BREEDING, EVALUATION, AND CULTURE OF BUFFALOGRASS FOR GOLF COURSE TURF

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Executive Summary - 1997

The current goals of the University of Nebraska buffalograss project are to improve germplasm and improve management of buffalograss for use in golf course turf, as well as other turf uses. Specifically, our objectives include selecting for exceptional turfgrass quality and color, heat and drought resistance, tolerance to low-mowing (for use in golf course fairways), insect resistance, and establishment vigor.

Overall, the top performers in our 1997 evaluations were NE91-118 and NE86-120 and NE86-61. A number of other accessions have shown great potential in low maintenance and low mowing evaluation trials and will be evaluated further and in larger plot areas. These include NE93-185, NE93-181, NE-91-181, and NE93-170. Three of these accessions are males, which now can be used in seeded varieties or recombination blocks. Identification of superior male germplasm has been an important objective in our recent breeding efforts. NE93-181 is a good compromise between summer color and fall color, ranking high in both categories. Many quality accessions have been included in new crossing blocks to evaluate F1 hybrid potential and for use in genetic studies.

Low mowing tolerance is an important selection criteria for part of our program. NE86-61, NE86-120 have both performed well under low-mowing conditions as well as several other newer accessions. Our efforts have turned to identifying additional germplasm to allow for further improvement and to study the genetics of low-mowing tolerant traits. In an evaluation of progeny families, ND86-61 and NE85-648 gave the best overall summer ratings and vigor characteristics, which follow parent performance. Families with desirable and uniform progeny performance will be evaluated for use in seeded cultivars tolerant to low mowing.

Buffalograss management research has shown management of 378 and NE 91-118 is best at 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} $year^{-1}$. A field study was initiated to further study effects of management on buffalograss to determine the quantity and turn-over rate of soil and fertilizer nitrogen in above-ground vegetation, thatch, roots, and soil for buffalograss and two other turfgrass species.

We now routinely use flow cytometry to evaluate ploidy level of accessions used in our program. Most are hexaploid (60 chromosomes) but a significant number are tetraploid (40 chromosomes). One pentaploid (50 chromosomes) was observed, cultivar '315'. This is the first record of a pentaploid buffalograss. Interestingly, '315' is fertile, and is a parent in the seeded variety 'Tatanka'. When the NTG seed producers began reporting poor seed harvests and management problems, we began to suspect genetic causes due to the pentaploid parent(s). We are studying this variety for chromosomal irregularities and inbreeding depression.

Total numbers of beneficial arthropods collected from buffalograss sites maintained at the high and low management regimes were not significantly different, suggesting that beneficial arthropods can be conserved over a fairly wide range of buffalograss maintenance levels. This information will be valuable for implementing site specific management practices that preserve existing natural enemies.

Patents have been filed for new releases NE 86-61, NE 86-120 and NE 91-118. Official UNL release statements will be finished by December 15, 1997. Sales for 1997 of '609' will be approximately at the 1996 level, or $1.5 million dollars. Sales have continued to increase for '378' from Todd Valley Farms.

Status of New Releases

Seeded Releases

Dr. Charlie Rodgers, a former Ph.D. student at Nebraska, has replaced Dr. Jeff Klingenberg at Seeds West, Phoenix, Arizona. Dr. Rodgers will continue to work with our germplasm and their derived germplasm to develop new seeded cultivars. A new agreement is in place between UNL and Seeds West which gives them the proprietary rights to all our germplasm to develop seeded buffalograss and requires them to pay a royalty on all cultivars developed in cooperation with UNL. I believe they also plan to increase plant collection efforts, in order to have their own proprietary germplasm

Seeds West is considering the possibility of selling NTG-5, which was included in the 1991 NTEP Trial, and they are looking at NTG-7 and FW-3 (a low mowing tolerant experimental) for future release and production.

We will continue to evaluate the potential of seed produced from NE 85-436 male and female lines as a possible variety. This hybrid would provide a vigorous, dense, and uniform cultivar as a F2 or F3 for use in golf course roughs.

