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

United States Golf Association Research Summary and Annual Report: Fall, 1995

USGA Progress Report - Fall, 1995


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## EXECUTIVE SUMMARY


### Breeding, evaluation, and culture of Buffalograss for Golf Course Turf

**Status of Vegetative Varieties**

Through September 1995, sales of '609' were approximately $1,125,000. This is slightly better than in 1994. Total production is now 440 acres at four locations in Texas. In September, a royalty check for $48,642.86 was received from Crenshaw & Doguet for '609' sales during the first half of 1995. Sales of '378' have been fairly good ($53,424) although the weather in Nebraska this spring and summer was poor, having a significant effect on sales. Figures for '315' have not been released. Three new vegetative buffalograsses are targeted for release in 1996. Those are NE 86-61, NE 86-120 and NE 91-118. Crenshaw & Doguet continues to try to expand through sub-licensees. So far this has been a small part of their business, but there is potential for growth in Arizona, Missouri, and Colorado.

**Status of Seeded Varieties**

Native Turf Group and the University of Nebraska cooperatively released 'Cody' and 'Tatanka' seeded buffalograsses in 1995. There was only a limited amount of 'Cody' available this year, and it was sold in mainly small (2 lb.) lots. However, interest was very strong, and fair supplies of seed will be available next year. Only research supplies of Tatanka were available this year, but it should be commercially available next year. Sharp Bros. Seed has planted production fields of their UNL derived synthetics, but their first production will not be available until 1997.

**Evaluations and Breeding Work**

The hot and dry summer that we experienced in Nebraska this year was ideal for evaluating buffalograss selections for tolerance to heat and drought. However the best performing genotypes in other years have been very consistent. This is evident in the recent National Turfgrass Evaluation trial where '378', '609', and '315' were the top vegetative materials in the test. These buffalograsses also perform very well under a number of environments. Top experimentals and cultivars in a low mowing height evaluation were put into a crossing block for the development of a buffalograss variety appropriate for fairway use. In other evaluation trials, several entries repeatedly show up at the top of the rankings even ahead of currently released '315' and '378'. These include the potential new releases 86-61 and 86-120, but also the experimentals: 91-181, 92-116, 92-135, and 93-181. Real improvement in the seeded varieties is also evident. The experimental synthetics 90-504-JK and 90-503-JK show very good quality and color ratings, better than the standard seeded varieties. Four synthetic populations are undergoing the third

cycle of recurrent selection to improve each population further for turfgrass quality and disease resistance characteristics. After further testing one of these populations may be released from the University of Nebraska breeding program.

Divergent selection for caryopsis size on two synthetic populations has shown inheritance and potential breeding progress. Realized heritabilities for caryopsis size in both populations are low (0.08 to 0.26) indicating that multiple cycles of selection will be necessary to improve this trait. In separate work, we are also selecting for increased germination percentage to improve establishment.

We are also using laboratory techniques for buffalograss improvement through tissue culture and transformation procedures. Thus far, plants of two female clones and a male clone were regenerated through immature inflorescence culture. Callus induction was promoted in the male by an ethylene antagonist ($AgNO_3$), but not in the female. Efforts will continue in refining the cell-culture techniques. When possible, transformations of buffalograss cell cultures will begin, likely including genes conferring resistance to herbicides.

**Buffalograss Management Studies**

Initial establishment research at two locations indicates significant differences for percent cover of buffalograss and percent weed cover. These preliminary results indicate the best planting date is between May 15 and July 15 for the Nebraska location, and August 15 for Logan, Utah. Final recommendations for planting dates will be made after determining winter survival and the effectiveness of the fall planting dates. Mowing and fertilization studies will be initiated in 1996.

**Buffalograss Insect Research**

SEM observations of mealybugs on buffalograss leaves suggest that pubescence may facilitate oviposition by providing a framework for the waxy filamentous ovisac, and/or provide a foothold for mealybugs. Evidence suggests that mealybug resistance mechanisms may operate primarily on a whole plant basis or may involve interactions with parasitoid wasps. Heritability estimates for mealybug resistance using maternal half-sib analysis ($h^2_m$) and offspring-parent regression ($h^2_{op}$) were 0.87 and 0.56, respectively. These relatively high heritabilities suggest that improvements in resistance should be possible.

**Personnel**

Jennifer Johnson-Cicalese received her Ph.D. in May and accepted a position at Rutgers University. Dr. Paul G. Johnson, who received his Ph.D. from the University of Minnesota under Dr. Don White in June, accepted a Post Doctoral position at Nebraska, with his major responsibility coordination of the USGA Buffalograss Project.

## STATUS OF CULTIVAR RELEASES

### Vegetative Releases

In 1995 three vegetative buffalograsses were commercially available. '609', first marketed in 1991, continued to grow in both production and sales. Through September 1995, sales were approximately $1,125,000. This is slightly better than in 1994. Total production is now 440 acres at four locations in Texas. However, while production (total acres) is up, the selling price of all grass, including '609', is down in Texas. This may affect the royalty income from '609' next year. In September, a royalty check for $48,642.86 was received from Crenshaw & Doguet for '609' sales during the first half of 1995.

`378' and `315' buffalograsses are now being sold, but only in Nebraska. Although sale figures for '315' have not been released, it is thought that sales have been slow. It is possible that this is more of a marketing situation, since sales for '378' have been fairly good (sales of $53,424). Weather in Nebraska this spring and summer was poor, and this had a significant effect on sales.

### New Releases

Three new vegetative buffalograsses are targeted for release in 1996 -- NE 86-61, NE 86-120 and NE 91-118 (Table 1). These offer better turf quality ratings, genetic color, and/or growth habit characteristics than those already available. All three have been vegetatively increased, included in additional performance testing, and patents are being prepared. Additional selections that have been superior in recent turfgrass quality ratings during 1994 and 1995 are also being evaluated for possible release (Table 1).

### Crenshaw & Doguet Turfgrasses, Inc.

This summer Crenshaw & Doguet Turfgrass, Inc., restructured to increase capital within their company. Major changes include increased capital for growth and expansion, and an ability to explore the use of other turf species. Ben Crenshaw is now only an investor, and Bob Kay is a consultant. David Doguet is now a managing partner along with longtime sod producer/attorney Arthur Milberger. These changes should have no appreciable effect on their contracts with the University of Nebraska, therefore, not affecting the USGA.

Other than in Texas, Crenshaw & Doguet continues to expand beyond Texas through sub-licensees. Currently, they have sub-licensees in California, Arizona, Oklahoma, Colorado, Missouri, and Maryland. So far this has been a small part of their business, but there is potential for growth in Arizona, Missouri, and Colorado.

