CHAPTER 2

Turf-type Buffalograss Management

ABSTRACT

Buffalograss is a turfgrass species that has reduced irrigation and fertilization requirements. Interest in reducing the amount of chemicals and water applied to turfgrass have resulted in increased efforts to improve buffalograss as a turfgrass. As interest in using the new turf-type buffalograss cultivars has increased, the need for nitrogen rate and mowing height recommendations supported by research have become necessary. 'Cody', 'Texoka', 378, and experimental selection NE 91-118 were planted at sites located in Nebraska, Kansas, and Utah to determine nitrogen rate and mowing height effects on buffalograss quality, color, density, and clipping weights.

There were significant cultivar x nitrogen rate interactions at all sites for quality, color, and density that revealed differences in cultivar response to nitrogen rates at the different sites. Regardless of cultivar, there were significant nitrogen rate x year interactions at all sites. The nitrogen rate x year interactions revealed that the 98 kg N ha^{-1} rate sustained quality, color, and density over the 3 yr period, while lower nitrogen rates had decreased quality, color, and density over time.

Mowing height recommendations vary among the cultivars. For NE 91-118 the best mowing height was the 2.5 or 5.0 cm mowing height. Cultivar 378 performed well at all mowing heights and Cody and Texoka were best at the 5.0 or 7.5 cm mowing height.

LITERATURE REVIEW

Buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] is a warm season ,C_4, grass native to the subhumid and semiarid regions of the Great Plains (Beard, 1973). Exceptional drought tolerance and good heat resistance and cold tolerance enable buffalograss to be distributed across the Great Plains (Beard, 1973; Beetle, 1950; Savage, 1933; Wenger, 1943). The distribution of buffalograss ranges from central North Dakota and Montana to southern Texas; and from eastern Wyoming, Colorado, and New Mexico to the eastern border of South Dakota, Nebraska, Kansas, and Oklahoma (Beetle, 1950; Savage, 1934; Wenger, 1943).

Interest in buffalograss as a turfgrass is due to exceptional drought tolerance and characterization as a minimal maintenance turfgrass with reduced irrigation, fertilization, and mowing requirements (Pozarnsky, 1983; Riordan, 1991; Wu and Harivandi, 1989). Interest in water conservation and reducing chemical inputs have stimulated breeding efforts to develop turf-type buffalograss cultivars (Riordan, 1991). The new turf-type buffalograsses have been used on home lawns, golf courses, around public buildings, and for erosion control along highways (Cline, 1994; Falkenberg-Borland and Butler, 1982; Fry, 1995; Wu and Harivandi, 1989).

Buffalograss has a prostrate growth habit and spreads by stolons (Beetle, 1950). Buffalograss is a dioecious species with male and female inflorescence on separate plants (Wenger, 1943). The staminate inflorescence extends several cm above the leaf canopy while the pistillate inflorescence, in the

form of burs, is concealed within the turfgrass canopy (Wenger, 1943). Turfgrass composed exclusively of female buffalograss plants is sometimes preferred over male buffalograss because the brown staminate inflorescence detracts from the uniformity and green appearance of the turfgrass (Savage, 1933; Wenger, 1943).

Some of the characteristics that contribute to the exceptional drought tolerance of buffalograss are a prostrate growth habit, finely branched root system, leaf curling and the ability to enter quiescence when water is limited (Savage and Jacobson, 1935). Comparisons among warm season turfgrasses have shown buffalograss to have a low evapotranspiration rate which is attributed to pubescent leaves, low leaf area, and narrow leaves (Kim and Beard, 1988).

Optimum precipitation for buffalograss ranges from 31 to 64 cm, and 2000 m is the reported maximum altitude where buffalograss is found naturally (Beetle, 1950; Savage 1934). Buffalograss is not shade tolerant (Beard, 1973) and does not compete with taller grasses that are favored when annual precipitation exceeds 50 cm (Beetle, 1950; Wenger, 1943). During dry years, the drought resistance of buffalograss provides a competitive advantage over taller grasses, resulting in a fluctuating eastern boundary of distribution. Buffalograss is adapted to finer textured soils and does not grow well on sandy soil sites (Beetle, 1950; Savage 1934; Wenger 1943).

Buffalograss has been referred to in numerous extension and trade publications as a low maintenance turfgrass that has reduced irrigation, nitrogen, and mowing requirements and few disease and insect pests (Pozarnsky, 1983;

Leuthold et al., 1991; Riordan, 1991; Wu et al., 1991) but scientific research to support these claims is generally lacking. Current management recommendations appear to be based on observation and not scientific research. Extension bulletins suggest the desired use and quality of buffalograss determines the choice of mowing height and frequency. Current mowing height recommendations for buffalograss are between 5 and 10 cm (deShazer et al., 1992).

Research on buffalograss response to nitrogen fertilization reported no increases in seed or forage yields (Wenger, 1943). Wenger wrote with respect to buffalograss that, "the use of fertilizers in western Kansas is a waste of time and money." Recent research on turf-type buffalograss has indicated that moderate levels of nitrogen fertilization improve buffalograss growth, quality, color, and density (Falkenberg-Borland and Butler, 1982). Current recommendations are to fertilize buffalograss in the range of 0 to 98 kg N ha^{-1} $year^{-1}$ (deShazer et al., 1991; Leuthold et al., 1991; Riordan, 1991). It has been reported that excessive or frequent fertilizer applications should be avoided because they encourage weed interference and have little, if any, positive effect on buffalograss quality (deShazer et al., 1991; Harivandi and Wu, 1995; Leuthold et al., 1991; Riordan, 1991).

Although general buffalograss management recommendations pertaining to fertilization and mowing are available, research on turf-type buffalograss management is lacking. The research objectives were to determine nitrogen rate

and mowing height effects on buffalograss quality, color, density, and clipping weights.

MATERIALS AND METHODS

Two vegetatively established cultivars, '378' and experimental selection NE 91-118, and two seeded cultivars, 'Cody' and 'Texoka', were planted at three sites in 1995. The three sites were the John Seaton Anderson Turfgrass and Ornamental Research Facility located at the University of Nebraska Agricultural Research and Development Center near Mead, the Kansas State University Rocky Ford Turfgrass Research Center at Manhattan, and the Utah State University Greenville Research Farm at Logan. The soil types at the Nebraska, Kansas, and Utah sites were a Tomek silty clay loam (fine montmorillonitic, mesic Typic Argiudoll), a Chase silt loam (fine, montmorillonitic, messic, Aquic, Arquicolls), and a Millville silt loam (coarse-silty, carbonatic, mesic Typic Haploxepolls), respectively.

Experimental selection NE 91-118 and cultivar 378 were planted on 30 cm centers and Cody and Texoka were seeded at 98 kg burrs ha^{-1}. Cody and Texoka were seeded with a drop spreader and incorporated into the soil to a depth of approximately 1 cm using a leaf rake. After the seeding and planting of vegetative plugs, a cultipacker was rolled over the plots to facilitate plug and seed to soil contact. Starter fertilizer (19N-26P-5K) was applied at 49 kg N ha^{-1} and simazine (6-chloro-N, N'-diethyl-1,3,5-triazine-2,4-diamine) was applied at 1.12 kg a.i. ha^{-1} at planting. At four weeks after planting (WAP) sulfur coated urea fertilizer (25N-0P-10K) was applied at 49 kg N ha^{-1} and at 8 WAP urea (46N-0P-0K) was applied at 24 kg N ha^{-1}. Plots were mowed periodically at 6.4

cm and irrigation was applied as necessary to maintain a moist seedbed during establishment.

Buffalograss was successfully established at the Nebraska and Kansas sites in 1995. At the Utah site, 378 and NE 91-118 failed to cover the plots in 1995 but the seeded cultivars were successfully established. The transport of plugs to Utah, which included washing of soil from the plugs, was believed to be a factor slowing establishment. Due to negligible survival of the 378 cultivar at the Utah site, the decision was made to abandon 378 at the Utah site and concentrate on completing establishment of NE 91-118. Additional NE 91-118 plant material was transported to the Utah site and planted in May of 1996. By the end of the 1996 growing season the NE 91-118 plots had at least 70% buffalograss cover.

Preemergence herbicides were applied each year from 1996 to 1998. At the Nebraska and Kansas sites, pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl-2,6-dintrobenzenamine] was applied in 1996 and dithiopyr [S,S-dimethyl 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-3,5-pyridinedicarbothioate] was applied in 1997 and 1998. At the Utah site simazine was applied at 1.12 kg a.i. ha^{-1} in May 1996. In 1997 and 1998, pendimethalin was applied at the Utah site for preemergence weed control. In 1996 mowing heights and nitrogen treatments were initiated. The mowing heights were 2.5, 5.0, and 7.5 cm. Plots were mowed weekly and clippings removed. Nitrogen was applied in two equal applications with the first application in early June and the second application in mid-July, 6 wk after the first application. A polymer coat fertilizer (36N-1P-6K)

was used to apply total nitrogen amounts of 24, 49, 98, and 195 kg N ha^{-1} $year^{-1}$. In addition an untreated control was investigated. Immediately after fertilizer applications, plots were irrigated with 1.3 cm water. After adjusting for precipitation, at each site 5.0 cm of water was applied every 2 wk throughout the research.

Turfgrass quality, color, and density were rated visually on a scale of 1-9. The rating scale for quality was 1 is poor, 9 is excellent, and 6 is acceptable. The rating scale for density was 1 is lowest and 9 is highest density. The rating scale for color was 1 is straw brown, 9 is dark green, and 6 is acceptable. Ratings were taken every 2 wk starting 2 wk after the first nitrogen application and continued until 6 wk after the second nitrogen application. Clippings were harvested 4 wk after each fertilizer treatment, dried at 60° C for 48 h and weighed.

