United States Golf Association Research Summary and Annual Report: 1999

A. Germplasm Development for Buffalograss Varieties

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

United States Golf Association

Executive Summary – 1999

Seeded Releases: Seed West has elected to leave the Native Turf Group (NTG). This was over a decision on who would market the new release NTG-5. NTG-7 and FW-3 are being evaluated at the John Seaton Anderson Turfgrass and Ornamental Research Facility. Charlie Rodgers of Seeds West has indicated that they would still like to market NTG-5. Terry Riordan is encouraging Seeds West and NTG to do this. It would mean $ 10,000 in royalties to the USGA.

Vegetative Released: Patents have been approved for releases Ne 86-61, NE 86-120, and Ne 91-118. Publication of the crop registration should occur this winter in the *Crop Science Journal*. Ne 86-61 has been named 'Legacy' and 35 acres are being produced by Todd Valley Farms at Mead, Ne. Legacy will be available in the northern United States next year.

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

Sales of buffalograss for 1999 are down, but they have indicated that this is due more to reorganization of the companies than lack of interest in buffalograss.

Summary of Breeding Work: Performance levels continued to improve with the establishment of a new breeding nursery in 1999. 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. The establishment of six new crossing blocks in 1999 with selections exhibiting fairway type characteristics should provide germplasm with higher levels of turf quality and adaption to golf course management systems.

Seed Production: Buffalograss seed production has received major attention in 1999. 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: Establishment of buffalograss has always been a major objective of the project. Great strides have been made with buffalograss establishment since the project was first initiated. Initial studies in the 1980's indicated that pre-rooted plugs had an advantage in establishment over seeded varieties. However, present studies have shown that seeded varieties now establish as rapidly as vegetative plugs. These improvements are due to improved selections that exhibit quicker germination and improved seedling vigor, and because of better production of seed by producers. Sprigging of buffalograss has also shown potential to provide very rapid establishment rates. The research project will focus on improving sprigging characteristics in addition to seed production.

USGA Progress Report - 1999
University of Nebraska-Lincoln

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A USGA/GCSAA/University of Nebraska Research Project Initiated February, 1993

Status of New Releases

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1999 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 top performers in the NE test were 91-118 and 'Legacy'. 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 period well in Nebraska and most of theses plots were replanted to Texoka to maintain a uniform turf area. 609 usually survives better than in this test, but was also winter killed due to adverse winter weather conditions in 1997. It was re-established by plugs from a near by turf area of 609, therefore, its ratings reflect this re-establishment.

The seeded varieties showed little differentiation in the first year of this study (Table 1). However, in 1999 the advance-seeded types began to show their improvements over the common types like Texoka. Although Tatanka and Bison showed slower establishment than the other varieties in 1996, their performance was not effected. Both cultivars exhibited good color and quality characteristics.

Table 1. Color and Quality ratings from the National Turfgrass Evaluation Programs 1993 Buffalograss Evaluation Trial for 1999.

NTEP 1993 National Buffalograss Trial Data for 1999

Name	Estab.	Percent Greenup 5/3/99	5/15/99	6/17/99	Color 7/15/99	8/12/99	9/13/99	% Fall Color 10/5/99	avg
Legacy	Veg	3.0	7.0	7.0	8.0	8.0	7.3	4.7	7.5
86-120	Veg	2.3	6.3	6.3	7.0	7.0	7.0	2.0	6.7
'378'	Veg	4.3	6.7	6.3	6.7	6.7	6.7	2.7	6.6
91-181	Veg	3.0	5.7	6.3	7.0	7.0	6.0	2.3	6.4
'609'	Veg	1.0	6.0	5.7	7.0	7.0	6.3	8.7	6.4
Bonnie-Brae	Veg	2.7	5.3	6.0	7.0	6.7	6.3	2.7	6.3
93-170	Veg	5.3	6.0	6.0	6.7	6.3	6.7	3.0	6.3
91-118	Veg	1.3	5.7	5.7	6.0	6.0	5.7	6.7	5.8
Midget	Veg	2.3	5.0	5.3	5.0	5.0	6.0	3.7	5.3
93-181	Veg	4.7	5.0	4.3	5.0	5.3	5.7	3.3	5.1
UCR-95	Veg	.	.	.	.	.	.	.	.
Stampede	Veg	.	.	.	.	.	.	.	.
Mean		3.4	5.7	5.7	6.4	6.3	6.2	3.8	6.1
LSD (.05)		2.35	1.53	1.64	0.56	0.74	1.01	1.25	0.93
Tatanka	Seed	2.3	6.0	6.0	6.3	6.7	6.3	4.3	6.3
Bison	Seed	3.0	5.3	6.3	6.0	6.7	6.0	4.0	6.1
Cody	Seed	2.3	6.0	6.0	6.7	5.7	6.0	3.0	6.1
BAM-1000	Seed	2.7	5.3	5.7	5.7	5.7	5.7	2.7	5.6
Texoka	Seed	3.0	4.3	5.3	5.3	5.3	5.3	2.7	5.1
Mean		2.7	5.4	5.9	6.0	6.0	5.9	3.3	5.8
LSD (.05)		1.31	0.84	0.91	0.81	0.88	0.91	0.91	0.49

