GE 9817-125

United States Golf Association Research Summary and Annual Report: 2000

A. **Germplasm Development for Buffalograss Varieties**

B. **Management Practices for Golf Course Roughs, Fairways, and Tees Using Buffalograss**

United States Golf Association

EXECUTIVE SUMMARY – 2000

Seeded Releases

Native Turf Group (NTG)

NTG is having a good year and they are basically sold out of buffalograss seed. They have decided to drop Tatanka, because of production problems, and to start production of a new cultivar NTG-6.

Seed West

Seed West has left the Native Turf Group; however, they are still interested in buffalograss. Dr. Charlie Rodgers indicates that they would like to have there own cultivar that they could put in the product line of Pennington Seed, their owner, and then market nationally. Plant material has been made available to Seeds West and a commercialization agreement is being developed.

Bamert Seed

An agreement to produce a new seeded buffalograss has been signed by UNL and Bamert Seed. Material as been planted in Texas and is doing well.

Vegetative Releases

Todd Valley Farms, Inc. (TVF)

Wayne Thorson of TVF had made excellent progress with 'Legacy' (86-61) during 2000, the first year of its commercialization. He has marketed a little sod, but his main accomplishment has been to develop a plug system that works and is profitable. He is sticking stolons in 96 unit trays and marketing the tray at $30 with no resistance to price. This year he did 5,000 trays and next year he hopes to do 10,000. Sales of '315' and '378' were good, but he is phasing them out as he goes to Legacy.

Turfgrass America. Inc. (TGA)

Crenshaw Turf is now part of Turfgrass America, Inc. along with Thomas Bros. Sod and Milberger Turf. Their goal is to be the premier supplier of proprietary southern turfgrasses, i.e. bermudagrass, zoysiagrass, St. Augustinegrass, and buffalograss. This would include genetically enhanced turfgrasses.

Sales of buffalograss for 2000 continue to be down and a meeting was just held in Lincoln to discuss the situation and hopefully turn things around. They seem to have lost interest in buffalograss and have only sold it when people asked for it. There has been <u>no</u> marketing effort at all. We asked if they wanted to drop the contract and they admitted that buffalograss has the best margin of any of the turfgrasses they market and it has been performing well during the heat and drought in Texas. They indicated they will put more emphasis on '609' and 91-118 (will require starting over with this new cultivar). They also indicated they are receptive to increasing research funding as USGA funding drops off.

Summary of Breeding Work

Performance data from the 1999 breeding nursery shows excellent progress on development of low mowing tolerant buffalograss. Numerous accessions in this nursery have exhibited increased establishment rate over commercially available cultivars. Newly released cultivars continue to show their superiority over older varieties with improved sod strength, color, turfgrass quality, and density. A number of the advance selections have been planted in Texas at Bamert Seeds for observations for turf, seed production characteristics and southern adaptation.

The first crossing block plantings were harvested in 2000. Seed from these blocks will be germinated this winter in the greenhouse and planted to turf nurseries in the spring of 2001. Ploidy levels will be determined from these plants in the next few months. Numerous selections appear to have very good seed yield and turf characteristics.

Seed Production

Buffalograss seed production has received major attention in 1999 and has continued into 2000. To insure the successful use of buffalograss, seed production characteristics must be a major factor in the selection process. The buffalograss project has initiated a three-phase approach to provide high turf quality varieties with high seed yields. Phase one involves breeding of high yielding female lines with advanced male accessions that contribute to seed yield, seedling vigor, and turf performance characteristics. The second phase is the use of flow cytometry to identify crossing accessions of similar ploidy levels. The third phase is to explore chemical applications of plant hormones to enhance seed production.

Sprig Establishment

Continued work on sprig establishment is underway. While sprig establishment has shown an advantage over conventional methods, work continues on factors that influence establishment such as weed control, mechanical methods, and optimal timing.

Buffalograss Resistance to Chinch Bugs

The development of turfgrasses with resistance to insects offers an attractive approach for managing insect pests associated with buffalograss because it is sustainable, environmentally-responsible, and fits well with buffalograss' low maintenance, reduced pesticide input philosophy. Greenhouse experiments were conducted to determine the categories of resistance of 10 buffalograss cultivars/selections ('Cody', 'Tatanka', '609', '315', '378', 'Texoka', NE84-45-3, NE91-118, NE86-120, NE86-61) screened previously for resistance to the chinch bug, *Blissus occiduus*. From these initial greenhouse screenings, 'Cody', 'Tatanka', and NE91-118 were selected as resistant to *B. occiduus* and NE84-45-3 and '378' susceptible. Although these three selections have been identified as chinch bug resistant, further evaluation is needed to determine the categories of their resistance (antixenosis, antibiosis, and/or tolerance).

USGA Progress Report - 2000

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Table of Contents

GERMPLASM DEVELOPMENT OF BUFFALOGRASS VARIETIES

2000 Results from the 1996 National Buffalograss Trial

S.R. Westerholt, and T.P. Riordan

The 1996 buffalograss test was planted at eleven sites around the country including at our research facility near Mead, Nebraska. The John Seaton Anderson Turf Farm experienced mild temperatures and 6 months of drought conditions during the winter of 1999-2000. Little to no reserve soil moisture, with few timely rains, and no supplemental water provided a good test for drought. All cultivars performed very well and maintained good turf performance despite the drought conditions.

The top performers in the NE test were 91-118, Bonnie-Brae, and 'Legacy' (see Table #). Bonnie-Brae was the best overall of the non-Nebraska cultivars in this test. The southern adapted types, especially diploid varieties like Stampede and UCR-95, did not survive the winter of 1997 and their plots were replanted to Texoka to maintain a uniform turf area. '609' survived the winter of 1999-2000, but was set back because of winter damage. By July, '609' had completely recovered from winter injury.

The seeded varieties showed little differentiation in 2000 (see Table #). Cody, Bison, BAM-1000, and Tatanka all exhibited good color and quality characteristics throughout the summer.

Table 1. Color, Quality and Greenup ratings from the National Turfgrass Evaluation Programs 1993 Buffalograss Evaluation Trial for 2000.