Experimental design for each site was a randomized complete block design and treatment design was a split-split-plot design. Main plot was buffalograss cultivar, split plot was mowing height, and split-split plot was nitrogen rate. Initial statistical analysis indicated sites were involved in interactions, therefore analyses were conducted separately by site. Treatment differences were tested using Proc Mixed statistical anlysis (SAS Institute Inc., 1997). When appropriate, means were separated using Fisher's LSD procedure.

RESULTS AND DISCUSSION

Quality – Cultivar x Nitrogen Rate Interaction

Nebraska site

There were significant cultivar x nitrogen rate interactions in each year from 1996 to 1998 (Table 2.1). At four weeks after the second nitrogen application in 1996, cultivar 378 had the best quality when no nitrogen was applied (Table 2.2). There were no differences in quality among NE 91-118, 378, or Cody when nitrogen was applied. Cultivar 378 had acceptable quality at all nitrogen rates ,including the untreated control, while NE 91-118 and Cody required 49 kg N ha^{-1} for acceptable quality. Texoka never had acceptable quality at any nitrogen rate.

Four weeks after the second nitrogen application in 1997, Cody, 378, and NE 91-118 had the best quality when no nitrogen was applied (Table 2.3). There were no differences in quality among the cultivars at the 24, 49, and 98 kg N ha^{-1} rates but at the 195 kg N ha^{-1} rate, NE 91-118, 378, and Cody had the best quality. For NE 91-118, 378, and Cody, 98 kg N ha^{-1} were required for acceptable quality. Texoka required 195 kg N ha^{-1} for acceptable quality.

Four weeks after the second nitrogen application in 1998, cultivar 378 and Cody had the best quality when no nitrogen was applied but the quality rating for 378 had decreased from 6.1 in 1996 to 4.0 in 1998 (Table 2.4). Experimental selection NE 91-118 and 378 had the best quality at the 98 and 195 kg N ha^{-1} rates. All cultivars except Texoka had acceptable quality at the 98 kg N ha^{-1} rate. As in 1997, Texoka required 195 kg N ha^{-1} for acceptable quality.

Table 2.1 Analysis of variance table for buffalograss quality at the Nebraska site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 4WAT	1997 4WAT(2nd)	1998 4WAT	1998 4WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	3	**	**	*	NS	*	NS
W.P. Error	6						
Mowing height	2	**	**	**	*	**	**
Cult. x Mow	6	**	*	*	**	*	**
S.P. Error	16						
N rate	4	**	**	**	**	**	**
Cult. x N	12	NS	**	**	*	**	**
Mow x N	8	NS	**	NS	NS	NS	**
Cult. x Mow x N	24	NS	NS	NS	NS	NS	NS
Error	48						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
*, **, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.2 Mean buffalograss quality for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Nebraska site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss quality†				
NE 91-118	5.7	5.9	6.1	6.2	6.4
378	6.1	6.1	6.2	6.2	6.3
Cody	5.7	5.9	5.9	6.1	6.2
Texoka	5.6	5.5	5.5	5.7	5.9

LSD within cultivar is 0.2
LSD within N rate is 0.3
LSD for the cultivar x nitrogen rate interaction is 0.3
† Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

Table 2.3 Mean buffalograss quality for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 at the Nebraska site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss quality[†]				
NE 91-118	4.5	5.4	5.8	6.4	7.0
378	5.0	5.6	5.9	6.4	6.7
Cody	4.8	5.5	5.7	6.2	6.6
Texoka	4.1	5.4	5.6	5.9	6.4

LSD within cultivar is 0.4
LSD within N rate is 0.5
LSD for the cultivar x nitrogen rate interaction is 0.5
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

Table 2.4 Mean buffalograss quality for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1998 at the Nebraska site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss quality[†]				
NE 91-118	3.0	4.3	5.3	6.4	7.7
378	4.0	4.9	5.8	6.8	7.4
Cody	3.4	4.6	5.1	6.1	7.1
Texoka	3.3	4.2	4.9	5.7	6.7

LSD within cultivar is 0.4
LSD within N rate is 0.6
LSD for the cultivar x nitrogen rate interaction is 0.6
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

There was a significant linear effect for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 and 1998. Experimental selection NE 91-118 had the steepest slope among the cultivars, thereby indicating the greatest increase in quality from the 0 to 195 kg N ha^{-1} rate (Figures 2.1 and 2.2). In 1996, Texoka and 378 had small increases in quality as nitrogen rate increased. Experimental selection NE 91-118 had an increase of 0.7 quality units from 0 to 195 kg N ha^{-1}, while 378 and Texoka had an increase of 0.3 quality units. Texoka had no differences in quality among the 0 to 98 kg N ha^{-1} rates. Cody's quality response as nitrogen rate increased was intermediate among the cultivars. In 1998, there was relatively no difference in the quality response to nitrogen rate among 378, Cody, and Texoka but the slopes for the cultivars had increased from 1996 which indicates a greater quality response to nitrogen applications (Figure 2.2). Experimental selection NE 91-118 had the greatest improvement in quality as nitrogen rate increased.

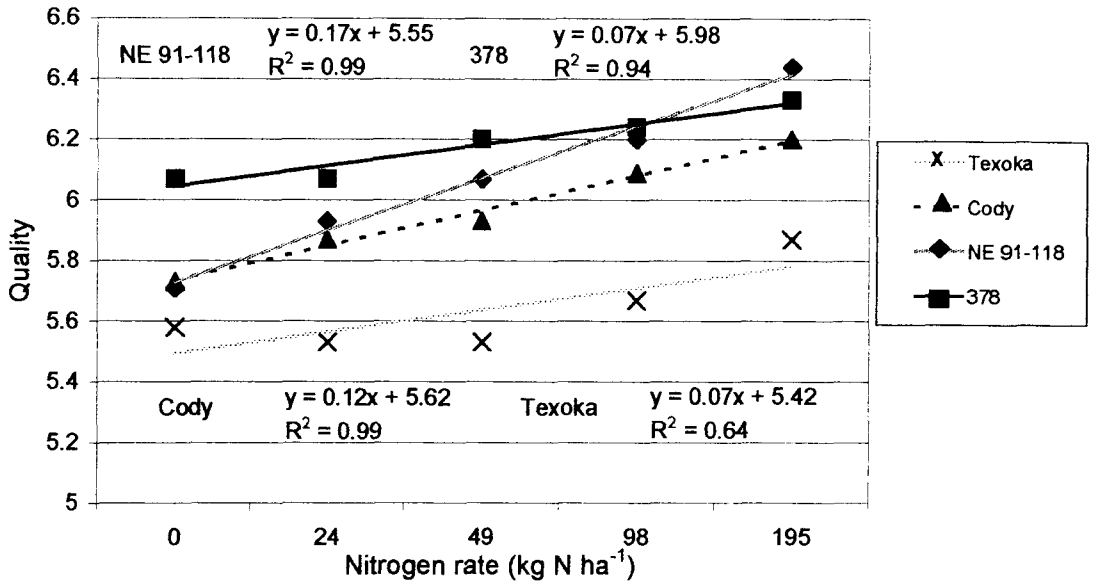

Figure 2.1. Buffalograss quality for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Nebraska site.

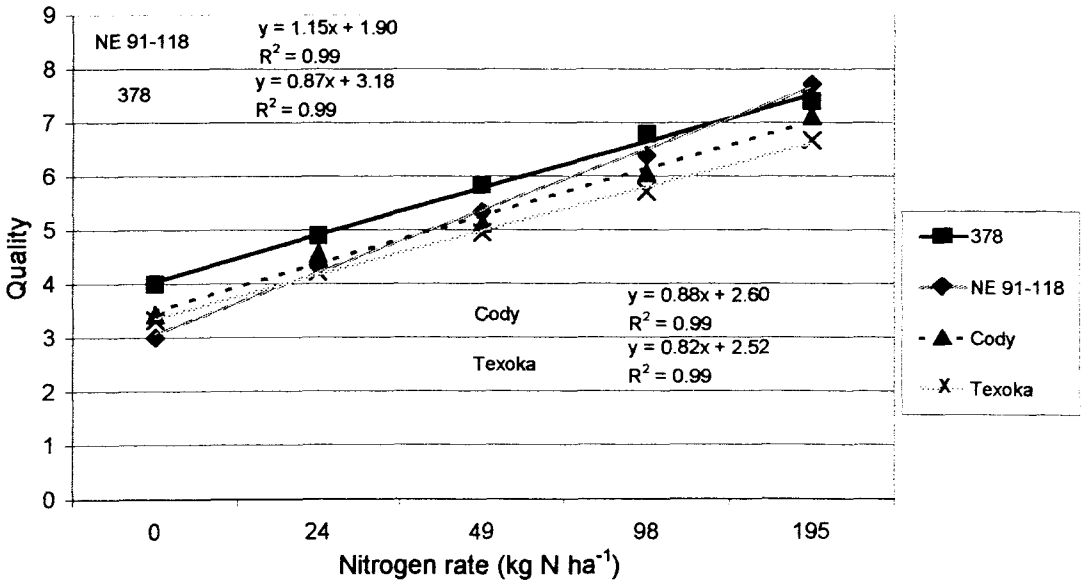

Figure 2.2. Buffalograss quality for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1998 at the Nebraska site.

Kansas site

There was a significant cultivar x nitrogen rate interaction in 1997 (Table 2.5). At four weeks after the second nitrogen application, NE 91-118 and Cody had the best quality when no nitrogen was applied (Table 2.6). There were no significant differences in quality among the cultivars at the 49, 98, and 195 kg N ha^{-1} rates. Within cultivars, there were no significant differences in quality between the 98 and 195 kg N ha^{-1} rates. Experimental selection NE 91-118 had acceptable quality at the 49 kg N ha^{-1} rate but all other cultivars required 98 kg N ha^{-1} for acceptable quality.