Table 1. Experimental selections increased for potential commercialization

| Experimental Selection | Square Feet Available | Commercialization Date | Use |
|---|---|---|---|
| 86-61 | 6000 | 1996 | Home Lawn, Fairways Northern U.S. |
| 91-118 | 6000 | 1996 | Home lawns, Roughs Northern U.S. - Transition zone |
| 86-120 | 4000 | 1996 | Home Lawn, Fairways Northern U.S. |
| 84-436 | 2200 | ? | General |
| 91-94 | 1500 | ? | General |
| 90-72 | 2250 | ? | General |
| 91-181 | 225 | ? | General |
| 92-116 | 225 | ? | General |
| 92-135 | 225 | ? | General |
| 93-181 | 225 | ? | General |

**Seeded Releases**

Native Turf Group and the University of Nebraska cooperatively released `Cody' and `Tatanka' seeded buffalograsses in 1995. Cody is a blend of experimentals NTG-1 through 5 and it has excellent performance and wide adaptation. There was only a limited amount of seed available this year, and it was sold in mainly small (2 lb) lots. However, interest was very strong, and fair supplies of seed will be available next year. Only research supplies of Tatanka (NTG-1) were available this year, but it should be commercially available next year.

Sharp Bros. Seed has planted production fields of their UNL derived synthetics, but their first production will not be available until 1997. They have been very closed concerning their production and plans. It is anticipated that there will be some royalty income from seeded buffalograss in 1995 and 1996, but it will not be a great deal of money. The value and royalty for seed is much less than for sod.

## LICENSING AGREEMENTS

There have been no changes in licenses (Table 2) in 1995, and currently each license should return income to the USGA and the University of Nebraska. NTG has discussed a new license with the University, but no progress has been made.

Table 2. Licenses currently in effect.

| | |
|---|---|
| '609' | Proprietary license to grow, market, and sub license '609' - Crenshaw & Doguet |
| Vegetative Buffalograsses | Proprietary license to grow and market all vegetatively-propagated buffalograsses from our program - Crenshaw & Doguet |
| Seeded Buffalograss | Proprietary license to produce seed from a select group of experimentals - NTG |
| Seeded Buffalograss | Proprietary license to produce seed from a select group of experimentals - Sharps Brothers |
| '315' | Proprietary license to grow and market '315' in Nebraska - Oak Point Sod |
| '378' | Proprietary license to grow and market '378' in Nebraska - Todd Valley Farms |
| '315' | Proprietary license to grow, market, and sub license `315' - Crenshaw & Doguet |

## NTEP RESULTS

The first National Buffalograss Trial was planted in June 1991 at 39 locations throughout the United States. The trial included eleven vegetative and eleven seeded experimental and/or standard varieties. The seeded plots were planted using plugs of seedlings started in the greenhouse. A randomized complete block design was used with three replications. This data provides useful information on adaptation and performance of buffalograss throughout the United States.

The quality of the 22 seeded/vegetative experimentals/standards are shown in Table 3. This table was taken from the 1994 NTEP Progress Report #95-7. The 1994 data ranks '378', '609', and '315' as the top three vegetative materials in the test. This national test is now over, and a final report will be released shortly. It is also anticipated that a new National Trial will be initiated during 1996.

## BREEDING WORK

The hot and dry summer that we experienced in Nebraska this year was ideal for evaluating buffalograss selections for tolerance to heat and drought. During the month of July only a trace of rain was received at the research facility along with extended periods of temperatures above 90°F, with no fewer than seven days above 100°F. Irrigation was only supplied to new plantings to ensure good establishment of the plots, and to the other evaluations two to three times at the end of July in preparation for field days. The soil conditions were very dry, with wide cracks in the heavy clay soil, but many of the buffalograss selections maintained exceptionally good turfgrass color and quality.

The best genotypes perform consistently well over a number of environments. The summers of 1993 and 1994 were relatively wet, yet the relative rankings of the selections are very similar through 1993 to 1995. This bodes well for the flexibility and wide adaptability of these improved types of buffalograsses.

### Evaluation of Buffalograss Selections at Golf Course Fairway Mowing Heights

Buffalograss has historically been used as a low maintenance turfgrass species typically mowed at and above 2". The goal of this specific project is to determine if buffalograss is tolerant to the lower mowing heights of golf course fairways, and if so, develop varieties for these environments. Low mowing-tolerant buffalograsses would be particularly suited to dryland areas and areas where irrigation may in the future be prohibited on golf course fairways, as well as to reduce fertilizer and pesticide applications.

The low-mowing evaluation began in 1993 by lowering the mowing height on a replicated plant evaluation plot established in 1990. The plots were then mowed at 5/8" twice per week, with the clippings returned to the turf. The trial has received 1-2 lbs. N/M/year and preemergent and postemergent herbicides as needed. The plots were not irrigated during the 1993 and 1994 growing seasons, and were irrigated three times (.25"/irrigation) in 1995. The plot design is a randomized complete block design with 3 blocks and 98 buffalograss entries. Quality and color data was recorded using a 1-9 scale with 1=very poor to 9=excellent.

After observing these and other plots mowed at 5/8" over the past two years, the turf quality of these low-mowed sites is in general, quite outstanding. In fact we may consider recommending lower mowing for buffalograss turfs. The density and quality of many selections is very satisfactory, and the low mowing height is quite desirable for more formal situations. The water use seems to be reduced even lower than other buffalograss plots, likely due to the reduced leaf surface.

Several entries have consistently been rated at or near the top in turfgrass quality ratings at these low mowing heights (Table 4). These include '315', 86-61, 86-120, 87-24, 87-76, and 84-45-3. These also performed well in 1992 when the plots were at the higher mowing height as well as in other evaluation plots. Male plants, like 84-45-3, are often rated lower in other evaluations because of the male flowers extending above the turf canopy. But with frequent low mowing, these flowers are removed, resulting in better turf quality.

In attempts to combine characteristics of individual plants tolerant of low mowing, a crossing block of four male and six female plants (Table 4) was established in 1994. Seed was harvested in hopes of planting out progeny rows from each plant for parent and progeny evaluation. Unfortunately, this seed was mistakenly bulked. We none-the-less planted a sample of these progeny in 1995 for evaluation and observed considerable variation for plant vigor, density, growth habit, along with color and turf quality. The polycross was again harvested this year (August, 1995) and maternal lines of progeny will be planted in 1996. This planting will provide substantial information about the potential each parent has in producing low-mowing tolerant progeny as well as other turfgrass quality characteristics at low or higher mowing heights.

**Performance of buffalograss selections in primary selection and advanced replicated trials.**

Our breeding program is set up to initially evaluate large numbers of individual plots in unreplicated trials. These may include vegetative selections made in the native or undisturbed sites, from maintained turfgrass areas, or forage-pasture areas. These evaluations may also include plants from seed populations where we can study the uniformity of a population or from a parent, as well as identify individual plants for possible vegetative propagation. Superior individuals and seed populations are then propagated into replicated field trials for more critical turfgrass evaluation.

*Replicated Trial: 1994 (Area 17)*

This trial consists of 32 vegetative and 16 seed propagated entries planted June of 1994. The vegetative entries were established using 16 plugs per 5'x5' plot. Sixteen entries are selections from our single plant nurseries, five are collections from old turf stands, nine are potential releases, and two are standards. The seeded entries, include five experimentals from our breeding project, two from NTG (Native Turf Group), six from Sharps Seed Co., and three commercial varieties. These were seeded at 2 lb/1000 sq. ft.