Name	Estab.	Greenup†			Color††			
		25-Apr	10-May	14-Jun	12-Jul	15-Aug	13-Sep	Avg
86-61	Veg	2.3	7.0	7.3	7.3	7.3	7.3	7.3
Bonnie -Brae	Veg	4.0	7.3	7.0	6.7	6.7	7.0	6.9
'378'	Veg	3.3	6.3	6.3	6.7	6.3	6.3	6.4
91-181	Veg	4.0	6.3	6.3	6.3	6.3	6.3	6.3
'609'	Veg	3.3	6.0	6.0	6.0	6.0	6.0	6.0
86-120	Veg	3.7	6.0	6.0	6.0	6.0	6.0	6.0
93-170	Veg	4.7	6.0	6.0	6.0	6.0	6.0	6.0
93-181	Veg	5.7	5.3	5.7	6.0	5.7	5.3	5.6
Midget	Veg	4.3	5.3	5.3	5.3	5.3	5.3	5.3
91-118	Veg	4.0	5.0	5.0	4.7	5.0	5.0	4.9
Stampede		Winter Killed in 1997						
UCR-95		Winter Killed in 1997						
Mean		**4.1**	**6.1**	**6.1**	**6.1**	**6.1**	**6.1**	**6.1**
LSD		**2.0**	**0.8**	**0.9**	**0.8**	**0.8**	**0.7**	**1.0**
Cody	Seed	5.7	6.3	6.3	6.3	6.3	6.0	6.3
Bison	Seed	4.3	6.0	6.0	6.0	6.0	6.0	6.0
BAM-1000	Seed	6.3	5.7	5.7	5.7	5.7	5.7	5.7
Tatanka	Seed	6.0	5.7	5.7	5.7	5.7	6.0	5.7
Texoka	Seed	3.0	5.0	5.0	5.0	5.0	5.0	5.0
Mean		**5.1**	**5.7**	**5.7**	**5.7**	**5.7**	**5.7**	**5.7**
LSD		**2.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.5**	**0.9**

Table 1. Continued.

Name	**Estab.**			**Quality†††**			
		10-May	**14-Jun**	**12-Jul**	**15-Aug**	**13-Sep**	**Avg**
86-61	Veg	6.7	7.3	7.3	7.3	7.3	7.2
Bonnie-Brae	Veg	7.3	6.7	6.7	6.7	7.0	6.9
91-118	Veg	6.0	6.7	6.7	7.0	6.7	6.6
'378'	Veg	6.3	6.3	6.7	6.7	6.3	6.5
93-181	Veg	6.7	6.3	6.3	6.3	6.3	6.4
91-181	Veg	6.3	6.3	6.3	6.0	6.0	6.2
93-170	Veg	6.0	6.0	6.0	6.0	6.0	6.0
86-120	Veg	5.0	5.7	6.0	6.0	6.0	5.7
'609'	Veg	3.3	5.0	6.3	6.3	6.3	5.5
Midget	Veg	3.3	4.0	4.0	4.3	4.3	4.0
Stampede	Veg	Winter Killed in 1997					
UCR-95	Veg	Winter Killed in 1997					
Mean		5.7	6.0	6.2	6.3	6.2	6.1
LSD		1.2	1.0	1.0	1.0	0.8	0.9
Cody	Seed	5.7	6.0	6.0	6.3	5.7	5.9
BAM-1000	Seed	5.7	5.7	5.7	5.7	5.7	5.7
Bison	Seed	5.3	5.7	5.7	5.7	5.7	5.6
Tatanka	Seed	4.7	5.0	5.7	5.7	5.3	5.3
Texoka	Seed	4.7	4.3	4.7	5.0	4.7	4.7
Mean		5.2	5.3	5.5	5.7	5.4	5.4
LSD		**ns**	**0.9**	**0.9**	**1.0**	**ns**	**0.8**

† *Greenup ratings based on 1-9 scale with 1=0-10% and 9=90-100% green.*

†† *Color ratings based on a 1-9 scale with 1=yellow, 5=green, and 9=very dark green.*

††† *Quality ratings based on a 1-9 scale with 1=poor 9=excellent quality.*

Breeding Evaluation of Low Mowing Tolerant Buffalograss

Introduction

Buffalograss is most commonly grown at high mowing heights and under low maintenance situations. However in recent years, we have evaluated the species for use on golf course fairways in arid regions where water may be an issue. We have observed that buffalograss does quite well at mowing heights even as low as 1.4 cm (5/8"). Our oldest plot in this evaluation has been mowed at 1.4 cm for 9 years and continually provided high quality, low maintenance fairway-type turf.

Selecting for improved low mowing characteristics can enhance the quality and functionality of buffalograss maintained under these mowing heights. For this reason, vegetative selections that have shown superior tolerance to low mowing have undergone two generations of selection and are currently under evaluation.

Methods and Materials

In 1994, the first crossing block consisting of selections tolerant to low mowing was planted. Progeny from that crossing block was planted, evaluated, and reselected for recombination in 1998. Advance selections from this material was increased and planted in the 1999-breeding nursery in Area 13 of the John Seaton Anderson Turf Farm located at Mead, Nebraska. Check cultivars of NE 91-118, Legacy, and '315' were used for comparisons. Initial turf ratings of spread, color, quality, and density were collected in 2000.

Results and Discussion

During the summer of 1999, a number of new selections showed very rapid establishment over the checks. Cultivars NE98-0014, NE98-0013, NE98-0022, NE98-0047, and NE98-0048 were some of the better cultivars (see Table 2). Despite drought conditions and the trial maintained with natural rainfall, all cultivars preformed exceptionally well. Some of the better cultivars for quality were NE98-0009, NE98-0014, and NE98-0017 which were similar to NE91-118 in color. Cultivars NE98-0048, NE98-0003, and NE98-0045 had the better of the overall performances with regards to quality and color. These cultivars were very competitive with the NE86-61 (Legacy) check.

Density ratings, which measures the thickness and resiliency of the turf, had three exceptional cultivars NE98-0046, NE98-0040, and NE98-0009. These cultivars not only showed very tight and thick turf, but also were very soft to walk on.

Crossing blocks planted in 1999, were harvested in 2000 and their progeny will be planted in the spring of 2001. In-addition, ploidy levels will be determined using flow cytometry which has been a major asset in the development of new cultivars. The matching of ploidy should have a positive impact on germination, seed yields, and turf performance.

Table 2. Spread, color, quality, and density ratings from the 1999 buffalograss low mowing breeding nursery.

Name	Gender	Spread* 08/24/99	Spread* 05/03/00	Color† Avg	Quality†† Avg	Density††† 08/30/00
98-0042	Replanted			5.3	5.3	5.0
98-0039	Replanted			5.3	4.7	3.7
98-0043	Replanted			6.7	4.3	4.3
95-56	Replanted	3.0	7.0	6.8	3.0	3.0
95-38	Both	5.0	7.7	6.2	5.2	4.3
91-118	Female	5.7	9.0	4.3	8.0	6.7
98-0009	Female	4.7	8.0	4.7	7.5	7.0
98-0014	Female	8.3	9.0	4.7	7.2	5.7
98-0017	Female	2.7	5.0	4.5	7.0	6.7
98-0048	Female	7.0	9.0	7.7	7.0	6.0
98-0005	Female	6.3	8.3	5.8	6.8	6.3
98-0020	Female	6.7	8.0	6.2	6.8	6.7
98-0032	Female	2.7	5.3	4.5	6.7	5.0
98-0047	Female	7.0	8.7	6.3	6.7	5.3
98-0013	Female	8.3	9.0	6.3	6.5	6.3
98-0041	Female	6.7	8.3	5.8	6.5	6.3
98-0025	Female	6.3	8.7	6.0	6.3	5.7
95-39	Female	4.0	6.3	4.5	6.3	5.3
98-0037	Female	4.0	7.3	6.5	6.3	6.3
86-61	Female	8.5	9.0	7.1	6.3	6.3
98-0046	Female	4.3	8.3	6.3	6.2	7.7
98-0012	Female	5.0	7.7	4.7	6.2	5.3
98-0038	Female	3.7	6.3	6.7	6.2	6.3
84-315	Female	6.0	8.3	6.0	5.8	6.7
98-0003	Male	4.7	7.0	6.8	7.5	5.7
98-0019	Male	7.7	9.0	6.8	7.2	6.3
98-0045	Male	4.7	5.7	6.5	6.8	6.7
98-0021	Male	6.3	8.0	6.0	6.7	5.7
98-0040	Male	4.0	8.0	5.7	6.7	7.3
98-0023	Male	7.0	8.7	7.0	6.5	6.0
98-0028	Male	4.7	7.7	4.8	6.5	5.3
98-0007	Male	6.3	8.7	4.5	6.3	5.0
98-0011	Male	4.0	7.7	5.8	6.3	6.7
98-0022	Male	7.7	8.7	6.0	6.3	4.3
95-57	Male	3.3	6.0	5.8	6.2	4.7
98-0044	Male	6.0	9.0	5.0	6.0	4.7
Means		**4.9**	**7.3**	**5.8**	**5.8**	**5.3**
LSD (.05)		**2.7**	**1.6**	**1.7**	**1.7**	**1.6**