There was a significant linear effect for the cultivar x nitrogen rate interaction. The linear effect for the cultivar x nitrogen rate interaction at the Kansas site was different than at the Nebraska site. Texoka and 378 had the greatest increase in quality from the 0 to 195 kg N ha^{-1} rate, and NE 91-118 had the smallest increase in quality (Figure 2.3). Texoka and 378 had an increase of 2.3 and 2.1 quality units, respectively. NE 91-118 had an increase of 1.2 quality units from 0 to 195 kg N ha^{-1}. Similar to the Nebraska site, Cody's increase in quality as nitrogen rate increased was intermediate among the cultivars.

Table 2.5 Analysis of variance table for buffalograss quality at the Kansas site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 2WAT§	1997 4WAT(2nd)	1998 4WAT	1998 4WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	3	*	**	**	NS	NS	NS
W.P. Error	6						
Mowing height	2	*	*	NS	NS	NS	**
Cult. x Mow	6	NS	NS	NS	*	*	*
S.P. Error	16						
N rate	4	NS	**	**	**	**	**
Cult. x N	12	NS	NS	*	**	NS	NS
Mow x N	8	NS	NS	NS	NS	NS	*
Cult. x Mow x N	24	NS	NS	NS	NS	NS	NS
Error	48						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
§ 2WAT = Two weeks after the first nitrogen application
*,**, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.6 Mean buffalograss quality for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 at the Kansas site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss quality[†]				
NE 91-118	5.3	5.6	6.0	6.4	6.6
378	4.5	5.3	5.6	6.4	6.6
Cody	4.7	5.4	5.7	6.2	6.4
Texoka	3.9	4.8	5.4	6.0	6.2

LSD within cultivar is 0.3
LSD within N rate is 0.6
LSD for the cultivar x nitrogen rate interaction is 0.6
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

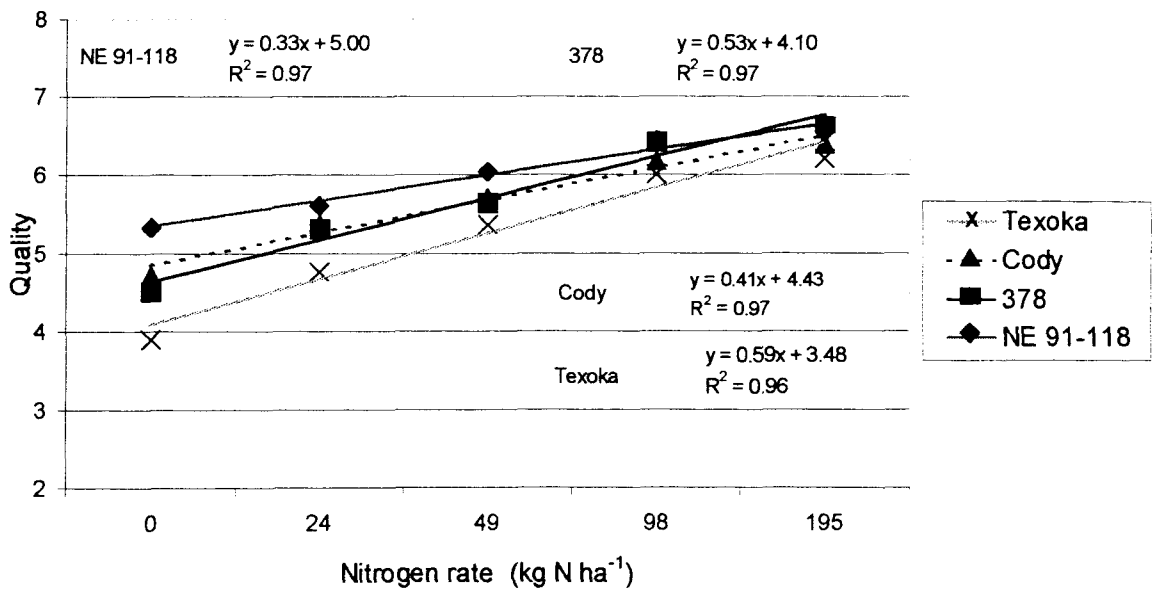

Figure 2.3. Buffalograss quality for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 at the Kansas site.

Utah site

The cultivar x nitrogen rate interaction was significant at four weeks after the second nitrogen application in 1996 (Table 2.7). Experimental selection NE 91-118 had the best quality when no nitrogen was applied (Table 2.8). Cody and NE 91-118 had the best quality at the 24 and 195 kg N ha^{-1} rates, and there were no differences in quality among the cultivars at the 49 and 98 kg N ha^{-1} rates. NE 91-118 and Cody had acceptable quality at the 98 kg N ha^{-1} rate but Texoka required 195 kg N ha^{-1} for acceptable quality.

The linear effect for the cultivar x nitrogen rate interaction at the Utah site was different than the linear effect at the Nebraska and Kansas sites. Cody had the greatest while NE 91-118 had the smallest increase in quality from the 0 to 195 kg N ha^{-1} rates (Figure 2.4). Texoka was intermediate between Cody and NE 91-118.

Discussion of the linear effect for the cultivar x nitrogen rate interaction

The linear effect for the cultivar x nitrogen rate interaction was different among sites. Among cultivars at the Nebraska site, NE 91-118 had the greatest quality response as nitrogen rate increased but at the Kansas and Utah sites NE 91-118 had the smallest quality response. Although the response of NE 91-118 to nitrogen rates was different at the sites, at the Nebraska and Utah sites in 1996 the slope of the line for NE 91-118 was the same. This indicates that at the Nebraska and Utah sites, Cody and Texoka differ in their response to nitrogen rates and not NE 91-118. At the Kansas site in 1997, NE 91-118 had the greatest increase in quality as nitrogen rate increased. It is difficult to

Table 2.7 Analysis of variance table for buffalograss quality at the Utah site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 4WAT	1997 4WAT(2nd)	1998 2WAT§	1998 2WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	2	*	NS	*	*	NS	NS
W.P. Error	4						
Mowing height	2	*	**	**	**	*	NS
Cult. x Mow	4	*	**	*	**	NS	NS
S.P. Error	12						
N rate	4	**	**	**	**	**	**
Cult. x N	8	NS	**	NS	NS	NS	NS
Mow x N	8	NS	NS	NS	NS	NS	NS
Cult. x Mow x N	16	NS	NS	NS	NS	NS	NS
Error	36						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
§ 2WAT = Two weeks after the first nitrogen application
*,**, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.8 Mean buffalograss quality for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Utah site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss quality†				
NE 91-118	5.5	5.6	5.8	6.0	6.1
Cody	4.9	5.4	5.5	6.0	6.3
Texoka	4.9	5.1	5.4	5.6	5.8

LSD within cultivar is 0.2
LSD within N rate is 0.4
LSD for the cultivar x nitrogen rate interaction is 0.4
† Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

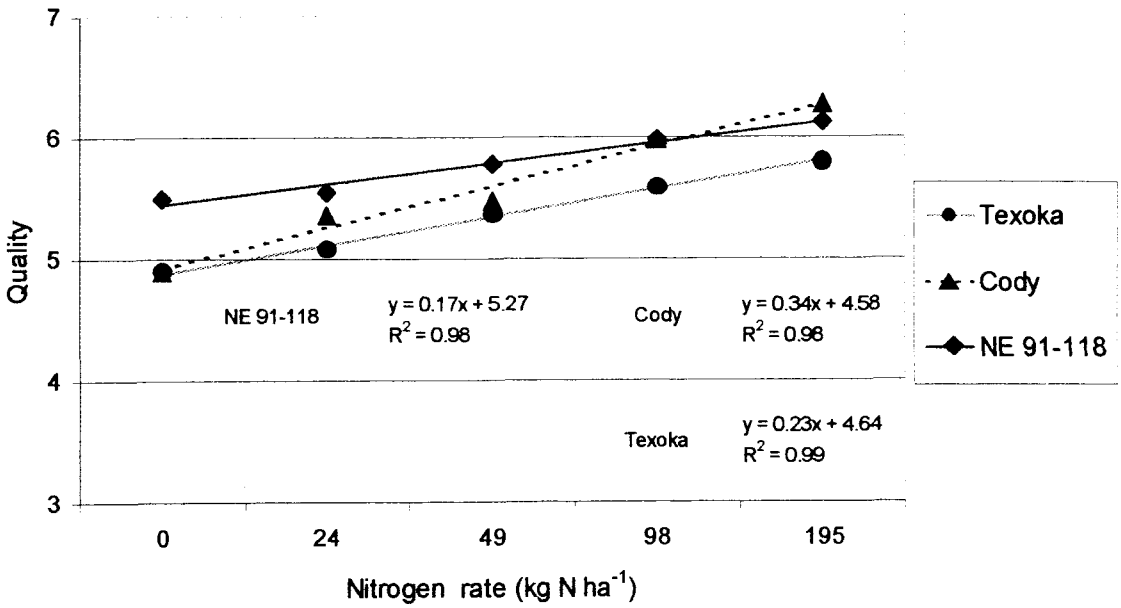

Figure 2.4. Buffalograss quality for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Utah site.

ascertain the factors responsible for the difference among cultivars quality response to increasing nitrogen rates among the sites. The cultivar x nitrogen rate interaction was not significant at all sites throughout 1996 to 1998, therefore direct comparisons among sites are limited. Furthermore, environmental conditions and soil characteristics at the sites may favor one cultivar over another. Identification of the factors that are the primary determinants of quality at the sites is beyond the scope of this research. However, it should be recognized that the cultivars quality response did differ among sites and could potentially influence management recommendations.

Although the linear effect for the cultivar x nitrogen rate interaction differed among sites, the overall quality response of the cultivars to nitrogen rates was similar. As nitrogen rate increased, quality improved for all cultivars and acceptable quality for all cultivars, except Texoka, required 98 kg N ha^{-1}. The primary difference among the cultivars at the sites was at the low nitrogen rates where quality was often unacceptable. Therefore, nitrogen rate recommendations among sites will be similar.