Vegetative Releases

Patents have been filed for new releases NE 86-61, NE 86-120 and NE 91-118. Official UNL release statements will be finished by December 15, 1997. These were included in the 1996 NTEP Buffalograss Trial and have been vegetatively increased at Todd Valley Farms, Mead, Nebraska. NE 91-118 has also been vegetatively increased at the Crenshaw & Doguet Turfgrass, Inc. (CDT) location at Poteet, Texas.

Presently, CDT is planning to further increase NE 91-118 and evaluate its potential use in the South and in the Transition Zone. Also under discussion is the possibility of Todd Valley Farms increasing, evaluating and handling either NE-86-61 or 86-120 in the North.

Other plant materials are in the evaluation process and included in our advanced trials at our research facility.

Crenshaw & Doguet Turfgrass, Inc. Update

CDT has had a fairly good year considering that they were out of buffalograss, especially `609' for most of the year. Management of the company seems to be very good, and the principals, Jimmy Raines, a venture capitalist from San Antonio, Texas, and Arthur Milberger of Milberger Sod, are providing vision and stability that were lacking in the past. Sales for 1997 of `609' will be approximately at the 1996 level, or $1.5 million dollars.

CDT has been working with UNL for most of the year on a long-term licensing agreement. Presently, a year-to-year extension is in effect, but both parties are close to completing a five-year agreement that has only relatively minor changes.

Todd Valley Farms

Sales have continued to increase for `378' from Todd Valley Farms (TVF), but growth is limited because of the restriction in his license agreement. As we release new cultivars, TVF may have a greater role in developing the market in the Northern United States. UNL, CDT and TVF are working cooperatively on a new license agreement for our new releases.

Oak Point Farms

With the death of Bill Steavenson, limited sales of '315' are being made through Todd Valley Farms. There will probably be no further sales of this cultivar.

Monsanto/Scotts Agreement

A research agreement is in the final stages of preparation which would allow us to use Monsanto genes and Scotts technology to transform vegetative cultivars and experimentals. The first effort will involve the glyphosate resistance gene. This project which will be funded completely by Crenshaw & Doguet Turfgrass, Inc. will involve a new Post-Doc and new Ph.D. student and extensive cooperation from the plant transformation facility in the Center for Biotechnology. This research effort will take approximately two years, and at the present time only involves a research license. Sometime in the future there will be discussions between Monsanto, Scotts and CDT concerning possible commercialization. This will not be a USGA-funded research project, based upon projects selected for funding.

Summary of Breeding Work

Paul G. Johnson and Terrance P. Riordan

The current goals of the University of Nebraska buffalograss project are to improve germplasm and improve management of buffalograss for use in golf course turf, as well as other turf uses. Specifically, our objectives include selecting for exceptional turfgrass quality and color, heat and drought resistance, tolerance to low-mowing (for use in golf course fairways), insect resistance, and establishment vigor. We also use molecular breeding techniques, such as flow cytometry and random amplified polymorphic DNA (RAPD) markers to better characterize germplasm.

The 1997 growing season consisted of relatively average temperatures, but below normal precipitation. These conditions therefore provided good study of drought resistance characteristics. Overall, the best selections selected in earlier years continue to do well, but several relatively new accessions have appeared as promising and demand further study. All turfgrass quality, color, and fall color ratings are based on a 1-9 scale of 1 = poor and 9 = best.

National Turfgrass Evaluation Program (NTEP) 1996 Buffalograss Test

The 1996 buffalograss test was planted at a number of sites around the country including at our research facility near Mead, Nebraska. An additional planting, although unsupported by NTEP, was established in 1997 at the Horticultural Research Center at Wichita, Kansas. Unfortunately data from locations other than Nebraska was not available at the time of writing this report.