* *Spread ratings are based on a 1-9 scale with 1=0-10% 9=90-100% of plot filled.*
† *Color ratings are based on a 1-9 scale with 1=yellow, 5=green, and 9=very dark green.*
†† *Quality ratings are based on a 1-9 scale with 1=poor 9=excellent quality.*
††† *Density ratings are based on visual scale of 1-9 with 1=thin stand 9=very thick stand.*

Development of Glyphosate Resiatant Buffalograss Using Particle Bombardment

Dr. Schuizhang Fei
(non-USGA Project)

Introduction

The excellent drought tolerance of buffalograss makes it an excellent choice for low maintenance turfgrass in home lawns and potentially in golf course fairways. However this potential has not been fully realized due to the slow growth rate that make buffalograss susceptible to weed invasion. Development of buffalograss cultivars with glyphosate tolerance would greatly facilitate the establishment of buffalograss at low maintenance sites with the use of glyphosate without compromising its characteristic slow growth rate.

Particle bombardment has been a major tool in genetic transformation of monocot crops including most turfgrass species. Plant regeneration, an essential step for genetic transformation, has been established for buffalograss in our laboratory in the past. In this report, we will describe the progresses we have made on buffalograss genetic transformation in the past three years in cooperation with the Scotts company, the Monsanto company as well as with the Plant Transformation Core Facility at the University of Nebraska-Lincoln.

Results

Embryogenic calli derived from immature inflorescence culture of a vegetative cultivar '91-118' were used for particle bombardment. The gene construct used in our experiment contains two CP4 genes in the same construct with one CP4 driven by a 35S promoter and the other CP4 driven by a rice actin promoter.

Shooting parameters were optimized based on the result obtained from the use of a reporter gene, GUS. Major shooting parameters optimized include helium pressure, particle size and travel distance, the amount of DNA used for each bombardment and the number of bombardments per plate. Glyphosate concentrations and the length of delay for selection were also experimented to maximize the selection efficiency and minimize negative effects of the glyphosate on buffalograss callus.

Embryogenic calli were precultured on a high osmotic medium containing 0.2M sorbitol and 0.2 M mannitol 4 hours before bombardment. Bombarded calli were again moved back to the same high osmotic medium containing sorbitol and mannitol for another 20 hours before they were moved to the regular callus maintenance medium containing MS basal medium, 2mg 2,4-D/l and 2g proline/l. After a certain period of delay for selection, bombarded calli were transferred to callus maintenance medium supplemented with 1 or 2 mM glyphosate. After at least two passages of selection, surviving calli were tested for the expression of CP4 gene using test strips developed by Agdia Inc. (Elkhart, IN). So far, more than forty independent callus lines have been identified using these test strips. Transformation frequency (Number of glyphosate resistant callus / Total number of callus bombarded) can reach as high as 8% in some of the experiments. Glyphosate resistant calli were transferred to regeneration medium containing MS basal medium, 0.1 mg BA/l and low concentrations of glyphosate. Cultures are currently being evaluated to assess the regeneration efficiency in the presence of glyphosate at different concentrations. Healthy shoots will be moved to rooting medium and subsequently transferred to greenhouse.

Once plants from glyphosate resistant callus are established in soil, herbicide spray experiments, evaluation of morphological characteristics and molecular characterization of the transformed plants will be performed.

The successful transformation of buffalograss cv 91-118 callus will allow us to extend this technology to other buffalograss cultivars. We hope that the use of buffalograss will be positively influenced with enhanced glyphosate tolerance.

Screening Natural Buffalograss Tolerance to Glyphosate (Roundup®)

Steve Westerholt

Introduction

With the advent of the roundup gene and trans-genetic methods, the development of roundup resistant buffalograss has been a major goal of the buffalograss-breeding program. Once buffalograss is transformed, greenhouse and field screenings for glyphosate resistance will be conducted to determine the success of the genetic transformation. This requires an understanding of buffalograss tolerance levels to glyphosate.

Methods and Materials

Preliminary screenings for glyphosate were conducted in greenhouse conditions during December and January of 1999-2000. Ten replications consisting of two vegetative cultivars of buffalograss 'NE 91-118' and '609', which are presently being used in transgenic research, were established from stolons in 10 cm diameter pots. Herbicide treatments consisting of a balance mixture of Roundup Ultra® and Accord® was used to minimize burning effects caused by the surfactant in greenhouse conditions. Glyphosate treatments of .56 L/ha (.25 qt/ac), 1.125 L/ha (.5 qt/ac) 2.25 L/ha (1 qt/ac), and 4.5 L/ha (2 qt/ac) active ingredients were applied using spray table emitting water at the rate of 360 L/ha (40 gal/ac). None of the pots were irrigated for 24 hours after treatment to allow the herbicide to dry on the leaves.

Damage ratings were collected 5 and 14 days after treatment using a visual scale of 1-9 based on the percent dead leaf area. Data was analysis using a completely random design with a two-factor factorial.

Results and Discussion

Both cultivars used in this experiment had similar effects to the Roundup® treatments for both time periods. Glyphosate treatments of 1.125 L/ha (.5qt/ac) or less were not high enough concentrations of herbicide to be lethal to buffalograss (see Table 3). Rates of 2.25 L/ha (1 qt/ac) or higher were sufficient to cause 70 – 100 percent death of the plant.

Results of this experiment would indicate that screening of glyphosate tolerant material could be accomplished using a rate as low as 2.25 L/h (1 qt/ac). This rate would cause sufficient burning in susceptible lines to identify Roundup® ready cultivars.

Table 3. The effects of glyphosate concentrations applied to buffalograss 5 and 10 days after treatment.