mg of pMon25496 was used for DNA coating (ca.0.8 mg DNA per shot). Three plates each were bombarded using both gold and tungsten particles with two shots per plate. M10 tungsten preparation followed SSI's standard protocol. Gold particle preparation and DNA coating for both particles followed Scotts's revised protocol III.

After reviewing bombardment and through observations of some culture plates, the following conclusions were made.

1: *Particles* M17 tungsten particles have been used for buffalograss embryogenic callus bombardment. However, tungsten may exert some toxic effects on plant tissues and smaller gold particles will by use for future experiments.

2: *Particle size*: The velocity of M17 may be too high for tender tissues such as soft friable callus in this case. M10 will used if tungsten use is continued. Some of the larger GUS spots observed in some of our cultures were believed to come from injured cells.

3: *A isolation chamber* will be used after the loading of the DNA–coated particles to minimize the water absorption and any other subsequent impact caused by the excessive exposure to the air.

4: *DNA amount* In past experments 10 mg DNA per preparation (1.6 mg per shot) has been used. This amount may be too high. Higher amounts of DNA may be responsible for the higher copy numbers of insert, or the formation of large clumps during DNA precipitation. An amount of 2.5 mg (0.4 mg per shot) or lower was suggested for future experiments.

5: *Sonication* of the DNA and particle mixture has been used before loading to the macrocarrier. This practice was used to break the clumps effectively. However, this will be done in the future.

6: Rate of *vaccum drawing*. It takes more than a minutes to reach a vaccum of 27 inch Hg. Callus tissues could be significantly damaged by the extended long time of vaccum drawing. This problem seems inherent. Dr. Tom Clemente mentioned the pump itself is one of the top lines, the slow flow rate is caused by the security feature with the PDS/1000 mode. This information need to be confirmed.

7: *Tissue preparation:* Buffalograss callus is now being prepared in a way similar to bluegrass callus preparation.

Culture Observations

Cultures are at a critical stage. Some of the cultures may have transformants, but transferring these calli to a regeneration medium containing lower glyphosate concentration in a timely fashion is absolutely necessary to differentiate the transformants from non-transformants. Further research will be conducted as follows:

1: Reduce the number of calli per plate on selection to insure enough selection pressure during the selection cycle.

2: Reduce individual callus size as much as possible and spread callus as thin as possible.

3: Work on the regeneration for the intermediate type callus (relative to the soft friable and compact calli) that emerged during the subculture. Dr. Usha Saran will most likely work on this. An experi-

BUFFALOGRASS MANAGEMENT RESEARCH

Buffalograss Stolon Research

Introduction

Vegetative propagation has been a very important means of establishing stands of buffalograss in the absence of seed or in the increase vegetative female cultivars. Because of buffalograss growth habits, it is well adapted to many of the vegetative propagation methods. The propagation of buffalograss using sprigs was used as early as the 1920's. Wenger (1943) identified four types of vegetative propagation for the establish of buffalograss; transplanted runners or stolons, broadcasting sod, spot sodding, and plugging. Under field conditions for forage use, sprigging was not considered practical due to lack of water for establishment, it was too laborious, and no equipment existed to harvest runners. However, with use of buffalograss in home lawns and golf courses, sprigging has a practical application.