Several entries repeatedly show up at the top of the rankings even ahead of currently released '315' and '378' (Table 5). These include the potential new releases 86-61 and 86-120, but also 91-181 and 93-181. The latter two genotypes will be increased in 1996 to further evaluate for commercial potential. Seeded entries were typically not rated as high as the vegetative entries, mostly due to less uniformity and appearance of male flowers when unmowed. Still experimentals 92-501-JK1, 92-502-JK1, 92-503-JK1, and 92-504-JK1 were consistently higher than the commercially available 'Texoka' and usually higher than 'Topgun'. Rate of establishment however is often better for the seeded varieties compared to the vegetatively propagated types. This is due to the more uniform coverage of many seedlings vs. the smaller number of plugs. However, after one year, little difference between vegetative and seeded plots exists. Further improvement of seeded types will hopefully close the quality rating gap between vegetative and seed varieties.

Fall dormancy is typically correlated with reduced summer quality, but there are exceptions. The maintenance of active growth into the fall typically reduces the winter hardiness of the plant, thereby affecting the next years turf quality. Experimentals 93-181 and 91-118 have good retention of color into the fall yet have good summer turf quality.

*Replicated Trial: 1993 (Area 23)*

This trial, planted June of 1993, consists of 53 vegetative and 25 seeded entries arranged in a randomized complete block design with three replications. The vegetative entries were established using 16 plugs per 5'x5' plot. Thirty-seven are selections from crossing blocks initiated by Jeff Klingenberg, and sixteen are desirable plants taken from other plantings. These include standards such as '315', '378', '609', and 'Prairie'. The seeded entries included 12 populations from crossing blocks and half-sib families taken from other desirable selections. Standard seeded varieties included 'Texoka', 'Bison', as well as Sharps Seed Co. and NTG varieties. All seeded plots were seeded at 2 lb/1000 sq. ft.. All the plots, both seeded and vegetative, received 1 lb/N/M per growing season, pre- and post-emergence herbicides as needed and were mowed biweekly at two inches

Released cultivars '315' and '378' continue to perform well, while two new selections (92-135 and 92-116) show promise in this evaluation (Table 6). These experimentals both performed better than the two releases in at least one rating. Cultivars '315' and '378' were best for spring greenup characteristics, but not significantly better than 92-135. Further evaluation is needed to determine if these differences are significant. Experimental 91-118 continues to perform well.

Although its color ratings are not among the top rankings, 91-118 exhibits very good fall color characteristics and reasonably good greenup characteristics.

Real improvement in the seeded varieties is evident in this evaluation. Experimentals 90-504-JK and 90-503-JK show very good quality and color ratings, not significantly different than the top vegetative types (Table 6). The fall color (dormancy ratings) are also much improved compared to the vegetative types. Experimental 90-503-JK shows slightly (although not significant) improved fall color performance. This may be due to the presence of southern adapted types in its parental lines. Mixing parents in these seeded populations may be a strategy to improve and combine these traits yet not greatly sacrificing the winter hardiness of the variety. And these two seeded varieties are significantly better than currently available 'Texoka' and 'Bison'. Further improvement is also likely because two additional cycles of phenotypic recurrent selection have been made on these populations. Seeded populations from the latest round will be planted in 1996 for evaluation. For additional information, refer to the Seeded Variety Improvement & Development section.

The data for fall color (dormancy) in the seeded populations is especially interesting because inheritance of this characteristic can be observed. Although the half-sib families had a mixture of northern and southern type buffalograsses, the maternal parent had a significant effect on the rate of the plant entering winter dormancy. 'Prairie' and '609', both southern adapted parents, yielded progeny with similar good fall color characteristics, while '378' and 85-217 yielded progeny that went dormant very quickly (Table 6).

*Replicated Trial: 1995 (Area 25)*

This trial (planted in June of 1995) consists of 56 vegetative and eight seeded entries arranged in a randomized complete block design with three replications. The vegetative entries were established using nine or 16 plugs per 5'x5' plot. They included four standards ('378', '315', 86-61, and 91-118) and 52 selections made from a population of 2000 plants that were subjected to extreme traffic treatments during 1993 and selected from the field in 1994, based on reqrowth and quality the following summer. The seeded entries included four composites of material determined to be resistant to mealybug infestation, one composite from the low mow crossing block (See selections at fairway heights section), and three standards 'Texoka', 'Cody' (NTG-6), and 'Tatanka' (NTG-1). All the plots were irrigated throughout the summer to improve establishment and fertilized with 2 lb/N/M.

In the establishment year of this trial, some differences occurred, primarily for establishment rate and uniformity (Table 7). Seeded plots covered the fastest, but several vegetative types also covered the plot quickly. Experimentals 94-38 and 94-88 were significantly better than older varieties. In addition, a number of new materials were very uniform. They did not exhibit the typical clumpiness that is frequently observed with the vegetative plantings. Once all the plants are well established (in 1996), regular turf quality, color, density, etc. ratings will be made on these plots.

*Primary Evaluation Trial: 1993-4 (Areas 21 & 22)*

This trial consists of greater than 1500 individual, non-replicated plants from very diverse backgrounds and is maintained as a nursery for future genetic and breeding work. In 1995 the trial was not mowed and not irrigated, and was fertilized with 2 lb. N/M during the growing season. Thirty-five selections were made and will be planted in a replicated trial in 1996. These plants were selected on the basis of plant vigor, color, density, and lack of dormancy during the heat and drought in 1995.

A number of the selections were made from a full-sib family where the female parent is 85-436, a selection that has been noted as having desirable turf characteristics. Nearly all these plants had very good summer quality and may be very useful in future crossing work. In addition, the full-sib family of plants will enable genetic evaluations of buffalograss that were not previously possible with half-sib families and individual progenies. Refer to the Future Research section for more information.

*Primary Evaluation Trial: 1995 (Area 27)*

This trial consists of progeny obtained from the low-mowing tolerant crossing block. Five hundred individual progeny were planted in June of 1995 for evaluation of their tolerance to low mowing. These plants are spaced 3 feet apart. During this first year, the plots were mowed twice at 2.5 inches, but will be gradually lowered in 1996. The parents used in the crossing block are also planted here, in 5'x5' plots, and will be treated and evaluated in a similar manner. Unfortunately the seed from the crossing block was bulked so maternal parents of these progeny are not known. Only establishment and gender data was obtained this year, but regular ratings of turfgrass quality will be made and reported in 1996.

*Trials to be established in 1996*

A second planting of the progeny from the low-mowing tolerant crossing block will be established in a progeny row design. In addition, a new replicated trial will be planted to evaluate new materials selected from the 1993-4 primary evaluation trial, and from the recurrent selection populations.