Rate		**Roundup Damage Rating***			
(L/ha)	**(qt/ac)**	**06/20/2000**		**06/29/2000**	
0.00	0.00	1.3	e	1.2	e
0.56	0.25	2.1	d	1.8	d
1.125	0.50	4.3	c	4.0	c
2.25	1.00	7.0	b	7.2	b
4.50	2.00	7.8	a	8.1	a
Mean		4.5		4.5	
LSD (.05)		0.4		0.6	

*Ratings Scale (1-9) with 1=no damage 9=dead plants
Letters indicate significant differences at .05

BUFFALOGRASS MANAGEMENT RESEARCH

Buffalograss Fairway Management Evaluation

Steve Westerholt

Introduction

The management recommendations for buffalograss fairways are relatively unknown. This study was initiated to evaluate buffalograss under fairway management to evaluate the effects of nitrogen rate, cultivar, verticutting, and simulated traffic treatment. From this information, an efficient maintenance program could be developed.

Materials and Methods

Four seeded and four vegetative cultivars were planted June 23, 1998. The study was maintained at a 6.3 cm (2.5") mowing height until plots were totally covered. The mowing height was gradually reduced to 1.4 cm (5/8") in July of 1999. Mowing height could have been reduced as early as September 1998 except for the slow establishment of the cultivar entries '378', NE86-120, and NTG-7.

Fertilizer treatments using a split plot design were initiated in May and consisting of three treatments with 5g N/m^{-2} (1 lb N/m) per application applied in: April (treatment 1); April and June (treatment 2); and April, June, July, August, and September (treatment 3). Spring greenup ratings were collected April 15, 2000 when 50% of the turf was showing a green color. Color ratings were taken monthly throughout the summer.

Simulated traffic treatments were initiated April 19, 2000 using a Brinkman traffic simulator. Three treatments were applied in a split plot design consisting of 8 passes (high traffic), 4 passes (medium traffic), and 2 passes (low traffic) weekly through the summer and into the fall of 2000.

Verticutting was used to determine if surface stolons could be reduced and turf density increased. The concept was to improve turf quality by cutting and removing surface runners that sometimes form with some cultivars of buffalograss. Vertical mowing treatments were applied June 5 and August 2 using a Ryan vertical mower set to ground level. A split-split design was used for statistical analysis. A power sweeper was used to remove any surface debris left behind by the vertical mower. Removal of debris was necessary to prevent potential plugging of the fairway mower.

Results and Discussion

Data collection for color, quality, and density was collected monthly using a visual 1-9 rating scale. In general, color ratings were greatly affected by fertilizer application rates while unaffected by traffic or vertical mowing. Quality and density ratings were affected by fertilizer, traffic, and vertical mowing treatments.

Male Sex Expression Among Seeded Varieties

The production of male inflorescences have been considered a concern in buffalograss fairway turf. Although most inflorescences are removed with regular mowing, it remains a major concern with the use of seeded buffalograss varieties. In June, differences in the amount of male inflorescences were observed and rated in-order to determine the effect of management practices on the their occurrence.

Preliminary results indicate that male sex expression appears to be affected by variety and stress conditions. Data indicates that the appearance of male inflorescences is dependent upon varieties, with Texoka exhibiting the fewest number of heads; while the more advance varieties of Cody and FW3 had higher incidences of male heads.

Stress conditions caused by simulated traffic and vertical mowing in conjunction with low moisture conditions resulted in higher production of male inflorescences (see tables 4, 6, & 8). The data suggest that buffalograss responses to stress by a increasing flowering. This response is known to exist in other turf species such as *Poa annua.*

Cultivar Effects

Quality and density ratings indicate that the vegetative cultivars showed better overall performance than the seeded types (see Table 4). NE 91-118 was the best vegetative cultivar in this study for quality and density while Legacy (NE86-61) exhibited the highest color ratings. Based on the data from this study, both NE91-118 and Legacy would have acceptable performance if used under fairway conditions.

Cody had the better quality ratings with FW-3 having the best color rating of the seeded types. Both varieties have similar characteristics when maintained under low mowing height.

Fertilizer Effects

During 2000, all characteristics measured showed a positive response to Nitrogen applications up to 10 g N/m^{-2} /yr (2 lbs N/m^{-2} /yr), however, no significant improvement was shown with higher fertilizer rates (see Table 5). The most noticeable response to Nitrogen fertilization was with greenup and color ratings.

Simulated Traffic Effects

Quality and density had significant responses to all simulated traffic treatments, while color was relatively unaffected (see Table 6). Statistical analysis of quality and density data showed a cultivar x traffic interaction that would indicate a difference in cultivar response to traffic (see Table 7).

Vegetative cultivars showed initially less injury and quicker recovery than seeded varieties. In general, recovery from traffic injury was the product of cultivar and water availability. Typically recovery from traffic treatments would occur within a week of applied treatments with good water availability. However, as water availability decreased, recovery from turf injury would require 2-3 additional days to return to pre-treatment conditions.

Vertical Mowing Effects

Application of vertical mowing treatments resulted in a thinning of the turf and depositing of the stolons on the surface, which were removed with turf sweeper. Recovery from this treatment required at least 2-3 weeks depending on water availability. Although the treatment did remove the unsightly surface stolons from the two of the seed cultivars, the remaining cultivars showed no improved quality and reduced turf density (see table 8).

Plans for 2001

All treatments will be repeated in 2001 to confirm the results of 2000. Data from this study have supported current management recommendations for buffalograss.

Table 4. The effect of cultivars on color, quality, density, and male sex expression maintained under 1.4 cm (5/8") mowing height.

Cultivar	Propagation	Color†	Quality††	Density†††	Male Sex Exp.*
91-118	Veg.	5.9	7.7	7.7	Female only
86-61	Veg.	6.8	6.9	7.3	Female only
86-120	Veg.	6.7	6.5	7.1	Female only
378	Veg.	6.4	5.8	6.1	Female only
Cody	Seeded	5.7	5.7	6.0	5.7
FW-3	Seeded	5.9	5.5	6.0	5.1
NTG7	Seeded	5.7	5.1	5.4	5.4
Texoka	Seeded	4.7	4.9	5.1	4.2
Mean		6.0	6.0	6.3	5.1
LSD (.05)		0.1	0.2	0.2	0.2

† *Color ratings based on a 1-9 scale with 1=yellow, 5=green, and 9=very dark green.*
†† *Quality ratings based on a 1-9 scale with 1=poor 9=excellent quality.*
††† *Density ratings are based on visual scale of 1-9 with 1=thin stand 9=very thick stand.*
* *Male sex expression ratings are based on 1-9 scale with 1=0-10% 9=9-100% of the plants with male inflorescences.*

Table 5. The effect of fertilizer rates on color, quality, density, greenup and male sex expression maintained under 1.4 cm (5/8") mowing height.