Developing techniques for sprig establishment will allow for rapid expansion of buffalograss material and potentially reduce establishment costs. Expected gains from sprigging establishment include more uniform stands (similar to seeded stands); quicker establishment (since stolons are actively growing plants and do not experience transplant shock as plugs); and better weed control measures can be used (stolons are mature plants and are not as susceptible to damage from preemergence herbicides).

Sprigging research will look at three aspects of stolon establishment. First, stolon activity will be studied to determine what parts of the buffalograss stolons have the ability to root and how temperature effects rooting. Second, stolon longevity will be evaluated to determine storage and transport limitations. Third, field establishment techniques will be studied.

The Effect of Age and Temperature on Sprig Rooting in Buffalograss

Objectives:

This study will evaluate the physical conditions that influence sprig root development in buffalograss. Sprig development will be evaluated for the effects of sprig age and temperature on the rate of root development.

Methods and Materials

Runners from NE 91-118 were collected from plants growing under greenhouse conditions. Individual sprigs consisting of 6 nodes per runner were clipped from the main plant and separated according to age, with the youngest node coming from the end of the runner and oldest closest to the mother plant. Individual nodes were placed in labeled petri dishes on a agar medium. Treatments consisted of internodes of varying ages, two temperature regimes (21° C and 5° C), and three replications. Stolons were examined every 12 hours for developing roots, and root length measured. The experiment was concluded after 60 hours when it was evident that no further rooting would occur. The experiment was repeated to confirm the results.

Results and Discussion

First signs of rooting were noted as early as 6 hours after placing the sprigs in the agar medium.

Sprig Establishment of Buffalograss

Introduction

This preliminary investigates different establishment techniques and their effectiveness establishing a new stand of buffalograss. It will look at pre-rooted versus non pre-rooted stolons as well as the use of a mulch. In-addition, incorporation versus non-incorporation of stolons will also be studied. The idea of pre-rooting sprigs is intended to extend the storage life of stolons and expedite the pegging of roots while providing cover mulch to prevent desiccation. Pre-rooting consist of mixing sprigs with rooting material prior to planting to in order to have actively growing roots at planting time.

Material and Methods

A bare soil area was used to establish two vegetative cultivars of buffalograss NE 86-118 and 'Legacy' using plugs and sprigs. Treatments consisting of sprigs incorporated in the top 2 cm, non-incorporated, pre-rooted (premixed with potting soil 24 hours prior to planting and incorporated in the top 2 cm), non-incorporated with straw mulch, chop sod (sod strips chopped up into 2 – 3 cm pieces and incorporated in the top 2 cm), and vegetative plugs (planted on 30 cm (12") centers) were planted June 24, 1999 in 2 m^{-2} plots. 'Simazine' herbicide was applied for pre emergence weed control and escapes hand weeded. To maintain optimum soil moisture conditions during pegging, water was applied twice daily for the first two weeks.

Coverage ratings were collected every two weeks until at least one treatment was 100 percent covered.

Results and Discussions

Initial sprig establishment was observed as early as a week after planting. Pre-rooted, incorporated sprigs and chopped sod treatments were first to root and initiate growth (Table 3). However, the pre-rooted sprigs had a greater coverage than the chopped sod after six weeks. Surface applied sprigs with no incorporation failed to root despite good soil moisture conditions. The straw mulch treatments were slightly better than the non mulched surface applied treatments. Only a few sprigs managing to establish. There were no significant differences between incorporated sprigs and plugs treatments.

Pre-rooted sprigs were clearly the best treatment overall with a 2 –3 week coverage advantage over other treatments. This study demonstrated that sprigs could be used to establish buffalograss turf complete coverage within 12 weeks.