Quality – Cultivar x Mowing Height Interaction

Nebraska site

The cultivar x mowing height interaction was significant in each year from 1996 to1998 (Table 2.1). The results of the interaction were similar in each year from 1996 to 1998 at four weeks after the second nitrogen application. From 1996 to 1998, NE 91-118, 378, and Cody had the best quality at the 2.5 cm mowing height (Tables 2.9, 2.10, and 2.11). In 1996 and 1998, NE 91-118, 378, and Cody had the best quality at the 5.0 cm mowing height. There were no differences in quality among the cultivars at the 5.0 cm mowing height in 1997. In 1996 and 1997, there were no differences in quality among cultivars at the 7.5 cm mowing height. Cody, Texoka, and 378 had the best quality at the 7.5 cm mowing height in 1998. The best quality for NE 91-118 was at the 5.0 cm mowing height in 1996 and at the 2.5 or 5.0 cm mowing height in 1997. There were no differences in quality among mowing heights for NE 91-118 in 1998. For 378 and Cody, the best quality was at the 5.0 or 7.5 cm mowing in 1996 and 1998 and there were no differences in quality among the mowing heights in 1997. For Texoka the best quality was at the 5.0 or 7.5 cm mowing heights.

Table 2.9 Mean buffalograss quality for the cultivar x mowing height interaction at four weeks after the second nitrogen application in 1996 at the Nebraska site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss quality[†]		
NE 91-118	5.8	6.4	6.0
378	6.0	6.3	6.2
Cody	5.7	6.1	6.2
Texoka	5.2	5.8	5.9

LSD within cultivar is 0.2
LSD within mowing height is 0.3
LSD for the cultivar x mowing height interaction is 0.3
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

Table 2.10 Mean buffalograss quality for the cultivar x mowing height interaction at four weeks after the second nitrogen application in 1997 at the Nebraska site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss quality[†]		
NE 91-118	6.0	6.1	5.5
378	6.0	6.0	5.8
Cody	5.9	5.7	5.7
Texoka	5.2	5.6	5.6

LSD within cultivar is 0.3
LSD within mowing height is 0.5
LSD for the cultivar x mowing height interaction is 0.5
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

Table 2.11 Mean buffalograss quality for the cultivar x mowing height interaction at four weeks after the second nitrogen application in 1998 at the Nebraska site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss quality[†]		
NE 91-118	5.4	5.6	5.1
378	5.4	6.1	5.9
Cody	4.8	5.5	5.5
Texoka	4.2	5.2	5.5

LSD within cultivar is 0.5
LSD within mowing height is 0.7
LSD for the cultivar x mowing height interaction is 0.7
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

Kansas site

The cultivar x mowing height interaction was significant at four weeks after the second nitrogen application in 1997 and 1998. In both years, NE 91-118, 378, and Cody had the best quality at the 2.5 cm mowing height (Tables 2.12 and 2.13). In 1997, NE 91-118, 378, and Cody had the best quality at the 5.0 cm mowing height and in 1998 NE 91-118 and 378 had the best quality at the 5.0 cm mowing height. Within each cultivar, quality at the different mowing heights was inconsistent between 1997 and 1998. For NE 91-118, the best quality in 1997 was at the 2.5 or 5.0 cm mowing height but in 1998 the best quality was at the 5.0 cm mowing height. For 378 and Cody, there were no differences in quality among the mowing heights in 1997 and 1998. For Texoka there were no differences in quality among mowing heights in 1997 but in 1998 the best quality was at the 5.0 or 7.5 cm mowing height.

Utah site

The cultivar x mowing height interaction was significant in 1996 and 1997. The results of the interaction at four weeks after the second nitrogen application in 1996 and 1997 were similar. NE 91-118 had the best quality at the 2.5 cm mowing height (Tables 2.14 and 2.15). In 1996 there were no differences in quality among the cultivars at the 5.0 cm mowing height, but in 1997, NE 91-118 and Cody had the best quality. There were no differences in quality among the cultivars at the 7.5 cm mowing height in 1996 and 1997. For NE 91-118, the best quality was at the 2.5 or 5.0 cm mowing height. In 1997 for Cody and Texoka, the best quality was at the 5.0 or 7.5 cm mowing height.

Table 2.12 Mean buffalograss quality for the cultivar x mowing height interaction at four weeks after the second nitrogen application in 1997 at the Kansas site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss quality[†]		
NE 91-118	6.2	6.1	5.7
378	5.8	5.8	5.5
Cody	5.6	5.8	5.6
Texoka	5.0	5.4	5.4

LSD within cultivar is 0.4
LSD within mowing height is 0.6
LSD for the cultivar x mowing height interaction is 0.6
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

Table 2.13 Mean buffalograss quality for the cultivar x mowing height interaction at four weeks after the second nitrogen application in 1998 at the Kansas site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss quality[†]		
NE 91-118	5.7	6.4	5.3
378	5.1	5.7	5.6
Cody	5.2	5.5	5.2
Texoka	4.5	5.0	5.3

LSD within cultivar is 0.6
LSD within mowing height is 0.7
LSD for the cultivar x mowing height interaction is 0.7
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

Table 2.14 Mean buffalograss quality for the cultivar x mowing height interaction at four weeks after the second nitrogen application in 1996 at the Utah site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss quality[†]		
NE 91-118	5.9	6.1	5.4
Cody	5.3	5.8	5.6
Texoka	5.0	5.7	5.3

LSD within cultivar is 0.3
LSD within mowing height is 0.4
LSD for the cultivar x mowing height interaction is 0.4
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

Table 2.15 Mean buffalograss quality for the cultivar x mowing height interaction at four weeks after the second nitrogen application in 1997 at the Utah site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss quality[†]		
NE 91-118	5.9	6.3	5.3
Cody	5.1	5.9	5.7
Texoka	4.5	5.5	5.5

LSD within cultivar is 0.4
LSD within mowing height is 0.5
LSD for the cultivar x mowing height interaction is 0.5
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

Quality – Nitrogen rate x Year Interaction

There was a significant nitrogen rate x year interaction at all sites. The quality response to nitrogen rates from 1996 to 1998 was similar at all sites. Quality declined from 1996 to 1998 for the 0, 24, and 49 kg N ha^{-1} rates (Tables 2.16, 2.17, and 2.18; Figures 2.5, 2.6, and 2.7). There were no differences in quality from 1996 to 1998 for the 98 kg N ha^{-1}. Quality improved from 1996 to 1998 at the 195 kg N ha^{-1} rate, but the year when quality improved was different at the sites. At the Nebraska site, quality improved each year from 1996 to 1998. At the Kansas site, quality improved from 1997 to 1998 and at the Utah site quality improved from 1996 to 1997. The 98 kg N ha^{-1} rate sustained turfgrass quality over three years, while lower nitrogen rates did not.

Table 2.16 Mean buffalograss quality for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Nebraska site.

	Year		
Nitrogen rate[†]	1996	1997	1998
— kg N ha^{-1} —	Buffalograss quality[†]		
0	5.8	4.6	3.4
24	5.9	5.5	4.5
49	5.9	5.7	5.3
98	6.1	6.2	6.2
195	6.2	6.7	7.2

LSD within nitrogen rate is 0.2
LSD within year is 0.2
LSD for the nitrogen rate x year interaction is 0.2
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

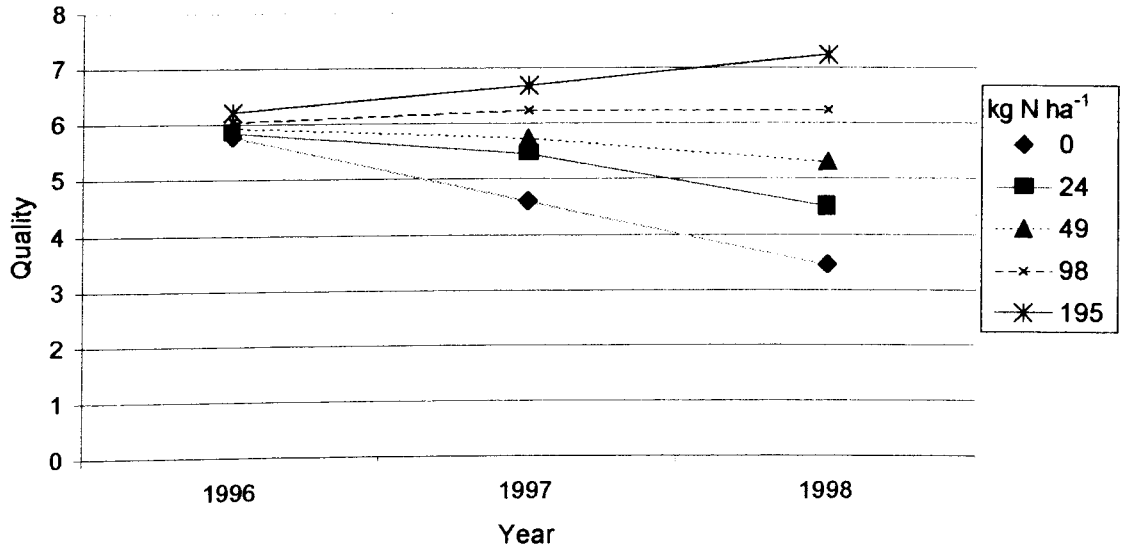

Figure 2.5. Buffalograss quality for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Nebraska site.

Table 2.17 Mean buffalograss quality for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Kansas site.

	Year		
Nitrogen rate	1996	1997	1998
— kg N ha^{-1} —	Buffalograss quality[†]		
0	6.2	4.6	3.6
24	6.2	5.3	4.7
49	6.2	5.7	5.2
98	6.2	6.3	6.2
195	6.3	6.4	7.2

LSD within nitrogen rate is 0.2
LSD within year is 0.2
LSD for the cultivar x nitrogen rate interaction is 0.2
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = excellent, and 6 = acceptable.