The top performers in the NE test were 91-118 and 86-61. Midget was the best in fall color ratings and fared ok during the summer quality ratings. The southern adapted types, especially diploid varieties like Stampede and UCR-95, did not survive the winter period well in Nebraska. 609 usually survives better than in this plot, but was especially hard hit due to the late planting of this plot area (July 12, 1996).

The seeded varieties showed little differentiation due to the "first year effect". All plots tend to look similar in the first year after planting. Differences will likely be more evident in this planting in 1998. Nonetheless, Tatanka and Bison showed slower establishment than the other varieties. Tatanka has showed problems, possibly due to the mixture in ploidy levels experienced (see flow cytometry section for more information.).

Table 1. National Turfgrass Evaluation Program 1996 Buffalograss Test†; Nebraska Location.

Entry	Turf Quality 1997	Entry	Fall Color 1997
	1-9		1-9
91-118	7.33	Midget	8.33
86-61	7.33	91-118	7.00
378	6.44	86-61	5.67
Bonnie Brae	5.44	86-120	4.33
86-120	5.22	378	4.00
Midget	3.56	Bonnie Brae	3.00
609	0.00	Stampede	1.67
Stampede	0.00	609	0.00
UCR-95	0.00	UCR-95	0.00
LSD (0.05)	1.12	LSD (0.05)	2.48

† 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)

Evaluation of Low Maintenance Test Areas

Most commonly, buffalograss is used as a low maintenance turf with minimal fertilization and mowing, and no irrigation after establishment. Our low maintenance test areas are maintained at this level to select the hardiest, but best performing germplasm.

Area 17: 1994 Advanced evaluation (Table 2)

NE86-61 and NE86-120 are at the top of most ratings, but rate lower in fall color, typical of the northern Great Plains adaptation of these varieties.

Three other accessions have also been near the top in most ratings. These include NE93-185, NE93-181, NE-91-181, and NE93-170. The last three accessions are males, which now can be used in seeded varieties or recombination blocks. Identification of superior male germplasm has been an important objective in our recent breeding efforts. NE93-181 is a good compromise between summer color and fall color, ranking high in both categories

Although the newly identified selections have not outperformed NE-86-61, they are valuable in recombination blocks and parent development for seeded varieties. All of these quality accessions have been included in a new set of crossing blocks to evaluate F1 hybrid potential and for use in genetic studies.

Area 25: 1995 Advanced evaluation (Table 3)

Again, NE86-61 tops the evaluation in turf quality and color. NE94-79 is notable since it ranks fairly high in turfgrass quality, and high in fall color. NE90-164 shows good fall color, but only medium turfgrass quality ratings. This accession might be appropriate however for use in southern locations. A number of additional selections also show potential for use in recombination blocks and seeded varieties.

Performance of Cody and Tatanka is somewhat disappointing. Poor performance of Tatanka may be due to chromosome number irregularities. Cody has a broad parent base with a number of relatively average quality plants. The use of several of the new selections from this program will improve the quality of upcoming seeded varieties.

Table 2. Low maintenance† evaluation established in 1994 (Area 17).

Selection	Turf Quality 1997	Color 1995-97	Fall Color 1995-97	Turf Quality 1995-97
	1-9	1-9	1-9	1-9
86-61	6.12	6.33	4.75	6.93
93-185	5.83	6.26	4.00	6.30
93-181	5.83	3.85	6.58	6.22
91-181	5.67	5.85	2.67	6.30
86-120	5.50	5.48	3.25	6.37
91-118	5.53	4.52	5.75	5.48
93-170	5.33	5.85	2.08	6.22
'Texoka'	4.83	4.37	5.58	4.56
'Sharps Improved'	4.83	4.82	5.83	4.44
LSD (0.05)	1.08	0.47	0.77	0.60

† 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)

Table 3. Low maintenance† evaluation established in 1995 (Area 25).