Nitrogen Fertilization and Mowing Height Effects on Buffalograss

K.W. Frank, R.E. Gaussoin, and T.P. Riordan

'Cody', 'Texoka', '378', and NE 91-118 buffalograss genotypes were planted at locations in Nebraska, Utah, and Kansas in 1995 to determine the effect of nitrogen fertilization and mowing height on turf-type buffalograsses. The three locations were the John Seaton Anderson Turfgrass Research Facility near Mead, Nebraska, the Rocky Ford Turfgrass Research Center at Manhattan, Kansas, and the Greenville Research Farm at Logan, Utah. The soil types at the Nebraska, Kansas, and Utah sites are a Sharpsburg silty clay loam (fine montmorillonitic, mesic Typic Argiudoll), a Chase silt loam (fine, montmorillonitic, mesic, Aquic, Arquicolls), and a Millville silt loam (coarse-silty, carbonatic, mesic Typic Haploxepolls), respectively.

In 1996 mowing heights of 2.5, 5.1, and 7.6 cm and nitrogen treatments of 0, 2.4. 5, 10, and 20 g N m^{-2} $year^{-1}$ were imposed to identify best management practices for turf-type buffalograss. Nitrogen rates were applied as a split application with the first application in early June and the second application in mid-July, 6 weeks after the first application. The nitrogen source was a polymer coat ,36N-3P-7K. Immediately following nitrogen applications, plots were irrigated with 1.3 cm water. Plots were mowed weekly and clippings collected.

Turfgrass quality, density, uniformity, and color were rated visually on a scale from 1-9. The rating scale for quality, density, and uniformity can be described as 1 being poor, and 9 excellent. Turfgrass color was rated from 1-9 with 9 being dark green and 1 straw brown. Ratings were taken every 2 weeks starting 2 weeks after nitrogen treatment (WAT) and continued until buffalograss quiescence in the fall.

Experimental design for each location is a randomized incomplete block design and treatment design is a split-split-plot design. Main plot is buffalograss entry, split plot is mowing height, and split-split plot is nitrogen level.

Statistical analysis indicated that locations and years should be analyzed separately. From 1996 to 1998, buffalograss quality and color ratings decreased for the 0 and 2.4 g N m^{-2} treatments (Table 4.) Turfgrass quality and color decreased for the 5 g N m^{-2} treatment from 1997 to 1998. At the 10 and 20 g N m^{-2} treatment, turfgrass quality increased each year from 1996 to 1998. These trends suggest that although buffalograss may not initially respond to nitrogen applications, after several years of management buffalograss quality improves with nitrogen applications.

There was a significant entry X mowing height interaction for buffalograss quality at two weeks after the second nitrogen application at the Nebraska site in 1996, 1997, and 1998. At the Nebraska site, NE 91-118 and 378 had the highest quality ratings at the 2.5 cm mowing height in each year from 1996 to 1998 (Table 5). Cody and Texoka had poor quality ratings at the 2.5 cm mowing height all years. There were no differences in turfgrass quality between the 5.1 and 7.6 cm mowing heights in 1998 for Texoka, Cody, or 378. Turfgrass quality of NE 91-118 was highest at the 5.1 cm mowing height.

This research indicates that buffalograss response to nitrogen applications may be minimal the first

BUFFALOGRASS ENTOMOLOGY AND PATHOLOGY RESEARCH

Resistance of Turf-type Buffalograsses to the Chinch Bug, *Blissus occiduus* Barber (Hemiptera:Lygaeidae)

Tiffany Heng-Moss and Frederick P. Baxendale

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)

Choice and no-choice experiments served to assess the relative levels of antixenosis and tolerance among these buffalograsses. Choice studies revealed that the mean number of chinch bugs on NE91-118 was significantly lower than on the other buffalograsses tested, indicating that this selections displays high to moderate levels of antixenosis. No-choice experiments which served to quantify levels of chinch bug tolerance among the 10 buffalograss cultivars/selections found no statistical differences in turfgrass quality between infested and non-infested 'Cody', 'Tatanka', and NE91-118 plants. These experiments served to develop and evaluate several tolerance indices based on turfgrass quality, chinch bug damage ratings, plant height, and plant biomass. Turfgrass quality and chinch bug damage ratings were identified as the most suitable parameters for assessing buffalograss tolerance to *B. occiduus*.

Antibiosis studies designed to evaluate differences in chinch bug fecundity and development rate among the 3 buffalograsses are underway. This research provides valuable information necessary for characterizing antibiotic, antixenotic, and tolerance mechanisms of resistant buffalograsses.