Treatments	Color†	Quality††	Density†††	Greenup††††
10 g N/m/yr (2 lbs)*	6.2 a	6.2 a	6.5 a	5.8 a
25 g N/m/yr (5 lbs)*	6.2 a	6.2 a	6.5 a	5.4 a
5 g N/m/yr (1 lbs)*	5.4 b	5.7 b	6.0 b	4.1 b
Mean	6.0	6.0	6.3	5.1
LSD (.05)	0.6	0.1	0.1	0.4

* *Fertilizer rates indicated are grams or lbs of Elemental Nitrogen applied per 1000 square feet of turf per year.*
† *Color ratings based on a 1-9 scale with 1=yellow, 5=green, and 9=very dark green.*
†† *Quality ratings based on a 1-9 scale with 1=poor 9=excellent quality.*
††† *Density ratings are based on visual scale of 1-9 with 1=thin stand 9=very thick stand.*
†††† *Greenup ratings based on a 1-9 scale with 1=0-10% and 9=90-100% green.*

Table 6. The effect of simulated traffic on color, quality, density, and male sex expression maintained under 1.4 cm (5/8") mowing height.

Simulated Traffic*	Passes*	Color† Avg.	Quality†† Avg.	Density††† Avg.	Male+ Avg.
Low	2	6.0 a	6.8 a	7.3 a	5.4 a
Medium	4	5.9 a	6.0 b	6.2 b	4.8 c
High	8	5.9 a	5.3 c	5.5 c	5.1 b
Mean		6.0	6.0	6.3	5.1
LSD (.05)		ns	0.2	0.3	0.4

* *Low, Moderate, and High traffic was simulated using a traffic simulator and 2, 4, and 8 passes respectively applied weekly.*
† *Color ratings based on a 1-9 scale with 1=yellow, 5=green, and 9=very dark green.*
†† *Quality ratings based on a 1-9 scale with 1=poor 9=excellent quality.*
††† *Density ratings are based on visual scale of 1-9 with 1=thin stand 9=very thick stand.*
+ *Male sex expression ratings are based on 1-9 scale with 1=0-10% 9=9-100% of the plants with male inflorescences.*

Table 7. The interaction of simulated traffic x cultivar treatments on turf quality and density maintained under 1.4 cm (5/8") mowing height.

	Quality††				Density†††			
	Traffic				Traffic			
Vegetative	**Low†**	**Med†**	**High†**	**Mean**	**Low†**	**Med†**	**High†**	**Mean**
91-118	8.5	8.0	7.1	7.9 a	8.4	7.7	7.2	7.8 a
86-61	7.3	6.6	5.8	6.5 b	7.7	7.2	6.3	7.1 b
86-120	7.1	6.4	5.8	6.4 b	7.8	7.0	6.3	7.0 b
378	6.4	5.3	4.8	5.5 c	6.9	5.5	5.0	5.8 c
Seeded								
Cody	6.0	5.3	4.7	5.3 cd	6.7	5.5	4.9	5.7 c
FW-3	5.9	5.2	4.3	5.1 d	5.9	5.9	5.9	5.9 c
NTG7	5.4	4.6	4.2	4.7 e	5.9	4.9	4.3	5.0 d
Texoka	5.2	4.6	3.9	4.6 e	5.7	4.9	3.8	4.8 d
Mean	6.5	5.7	5.1	5.8	6.0	5.9	5.9	5.9
LSD (.05)	0.4	0.4	0.3	0.2	0.5	0.4	0.4	0.3

† *Low, Moderate, and High traffic was simulated using a traffic simulator and 2, 4, and 8 passes respectively applied weekly.*
†† *Quality ratings based on a 1-9 scale with 1=poor 9=excellent quality.*
††† *Density ratings are based on visual scale of 1-9 with 1=thin stand 9=very thick stand.*

Table 8. The effect of vertical mowing on color, quality, density, and male sex expression maintained under 1.4 cm (5/8") mowing height.

Treatments	Color†	Quality††	Density†††	Male Sex Exp.*
Non Vertical Mowed	6.0 a	6.2 a	6.7 a	4.7 b
Vertical Mowed	6.0 a	5.9 b	6.0 b	5.5 a
Mean	6.0	6.0	6.3	5.1
LSD (.05)	0.05	0.1	0.1	0.3

† *Color ratings based on a 1-9 scale with 1=yellow, 5=green, and 9=very dark green.*
†† *Quality ratings based on a 1-9 scale with 1=poor 9=excellent quality.*
††† *Density ratings are based on visual scale of 1-9 with 1=thin stand 9=very thick stand.*
* *Male sex expression ratings are based on 1-9 scale with 1=0-10% 9=9-100% of the plants with male inflorescences.*

BUFFALOGRASS ENTOMOLOGY AND PATHOLOGY RESEARCH

Buffalograss Resistance to the Chinch Bug, *Blissus occiduus*

Tiffany Heng-Moss, Fred Baxendale, Terry Riordan, Roch Gaussoin, and Kevin Frank

In late July 2000, a chinch bug infestation was detected in a buffalograss evaluation plot established in 1995 to assess the effects of mowing height and nitrogen rate on buffalograss quality. This evaluation plot provided an excellent opportunity to investigate interactions among chinch bug injury, mowing height, and nitrogen rate.

The experimental design was a randomized complete block design with 3 replications. The treatment design was a split-split-plot design. The main plot effect was buffalograss cultivar/selection (378 and NE 91-118), the split plot effect was mowing height (2.5, 5.0, and 7.5 cm), and the split-split plot was nitrogen rate (0, 24, 49, 98, and 195 kg N ha^{-1} $year^{-1}$). Plot maintenance included weekly mowing, nitrogen rates were applied in 2 equal applications, and preemergence herbicides were applied each year after establishment. Cultivars/selections were assessed for chinch bug damage and chinch bug numbers on 9 August, 2000. The damage rating scale was based on a 1-5 rating scale; with 1 = 10% or less damage; 2 = 11% to 30%; 3 = 31% to 50%; 4 = 51% to 70%; and 5 = 71% or more and plant close to death. To obtain chinch bug infestation levels, 10.6 cm diameter soil plugs were extracted using a golf cup cutter. Three of these samples were randomly collected from each cultivar/selection to provide information on chinch bug densities.

No significant differences in chinch bug numbers were detected among the buffalograsses evaluated. However, significant differences in chinch bug damage were observed among cultivars/selections, mowing height, and nitrogen rate. Differences in chinch bug damage were detected among nitrogen rates at the 2.5 cm mowing height. The highest level of damage was observed in the plots receiving the highest rate of nitrogen (195 kg N ha^{-1} $year^{-1}$), while plots receiving no nitrogen had the lowest damage ratings (Figure 1). No differences in chinch bug damage were detected among the nitrogen rates at the 5.0 and 7.5 cm mowing heights. These differences in chinch bug damage ratings among management practices likely resulted in the significant interaction between mowing height and nitrogen rate detected by the mixed model analysis.