**Seeded Variety Improvement Research**

*Breeding for Seedling Vigor in Buffalograss (Charles Rodgers)*

The objective of this research is to use phenotypic recurrent selection for seed size in two synthetic buffalograss populations as a means of improving seedling vigor and gaining heritability information on this important characteristic. Seeded buffalograss stands can be slow to establish, because of poor germination, and lack of seedling vigor. Poor germination can be alleviated by seed priming. However, stand establishment of buffalograss is still difficult. The resulting seedlings are relatively slow growing, and not competitive with weeds. The literature shows that larger seeds are correlated with increased seedling vigor and a more competitive and quicker establishing stand. However, no breeding efforts have been previously attempted to increase seedling vigor in buffalograss.

Two synthetic buffalograss populations, NE-501 and NE-503, were chosen for divergent phenotypic recurrent selection. Caryopses were removed from burs and screened using a series of sieves having holes ranging in size from 1/23" to 1/15". Caryopses larger than the 1/16" were used to comprise the large seeded population, and caryopses smaller than the 1/21" screen were used to generate the small seeded population.

One hundred and forty-four seedlings for the large, unselected, and small seeded populations of each synthetic were established and transplanted to the field in isolated crossing blocks. Plots were rated for rate of spread, percent cover, and gender. Individual plants were harvested and cleaned, and caryopses removed from the burs. Bur yield and weight per 100 caryopses were obtained on an individual plant basis.

Realized heritabilities in NE-501 for large and small seed size were 0.08 and 0.15, respectively. Gain from selection for large seed size was 5.3 mg per 100 caryopses (Table 8). For NE-503 realized heritability estimates were 0.26 and 0.23 for large and small seed size, respectively. Gain for selection for large seed size was 19.7 mg per 100 caryopses (Table 8). Low heritability estimates and gains from selection indicate that multiple cycles of selection will be necessary to improve this trait. Bur weight was positively correlated with the number of caryopses per bur, r=0.68, indicating that bur weight could be used for selection for higher seed set or caryopsis yield. This year (1995) 10 half-sib families were selected and planted in replicated crossing blocks from each crossing block to constitute the second cycle of selection. In total, 18 crossing blocks were established in 1995.

*Seed Germination Improvement (Charles Rodgers)*

This work will select maternal plants that produce caryopses and burs with higher germination rates. In 1994, 22 genotypes with superior turfgrass characteristics and 8 other genotypes were established in a replicated top cross. The male plant used was 84-45-3, an experimental with high turf quality. The burs from this plot have been harvested and during the winter of 1995-96, germination tests will be performed on burs and caryopses. This experimental design will make any differences observed in seedling vigor due to maternal effects only. Bur yield, seedling vigor, and turf quality data were also taken. Full-sib families with high vigor values can then be combined for the development of a synthetic cultivar, or a maternal plant could be vegetatively established with 84-45-3 in isolation for the development of an $F_1$ hybrid.

*Seeded Variety Improvement and Development*

In addition to vegetative cultivar development, seeded populations are also being developed in the University of Nebraska program. Sixteen half-sib families selected from previous seeded progeny evaluations were combined for the development of four synthetic cultivars. These synthetics were planted in isolated crossing blocks in 1992, harvested in 1993, and are being tested in the 1994 replicated evaluation trial. Two hundred eighty eight individual plants from each synthetic population were planted in 1994, evaluted for turf quality, and resistance to rust diseases in 1994 and 1995. The 50 best male and 50 best female plants were selected and allowed to interpollinate. Seed was then harvested in hopes of improving each population. After further testing it is hoped that one of these populations will be released from the University of Nebraska Breeding program.

**Tissue Culture and Transformation of Buffalograss**

*(Shuizhang Fei)*

Tissue culture and transformation of buffalograss lines will provide novel sources of variation that can be used in the breeding program. The goals of this work are to develop cell - culture and regeneration methods, and transformation procedures using biolistic techniques.

Thus far, intact plants of two female clones ('609' and '315') and a male clone (NE84-45-3) were regenerated through young inflorescence culture. In this process the young inflorescences are disinfected and cultured in the dark on Murishige-Skoog medium, supplemented with 2 mg/l 2,4-D and 1000 mg/l casein hydrolysate. After one month, 76.5% of young inflorescences from NE84-45-3 developed embryogenic callus. The male clone has a higher *in vitro* response than the other two female clones ('609' and '315'). Callus from 'Texoka' did not differentiate. When these calli from NE84-45-3 were transferred to differentiation medium (containing either no plant growth regulator or 0.3 mg/l BA), 48.3% formed shoots with an average of 3.17 shoots per callus. Media supplemented with 0.3 mg/l NAA caused roots to form.

Callus induction was promoted in the male NE84-45-3 by an ethylene antagonist ($AgNO_3$), but not in the female '609'. The positive effects of $AgNO_3$ is well documented in corn tissue culture. In 1996 additional male and female lines will be tested to test for genotypic differences. in regeneration and in response to $AgNO_3$. Efforts will continue in refining the cell-culture techniques in hopes of increasing regeneration frequency. Finally, when possible, transformations of buffalograss cell cultures begin, and will likely include genes conferring resistance to herbicides.

**Illinois Planting**

An experimental planting was planted at the Sears World Headquarters at Hoffman Estates outside of Chicago. This study included released and experimental buffalograsses, zoysiagrass from Texas A&M, and other commercial standards. This study will be regularly observed in 1996.

**Future research areas**

*Evaluation of Buffalograss Germplasm: proposal*

A proposal was submitted to the USDA Forage and Turfgrass Crop Germplasm Committee to initiate efforts to evaluate and preserve buffalograss germplasm. We feel that if we receive this funding, it would complement the support from the USGA to enable evaluation of plants and characteristics not immediately applicable to golf course purposes. This project would involve evaluation of many characteristics, chromosome counts through microscopic and flow cytometric methods, germplasm maintenance, and introduction of germplasm and populations into the USDA's germplasm system.

*Floral Development and Flowering Physiology*

Rather little is known of the genetic and environmental controls of the flowering process in buffalograss. These topics are vitally important to a breeding program to continue progress in plant improvement. Our plans for 1996 are to initiate efforts to document the development of floral meristems in buffalograss carefully. Experiments with gibberellic acid (GA) may also be conducted to test the hormone's possible role in gender determination in this dioecious species. Some literature points to differences in endogenous GA levels; higher concentrations correlated with male flowers, lower concentrations with female flowers[1]. We also plan to study flowering requirements for the species. This will improve our ability to make controlled crosses in the greenhouse or growth chambers, and better understand adaptation of various races of buffalograsses.

Efforts will also be initiated to investigate inbreeding in buffalograss populations using the numerous full-sib and half-sib families that are now available. This project will likely lead to better knowledge of developing F1 hybrids and also generating additional variation that can be used in all aspects of the breeding program.

## BUFFALOGRASS ESTABLISHMENT AND CULTURAL PRACTICES

*(Kevin Frank)*

The objective of this research is to determine management practices of buffalograss for golf course use. The research is composed of two main studies: (1) optimum date of planting, and (2) fertilizer and mowing regimes.