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. It is not clear if buffalograss is a primary host since Koch's postulates has not been preformed. Preliminary work conducted indicates that the infestation of this pathogen could be reduced through stress management and the early application of Nitrogen fertilizer. In-addition, preliminary fungi test have indicated that some fungicide treatments are available.

Student Progress

Kevin Frank will complete his Ph.D. program this winter. Kevin has interviewed for several university positions.

Tiffany Moss continues to make excellent progress toward her Ph.D. She will be teaching an entry level Entomology course next semester.

Shuizhang Fei is a Post-Doc in the turfgrass program at UNL.

PLANNED EVALUATIONS FOR 2000

Buffalograss renovation and establishment study

With an increase 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 re-establish roughs or fairways with as 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 dought 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 inflorescence that sometime appear in female vegetative cultivars.

year after establishment but after several years display significant improvements in turfgrass quality and color. Mowing height and nitrogen rate recommendations for 378 and NE 91-118 are 2.5 or 5.1 cm mowing heights and a nitrogen rate of 10 g N m^{-2} $year^{-1}$. Recommendations for Cody and Texoka are 5.1 or 7.6 cm mowing heights and a nitrogen rate of 10 g N m^{-2} $year^{-1}$.

Table 4. Buffalograss quality and color ratings for nitrogen rates at the Nebraska site two weeks after the second nitrogen application for 1996-1998.

Nitrogen Rate (g N m^{-2} $year^{-1}$)	Quality 1996	Quality 1997	Quality 1998	Color 1996	Color 1997	Color 1998
0	5.71†	4.77	3.25	5.57 ‡	4.89	3.19
2.4	5.80	5.60	4.47	5.74	5.61	4.22
5	5.91	5.94	5.22	5.86	5.94	5.14
10	6.06	6.41	6.44	6.07	6.40	5.97
20	6.15	6.63	7.29	6.27	6.63	6.57
LSD (0.05)	0.19	0.16	0.23	0.08	0.13	0.14

† Buffalograss quality rated from 1-9, with 9 = excellent, and 1 = poor.
‡ Buffalograss color rated from 1-9, with 9 = dark green, and 1 = straw brown.

Table 5. Quality ratings for Entry X Mowing Height at the Nebraska site at two weeks after the second nitrogen application for 1996-1998.

Entry	Mowing Height 2.5 cm	5.1 cm	7.6 cm
1996			
NE 91-118	5.85† Ab	6.19 Aa	5.97 Bb
378	5.84 Ab	6.19 Aa	6.16 Aa
Cody	5.53 Bb	6.17 Aa	6.15 Aa
Texoka	5.16 Cc	5.87 Bb	6.09 Aa
1997			
NE 91-118	6.04 Aa	5.96 Aa	5.60 Bb
378	6.04 Aa	6.21 Aa	5.63 Bb
Cody	5.63 Ba	6.03 Aa	5.92 Aa
Texoka	5.16 Cb	6.12 Aa	6.09 Aa
1998			
NE 91-118	5.30 Ab	5.87 Aa	5.23 Bb
378	5.40 Ab	5.93 Aa	5.83 Aa
Cody	4.80 Bb	5.60 Aba	5.37 Aba
Texoka	4.03 Cb	5.33 Ba	5.33 Ba

Means within columns followed by the same capital letter are not significantly different (p=0.05; LSD).
Means within rows followed by the same small letter are not significantly different (p=0.05; LSD).
† Buffalograss quality rated from 1-9, with 9 = excellent, and 1 = poor.

Table 3. Sprig establishment coverage ratings with five spigging methods and two cultivars of buffalograss.