Selection	Turf Quality 1997	Turf Quality 1996-97	Fall Color 1997
	1-9	1-9	1-9
86-61	6.67	6.60	3.89
'315'	5.83	6.07	3.89
91-118	4.17	5.60	5.56
94-100	4.83	6.33	4.67
'Cody'	5.00	5.20	5.33
'Tatanka'	5.00	5.13	4.67
'Texoka'	4.33	4.67	5.89
90-164	5.67	5.47	7.11
LSD (0.05)	0.96	0.64	0.60

† 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)

Area 29: 1996 Advanced evaluation (Table 4)

NE86-61 tops this evaluation for color and turfgrass quality as it has in other evaluations. However it has medium to poor fall color. Good compromises exist in NE95-22 and NE91-118.

NE95-16 may be desirable germplasm for southern regions because of its good fall performance, but it doesn't over-winter well in Nebraska.

Among other data taken, unmowed turf quality (appearance after no mowing for one month) showed some different accessions performing well, but also including NE86-61, NE86-120, and '315'. However an additional years data is needed for these comparisons to be meaningful.

Table 4. Low maintenance† evaluation established in 1996 (Area 29).

Selection	Turf Quality 1997	Color 1997	Fall Color 1997
	1-9	1-9	1-9
86-61	6.11	6.22	5.33
95-36	5.78	4.00	4.33
'315'	5.67	5.22	3.67
95-22	5.44	4.22	6.33
91-118	5.44	3.78	6.33
95-20	5.33	4.56	5.33
93-166	4.11	5.78	4.33
95-37	4.89	5.44	6.33
95-16	3.22	4.67	7.67
95-11	3.56	3.22	7.00
95-14	4.67	4.89	7.00
95-8	3.67	4.94	7.00
LSD (0.05)	0.91	0.81	1.46

† 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)

Evaluation for Low-mowing tolerance

Buffalograss is most commonly grown at high mowing heights and in low maintenance situations. However in recent years, we have evaluated the species as one for use on golf course fairways in arid regions where superintendents need to make drastic cuts in their water use. 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 5 years and continually has provided high quality low maintenance fairway-type turf.

NE86-61, NE86-120 have both performed well under these conditions. Our efforts have turned to identifying additional germplasm to allow for further improvement and to study the genetics of low-mowing tolerant traits.

Area 23: 1993 Advanced Evaluation (Table 5)

This plot area was mowed at 6.3 cm (2.5"(until 1996, when it was then gradually lowered to 1.4 cm. The plot was still exhibiting unevenness in 1997, but it still provided good evaluations. 1997 was the first year for low-mowing data on this plot.

92-135 outperformed all other entries in this plot in summer turf performance, even '315' which had showed very good low-mowing tolerance in the earlier evaluation. Fall color characteristics need to be further improved, and is one of the focuses of current breeding research, although physiological limitations of warm-season grasses will prevent fall color like in cool season grasses.

Table 5. Low mowing† evaluation established 1993 (Area 23).

Selection	Turf Quality 1997	Spring Color 1997	Fall Color 1997
	1-9	1-9	1-9
92-135	7.00	5.00	3.00
91-114	5.89	4.67	5.00
'315'	5.44	3.67	4.00
91-118	4.11	1.67	7.00
'Texoka'	3.22	3.00	5.33
'Prairie'	0.00	0.00	0.00
LSD (0.05)	0.93	0.85	1.46

† Plot maintained at 5/8 inch mowing height, 2 times per week, 3 lb. N/1000 sq. ft./year, no supplemental irrigation)

Area 27: 1995 Preliminary Evaluation

Preliminary tests of recovery from damage were carried out and gave promising results. The turf recovered from divots within one month, with some selections recovering earlier. More extensive tests will be done beginning in 1998.

Area 31: 1996 Preliminary Evaluation (Table 6)

This plot area was established with progeny from a crossing block of six parents that showed tolerance to low mowing. This plot has allowed study of parental effects (maternal only) on low mowing tolerance. A number of quantitative measurements were taken on these plants to differentiate between the families and individual progeny, and follow traits important to turfgrass quality.