In 1995, date of planting effects on seeded buffalograss were investigated at two locations. Two seeded buffalograss varieties, 'Texoka' and 'Cody', were planted monthly on seven different dates in 1995 at the John Seaton Anderson Turfgrass Facility near Mead, Nebraska and at the Greenville Farm in Logan, Utah. Areas were planted on the 15th of each month, between April and October.

Initial results indicate significant location differences for percent cover of buffalograss and percent weed cover. Planting dates at Nebraska had greater buffalograss cover at 8, 12, and 16 weeks after planting than corresponding dates at Utah. An interaction between location and planting date was observed at four weeks after planting where the August planting date had significantly greater buffalograss cover at Utah than at Nebraska. These preliminary results indicate the best planting date is between May 15 and July 15 for the Nebraska location, and August 15 for Logan, Utah. Final recommendations for planting dates will be made after determining winter survival and the effectiveness of the fall planting dates.

Buffalograss management research is ongoing at Manhattan, Kansas, near Mead, Nebraska, and at Logan, Utah. The four varieties of buffalograss planted in 1995 were 'Cody', 'Texoka', '378', and experimental NE 91-118. 'Cody' and 'Texoka' were established from seed and NE 91-118 and '378' were established from vegetative plugs. The management treatments

[1]Yin, T. and J. Quinn, 1995. Tests of a mechanistic model of one hormone regulating both sexes in *Buchloe dactyloides* (Poaceae). American Journal of Botany 82:745-751.

will be started in 1996 and will include mowing heights of one-half, one, and two inches and fertilization levels ranging from 0-4 pounds of nitrogen per 1000 square foot.

## BUFFALOGRASS INSECT RESEARCH

### Biological Control of Buffalograss insects

*(Tiffany Heng-Moss & Fred Baxendale)*

In the past decade, increased awareness of the adverse effect that pesticides can have on the environment has underscored the need to develop alternative, non chemical methods of controlling turfgrass pests and diseases. This concern has prompted renewed interest in biological control as an alternative management strategy to reduce pest populations. The purpose of this project is to determine if parasitoid wasps and other beneficial arthropods can serve as effective biological control agents against buffalograss mealybugs and other buffalograss insect pests.

Two potentially important insect pests of buffalograss are the grass-feeding mealybugs *Tridiscus sporoboli* and *Trionymus* sp. These insects which first appeared in buffalograss evaluation plots at the JSA Turfgrass Facility near Mead, NE in 1988, had caused extensive turf damage by 1989. In 1990, however only very low numbers of mealybugs could be detected in these same evaluation plots. A proposed explanation for this dramatic decline in mealybug infestation levels was the regulating effect of naturally occurring beneficial arthropods.

In 1988-1990 preliminary studies were conducted at the University of Nebraska-Lincoln to survey the arthropod community associated with buffalograss. In these surveys, numerous parasitic wasps were collected in evaluation plots where high numbers of mealybugs had been present in 1988 and 1989. In 1994, research was initiated to determine if any of these wasps were parasitoids of buffalograss mealybugs. Female mealybugs were dissected and reared to identify internal parasitoids. Parasitoid wasps subsequently identified as *Rhopus* sp., (family Encyrtidae) were reared from female mealybugs. This suggests their potential regulating influence on mealybug population dynamics in the field.

Further research is needed to fully understand the role these wasps and other natural enemies may play in reducing mealybug populations. Current efforts are focusing on identifying the beneficial arthropod complex associated with buffalograss. A survey will be undertaken by collecting and examining samples from buffalograss plots at the JSA facility and at vegetatively established buffalograss lawns at East Campus, Lincoln, NE. Samples could also be collected from pastures with native stands of buffalograss. In the field and greenhouse paired comparison tests will be conducted to evaluate the potential regulating effect, *Rhopus* sp. has on buffalograss mealybugs. Wasps and mealybugs will be isolated in cages while identical cages will isolate only mealybugs and exclude parasitoid wasps. These two sets of cages will be evaluated over time and the impact of parasitoids on the mealybug numbers will be observed. The overall goal of this research is to identify the natural enemy complex associated with buffalograss, and to develop effective and environmentally sound pest management alternatives for mealybugs in buffalograss.

## PERSONNEL CHANGES

Jennifer Johnson-Cicalese received her Ph.D. in May and accepted a position at Rutgers University. Dr. Paul G. Johnson, who received his Ph.D. from the University of Minnesota under Dr. Don White in June, accepted a Post Doctoral position at Nebraska, with his major responsibility coordination of the USGA Buffalograss Project.

## STUDENT PROGRESS

Two new students inititated their graduate programs during 1995. Kevin Frank began work on buffalograss management in January. He is being co-advised by Roch Gaussoin and Terry Riordan. Kevin is an excellent golfer (USGA index 1.8), and he will be evaluating new buffalograsses for use under golf course conditions. Tiffany Heng-Moss, a UNL horticulture graduate in May, initiated a project in entomology relating to parasites on buffalograss mealybugs. She is co-advised by Fred Baxendale and Terry Riordan. Ph.D. students, Shuizhang Fei and Charles Rodgers, continue to make excellent progress on their projects. Shuizhang works in the area of tissue culture and biotechnology, and eventually he would like to develop a system to incorporate beneficial genes into buffalograss. Charles is trying to improve the germination and establishment of seeded buffalograsses. He will complete his program in May of 1996, and at that time will have developed germplasm and possibly two synthetics which have increased seed size and vigor.

**Dissertation title: Buffalograss Resistance to Mealybugs: Germplasm Evaluation, Mechanisms, and Inheritance.**

Jennifer Mildred Johnson-Cicalese

Screening Turf-type Buffalograss Germplasm for Resistance to Mealybugs - In recent studies with turf-type buffalograss [*Buchloë dactyloides* (Nutt) Engelm.], two species of mealybugs [*Tridiscus sporoboli* (Cockerell) and *Trionymus* sp.] have emerged as potentially serious pests. Therefore, 72 buffalograss selections were screened for resistance to these mealybugs in five greenhouse screening trials. Plugs were removed from field plots, planted in 15 cm pots, and inoculated with mealybug-infested leaf clippings. Plants were evaluated for mealybug infestation and differences in resistance were found. 'Prairie' and '609' consistently showed excellent resistance to mealybugs, while several experimental selections, including 90-157 and 84-512, exhibited moderate resistance. Most selections were moderately susceptible and 85-97 was highly susceptible. Field mealybug infestations were also evaluated and found to be highly variable, both within and among plots. However, in most cases selections evaluated in the field showed similar responses as in greenhouse trials. Pubescence was positively correlated with susceptibility, and a glabrous leaf surface is suggested as a possible mechanism of resistance. These studies also found several parasitoid wasps that may have a significant impact on mealybug populations.