		Coverage*					
Cultivar	**Treatments**	**7/2/99**	**7/16/99**	**7/29/99**	**8/10/99**	**8/25/99**	**9/7/99**
86-118	No Incorporation	0.0	0.0	0.3	0.7	1.0	1.0
86-118	Incorporated	0.7	1.3	2.3	3.7	5.0	5.3
86-118	Pre-Rooted Incorporated	2.0	3.0	4.0	5.3	6.7	8.3
86-118	Mulch	0.3	0.3	0.3	1.0	1.7	2.0
86-118	Chop Sod & Incorporated	2.0	2.0	2.7	3.0	5.3	6.0
86-118	Plugs	1.0	1.0	2.0	3.0	4.0	4.7
86-61	No Incorporation	0.0	0.0	0.7	1.0	1.0	1.3
86-61	Incorporated	1.0	1.0	2.0	2.0	3.0	3.3
86-61	Pre-Rooted Incorporated	1.7	2.7	4.0	5.3	7.0	7.7
86-61	Mulch	0.3	0.3	0.7	1.0	1.7	1.7
86-61	Chop Sod & Incorporated	1.0	1.0	1.3	1.3	2.7	4.0
86-61	Plugs	1.0	1.0	2.0	2.7	4.3	4.7
Mean		0.9	1.1	1.9	2.5	3.6	4.2
LSD (.05)		0.6	0.8	1.0	1.3	1.3	1.6

***Coverage ratings 1=0-10% 9=90-100% plot coverage.**

Buffalograss Fairway Management Evaluation

The management recommendations for buffalograss fairways are relatively unknown. This study was initiated to evaluate buffalograss under fairway management to identify the best program. This study will evaluate the effects of nitrogen rate, aerification, cultivar, verticutting, and include a wear treatment. Four seeded and four vegetative cultivars and 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 consisted of applications 5g N/ m^{-2} (1 lb N/m) applied in: April; April and June; or April, June, July, August, and September. No fertilizer response was observed during the first year of these treatments.

Verticutting, aerification, and wear treatments will be examined beginning in the spring of 2000. The use of verticutting will be used to determine if surface stolons could be reduced and density increased. Aerification will be examined to determine its effects on turf density and water infiltration.

Sprigs maintained at 21°C were quicker in pegging than sprigs at 5°C. Overall, the sprig growth patterns were similar for both temperatures, however, at 5°C the growth rate was slower (see Table 2). The 5th and 6th internodes were the quickest to root and rooting declined as stolon age increased.

This experiment indicates that as stolon age increases the internodes gradually loose their ability to set roots. In addition, root growth is accelerated at higher temperatures. The experiment was repeated with identical results.

Table 2. Root development of buffalograss sprigs at two medium temperatures.

Stolon Pegging Experiment 1999

Exp # 1	Temp	12hr	24hr	36hr	48hr	60hr	72hr	Mean
Node 1	40C	0.0 1/	0.0	0.0	0.0	0.0	0.0	0.0
Node 2	40C	0.0	0.0	0.0	0.0	0.3	1.0	0.2
Node 3	40C	0.3	1.6	3.3	5.0	7.3	9.3	4.5
Node 4	40C	0.6	2.0	3.3	4.6	6.3	7.0	4.0
Node 5	40C	1.3	3.0	4.6	7.3	9.0	10.0	5.9
Node 6	40C	1.0	2.0	3.3	6.6	8.0	8.7	4.9
Mean		0.5	1.4	2.4	3.9	5.2	6.0	3.3
LSD		.64	1.9	2.1	4.2	4.2	4.5	
Node 1	5C	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node 2	5C	0.0	0.0	0.3	0.7	1.0	1.0	0.5
Node 3	5C	0.0	0.0	0.6	1.0	1.7	2.0	0.9
Node 4	5C	0.0	0.0	1.0	1.3	2.3	2.7	1.2
Node 5	5C	0.0	0.5	2.0	3.5	4.5	5.0	2.6
Node 6	5C	0.0	0.0	1.0	2.0	3.0	3.0	1.5
Mean		0.0	0.1	0.8	1.4	2.1	2.3	1.1
LSD		NS	NS	1.3	2.3	1.9	1.7	
Exp # 2	**Temp**	**12hr**	**24hr**	**36hr**	**48hr**	**60hr**	**72hr**	**Mean**
Node 1	40C	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node 2	40C	0.7	1.0	1.0	1.3	1.7	2.3	1.3
Node 3	40C	0.3	1.0	1.3	2.3	2.7	4.0	1.9
Node 4	40C	1.0	2.0	3.0	3.0	4.0	4.7	2.9
Node 5	40C	2.3	4.3	5.3	7.0	8.0	9.7	6.1
Node 6	40C	1.7	3.7	4.6	6.3	7.0	7.7	5.2
Mean		1.0	2.0	2.5	3.3	3.9	4.7	2.9
LSD		1.2	1.6	1.8	2.5	3.0	3.4	
Node 1	5C	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node 2	5C	0.0	0.0	0.0	0.0	0.7	1.0	0.3
Node 3	5C	0.0	0.0	0.3	1.0	1.7	2.0	0.8
Node 4	5C	0.0	0.0	0.3	0.7	1.3	2.0	0.7
Node 5	5C	0.0	0.3	1.0	1.3	2.7	3.3	1.4
Node 6	5C	0.0	0.0	0.7	0.7	1.7	2.3	0.9
Mean		0.0	0.1	0.4	0.6	1.3	1.8	0.7
LSD		NS	NS	0.9	1.5	2.0	2.4	