The families with the overall best summer ratings and vigor characteristics were 86-61 and 85-648, which follow parent performance. Families with desirable and uniform progeny performance will be evaluated for use in seeded cultivars tolerant to low mowing. This family analysis has not been done previously in buffalograss breeding.

Table 6. Low mowing† family progeny evaluation established 1996 (Area 31).

Family	TQ97	Col97	Fall Color	Plant Width	2nd internode length	Leaves on 2nd node
	1-9	1-9	1-9	cm	mm	no. of leaves
86-61	5.28	3.48	4.45	38.5	27.7	12.13
85-648	5.18	3.55	4.68	39.9	30.0	13.08
86-120	4.18	2.88	4.46	36.0	30.8	13.13
85-443	3.99	2.74	4.18	30.6	32.3	13.69
'315'	3.81	3.00	4.23	27.6	24.9	12.68
86-23	3.05	2.24	4.13	22.5	30.0	11.55
LSD (0.05)	0.72	0.39	0.50	5.9	5.7	2.8

† Plot maintained at 5/8 inch mowing height, 2 times per week, 3 lb. N/1000 sq. ft./year, no supplemental irrigation)

Buffalograss Management Research

Fertility and Mowing Effects on Buffalograss

Kevin Frank, Terrance Riordan, Roch Gaussoin

'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. In 1996 & 1997, 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.

At the Nebraska site, NE 91-118 and 378 had the highest quality ratings at the 2.5 cm mowing heights in both 1996 and 1997 (Table 1). Cody and Texoka had unacceptable quality ratings (i.e. < 6) at the 2.5 cm mowing height at both the Nebraska and Utah sites in 1996 and 1997. Cody and Texoka had the highest quality ratings at 7.6 cm and NE 91-118 and 378 had unacceptable quality at 7.6 cm at the Nebraska site in 1997. All cultivars had acceptable buffalograss quality, with the exception of Texoka at the Utah site, when mowed at 5.1 cm.

The results from the Nebraska site indicate, that among entries, NE 91-118 showed the greatest improvement in quality with increasing nitrogen rates. At the Kansas and Utah sites, NE 91-118 had the best quality at 0 and 2.4 g N m^{-2} $year^{-1}$. With the exception of Texoka at the Utah site, all entries had acceptable buffalograss quality at 10 g N m^{-2} $year^{-1}$.

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} $year^{-1}$.

Table 1. Quality ratings for Entry X Mowing Height at the Nebraska site at two weeks after the second nitrogen application in 1997.

Entry/Date	Mowing Height		
	2.5 cm	5.1 cm	7.6 cm
Year: 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
Year: 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

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, 6 = acceptable, and 1 = poor.

Table 2. Quality ratings for Entry X Nitrogen rate at the Nebraska, Kansas, and Utah sites at two weeks after the second nitrogen application in 1997.

Entry	Nitrogen application rate (g N m^{-2} $year^{-1}$)				
	0†	2.4	5.0	10	20
Location: Nebraska					
NE 91-118	4.56‡ Ce	5.49 Bd	5.96 ABc	6.51 Ab	6.82 Aa
378	5.36 Ae	5.73 Ad	6.07 Ac	6.24 Bb	6.40 Ca
Cody	4.69 Be	5.60 Bd	5.84 Cc	6.47 Ab	6.69 Ba
Texoka	4.47 Ce	5.58 Bd	5.91 BCc	6.40 Ab	6.60 Ba
Location: Kansas					
NE 91-118	5.56 Ae	6.04 Ad	6.20 Ac	6.40 Bb	6.67 Aa
378	4.69 Bd	5.71 Bc	5.93 Bb	6.62 Aa	6.56 ABa
Cody	4.60 Be	5.60 Bd	5.89 Bc	6.11 Cb	6.51 Ba
Texoka	3.84 Cd	5.27 Cc	5.62 Cb	6.16 Ca	6.22 Ca
Location: Utah					
NE 91-118	4.56 Ad	5.33 Ac	5.33 Ac	6.00 Ab	6.78 Aa
Cody	3.89 Be	4.67 Bd	5.22 Ac	6.11 Ab	6.89 Aa
Texoka	3.89 Bd	4.11 Cc	5.00 Ab	5.33 Bb	6.11 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).
† Nitrogen rates - g N m^{-2} $year^{-1}$
‡ Buffalograss quality rated from 1-9, with 9 = excellent, 6 = acceptable, and 1 = poor.