Evaluation of Buffalograss Leaf Pubescence and Its Effect on Mealybug Host Selection - Previous breeding work with turf-type buffalograss [*Buchloë dactyloides* (Nutt) Engelm] found a positive correlation between leaf pubescence and level of mealybug [*Tridiscus sporoboli* (Cockerell) and *Trionymus* sp.] infestation. Scanning electron microscopy (SEM) and light microscopy were used to evaluate buffalograss leaf pubescence and its possible effect on susceptibility to mealybugs. A range of trichome densities was found, with two highly susceptible selections, 85-97 and '378' averaging as many as 8.7 and 10.9 trichomes per $mm^2$, while two highly resistant selections, '609' and 'Prairie' had 0 and 0.1 trichomes per $mm^2$. Pubescence ratings of the whole plant (1-6 rating scale) were highly correlated with trichome counts, indicating the relative accuracy of the more time-efficient pubescence rating technique. SEM observations of mealybugs on buffalograss leaves suggest that pubescence may facilitate oviposition by providing a framework for the waxy filamentous ovisac, and/or provide a foothold for mealybug nymphs. In preliminary choice trials, mealybugs did not exhibit a preference for the susceptible 85-97. Evidence suggests that mealybug resistance mechanisms may operate primarily on a whole plant basis or may involve interactions with parasitoid wasps.

Inheritance of Resistance to Mealybugs in Turf-type Buffalograss - Dramatic differences in resistance to mealybugs, *Tridiscus sporoboli* (Cockerell) and *Trionymus* sp., were found among buffalograss genotypes [*Buchloe dactyloides* (Nutt.) Engelm.]. This resistance was associated with a glabrous leaf surface. To study the inheritance of these traits, progeny of 20 genotypes were evaluated in a greenhouse trial. Significant differences were found among half-sib families for resistance and pubescence. Heritability estimates for mealybug resistance using maternal half-sib analysis ($h^2_m$) and offspring-parent regression ($h^2_{op}$) were 0.87 and 0.56, respectively. These relatively high heritabilities suggest that improvements in resistance should be possible. Heritability estimates for leaf pubescence were $h^2_m$=0.59 and $h^2_{op}$=0.28. A non-significant correlation ($r^2$=0.06, P=0.0558) was found between progeny pubescence ratings and mealybug infestation ratings, and numerous pubescent plants showed no signs of mealybug infestation, indicating that additional factors are involved in resistance. Less than 1% of the progeny had a glabrous leaf surface and these were primarily offspring of glabrous maternal parents, suggesting a simply inherited recessive trait. Of the 1224 plants (Cycle 1) evaluated, 119 (10%) showed no signs of mealybug infestation. These plants were planted in an isolated crossing block in May 1993, and seed was harvested from individual female plants in October 1993. Progeny from 16 of these females (Cycle 2) were evaluated in a trial which also included vegetatively-propagated maternal parents and grandparents. Of the 842 progeny (Cycle 2) evaluated, 359 (43%) showed no signs of mealybug infestation. Because of the resistance of the parents and the high heritabilities previously obtained, a high percentage of resistant progeny would be expected. However, the mealybug infestation that developed on this trial may not have been adequate to definitively separate resistant progeny from progeny that escaped infestation.

**RELATED PUBLICATIONS AND PRESENTATIONS**

Baxendale, F.P. and T.P. Riordan, 1995. *Buffalograss: Entomological Perspective on a New Turfgrass* (invited paper). National Meeting of the Entomological Society of America, Las Vegas, NV, December 17-21, 1995.

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.

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

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Riordan, T.P., J. Johnson-Cicalese, F.P. Baxendale, M.C. Engelke, R.E. Gaussoin, G.L. Horst and R.C. Shearman. 1995. Registration of `315' buffalograss. Crop Science 35:1206 (J. Series 10688).

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Riordan, T.P., J.M. Johnson-Cicalese, C.A. Rodgers, T. Heng-Moss, A. Kramer and L. Wit. 1995. Performance of buffalograss cultivars and selections in several breeding and evaluation trials. Turfgrass Research Report for 1994. IANR/UNL TRTRR 95-1 pp.17-32.

Riordan, T.P. and J. Klingenberg. 1995. IANR/UNL official release of `Cody' buffalograss.

Riordan, T.P. and J. Klingenberg. 1995. IANR/UNL official release of `Tatanka' buffalograss.

Rodgers, C.A., J.M. Johnson-Cicalese and T.P. Riordan. 1995. Breeding for seedling vigor in buffalograss. Turfgrass Research Report for 1994. IANR/UNL TRTRR 95-1 pp.35-38.

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

Weinhold, A.P., F.P. Baxendale, R.E. Gaussoin, and T.M. Heng-Moss. 1996. Early season control of bluegrass billbug larvae on a Kentucky bluegrass lawn in Saunders Co., Nebraska, 1995. Arthropod Management Tests (*In Press*).

Table 3. Mean Turfgrass Quality Ratings of Buffalograss Cultivars for Each Month Grown at Nineteen Locations in the United States. 1994 Data.[2]