NE91-118 consistently had lower chinch bug damage ratings at all mowing heights and nitrogen rates when compared to 378. At the 2.5 cm mowing height, NE91-118's damage ratings were significantly lower than damage ratings for 378 at all nitrogen rates except 0 kg N ha^{-1} $year^{-1}$ (Figure 1). 378 plots receiving nitrogen had damage ratings of 3 or higher whereas damage ratings for NE91-118 plots were less than 2.5. NE91-118 also had lower damage ratings when compared to 378 at the 5.0 and 7.5 cm mowing heights for all nitrogen ratings. This study further documents NE91-118 resistance under field conditions.

This research suggests that regardless of the buffalograss cultivar/selection, the greatest level of chinch bug damage occurs at low mowing heights (2.5 cm) and high nitrogen rates (195 kg N ha^{-1} $year^{-1}$). By contrast, at higher (5.0 and 7.5 cm) mowing heights damage ratings are not impacted by the level of nitrogen. Further studies are needed to fully understand the influence of buffalograss management practices on chinch bug damage.

Curvularia Leaf Spot *Curvularia lunata*

Steve Westerholt, Lorin Geasler, and John Watkins

The fungi Curvularia leaf spot (*Curvularia lunata*) was isolated for the first time in buffalograss in 1999. This general pathogen, which is found on many other grass species, infests host species that may be under some form of stress. No new infestations were reported in 2000. It is believed that dryer and warmer conditions may have reduce the occurance of the disease.

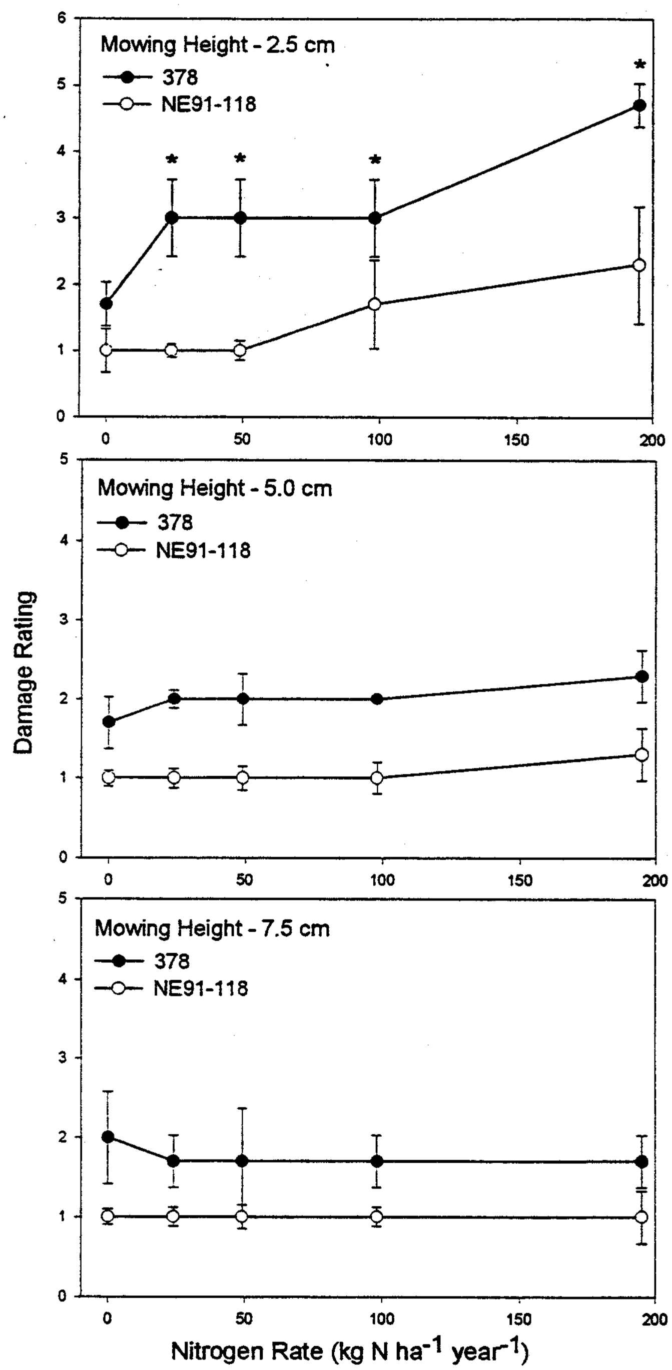

Figure 1. Effect of mowing height and nitrogen rate on chinch bug damage.
*** Significantly different at $P < 0.05$.**

Student Progress

Dr. Kevin Frank has accepted a position at Michigan State University.

Tiffany Moss is near finishing her work on her Ph.D., and has accepted a position at UNL.

Shuizhang Fei is presently finishing up on his Post Doc work with Roundup Resistance and has accepted a position at Iowa State University to continue to work on transgenetic research and plant breeding.

Planned Evaluations for 2000

Buffalograss renovation and establishment study

With an increased awareness of buffalograss and its benefits to the homeowner and golf course superintendent, the increased demand for buffalograss requires a better understanding of turf renovation and establishment. Golf courses that are under play and wish to convert to buffalograss must be able to reestablish roughs or fairways with as little down time as possible. An interdisciplinary study has been proposed to evaluate methods of converting cool season grass to buffalograss. This study will evaluate management practice required to convert or renovate golf course roughs or fairways to buffalograss with minimum intrusion of course play. Treatments would include weed control, vegetative or seed establishment, mowing practices, and irrigation management.

Determine profile water use of buffalograss

Buffalograss has a low water requirement. However, under extreme drought conditions proper water management could extend the playability of buffalograss. A study proposed for the summer of 2000 would investigate water use in the soil profile. This study would profile water consumption to determine where water is removed from the soil profile and the rate that is being used to maintain buffalograss.

Sex expression regulation using growth regulators

In 1999, preliminary evaluations were conducted using Primo® plant growth regulator which regulates GA levels in the plant and this may inhibit male inflorescences in buffalograss. This study will determine if the use of a GA inhibitor can reduce the production of male inflorescences that sometime appear in female vegetative cultivars.

LIST OF PUBLICATIONS

Refereed Journal Articles

Riordan, T.P., S.A. de Shazer, J.M. Johnson-Cicalese, and R.C. Shearman. 1993. An overview of breeding and development of buffalograss for golf course turf. Intl. Turfgrass Soc. Res. J. 7:816-822.

Baxendale, F.P., J.M. Johnson-Cicalese, and T.P. Riordan. 1994. *Tridiscus sporoboli* and *Trionymus sp* (Homoptera: Pseudococcidae): potential new mealybug pests of buffalograss turf. J. Kansas Entomol. Soc. 67(2):169-172. Journal Series No. 10377.

Browning, S.J., T.P. Riordan, R.K. Johnson, and J.M. Johnson-Cicalese. 1994. Heritability estimates of turf-type characteristics in buffalograss. HortScience 29:204-205.

Baxendale, F.P., D.H. Steinegger and R.W. Baxendale. 1995. Phytotoxicity evaluation of an insecticidal soap and horticultural oil on six turfgrass species. J. Turfgrass Management. 1(2):35-45. Journal Series No. 10508.

