	6.7	6.0
TMI-EXFL94	6.3	6.0	6.0	5.3	6.0	5.3	6.3	5.7	6.0	6.0
Williamsburg*	6.7	6.3	6.0	6.0	5.7	5.7	6.3	5.7	6.7	6.0
Achiever	7.0	6.3	6.0	4.0	6.3	5.7	6.0	5.0	6.7	5.9
APR 066	5.7	6.0	6.0	7.0	6.3	4.7	6.0	5.3	7.0	5.9
ELF*	7.0	7.0	6.0	5.7	5.7	5.7	6.3	5.0	6.7	5.9
ISI-R2	6.3	6.7	6.0	5.7	6.0	5.7	6.3	5.0	6.7	5.9
PS-D-9	6.3	6.7	6.3	5.7	6.3	5.3	6.7	4.3	6.7	5.9
PST-2CB	7.0	6.3	6.3	5.7	6.0	5.0	6.3	5.3	6.7	5.9

					Perennial Ryegrass Turf Quality					
Cultivar	Color	Greenup	Leaf Texture	Wilting	April	May	June	July	Aug	Mean
Vivid*	7.0	6.3	5.7	5.0	5.3	5.7	6.7	5.3	6.7	5.9
Express*	6.0	6.3	6.0	5.7	6.0	5.0	6.0	5.0	7.0	5.8
Pegasus*	6.0	6.3	6.0	5.3	6.3	5.7	6.3	4.3	6.3	5.8
Wizard (MB 41)*	7.3	6.3	6.3	5.7	6.3	5.3	6.7	4.7	6.0	5.8
BAR ER 5813	7.0	5.7	6.0	3.0	5.3	6.0	6.0	5.3	5.7	5.7
Nobility*	6.0	6.3	6.3	5.0	5.7	4.7	6.0	5.3	6.7	5.7
DSV NA 9402	5.3	6.3	5.3	5.7	6.0	4.3	5.7	5.7	6.3	5.6
Figaro*	6.0	6.0	6.0	4.7	5.7	5.0	6.0	4.7	6.7	5.6
Morning Star*	6.3	5.0	6.0	5.7	5.7	5.0	6.3	4.7	6.3	5.6
Roadrunner (PST-2ET)	7.7	5.7	5.7	4.3	6.3	6.7	5.7	4.3	5.0	5.6
Pennfine*	5.7	6.0	6.0	5.3	6.0	4.3	5.7	5.0	6.3	5.5
Linn*	4.0	3.7	4.0	3.0	2.7	2.7	3.0	5.7	4.3	3.7
LSD Value[3]	0.8	1.0	1.2	1.9	1.4	1.1	1.0	3.5	1.4	0.6

[1]All characteristics were rated on a 0 to 9 scale, 9 = best.

[2]Cultivars followed by an asterisk are commercially available in the U.S.

[3]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when this value is larger than the corresponding LSD value.

TITLE: Fineleaf Fescue Cultivar Trial

OBJECTIVE: To evaluate fineleaf fescue genotypes for adaptability and performance under Kansas environmental conditions**.**

PERSONNEL: Alan Zuk

SPONSOR: National Turfgrass Evaluation Program

INTRODUCTION:

A number of species are designated as fineleaf fescues. Those used in this trial include chewings fescue (26 cultivars), creeping fescue (17 cultivars), hard fescue (15 cultivars), and sheeps fescue (two cultivars). All fineleaf fescues have a texture that is finer than that of Kentucky bluegrass and much finer than that of any of the tall fescues. Though these fescues have good shade tolerance, they are susceptible to summer heat stress and various diseases. They are better adapted to northern climes and often are thinned severely by our hot summers.

MATERIALS AND METHODS:

A trial of 60 cultivars was established at the Rocky Ford Turfgrass Research Center in a full-sun site during the fall of 1993. The turf was maintained at 3 inches. No fungicides were applied, so that natural disease resistance could be rated. Turf color, green-up, and leaf texture were rated visually on one occasion using a 0 to 9 scale, 9 = best. Turf quality was rated visually each month, with 0 = brown turf; 6 = acceptable quality; and 9 = optimum color, density, and uniformity.

RESULTS:

No statistical differences occurred among cultivars for genetic color. Best spring green up was observed for Discovery, SR 3100, Vernon, Ecostar, and Spartan. Few differences were observed in leaf texture. Osprey and Brigade were significantly coarser than WX3-FF54, NJF-93, and Rondo.