Nitrogen Partitioning in Buffalograss and Other Turfgrasses

Kevin Frank, Terrance Riordan, Roch Gaussoin

Buffalograss is cited in numerous sources as having minimal response to fertilizer nitrogen applications but to date no research has investigated the fate of fertilizer nitrogen applied to buffalograss. Information on fertilizer nitrogen fate in turf-type buffalograss is not available and comparisons with nitrogen fate in other turfgrass species would be valuable to identify differences in nitrogen use. The objectives of this research will be to determine the quantity and turn-over rate of soil and fertilizer nitrogen in above-ground vegetation, thatch, roots, and soil for three turfgrass species. Field experiments to determine the fate of nitrogen fertilizer applied to three turfgrass species (buffalograss, Kentucky bluegrass, and tall fescue) were initiated in 1997 at the research facility near Mead, Nebraska.

The total amount of actual nitrogen that will be applied each year to a 9 m^2 plot is 0, 10, and 20 g N m^{-2}. The nitrogen amounts will be split among four applications for Kentucky bluegrass and tall fescue and over two equal applications for buffalograss. In 1997, 5% ^{15}N enriched NH_4NO_3 was applied on one of the application dates to all plots. All other nitrogen applications in the first and second year will use an unlabeled NH_4NO_3 fertilizer. Plots will be randomly sampled prior to each fertilizer application to analyze for nitrogen content in plant and soil fractions. Cores will be divided into thatch, verdure, roots, and soil components. Because buffalograss has no thatch layer, all above-ground vegetation will be analyzed together. The soil cores will be partitioned to four depths and analyzed for total N, NH4+-N, NO3--N, and N-isotope ratio. Roots will be washed from the remaining composite soil samples, dried at 60°C, weighed, and total N and N-isotope ratio determined. Results are not yet available as data from 1997 are currently being analyzed.

Flow Cytometry

Paul G. Johnson

General study

We now routinely use flow cytometry to evaluate ploidy level of accessions used in our program. Most are hexaploid (60 chromosomes) but a significant number are tetraploid (40 chromosomes). As we evaluate more accessions, we will begin to correlate ploidy level with field characteristics. Diploid types do not survive winters in Nebraska. One pentaploid (50 chromosomes) was observed, cultivar '315'. This is the first record of a pentaploid buffalograss. Interestingly, '315' is fertile, and is a parent in the seeded variety 'Tatanka'.

Southern Great Plains germplasm

We cooperated with Dr. Dick Auld of Texas Tech University in a study of a large collection of buffalograsses collected systematically throughout the southern Great Plains. Two-thirds of the 230 accessions studied were hexaploid, about one-quarter were tetraploid, eight were diploid, and five were pentaploid. This was the first time pentaploid accessions were observed I plants collected from natural stands. The cultivar '315' is also pentaploid, but was the product of controlled breeding efforts. Two additional plants from the Texas Tech program were identified as triploids.

Study of Tatanka

As mentioned above, '315' is a pentaploid, and it is one of the parents in the seeded Native Turf Group (NTG) variety 'Tatanka'. In fact, it is the only female parent in the foundation seed fields. When the NTG seed producers began reporting poor seed harvests and management problems, we began to suspect genetic causes due to the pentaploid parent(s). The problem of low seed set, poor germination, and lack of vigor point to such problems. Inbreeding depression may also cause these problems. We have begun a test to investigate this variety for chromosomal irregularities and inbreeding depression. This study should yield information on gene action in buffalograss. It may also lead to advances that could be used in seeded single cross varieties, to name one application.