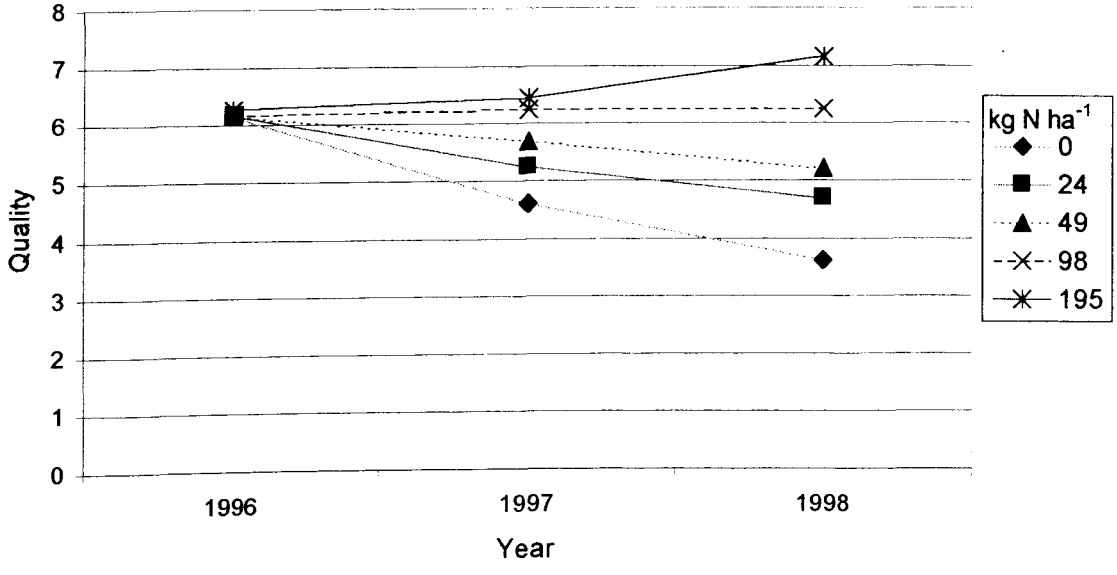

Figure 2.6. Buffalograss quality for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Kansas site.

Table 2.18 Mean buffalograss quality for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Utah site.

	Year		
Nitrogen rate	1996	1997	1998
— kg N ha^{-1} —	Buffalograss quality[†]		
0	5.1	4.4	2.7
24	5.3	4.8	3.7
49	5.5	5.5	4.7
98	5.8	6.1	5.9
195	6.1	6.9	7.1

LSD within nitrogen rate is 0.3
LSD within year is 0.3
LSD for the nitrogen rate x year interaction is 0.3
[†] Buffalograss quality was rated from 1 to 9, with 1 = poor, 9 = best, and 6 = acceptable.

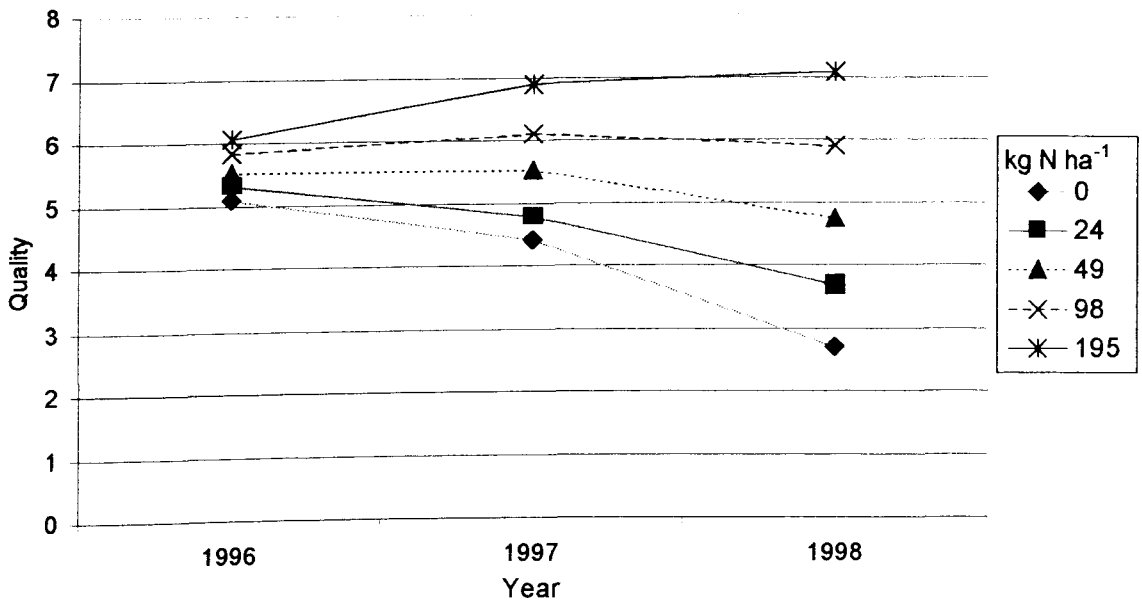

Figure 2.7. Buffalograss quality for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Utah site.

Color – Cultivar x Nitrogen Rate Interaction

Nebraska site

There was a significant cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 and at four weeks after the first nitrogen application in 1997 (Table 2.19). In 1996, 378 had the best color at all nitrogen rates except the 195 kg N ha^{-1} rate, where there were no differences in color among the culitvars (Table 2.20). In 1997, 378 had the best color at the 0, 24, 49, and 98 kg N ha^{-1} rates and there were no differences in color among NE 91-118, 378, and Cody at the 195 kg N ha^{-1} rate (Table 2.21). Within each cultivar the higher nitrogen rates had the best color.

There was a significant linear effect for the cultivar x nitrogen rate interaction indicating that the cultivars color response to the nitrogen rates was different. In 1996, NE 91-118 had the steepest slope indicating that it's color improved the most from the 0 to 195 kg N ha^{-1} rate (Figure 2.8). Cultivar 378 had a more gradual improvement in color and Cody and Texoka were intermediate between NE 91-118 and 378. In 1997, the slopes of NE 91-118, Cody, and Texoka were similar and had increased from the slopes of 1996 (Figure 2.9). Cultivar 378 still had the flattest slope indicating a more gradual improvement in color as nitrogen rate increased.

Table 2.19 Analysis of variance table for buffalograss color at the Nebraska site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 4WAT	1997 4WAT(2nd)	1998 4WAT	1998 4WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	3	NS	*	**	NS	*	NS
W.P. Error	6						
Mowing height	2	**	NS	**	**	NS	NS
Cult. x Mow	6	NS	NS	NS	NS	NS	NS
S.P. Error	16						
N rate	4	**	**	**	**	**	**
Cult. x N	12	NS	**	**	NS	NS	NS
Mow x N	8	NS	**	NS	NS	NS	NS
Cult. x Mow x N	24	NS	NS	NS	NS	NS	NS
Error	48						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
*, **, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.20 Mean buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Nebraska site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss Color†				
NE 91-118	5.5	5.8	6.0	6.1	6.5
378	6.1	6.2	6.3	6.4	6.6
Cody	5.8	5.9	6.0	6.1	6.5
Texoka	5.7	5.7	5.8	5.9	6.4

LSD within cultivar is 0.1
LSD within N rate is 0.2
LSD for the cultivar x nitrogen rate interaction is 0.2
† Buffalograss color was rated from 1 to 9, with 1 = straw brown, 9 = dark green, and 6 = acceptable.

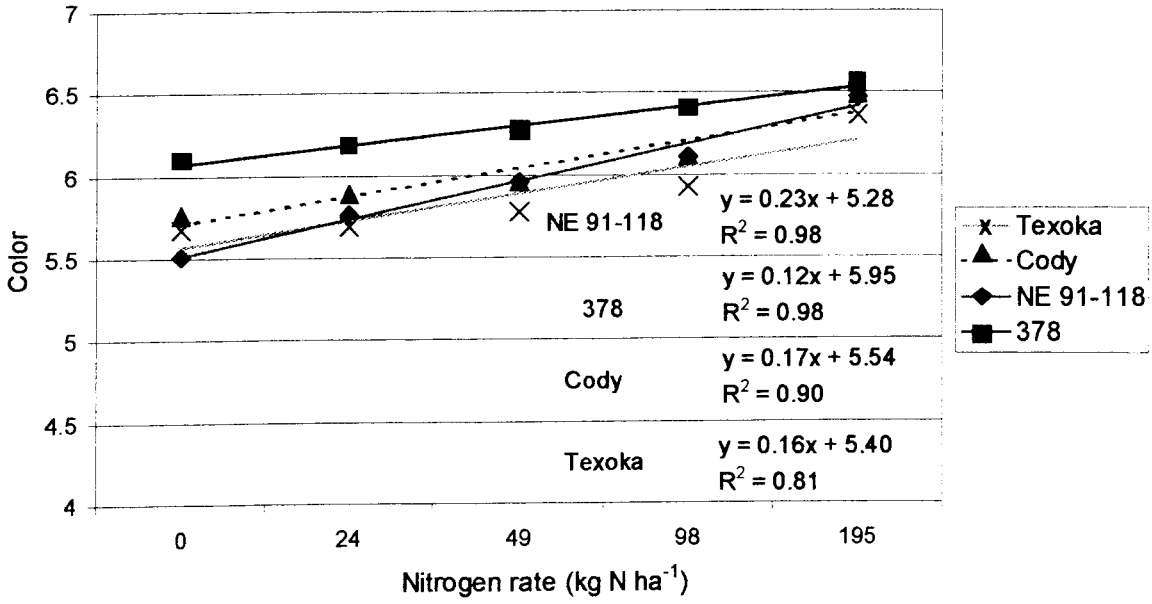

Figure 2.8. Buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Nebraska site.