***1/* Lentgh of roots in mm formed at nodes.**

ment design for this type of callus is being prepared. Factors such as the kinds and concentration of cytokinins, use of active charcoal, gelling agents and amount of callus (0.1 gram vs 0.2 or 0.3 gram per plate) are important considerations.

Future experiments will focus on using finer particles, lower DNA amount per shot and regeneration of the intermediate type callus. Initiating and maintaining of new embryogenic callus will be continued. Glyphosate level used for selection may need to be fine-tuned.

Table 1. Continued.

Name		Estab. 5/15/99	6/17/99	7/15/99	Quality 8/12/99	9/13/99	10/5/99	avg
91-118	Veg	6.7	6.3	8.0	9.0	8.7	8.0	7.8
Legacy	Veg	7.0	7.0	8.0	7.7	7.0	6.7	7.2
86-120	Veg	6.7	6.3	6.7	7.0	7.0	6.7	6.7
93-181	Veg	5.3	5.7	8.0	7.0	7.3	7.0	6.7
'378'	Veg	6.3	6.3	6.3	6.7	6.3	6.3	6.4
Bonnie-Brae	Veg	5.3	5.7	6.7	7.0	7.0	6.7	6.4
91-181	Veg	6.0	6.0	6.7	7.0	6.3	6.0	6.3
93-170	Veg	5.3	5.0	5.7	6.0	5.3	5.3	5.4
Midget	Veg	4.0	4.0	5.0	5.3	6.0	6.0	5.1
'609'	Veg	1.0	2.0	3.0	5.7	6.3	6.3	4.1
Stampede	Veg	.	.	.	.	.	.	.
UCR-95	Veg	.	.	.	.	.	.	.
Mean		5.2	5.2	6.2	6.6	6.4	6.1	6.0
LSD (.05)		1.5	1.5	0.8	1.0	0.7	0.9	0.7
Tatanka	Seed	6.0	5.7	6.3	6.7	6.3	6.0	6.2
Cody	Seed	6.0	5.7	6.3	6.3	6.0	6.0	6.1
BAM-1000	Seed	5.3	5.7	5.7	6.0	6.0	5.7	5.7
Bison	Seed	5.3	5.7	5.7	5.3	5.7	5.7	5.6
Texoka	Seed	4.3	5.0	4.7	4.7	5.3	5.0	4.8
Mean		5.4	5.5	5.7	5.8	5.9	5.7	5.7
LSD (.05)		0.8	1.3	1.2	1.0	0.9	1.1	0.5
Overall Mean		5.4	5.5	6.2	6.5	6.4	6.2	6.0
LSD (.05)		*1.3*	*1.4*	*0.9*	*0.9*	*0.7*	*0.9*	*0.7*

† Plot maintained as a low maintenance turf: (2.5 inch mowing height, 1-2 times per month, 2 lb. N/1000 sq. ft./ year, no supplemental irrigation)

Genetic Transformation of Buffalograss

(Non USGA Buffalograss Project)