Riordan, T.P., J.M. Johnson-Cicalese, F.P. Baxendale, M.C. Engelke, R.E. Gaussoin, G.L. Horst and R.C. Shearman. 1995. Registration of '315' buffalograss. Crop Sci. 35:1206. Journal Series No. 10688.

Riordan, T.P., S. Fei, and P. G. Johnson. 1996. Breeding, plant regeneration, and flow cytometry in buffalograss. Proceedings of recent cellular and molecular approaches to turfgrass improvement. Recent Cell & Molecular Genetics Approaches to Turfgrass Improvement: A Turfgrass Biotechnology Workshop.

Fei, S., P.E. Read, and T.P. Riordan. 1997. *In vitro* regeneration of buffalograss (*Buchloe dactyloides* [Nutt.] Englem. Through immature inflorescence culture. Intl. Turfgrass Soc. Res. J. 8(1):283-290.

Giese, M.S., R.E. Gaussoin, R.C. Shearman, and T.P. Riordan. 1997. Sod production characteristics of turf-type *Buchloe dactyloides*. Intl. Turfgrass Soc. Res. J. 8(1):455-466.

Heng-Moss, T.M., F.P. Baxendale, J.M. Johnson-Cicalese, and T.P. Riordan. 1997. Non-destructive monitoring of mealybugs (Homoptera: Pseudococcidae) on buffalograss. Intl. Turfgrass Soc. Res. J. 8(1):997-1002. Journal Series No. 11761.

Johnson, P.G., T.P. Riordan, R.E. Gaussoin, P.J. Schwarze, and K.A. Kerner. 1997. Vegetative establishment of *Buchloe dactyloides* (Nutt.) Engelm. with plugs. Int. Turf. Res. J. 8:467-476.

Klingenberg, J.P. and T.P. Riordan. 1997. Multiple trait selection for the improvement of turf type, seeded buffalograss (*Buchloe dactyloides* [Nutt.] Englem.). Intl. Turfgrass Soc. Res. J. 8(1):313-320.

Klingenberg, J.P., P.G. Johnson, and T.P. Riordan. 1997. Registration of 'Tatanka' Buffalograss. Crop Science 37:1672-1673.

Riordan, T.P., P.G. Johnson, R.E. Gaussoin, and J.F. Svoboda. 1997. Seedling germination and establishment of *Buchloe dactyloides* caryopses vs. burrs. Int. Turf. Res. J. 8:749-756.

Rodgers, C.A., T.P. Riordan, and B.E. Johnson. 1997. Inheritance of seed weight in two Nebraska synthetic buffalograss populations. Intl. Turfgrass Soc. Res. J. 8(1):367-376.

Heng-Moss, T.M., F.P. Baxendale and T.P. Riordan. 1998. Beneficial arthropods associated with buffalograss. J. Econ. Entomol.

Heng-Moss, T.M., F.P. Baxendale and T.P. Riordan. 1998. *Rhopus nigroclavatus* (Ashmead) and Psuedaphycus sp. (Hymenoptera: Encyrtidae): two parasitoids of the buffalograss mealybugs, *Tridiscus sporoboli* (Cockerell) and *Trionymus sp.* J. Kansas Entomol. Soc.

Johnson, P.G., T.P. Riordan, and K. Arumuganathan. 1998. Ploidy level determination in buffalograss clones and populations. Crop Science 38. p478-482.

Johnson-Cicalese, J.M., F.P. Baxendale T.P. Riordan and R.E Gaussoin. 1999. Evaluation of buffalograss pubescence and its effects on mealybug (Homoptera: Pseudococcidae) host selection. J. Econ. Entomol. Journal Series No. 11619. (In Preperation)

Johnson-Cicalese, J.M., F.P. Baxendale T.P. Riordan and T.M. Heng-Moss. 1998. Identification of mealybug (Homoptera: Pseudococcidae) resistant turf-type buffalograss germplasm. J. Econ. Entomol. 91: pp 340-346.

Heng-Moss, T.M., F.P. Baxendale and T.P. Riordan. 1999. Influence of *Rhopus nigroclavatus* (Ashmead) (Hymenoptera: Encyrtidae) on the buffalograss mealybugs, *Tridiscus sporoboli* (Cockerell) and *Trionymus sp.*

Environ. Entomol. 28(1). pp123-127..

Baxendale, F.P., T.M. Heng-Moss, and T.P. Riordan. 1999. *Blissus occiduus* Barber (Hemiptera: Lygaeidae): A chinch bug pest new to buffalograss turf. J. Econ. Entomol. vol. 92(5). pp 1172-1176.

Schuizhang Fei, P.E. Read, and T.P. Riordan. 1999. Improvement of embryogenic callus induction and shoot regeneration of buffalograss (*Buchloe dactyloides* nutt. engelm) by AGNO3. J. of Plant, Cell, Tissue and Organ Culture Series No. 948378. (In Press)

Johnson, P.G. , and T.P. Riordan. 1999. A Review of Issues Pertaining to Transgenic Turfgrasses. J. of HortScience. Vol. 34(4). pp 594-498.

Johnson-Cicalese, J.M., P.G. Johnson, T.P. Riordan, F.P. Baxendale, R.E. Gaussoin, J.E. Watkins, and R.V. Ckucas. 1999. Registration of '120' Buffalograss. Crop Science. Vol. 40.

Johnson, P.G., T.P. Riordan, J.M. Johnson-Cicalese, F.P. Baxendale, R.E. Gaussoin, R.C. Shearman, and R.V. Klucas. 1999. Registration of '61' Buffalograss. Crop Science. Vol. 40.

Riordan, T.P., P.G. Johnson, J.M. Johnson-Cicalese, R.E. Gaussoin, F.P. Baxendale, R.C. Shearman and R.V. Klucas. 1999. Registration of '118' Buffalograss. Crop Science. Vol 40.

Abstracts

Baxendale, F.P., A.P. Weinhold, and T.P. Riordan. 1993. Comparison of chinch bug control on buffalograss with chlorpyrifos, neem and entomophagous nematodes, 1992. Insecticide and Acaricide Tests, 18:330.

Baxendale, F.P. and D.H. Steinegger. 1993. Reduced rates of Dursban combined with SunSpray Ultrafine Spray oil for control of chinch bugs on buffalograss, 1991. Insecticide and Acaricide Tests, 18:329.

Baxendale, F.P., A.P. Weinhold, T.P. Riordan, and D.H. Steinegger. 1993. Insecticidal control of first generation chinch bugs on buffalograss, 1992. Insecticide and Acaricide Tests, 18:329.

Baxendale, F.P., J.A. Kalisch and D.H. Steinegger. 1994. Control of buffalograss chinch bugs with combinations of insecticidal soap and reduced rates of conventional insecticides, 1993. Arthropod Management Tests, 19:328.

Heng, T., J.M. Johnson-Cicalese, F.P. Baxendale and T.P Riordan. 1994. A Non-destructive Method for Monitoring Mealybugs on Buffalograss. North Central Branch of the Entomological Society of America, Springfield, IL, March 12-17. 1994.