Table 2.21 Mean buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the first nitrogen application in 1997 at the Nebraska site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss color†				
NE 91-118	4.7	5.2	5.5	6.0	6.6
378	5.7	5.9	6.0	6.4	6.8
Cody	4.8	5.2	5.5	6.0	6.5
Texoka	4.5	5.2	5.4	5.8	6.4

LSD within cultivar is 0.2
LSD within N rate is 0.3
LSD for the cultivar x nitrogen rate interaction is 0.3
† Buffalograss color was rated from 1 to 9, with 1 = straw brown, 9 = dark green, and 6 = acceptable.

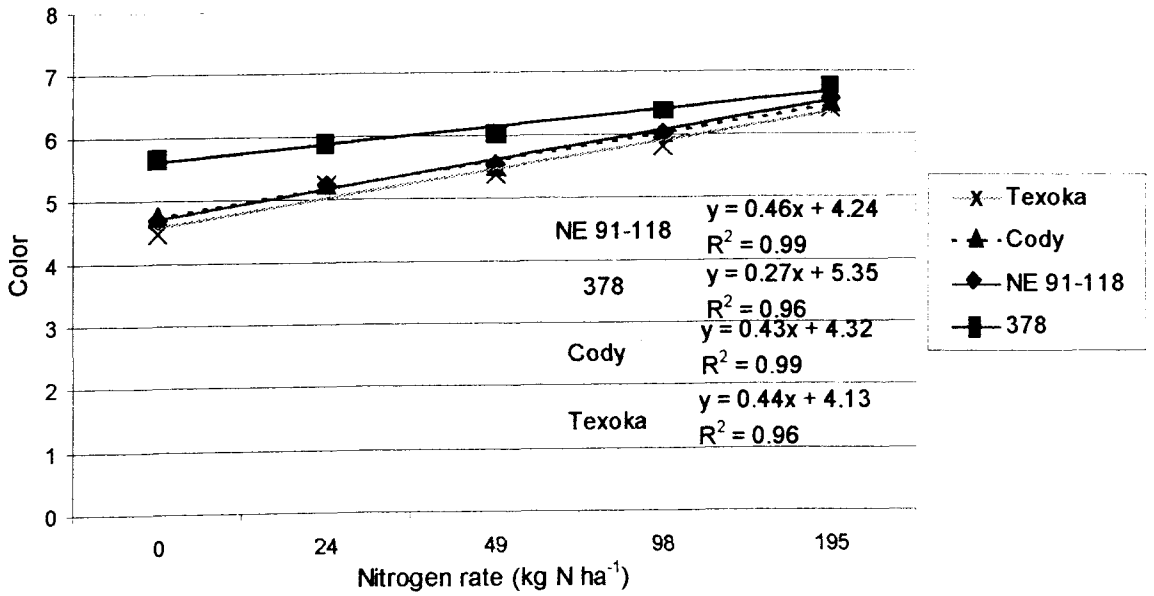

Figure 2.9. Buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the second nitrgoen application in 1997 at the Nebraska site.

Kansas site

There was a significant cultivar x nitrogen rate interaction at two weeks after the first nitrogen application in 1997 and at four weeks after the first and second nitrogen applications in 1998 (Table 2.22). In 1997, NE 91-118 and 378 had the best color when no nitrogen was applied and NE 91-118, 378, and Cody had the best color at the 24 kg N ha^{-1} rate (Table 2.23). There were no differences in color among cultivars at the 49, 98, and 195 kg N ha^{-1} rates (Table 2.23). In 1998, there were no differences in color among the cultivars for the 0, 24, 49, and 98 kg N ha^{-1} rates and 378 had the best color at the 195 kg N ha^{-1} rate (Table 2.24).

There was a significant linear effect for the cultivar x nitrogen rate interaction in 1997 and 1998. In 1997, NE 91-118 had the smallest and Texoka had the largest increase in color as nitrogen rate increased (Figure 2.10). In 1998, NE 91-118 once again had the smallest increase in color but 378 now had the largest increase in color as nitrogen rate increased (Figure 2.11). The steep slope of 378 in 1998 was attributed to the high color rating at the 195 kg N ha^{-1} rate.

Utah site

There were significant cultivar x nitrogen rate interactions throughout 1996 to 1998 (Table 2.25). At four weeks after the second nitrogen application in 1996, NE 91-118 had the best color when no nitrogen was applied (Table 2.26).

Table 2.22 Analysis of variance table for buffalograss color at the Kansas site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 2WAT§	1997 4WAT(2nd)	1998 4WAT	1998 4WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	3	NS	**	*	NS	NS	NS
W.P. Error	6						
Mowing height	2	NS	*	NS	**	**	**
Cult. x Mow	6	NS	NS	NS	NS	NS	NS
S.P. Error	16						
N rate	4	*	**	**	**	**	**
Cult. x N	12	NS	NS	**	**	*	**
Mow x N	8	NS	NS	NS	*	**	*
Cult. x Mow x N	24	NS	NS	NS	NS	NS	NS
Error	48						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
§ 2WAT = Two weeks after the first nitrogen application
*,**, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.23 Mean buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the first nitrogen application in 1997 at the Kansas site.

Cultivar	Nitrogen rate (kg N ha^{-1})				
	0	24	49	98	195
	Buffalograss color[†]				
NE 91-118	5.7	5.9	5.9	6.2	6.7
378	5.5	5.7	5.8	6.5	7.0
Cody	5.2	5.6	5.7	6.3	6.7
Texoka	4.8	5.3	5.6	6.3	6.7

LSD within cultivar is 0.2
LSD within N rate is 0.3
LSD for the cultivar x nitrogen rate interaction is 0.3
[†] Buffalograss color was rated from 1 to 9, with 1 = straw brown, 9 = dark green, and 6 = acceptable.

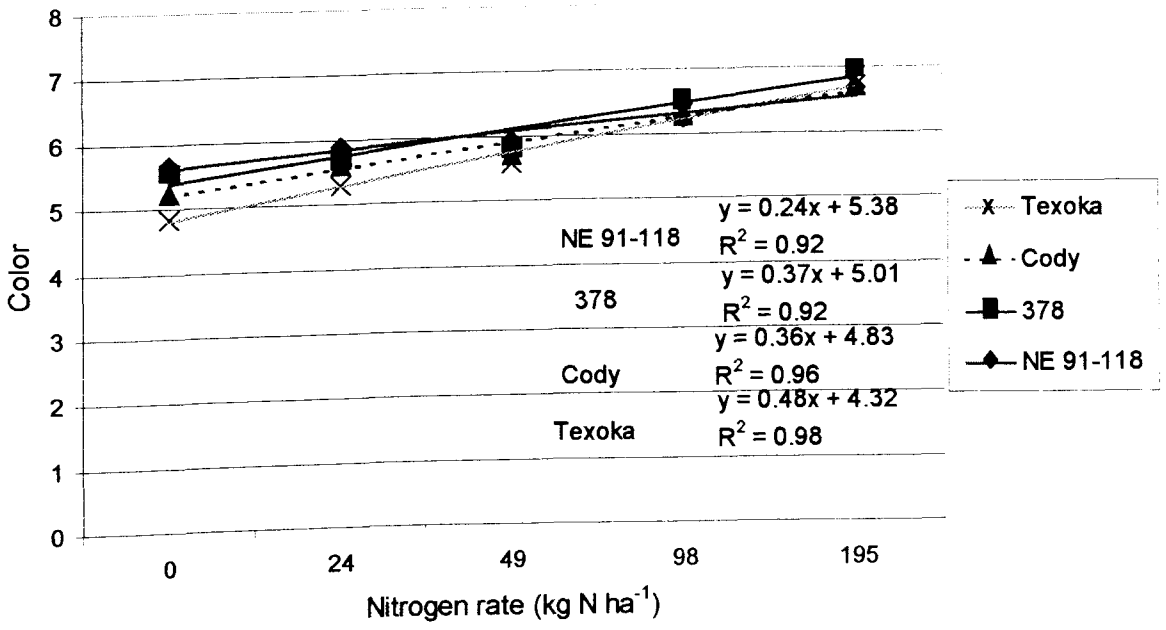

Figure 2.10. Buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 at the Kansas site.

Table 2.24 Mean buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1998 at the Kansas site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss color†				
NE 91-118	3.8	4.8	5.3	5.8	6.7
378	3.7	4.3	5.0	5.9	7.7
Cody	3.8	4.6	4.9	5.9	6.9
Texoka	3.6	4.4	4.8	5.6	6.9

LSD within cultivar is 0.4
LSD within N rate is 0.5
LSD for the cultivar by nitrogen rate interaction is 0.5
† Buffalograss color was rated from 1 to 9, with 1 = straw brown, 9 = dark green, and 6 = acceptable.