Genetic transformation of buffalograss with round-up tolerance would be very desirable since buffalograss is not a competitive species. Since the beginning of 1998, UNL has started the project of buffalograss transformation in cooperation with the Scotts Company and Monsanto. In 1998 most of the research focused on using meristem tissues as targets to deliver DNA and recover transformants. However, because of the poor penetration of the particles and other reasons, no significant progress was made. In November, 1998, Drs. Lisa Lee and Bob Harriman visited UNL and suggested shifting the research focus to using embryogenic callus as the target tissue for DNA delivery. Since then, the project has focused on maintaining embryogenic callus, improving shoot regeneration and using embryogenic calli as target tissues for particle bombardment. Embryogenic callus from a female genotype 91-118 can be generally divided into two main categories: soft friable or compact. Regeneration of soft friable callus has been considerably improved while the regeneration of compact callus remains difficult. However, bombardment of the soft friable callus causes severe tissue injuries and often leads to tissue death when coupled with glyphosate selection.

Bombardment

M10 tungsten and gold (0.75mm) particles were compared to see their effects on tissue injuries and transformation efficiency. Fixed shooting parameters were as follow: 27 inch Hg, 1/4 inch gap distance, two rings top on the stop screen, 900 psi rupture disk pressure and 9 cm target distance. Five

SUMMARY OF BREEDING WORK

Steve Westerholt and Terrance P. Riordan

Goals of Buffalograss Breeding Project

The continuing goals of the University of Nebraska buffalograss project are to improve germplasm and develop management practices for use on golf courses, as well as other areas. The project also addresses all insect, disease, and physiological problems that may arise from the use of buffalograss. Specifically, our objectives include selecting for turfgrass quality and color, heat and drought resistance, tolerance to low-mowing (for use in golf course fairways), insect resistance, and establishment vigor. A multidiscipline approach is utilized in finding solutions to problems that would hinder the growth and development of buffalograss. We also use molecular breeding techniques; such as flow cytometry, plant transformation, and random amplified polymorphic DNA (RAPD) markers to better characterize germplasm.

Weather

The 1999 growing season consisted of relatively mild wet weather early, turning to dry conditions in late summer. Regular precipitation throughout May, June, and July provided favorable conditions for buffalograss growth and evaluation of buffalograss chinch bugs and Curvularia leaf spot (*Curvularia lunata*).

Breeding Projects

Performance levels continued to improve with the establishment of a new breeding nursery in 1999. 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. The establishment of six new crossing blocks in 1999 with selections exhibiting fairway type characteristics should provide germplasm with higher levels of turf quality and adaption to golf course management systems.

Seed Production

Buffalograss seed production has received major attention in 1999. 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.

Establishment

Establishment of buffalograss has always been a major objective of the project. Great strides have been made with buffalograss establishment since the project was first initiated. Initial studies in the 1980's indicated that pre-rooted plugs had an advantage in establishment over seeded varieties. However, present studies have shown that seeded varieties now establish as rapidly as vegetative plugs. These improvements are due to improved selections that exhibit quicker germination and

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Fertility and Mowing Effects on Buffalograss: At the Nebraska site, NE 91-118 and 378 had the highest quality ratings at the 2.5 cm mowing heights for years 1996-1998. Cody and Texoka had poor quality ratings at the 2.5 cm mowing height for all years. In 1998, NE 91-118, 378, and Cody had the highest quality ratings at the 5.1 cm mowing height. At the 7.6 cm mowing height Cody and Texoka had the highest quality rating in 1997 but Cody and 378 had the highest quality ratings in 1998.

From 1997 to 1998 several trends are evident. First, turfgrass quality decreased from 1997 to 1998 for all cultivars at the 0, 2.4, and 5.0 g N m^{-2} rates. At 10 g N m^{-2}, NE 91-118 and 378 had higher quality in 1998 than in 1997. All cultivars had improved quality ratings in 1998 at the 20 g N m^{-2} rate. Quality ratings in 1998 were poor (ie. < 6) for all cultivars at 0, 2.4, and 5.0 g N m^{-2} rates. At 10 g N m^{-2} NE 91-118, 378, and Cody had good turfgrass quality. Management recommendations for 378 and NE 91-118 are 2.5 or 5.1 cm mowing heights and a nitrogen rate of 10 g N m^{-2} $year^{-1}$. Recommendations for Cody and Texoka are 5.1 or 7.6 cm mowing heights and a nitrogen rate of 10 g N m^{-2} $year^{-1}$.

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)