Johnson-Cicalese, J.M., F.P. Baxendale and T.P Riordan. 1994. Differences in Susceptibility to Mealybugs Among Turf-Type Buffalograss Selections. Eleventh Biennial International Plant Resistance Workshop. Stillwater, OK, February 27-March 2, 1994.

Johnson-Cicalese, J.M., T.P. Riordan and F.P. Baxendale. 1994. Resistance to mealybugs among turf-type buffalograss selections. 1994 Agronomy Abstracts p. 182.

Johnson-Cicalese, J.M., T.P. Riordan and F.P. Baxendale. 1994. Resistance to Mealybugs among Turf-type Buffalograss Selections. 1994 Agronomy Abstracts.

Riordan, T.P. C.A. Rodgers, and J.M. Johnson-Cicalese. 1994. Breeding and development of buffalograss, a native plains grass, for turfgrass use. 18th Ann. Interdisciplinary Symp. - Great Plains Grasslands, Lincoln, NE.

Baxendale, F.P. 1995. Buffalograss Insect Management Strategies in Nebraska. National Turfgrass Entomology Workshop, Omaha, NE, October 22-24, 1995.

Baxendale, F.P. and T.P. Riordan. 1995. Buffalograss: Entomological Perspective on a New Turfgrass. Entomological Society of America, Las Vegas, NV, December 17-21, 1995.

Frank, K.W., E.D. Miltner, R.E. Gaussoin, and T.P. Riordan. 1995. Date of planting effects on seeded buffalograss. 1995 Agronomy Abstracts p. 135.

Riordan, T.P., J.M. Johnson-Cicalese, and R.E. Gaussoin. 1995. Development of turf-type buffalograsses for golf course fairway use. 1995 Agronmy Abstracts p. 156.

Rodgers, C.A. T.P. Riordan, and J.M. Johnson-Cicalese. Breeding for seedling vigor in buffalograss. 1995 Agronomy Abstracts p. 156.

Heng-Moss, T.M., F.P. Baxendale and T.P. Riordan. 1996. Beneficial Arthropod Community Associated with Buffalograss. North Central Branch of the Entomological Society of America, Omaha, NE, March 24-27, 1996.

Heng-Moss, T.M., F.P. Baxendale and T.P. Riordan. 1996. Investigation of Interactions Between the Parasitoid *Rhopus sp*. and its Mealybug Hosts. Entomological Society of America, Louisville, KY, December 7-12, 1996.

Heng-Moss, T.M., F.P. Baxendale, A.P. Weinhold and T.P. Riordan. 1996. Mealybug control on buffalograss turf in Saunders Co., Nebraska, 1995. Arthropod Management Tests, 21:354.

Johnson, P.G., T.P. Riordan, and K. Arumuganathan. Analysis of buffalograss germplasm using flow cytometry. 1996 Agronomy Abstracts

Heng-Moss, T.M., F.P. Baxendale and T.P. Riordan. 1997. Natural Enemies Associated with Buffalograss. North Central Branch of the Entomological Society of America, Columbus, OH, March 23-26, 1997.

Heng-Moss, T.M., F.P. Baxendale and T.P. Riordan. 1997. The Influence of *Rhopus nigroclavatus* Buffalograss Mealybug Populations. Entomological Society of America, Nashville, TN, December 14-18, 1997.

Heng-Moss, T.M., F.P. Baxendale, K.A. Weinhold and T.P. Riordan. 1997. Insecticidal control of chinch bugs on buffalograss, 1996. Arthropod Management Tests 22:372.

Heng-Moss, T.M., T.P. Riordan and F.P. Baxendale. 1997. Buffalograss: an investigation of the beneficial arthropods. 1997 Agronomy Abstracts p. 182.

Heng-Moss, T.M., T.P. Riordan and F.P. Baxendale. 1997. Buffalograss: An Investigation of the Beneficial Arthropods. 1997 Agronomy Abstracts.

Johnson, P.G., C. Rodgers, and T.P. Riordan. Relatedness of buffalograss accessions using DNA markers. 1997 American Society of Agronomy annual meetings p. 128.

Heng-Moss, T.M., F.P. Baxendale, A.P. Weinhold and T.P. Riordan. 1998. Effect of post-treatment irrigation on control of buffalograss chinch bugs with deltamethrin, 1997. Arthropod Management Tests (In Press).

Frank K. W., J. F. Power, M. H. Bloom, R. E. Gaussoin, and T. P. Riordan. 1999. Fate of 15N-Labeled Ammonium Nitrate Applied to Three Turfgrass Species. 1999 American Society of Agronomy annual meetings Abstracts. p. 134.

Frank K. W., R. A. Drijber, R. E. Gaussoin, and T. P. Riordan. 1999. Variations in Microbial Community Structure Associated with Three Turfgrass Species. 1999 American Society of Agronomy annual meetings Abstracts. p. 134.

List of Patents

Riordan, T.P., S.A. de Shazer, F.P. Baxendale, E.J. Kinbacher, J.F. Svoboda, L.A. Wit, and M.C. Engelke. A Plant Patent (8475) for '609' buffalograss. Issued 1993.

Riordan, T.P., S.A. de Shazer, M.C. Engelke, L.A. Wit, F.P. Baxendale, E.J. Kinbacher, J.F. Svoboda, and J.M. Johnson-Cicalese. A Plant Patent for '315' buffalograss. Issued 1996.

Riordan, T.P., J. Johnson-Cicalese, E.J. Kinbacher, P.G. Johnson, F.P. Baxendale, R.E. Gaussoin, and R. Hansen. A Plant Patent for '61' Buffalograss. Issued, 1999.

Riordan, T.P., J. Johnson-Cicalese, E.J. Kinbacher, P.G. Johnson, F.P. Baxendale, R.E. Gaussoin, and R. Hansen. A Plant Patent for '120' Buffalograss. Issued, 1999.

Riordan, T.P., J. Johnson-Cicalese, P.G. Johnson, R.E. Gaussoin, F.P. Baxendale, E.J. Kinbacher, and R. Hansen. A Plant Patent for '118' Buffalograss. Issued, 1999.

List of Graduate Students and Thesis Titles

Completed

Jeffrey P. Klingenberg. Evaluation, genetic variation, and selection for improvment of a seeded, turf-type buffalograss population. Ph.D. 1992

Matthew S. Giese. Sod characteristics of turf-type buffalograss. M.S. 1995.

Jennifer M. Johnson-Cicalese. Buffalograss resistance to mealybugs: Germplasm evaluation, mechanisms, and inheritance. Ph.D. 1995

Charlie A. Rodgers Breeding and development of seeded turf-type buffalograss. Ph.D. 1997.

Kevin Frank. Date of planting effects on seeded turf-type buffalograss. M.S. 1997.

Tiffany Heng-Moss. Beneficial arthropods associated with buffalograss and the influence of *Rhopus nigroclavatus* (Ashmead) on buffalograss populations. M.S. 1997.

Shuizhang Fei. *In vitro* regeneration of buffalograss. Ph.D. 1997

In Progress

Tiffany Heng-Moss. Ph.D.