| NAME | Turfgrass Quality Ratings 1 - 9; 9 = Ideal Turf: Months[1] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | MEAN |
| NE 85-378 | 5.2 | 4.5 | 4.3 | 5.9 | 5.8 | 6.6 | 6.2 | 5.8 | 5.7 | 4.8 | 4.3 | 4.3 | 5.8 |
| 609 (NE 84-609) | 5.0 | 4.7 | 4.6 | 4.6 | 4.9 | 6.0 | 6.1 | 5.6 | 6.1 | 5.4 | 5.8 | 5.1 | 5.6 |
| NTG-4 | 4.8 | 4.5 | 4.7 | 6.1 | 5.2 | 6.1 | 5.9 | 5.7 | 5.6 | 4.9 | 4.8 | 4.1 | 5.6 |
| NTG-5 | 5.3 | 5.0 | 4.2 | 6.3 | 5.2 | 6.1 | 5.9 | 5.6 | 5.3 | 4.9 | 4.9 | 3.6 | 5.5 |
| 315 (NE 84-315) | 5.2 | 4.7 | 4.7 | 4.8 | 5.9 | 6.4 | 5.7 | 5.5 | 5.5 | 4.7 | 4.2 | 3.4 | 5.5 |
| NTG-2 | 5.5 | 4.2 | 4.6 | 6.0 | 5.1 | 5.9 | 5.7 | 5.6 | 5.5 | 4.9 | 4.8 | 3.6 | 5.5 |
| NE 84-436 | 5.0 | 5.2 | 4.7 | 4.8 | 4.8 | 6.1 | 5.8 | 5.7 | 5.6 | 4.7 | 5.1 | 3.4 | 5.4 |
| NTG-3 | 5.0 | 5.0 | 4.2 | 4.3 | 5.1 | 6.0 | 5.9 | 5.6 | 5.5 | 4.9 | 5.2 | 3.6 | 5.4 |
| AZ 143 | 5.5 | 4.7 | 4.4 | 4.9 | 4.9 | 6.1 | 5.6 | 5.6 | 5.4 | 4.7 | 4.4 | 3.9 | 5.4 |
| TATANKA (NTG-1) | 4.8 | 4.8 | 4.2 | 4.8 | 4.9 | 6.0 | 5.8 | 5.1 | 5.3 | 4.7 | 4.9 | 3.9 | 5.3 |
| TEXOKA | 5.2 | 4.3 | 4.3 | 4.8 | 4.6 | 5.7 | 5.6 | 5.2 | 5.2 | 4.8 | 4.8 | 3.8 | 5.2 |
| BISON | 5.2 | 4.3 | 4.8 | 5.4 | 4.8 | 5.1 | 5.4 | 5.0 | 5.5 | 4.8 | 5.3 | 3.6 | 5.1 |
| SHARPS IMPROVED | 4.8 | 4.7 | 4.8 | 4.2 | 4.6 | 5.7 | 5.4 | 5.0 | 5.3 | 4.8 | 5.0 | 3.7 | 5.1 |
| TOP GUN (BAM 101) | 5.0 | 4.7 | 4.3 | 5.4 | 4.6 | 5.6 | 5.5 | 5.0 | 5.1 | 4.6 | 4.9 | 3.3 | 5.0 |
| PLAINS (BAM 202) | 4.8 | 4.3 | 4.7 | 4.8 | 4.4 | 5.5 | 5.4 | 4.8 | 5.1 | 4.8 | 5.2 | 3.8 | 5.0 |
| PRAIRIE | 5.2 | 5.0 | 4.3 | 4.3 | 4.1 | 5.6 | 5.3 | 4.9 | 5.5 | 5.1 | 5.2 | 4.4 | 5.0 |
| BUFFALAWN | 5.0 | 5.0 | 4.1 | 4.1 | 3.7 | 5.5 | 5.4 | 5.4 | 5.7 | 5.0 | 5.3 | 4.2 | 4.9 |
| NE 84-45-3 | 5.0 | 4.2 | 4.1 | 4.1 | 4.3 | 5.3 | 5.2 | 4.6 | 4.4 | 4.0 | 4.2 | 3.1 | 4.6 |
| HIGHLIGHT 25 | 5.2 | 4.8 | 3.9 | 3.9 | 3.6 | 5.3 | 4.7 | 4.9 | 5.1 | 5.7 | 5.2 | 4.1 | 4.5 |
| HIGHLIGHT 4 | 5.2 | 4.7 | 3.8 | 4.0 | 3.5 | 5.0 | 4.9 | 4.8 | 5.1 | 5.0 | 5.4 | 4.1 | 4.5 |
| HIGHLIGHT 15 | 5.0 | 4.2 | 4.0 | 4.1 | 3.4 | 4.8 | 4.6 | 4.4 | 4.9 | 5.1 | 5.3 | 4.3 | 4.4 |
| RUTGERS | 5.3 | 4.2 | 3.4 | 3.8 | 3.3 | 4.8 | 4.7 | 4.5 | 5.0 | 5.1 | 5.0 | 4.0 | 4.3 |
| LSD VALUE | 1.6 | 1.1 | 1.9 | 1.7 | 0.9 | 0.8 | 0.7 | 0.8 | 0.7 | 0.9 | 1.3 | 1.9 | 0.6 |

1 To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD(0.05) value.

2 Source: National Turfgrass Evaluation Program. National Buffalograss Test - 1993.

Table 4. Turfgrass quality and color ratings and rankings for low-mowing tolerant evaluation.

| Selection | Quality Average 1992-95† | Quality Average 1995† | Quality Average 1993† | Quality Average 1992† | Color Average 1995† |
|---|---|---|---|---|---|
| 86-120‡ | 6.9 (1) | 6.7 (1) | 6.1 (3) | 7.3 (1) | 5.7 (14) |
| 86-61‡ | 6.9 (2) | 6.3 (2) | 6.4 (2) | 7.1 (3) | 6.7 (1) |
| 315‡ | 6.7 (3) | 5.9 (3) | 6.8 (1) | 7.3 (2) | 5.2 (38) |
| 87-76§ | 6.3 (4) | 5.7 (5) | 5.9 (4) | 6.7 (9) | 5.8 (8) |
| 86-23‡ | 6.1 (5) | 5.3 (13) | 5.2 (24) | 6.7 (8) | 5.3 (32) |
| 85-443‡ | 5.9 (7) | 5.3 (10) | 5.7 (7) | 6.5 (11) | 4.8 (70) |
| 378 | 5.8 (12) | 5.0 (22) | 5.3 (18) | 6.8 (5) | 6.2 (2) |
| 85-648‡ | 5.7 (16) | 5.3 (11) | 5.4 (11) | 6.1 (29) | 4.7 (77) |
| 84-45-3§ | 5.6 (19) | 5.6 (6) | 5.3 (16) | 5.9 (50) | 5.7 (9) |
| 87-93§ | 5.2 (43) | 4.0 (73) | 5.6 (10) | 5.9 (56) | 4.7 (85) |
| 87-80§ | 5.2 (45) | 3.8 (81) | 5.6 (9) | 5.7 (68) | 5.0 (66) |
| Texoka | 4.7 (78) | 4.1 (69) | 4.4 (79) | 5.5 (88) | 5.3 (37) |
| 609 | 4.4 (88) | 4.6 (36) | 4.7 (57) | 6.1(27) | 5.7 (10) |
| Prairie | 4.1 (94) | 4.0 (77) | 3.9 (96) | 5.6 (76) | 4.7 (86) |
| LSD (.05) | 0.5 | 1.1 | 0.8 | 0.6 | 0.9 |

† rank of the selection is noted in parentheses.

‡ Selected for use as female parents in the crossing block.

§ Selected for use as male parents in the crossing block.

Table 5. Quality, color, and dormancy rating for vegetative and seeded entries in the 1994 replicated evaluation trial.

| Selection | Quality 1995† | Quality 1994† | Quality Avg.† | Color 1995† | Dormancy 1994† |
|---|---|---|---|---|---|
| **Vegetative** | | | | | |
| 86-61 | 7.2 (1) | 6.2 (6) | 6.8 (1) | 7.3 (1) | 4.7 (28) |
| 85-158-2 | 7.0 (2) | 5.5 (22) | 6.5 (7) | 6.1 (10) | 3.0 (45) |
| 86-120 | 6.9 (3) | 6.0 (12) | 6.6 (3) | 6.3 (6) | 4.3 (35) |
| 91-181 | 6.9 (4) | 6.5 (2) | 6.8 (2) | 6.8 (4) | 3.7 (42) |
| 93-181 | 6.8 (7) | 6.2 (9) | 6.6 (6) | 4.7 (48) | 7.7 (1) |
| 315 | 6.6 (9) | 6.2 (5) | 6.4 (8) | 6.1 (9) | 5.7 (10) |
| 378 | 6.5 (10) | 5.5 (21) | 6.2 (12) | 6.8 (3) | 3.7 (39) |
| 91-248 | 5.9 (31) | 6.8 (1) | 6.2 (11) | 5.5 (30) | 5.3 (17) |
| 91-118 | 6.0 (27) | 5.7 (18) | 5.9 (26) | 5.5 (29) | 6.7 (3) |
| **Seeded** | | | | | |
| 92-504-JK1 | 6.2 (20) | 5.2 (33) | 5.8 (28) | 5.2 (43) | 5.7 (11) |
| 92-502-JK1 | 5.9 (32) | 5.3 (30) | 5.7 (31) | 5.6 (26) | 5.0 (22) |
| 92-501-JK1 | 5.6 (40) | 5.2 (32) | 5.4 (39) | 5.8 (18) | 4.7 (31) |
| 92-503-JK1 | 5.6 (40) | 5.2 (32) | 5.6 (37) | 5.4 (37) | 5.0 (23) |
| Topgun | 5.6 (41) | 4.8 (43) | 5.2 (44) | 5.5 (35) | 6.0 (9) |
| Texoka | 4.4 (48) | 4.8 (42) | 4.6 (48) | 4.8 (47) | 4.7 (34) |
| LSD (.05) | 0.7 | 1.0 | 0.7 | 0.6 | 1.0 |

† rank of the selection is noted in parentheses.