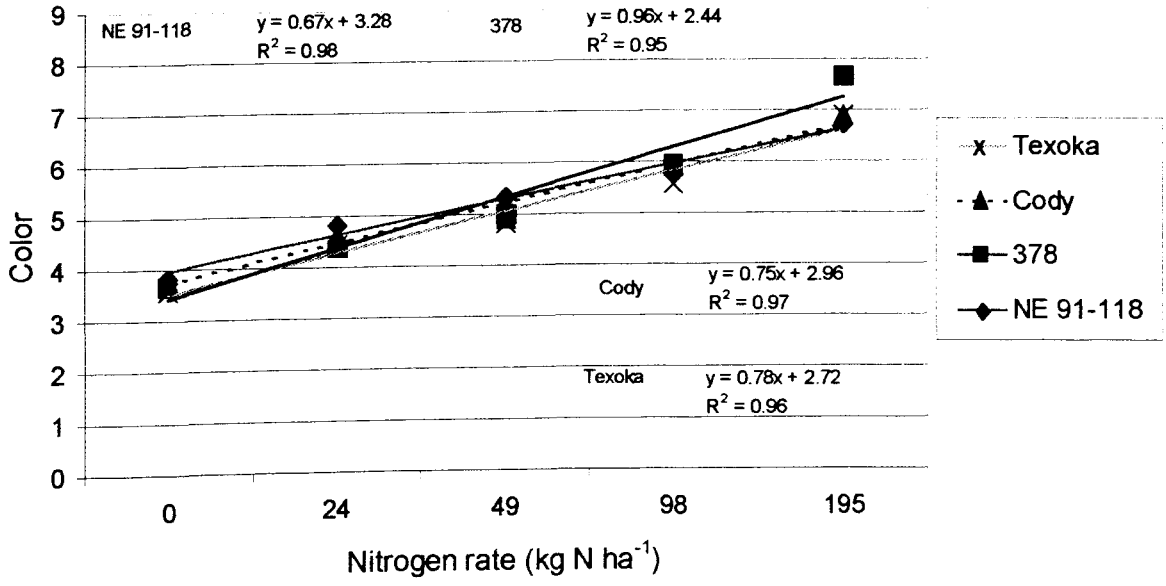

Figure 2.11. Buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1998 at the Kansas site.

Table 2.25 Analysis of variance table for buffalograss color at the Utah site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 4WAT	1997 4WAT(2nd)	1998 2WAT§	1998 2WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	2	NS	NS	NS	NS	NS	NS
W.P. Error	4						
Mowing height	2	*	*	*	NS	NS	NS
Cult. x Mow	4	NS	NS	NS	NS	NS	NS
S.P. Error	12						
N rate	4	**	**	**	**	**	**
Cult. x N	8	*	*	*	NS	NS	*
Mow x N	8	NS	NS	NS	*	NS	NS
Cult. x Mow x N	16	*	NS	*	NS	NS	NS
Error	36						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
§ 2WAT = Two weeks after the first nitrogen application
*,**, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.26 Mean buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Utah site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss color[†]				
NE 91-118	5.5	5.6	5.9	6.1	6.4
Cody	4.7	5.1	5.4	6.0	6.5
Texoka	4.8	5.1	5.4	5.8	6.2

LSD within cultivar is 0.3
LSD within N rate is 0.5
LSD for the cultivar x nitrogen rate interaction is 0.5
[†] Buffalograss color was rated from 1 to 9, with 1 = straw brown, 9 = dark green, and 6 = acceptable.

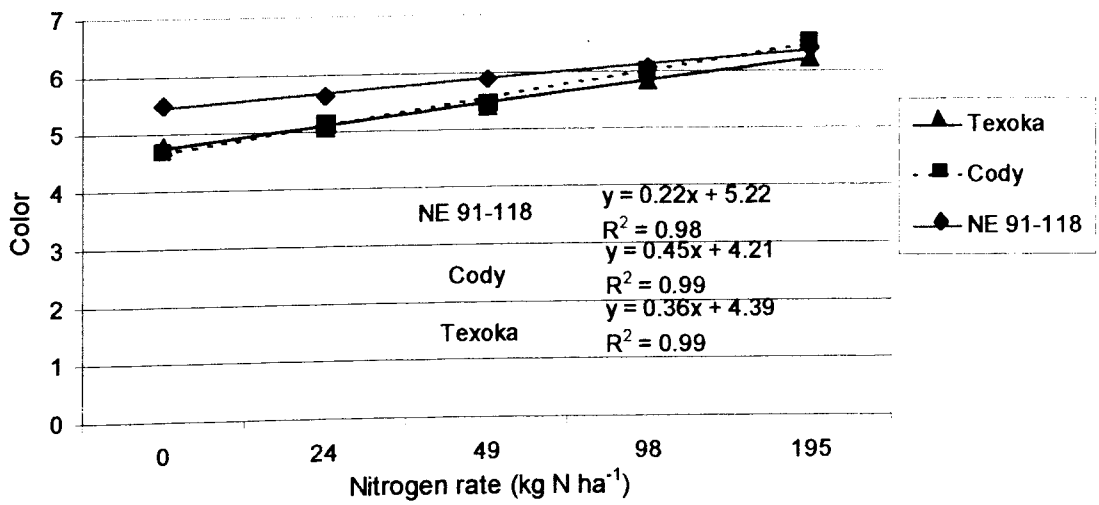

Figure 2.12. Buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Utah site.

There were no differences in color among the cultivars at the 24, 49, 98 and 195 kg N ha^{-1} rates. At two weeks after the second nitrogen application in 1998, there were no differences in color among cultivars from the 0 to 98 kg N ha^{-1} rate (Table 2.27). At the 195 kg N ha^{-1} rate, Cody had the best color.

There was a significant linear effect for the cultivar x nitrogen rate interaction in 1996 and 1998. In 1996 and 1998, NE 91-118 had the smallest and Cody had the greatest increase in color as nitrogen rate increased (Figures 2.12 and 2.13).

Color – Nitrogen Rate x Year Interaction

There was a significant nitrogen rate x year interaction at all sites and similar to the quality response to nitrogen rates, color declined over time at the low nitrogen rates. There is variability among the sites as to the year when color declined or increased for the different nitrogen rates, but overall the trends were similar at all sites. For the 0, 24, and 49 kg N ha^{-1} rates, color declined from 1996 to 1998 at all sites (Tables 2.28, 2.29, and 2.30; Figures 2.14,2.15, and 2.16). At the 98 kg N ha^{-1} rate there were no differences in color among years at the Nebraska site. At the Kansas site there were no differences in color at the 98 kg N ha^{-1} rate in 1996 and 1997 but in 1998 color was lower. At the Utah site, color was significantly greater in 1997 at the 98 kg N ha^{-1} rate but not significantly different between 1996 and 1998. The 98 kg N ha^{-1} rate sustained color over the three year period and the 195 kg N ha^{-1} rate improved color. The 0, 24, and 49 kg N ha^{-1} rates resulted in decreases in color over the three year period.

Table 2.27 Mean buffalograss color for the cultivar x nitrogen rate interaction at two weeks after the second nitrogen application in 1998 at the Utah site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss color[†]				
NE 91-118	2.8	3.8	4.8	5.7	7.0
Cody	2.4	3.4	4.8	6.3	8.1
Texoka	2.3	3.9	4.6	5.9	6.9

LSD within cultivar is 0.5
LSD within N rate is 0.8
LSD for the cultivar x nitrogen rate interaction is 0.8
[†] Buffalograss color was rated from 1 to 9, with 1 = straw brown, 9 = dark green, and 6 = acceptable.

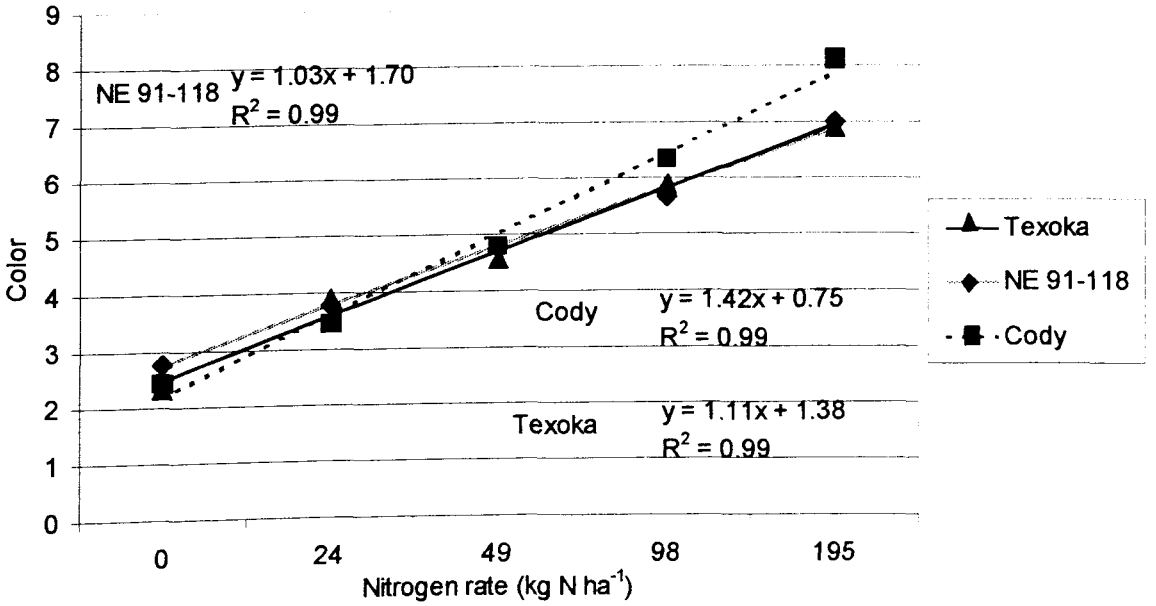

Figure 2.13. Buffalograss color for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1998 at the Utah site.

Table 2.28 Mean buffalograss color for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Nebraska site.

	Year		
Nitrogen rate	1996	1997	1998
— kg N ha^{-1} —	Buffalograss color†		
0	5.8	4.7	3.3
24	5.9	5.3	4.4
49	6.0	5.6	5.0
98	6.1	6.0	6.0
195	6.5	6.5	7.1

LSD within nitrogen rate is 0.1
LSD within year is 0.2
LSD for the nitrogen rate x year interaction is 0.2
† Buffalograss color was rated from 1 to 9, with 1 = straw brown, 9 = dark green, and 6 = acceptable.