Molecular marker research

Paul G. Johnson, Charlie Rodgers

We have continued efforts to evaluate buffalograss germplasm using randomly amplified polymorphic DNA (RAPD) molecular markers. Most efforts in 1997 have been to improve repeatability in the methods, but at the same time, we have identified unknown materials through fingerprinting, even if closely related. A poster was presented at the 1997 American Society of Agronomy meetings on some of this data used to determine genetic relationships. As our database of markers increases, we will be able to characterize germplasm, hopefully to identify divergent groups of germplasm, leading to heterosis, molecular markers linked to desirable traits to enable marker assisted selection, and fingerprinting of varieties.

Buffalograss Entomology Research

Tiffany Heng-Moss, Fred Baxendale

Recently, two grass-feeding mealybugs *Tridiscus sporoboli* (Cockerell) and *Trionymus* sp. (Homoptera: Pseudococcidae) were identified as potentially serious pests of buffalograss in Nebraska. The development and implementation of an effective biological control program of these pests requires detailed information on the biology, life history, and population dynamics of the beneficial arthropod community, and little information was available on the beneficial arthropods associated with buffalograss. Therefore, the objectives of this research were to identify the beneficial arthropods associated with buffalograss, and to investigate these beneficial arthropods as potential biological control agents for *T. sporoboli* and *Trionymus* sp.

The first objective of this research was to document the beneficial arthropod complex in buffalograss, monitor the seasonal abundance of selected beneficial arthropods, and investigate the influence of different management levels on the composition and abundance of natural enemies associated with buffalograss. A survey of the beneficial arthropod (predators and parasitoids) community in buffalograss was undertaken by collecting and identifying arthropods using pitfall traps and sod plug samples from selected buffalograss sites. Beneficial arthropods were also surveyed from buffalograss stands maintained at higher and lower management levels to determine the impact of management practices on the composition and abundance of resident natural enemies.

- Beneficial arthropods found inhabiting buffalograss in Nebraska included ants, spiders, ground beetles, rove beetles, big-eyed bugs, and several species of hymenopterous parasitoids.
- Pitfall traps are a more effective sampling technique than sod plugs for capturing highly mobile, surface dwelling arthropods.
- Total numbers of beneficial arthropods collected from sites maintained at the high and low management regimes were not significantly different, suggesting that beneficial arthropods can be conserved over a fairly wide range of buffalograss maintenance levels. This information will be valuable for implementing site specific management practices that preserve existing natural enemies.

For objective two we identified hymenopterous parasitoids associated with buffalograss, identified the parasitoids of *T. sporoboli* and *Trionymus* sp., and evaluated the effectiveness of these parasitoids as biological control agents for buffalograss mealybugs. Families of parasitoids collected included Scelionidae, Encyrtidae, Mymaridae, and Trichogrammatidae.

- In the rearing study, 48.6% (170/350) of the adult female mealybugs were parasitized by *Rhopus nigroclavatus*. A dissection study documented parasitism of both immature and adult female mealybugs.
- These results demonstrated *R. nigroclavatus* have clear preference for adult female mealybugs and later instar nymphs, and suggested that *R. nigroclavatus* can have an important regulating effect on mealybug populations in the greenhouse.
- Significant differences were detected in numbers of non-parasitized mealybugs between treatments containing only mealybugs and treatments containing both mealybugs and parasitoids.

- This study demonstrated the effectiveness of *R. nigroclavatus* as a biological control agent for buffalograss mealybugs under greenhouse conditions.

The third objective of this research was to investigate interactions between *R. nigroclavatus* and its mealybug hosts. These studies revealed that *R. nigroclavatus* will deposit eggs in all post-egg age classes of the mealybug, but 3rd - 4th instar nymphs and reproductive female mealybugs are preferred. Parasitized female mealybugs were reared to assess parasitoid developmental times, and the number and sex ratio of offspring produced by unmated *R. nigroclavatus*.