Table 6. Quality, color, and dormancy rating for vegetative and seeded entries in the 1993 replicated evaluation trial.

| Selection | Quality Avg. | Quality 1995† | Quality 1994† | Color Avg. 1994-95† | Greenup 5/1994† | Dormancy 10/20/94† |
|---|---|---|---|---|---|---|
| **Vegetative** | | | | | | |
| 92-135 | 6.6 (1) | 7.3 (1) | 6.0 (13) | 7.0 (5) | 5.7 (4) | 2.0 (70) |
| 92-116 | 6.5 (2) | 7.0 (3) | 6.1 (9) | 7.0 (4) | 4.3 (12) | 2.0 (69) |
| 315 | 6.4 (3) | 6.0 (21) | 6.7 (1) | 6.7 (10) | 6.3 (1) | 2.7 (60) |
| 92-134 | 6.4 (4) | 6.2 (17) | 6.5 (2) | 6.1 (38) | 5.7 (3) | 3.7 (38) |
| 91-118 | 6.3 (6) | 6.3 (10) | 6.3 (4) | 6.1 (36) | 4.0 (20) | 5.3 (7) |
| 92-103 | 6.1 (10) | 6.6 (5) | 5.8 (18) | 7.2 (1) | 4.0 (21) | 3.0 (53) |
| 378 | 5.3 (50) | 6.2 (13) | 4.5 (67) | 6.8 (7) | 6.3 (2) | 3.0 (52) |
| 609 | 3.5 (72) | 3.3 (72) | 3.6 (72) | 5.5 (58) | 1.0 (71) | 7.7 (2) |
| **Seeded** | | | | | | |
| 90-504-JK | 6.3 (5) | 6.6 (4) | 6.1 (7) | 6.5 (19) | 3.7 (32) | 3.3 (45) |
| 90-503-JK | 6.1 (11) | 6.1 (20) | 6.1 (8) | 6.7 (8) | 3.3 (44) | 4.0 (23) |
| 93-531-pra‡ | 5.7 (29) | 6.2 (19) | 5.3 (44) | 6.5 (17) | 3.7 (40) | 4.7 (12) |
| 93-532-609§ | 4.2 (70) | 4.3 (66) | 4.2 (70) | 6.1 (40) | 2.7 (64) | 6.0 (5) |
| 93-530-378¶ | 5.6 (34) | 6.2 (18) | 5.2 (49) | 6.7 (13) | 4.0 (29) | 3.3 (50) |
| 93-536-217# | 5.7 (31) | 5.7 (40) | 5.7 (27) | 6.7 (13) | 3.7 (41) | 3.3 (51) |
| Bison | 5.1 (56) | 5.1 (55) | 5.0 (56) | 6.7 (15) | 2.7 (65) | 5.4 (8) |
| Texoka | 4.9 (62) | 4.7 (63) | 5.1 (55) | 5.8 (50) | 3.0 (60) | 4.7 (20) |
| Prairie | 4.0 (71) | 4.1 (70) | 3.9 (71) | 5.3 (67) | 1.0 (74) | 7.0 (4) |
| LSD (.05) | 0.9 | 1.2 | 0.9 | 0.9 | 1.2 | 1.0 |

† rank of the selection is noted in parentheses.

‡ Seed from a crossing block, maternal line is 'Prairie'

§ Seed from a crossing block, maternal line is '609'

¶ Seed from a crossing block, maternal line is '378'

# Seed from a crossing block, maternal line is 85-217

Table 7. Coverage, quality, and uniformity ratings for vegetative and seeded entries in the 1995 replicated evaluation trial.

| Selection | Cover† 8/17/95‡ | Quality 8/23/95‡ | Uniformity§ 9/95‡ |
|---|---|---|---|
| **Vegetative** | | | |
| 94-88 | 7.7 (5) | 7.7 (1) | 7.7 (11) |
| 94-113 | 7.0 (9) | 6.7 (2) | 7.0 (16) |
| 86-61 | 6.3 (15) | 6.3 (4) | 7.0 (14) |
| 94-79 | 7.3 (7) | 5.7 (26) | 8.0 (6) |
| 94-38 | 7.7 (4) | 5.7 (21) | 8.0 (5) |
| 91-118 | 6.7 (13) | 5.3 (32) | 7.7 (8) |
| 315 | 6.0 (20) | 6.0 (10) | 5.7 (43) |
| 378 | 4.7 (56 | 4.7 (49) | 5.0 (53) |
| **Seeded** | | | |
| 93-540-mb | 8.7 (1) | 6.0 (11) | 9.0 (1) |
| 93-541-mb | 8.3 (2) | 5.7 (20) | 9.0 (2) |
| 93-538-mb | 8.0 (3) | 5.0 (44) | 8.3 (3) |
| Cody (NTG-6) | 7.0 (12) | 4.3 (56) | 8.0 (7) |
| Texoka | 7.7 (6) | 4.0 (60) | 7.7 (12) |
| Tatanka (NTG-1) | 5.7 (40) | 3.7 (62) | 7.0 (19) |
| LSD (.05) | 1.3 | 1.5 | 1.3 |

† Amount of plot covered rated: 1= no plants to 9= fully covered

‡ rank of the selection is noted in parentheses.

§ Uniformity of the turf over the plot area: 1= clumps and bare soil to 9= smooth and uniform turf.

Table 8. Cycle 1 seed size data for NE-501 and NE-503.

| | mg/100 caryopses | | | | |
|---|---|---|---|---|---|
| | mean | Range | sd | Bur Yld[1] | Qual Avg[2] |
| NE-501 | | | | | |
| Large | 152.2 | 108.1 - 213.4 | 20.6 | 41.2 | 4.6 |
| Unsel | 146.9 | 103.0 - 187.6 | 20.7 | 46.3 | 4.7 |
| Small | 140.7 | 82.6 - 180.7 | 22.0 | 24.2 | 4.1 |
| NE-503 | | | | | |
| Large | 178.7 | 125.0 - 229.6 | 22.6 | 41.2 | 4.7 |
| Unsel | 159.0 | 117.8 - 209.4 | 20.5 | 33.9 | 4.5 |
| Small | 144.1 | 61.5 - 191.7 | 23.1 | 24.7 | 4.2 |

[1] Grams per square meter

[2] 1 - 9 best quality