Available cultivars that had an average quality rating of 6.0 or higher included Shademaster II, Brittany, Flyer, Reliant II, ECO (MB 63-93), Jasper (E), K-2 (MB 65-93), and Tiffany. Pamela and Dawson had average quality ratings of < 5.0.

Table 1. Performance of fineleaf fescue cultivars under lawn conditions at Manhattan, KS in 1996.[1]

				Turf Quality							
Cultivar2	Color	Green-up	Leaf Texture	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean
Shademaster II*	6.7	5.7	6.7	5.3	7.7	6.7	6.0	5.3	6.7	8.0	6.5
Brittany*	7.0	4.7	7.3	5.7	7.0	6.3	6.0	5.0	6.3	7.3	6.2
CAS-FR13	6.0	6.0	7.0	5.3	7.0	7.0	5.7	5.3	6.0	7.3	6.2
Flyer*	6.0	6.0	7.0	6.0	7.7	6.0	6.0	5.3	6.0	6.7	6.2
MB 64-93	6.0	5.7	7.3	6.0	7.3	6.3	4.7	5.0	6.0	8.0	6.2
MB 61-93	7.3	5.0	.0	5.7	7.7	6.0	5.7	5.0	6.0	7.0	6.1
Reliant II*	6.7	6.3	6.7	5.7	6.3	5.3	6.0	5.7	6.3	7.7	6.1
TMI-3CE	6.3	5.0	7.0	5.3	6.3	6.3	5.0	5.3	6.7	7.7	6.1
ECO (MB 63-93)*	6.7	5.0	7.3	5.7	7.0	6.3	5.3	5.3	5.7	6.3	6.0
Jasper (E)*	5.7	5.7	6.7	4.7	6.0	6.3	5.3	5.0	6.7	7.7	6.0
K-2 (MB 65-93)*	6.7	5.3	6.7	5.7	7.7	6.0	5.0	5.0	5.7	6.7	6.0
PICK 4-91 W	6.7	5.0	7.3	6.3	7.0	5.7	5.0	5.0	6.0	6.7	6.0
PST-4VB Endo	6.0	6.3	7.0	5.3	8.0	6.7	7.0	5.3	4.0	5.3	6.0
Tiffany*	6.0	5.0	7.0	5.3	7.0	6.0	6.0	5.3	5.7	6.3	6.0
WX3-FF54	6.0	5.0	7.7	5.3	7.3	5.3	5.3	5.0	6.3	7.3	6.0
Aurora W/#ndo.*	6.0	6.7	6.7	6.0	6.0	6.3	6.0	4.7	5.7	6.3	5.9
BAR FRR 4ZBD	6.7	6.0	6.7	5.3	7.3	6.7	4.7	4.7	5.3	7.3	5.9
Discovery*	7.0	7.7	7.0	6.0	6.7	6.3	6.3	6.0	5.0	5.0	5.9
PST-44D	6.0	4.7	7.3	5.3	6.7	6.3	6.3	5.7	5.3	5.7	5.9
SR 3100*	7.0	7.3	7.0	5.0	6.0	6.0	6.7	5.0	5.7	7.0	5.9
Aruba*	5.7	6.0	7.0	5.0	5.7	7.0	5.7	5.7	5.3	6.3	5.8
ISI-FC-62	6.3	5.0	7.0	5.0	7.0	5.7	5.7	4.7	5.3	7.0	5.8
Jamestown II*	6.7	5.3	6.7	4.7	6.0	6.0	5.7	5.0	5.7	7.3	5.8
NJ F-93	6.3	5.0	7.7	5.3	7.0	6.0	4.7	4.3	6.0	7.3	5.8
PST-4DT	6.3	6.0	6.3	5.3	7.3	6.3	6.0	5.0	4.7	5.7	5.8
SR 5100*	6.0	6.0	6.7	5.0	6.3	6.7	5.7	5.0	5.3	6.7	5.8
BAR UR 204	7.0	5.7	6.3	4.7	5.3	5.3	4.7	5.0	7.0	7.7	5.7
Molinda*	6.0	6.3	7.3	5.0	6.0	6.3	5.0	5.0	5.7	6.7	5.7
Osprey (Pro 92/24)*	6.7	6.3	4.3	5.7	6.3	6.0	6.0	5.0	5.0	6.0	5.7
Sandpiper (Pro 92/20)*	6.0	5.7	6.7	5.0	5.7	6.0	5.0	5.0	6.0	7.0	5.7
Treazure (ZPS-MG)*	6.7	4.7	7.0	5.3	6.3	6.0	5.7	4.3	5.3	7.0	5.7
Flyer II (ZPS-4BN)*	7.0	6.7	6.7	5.7	8.0	6.7	4.3	3.7	5.0	6.0	5.6
Banner II*	7.0	5.3	6.7	5.3	6.3	5.3	4.3	4.0	5.7	7.3	5.5
Brigade*	5.3	7.3	4.7	6.0	6.3	6.7	5.0	4.7	4.3	5.7	5.5
MB 66-93	7.3	5.3	7.3	5.0	6.7	6.3	4.7	4.7	5.0	6.3	5.5
MB82-93	6.3	6.0	7.0	5.3	6.3	6.3	5.7	5.3	4.7	5.0	5.5
Nordic*	6.7	7.3	7.3	5.0	7.0	6.0	5.7	5.0	4.7	5.0	5.5
PST-4ST	6.7	5.3	6.7	5.0	6.7	6.3	6.3	4.7	4.3	5.0	5.5
Vernon (MB 83-93)*	6.7	7.7	7.0	5.3	6.7	6.0	5.7	4.7	5.3	5.0	5.5
Victory (E)*	7.0	5.7	7.0	5.3	6.0	6.0	5.3	5.0	5.3	5.3	5.5
WX3-FFG6	6.7	50	7.0	5.0	6.0	5.0	5.0	5.3	6.0	6.0	5.5
Bridgeport*	6.0	5.7	7.3	5.7	6.3	5.7	4.3	4.3	5.7	5.7	5.4
Common Creeping*	6.3	6.3	7.0	5.7	6.0	5.3	5.0	5.0	4.7	6.3	5.4
Ecostar*	7.0	7.3	6.7	5.7	6.0	6.0	5.7	4.7	4.3	5.7	5.4
Seabreeze*	6.3	6.0	7.3	4.3	6.3	5.7	6.3	6.0	4.3	5.0	5.4
67135	6.3	6.3	6.3	3.7	5.3	5.0	4.3	4.7	6.3	7.7	5.3
Darwin*	6.3	5.0	7.0	4.3	6.0	6.7	4.3	4.3	5.0	6.7	5.3
Jamestown*	7.0	5.3	6.7	5.3	6.0	6.0	4.7	4.0	5.0	6.0	5.3
MB 81-93	6.7	7.0	7.3	5.3	6.0	5.7	4.7	4.3	5.3	5.7	5.3
Spartan*	6.3	8.0	7.0	5.7	6.3	5.3	5.3	4.7	4.3	5.3	5.3
Medina*	6.0	6.0	7.0	5.0	7.0	6.0	4.0	4.3`	4.7	5.3	5.2