- At 30° C, the developmental time of *R. nigroclavatus* from egg deposition in the female mealybug to adult emergence ranged from 7 to 14 days.
- A mean of 1.2 *R. nigroclavatus* were produced per female mealybug.
- All offspring produced by the 25 virgin female *R. nigroclavatus* studied in this experiment were female. This was intriguing since unmated hymenopterous parasitoids typically produce haploid males.
- Further studies are needed to confirm the production of all female progeny by virgin female *R. nigroclavatus* under additional rearing conditions.

The successful control of buffalograss mealybugs depends on the development of alternative pest management strategies since insecticidal control has proven largely unsuccessful under both field and greenhouse conditions. Biological control may offer the most effective approach available for reducing mealybug populations. The development of a biological control program will be challenging, but it is important for establishment of a comprehensive integrated pest management program for the insects and mites affecting buffalograss.

Student Progress

- Charlie Rodgers finished his Ph.D. in spring of 1997. Charlie was awarded the Musser Fellowship of Excellence in 1997.
- Kevin Frank completed his M.S. degree and began his Ph.D. program. Kevin will receive a Watson Fellowship, to be awarded at the 1998 GCSAA Conference and Show.
- Tiffany Moss continues to make excellent progress toward her Ph.D. Tiffany place 2nd in the C-5 division graduate student paper contest at the 1997 meetings in Anaheim.
- Shuizhang Fei defended his Ph.D. thesis in December, 1997.
- Taotao Yu, began work on a Ph.D. in August of 1997.

Summary of Major Impacts: 1993-1997

- Commercialization of '609', '378', '315', '61', '120', '118' vegetative buffalograss cultivars. These are marketed by Crenshaw & Doguet Turfgrass Inc., Austin, TX, and Todd Valley Farms, Mead, NE.
- Developed germplasm for 'Tatanka' and 'Cody' seeded buffalograss varieties. These are marketed by the Native Turfgrass Development group of seed companies.
- Increased awareness and interest for use of buffalograss as a turfgrass species suitable for Great Plains turfs.
- Extended the potential growing range of buffalograss into areas of more rainfall and somewhat cooler temperatures.
- Development of superior germplasm having much improved turfgrass quality, dark green color, drought tolerance, density, reduced water use, and establishment characteristics.
- Development of germplasm tolerant to low mowing, suitable for use in unirrigated golf course fairway situations in the Great Plains.
- Identified sources of germplasm with improved sod strength.
- Studied the inheritance of important seedling vigor characteristics including seed size and seedling vigor.
- Initial study of single crosses for use as seeded cultivars and development of new germplasm.
- Identification of best management practices for fertilization, mowing, and weed control for buffalograss on golf courses and general use turf.
- Developed establishment procedures for vegetative and seeded buffalograss varieties.
- Identification of potential insect pests and control measures, including biological, cultural, and chemical controls.
- Studied ploidy levels in buffalograss germplasm and used flow cytometry as a rapid analysis tool for chromosome number. Did preliminary study of correlation between ploidy level and range of adaptation.
- Identified pentaploid and triploid germplasm of buffalograss.
- Developed methods for molecular marker analysis (RAPDs) of buffalograss germplasm for use in genome characterization, genetic diversity relationships, marker assisted selection, and genotype fingerprinting.
- Development of tissue culture and plant regeneration procedures, leading to use in transformation with new genes.
- Published a wide range of articles in numerous scientific journals, trade journals, extension publications, and proceedings.
- Presented many research papers and posters at meetings around the nation and world.
- Numerous citations of buffalograss in the popular literature including magazines, newspapers, television, and radio. Buffalograss marketing and use was even mentioned in the Wall Street Journal.
- And possibly most important is the generation of many new questions and uses of buffalograss that when researched further, will increase basic and applied knowledge of this species. This information will improve turfgrass quality and maintenance characteristics, allowing buffalograss to be used in a wider range of environments, thereby reducing overall inputs into the turfgrass systems.