Fineleaf FescueTurf Quality

Cultivar	Color	Greenup	Leaf Texture	April	May	June	July	Aug	Sep	Oct	Mean
Shadow (E)*	6.0	6.0	7.3	5.7	6.3	7.0	4.3	3.7	4.3	5.3	5.2
Cascade*	6.3	6.0	7.0	3.7	4.7	5.7	4.7	4.0	6.0	7.3	5.1
Quatro (FO 143)*	6.3	6.3	6.0	4.0	5.3	5.7	4.7	4.7	5.0	5.3	5.0
Rondo*	6.7	5.0	7.7	4.0	5.3	6.0	5.0	5.3	3.7	5.7	5.0
Scaldis*	6.3	7.0	7.0	5.7	6.0	6.0	5.7	3.3	4.0	`4.0	5.0
WVPB-STCR-101*	5.3	5.3	6.7	4.0	6.0	6.0	5.3	3.3	4.7	5.3	5.0
Pamela*	7.0	6.7	7.0	4.7	5.7	6.3	4.7	4.0	3.3	4.3	4.7
Dawson*	6.3	5.7	7.0	3.3	4.3	5.7	4.7	4.3	4.3	5.3	4.6
LSD Value4	3.7	1.0	2.9	1.3	1.4	1.6	1.7	1.9	2.4	3.6	0.8

[1]Established Sept. 9, 1993. Ratings based on a scale of 0-9 w/9 = least disease, darkest green and highest quality.

[2]Cultivar names followed by an asterisk are commercially available in the USA.

[3]Average of monthly ratings taken from March through October.

[4]To determine statistical differences among entries, subtract one entry's mean from another. A statistical difference occurs when this value is larger than the corresponding LSD value.

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- Grass Pad
- Great Plains Industries
- Heart of America GC Supt. Assn.
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- IMC Fertilizer, Inc.
- ISK
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Note: Trade names are used to identify products. No endorsement is intended, nor is any criticism implied of similar products not mentioned.

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