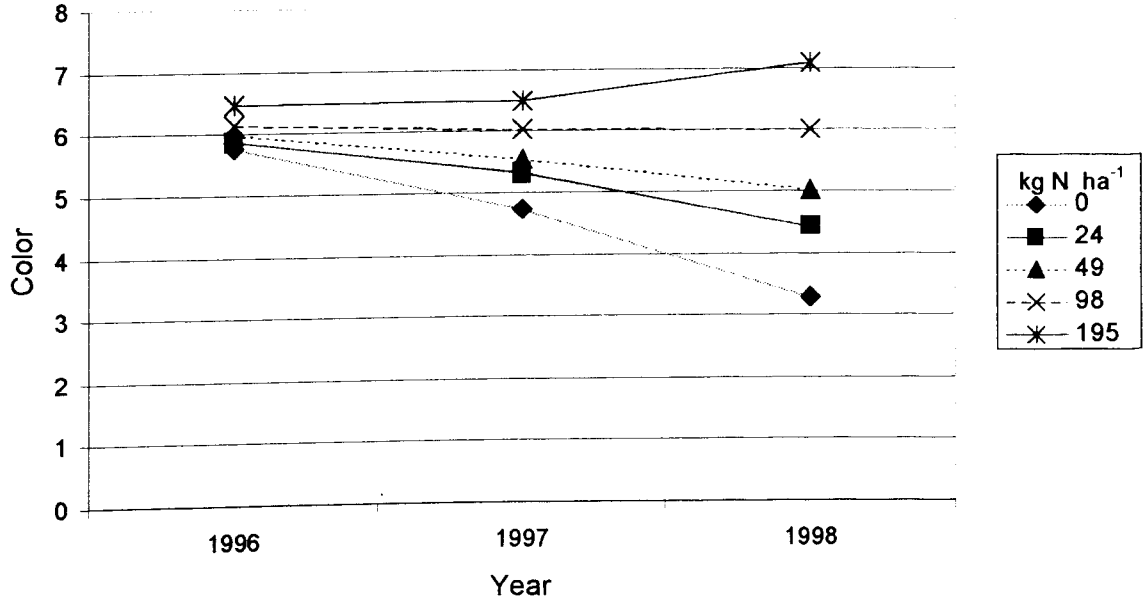

Figure 2.14. Buffalograss color for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Nebraska site.

Table 2.29 Mean buffalograss color for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Kansas site.

	Year		
Nitrogen rate	1996	1997	1998
— kg N ha^{-1} —		Buffalograss color†	
0	6.1	4.4	3.7
24	6.2	5.2	4.6
49	6.1	5.6	5.0
98	6.2	6.3	5.8
195	6.3	6.6	7.0

LSD within nitrogen rate is 0.1
LSD within year is 0.2
LSD for the nitrogen rate x year interaction is 0.2
† Buffalograss color was rated from 1 to 9, with 1 = straw brown, 9 = dark green, and 6 = acceptable.

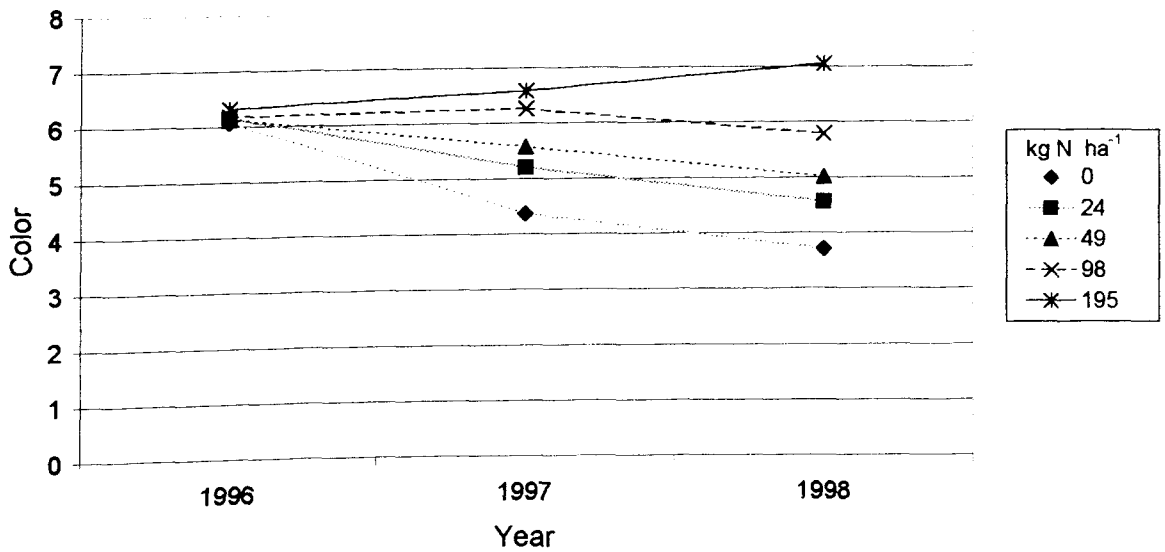

Figure 2.15. Buffalograss color for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Kansas site.

Table 2.30 Mean buffalograss color for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Utah site.

	Year		
Nitrogen rate	1996	1997	1998
— kg N ha^{-1} —		Buffalograss color[†]	
0	5.0	4.3	2.5
24	5.3	5.0	3.7
49	5.6	5.8	4.7
98	6.0	6.5	6.0
195	6.4	7.4	7.3

LSD within nitrogen rate is 0.1
LSD within year is 0.2
LSD for the nitrogen rate x year interaction is 0.2
[†] Buffalograss color was rated from 1 to 9, with 1 = straw brown, 9 = dark green, and 6 = acceptable.

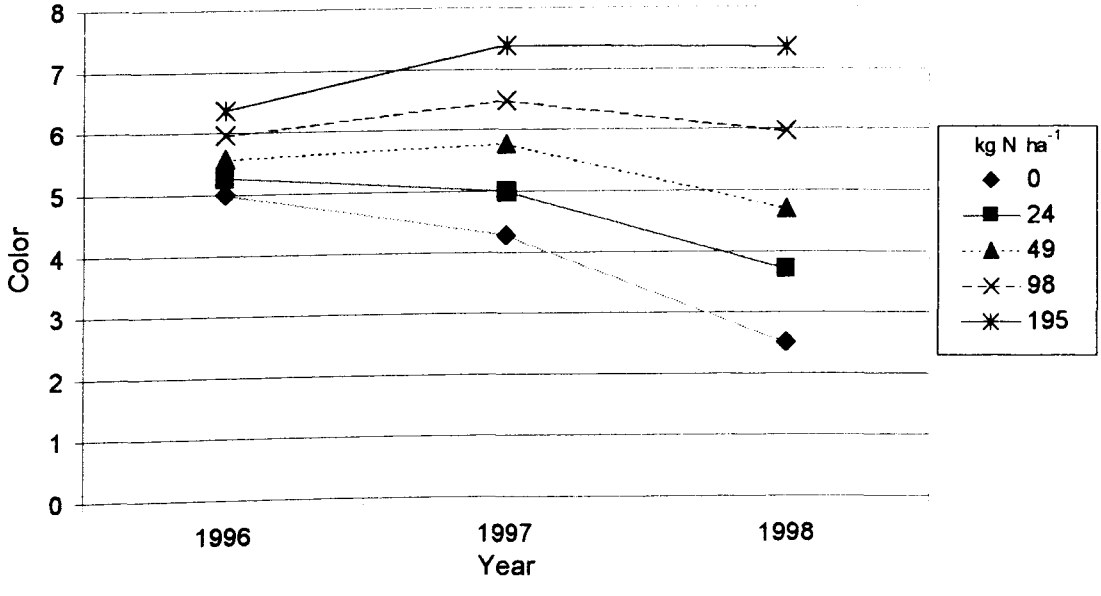

Figure 2.16. Buffalograss quality for the nitrogen rate x year interaction at four weeks after the second nitrogen application the Utah site.

Density – Cultivar x Nitrogen Rate

Nebraska site

There were significant cultivar x nitrogen rate interactions in each year from 1996 to1998 (Table 2.31). In 1996 and 1997 at four weeks after the second nitrogen application, NE 91-118 and 378 had the highest density when nitrogen was applied (Table 2.32 and 2.33). In 1996, NE 91-118 and 378 had the highest density when no nitrogen was applied but in 1997 and 1998, 378 alone had the highest density when no nitrogen was applied (Table 2.32, 2.33, and 2.34). By 1998, there were no differences in density among NE 91-118, 378, and Cody at the 49, 98, and 195 kg N ha^{-1} rates (Table 2.34). In 1998, with the exception of Texoka, there were no differences in density within each cultivar between the 98 and 195 kg N ha^{-1} rates. For Texoka, the highest density was at the 195 kg N ha^{-1} rate and among cultivars Texoka consistently had the lowest density at all nitrogen rates except the 195 kg N ha^{-1} rate.

Kansas site

There were significant cultivar x nitrogen rate interactions in 1997 and 1998 (Table 2.35). Experimental selection NE 91-118 had the highest density when no nitrogen was applied in 1997 and NE 91-118 and 378 had the highest density when no nitrogen was applied in 1998 (Table 2.36 and 2.37). In 1997, NE 91-118 and 378 had the highest density when nitrogen was applied (Table 2.36). In 1998, NE 91-118 and 378 had the highest density at the 49, 98, and

Table 2.31 Analysis of variance table for buffalograss density at the Nebraska site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 4WAT	1997 4WAT(2nd)	1998 4WAT	1998 4WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	3	**	**	**	**	**	*
W.P. Error	6						
Mowing height	2	**	**	**	**	**	**
Cult. x Mow	6	NS	NS	NS	**	*	NS
S.P. Error	16						
N rate	4	**	**	**	**	**	**
Cult. x N	12	NS	*	*	**	**	**
Mow x N	8	NS	NS	NS	NS	NS	NS
Cult. x Mow x N	24	NS	NS	NS	NS	NS	NS
Error	48						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
*,**, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.32 Mean buffalograss density for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Nebraska site.

Cultivar	Nitrogen rate (kg N ha^{-1})				
	0	24	49	98	195
	Buffalograss density†				
NE 91-118	7.4	7.6	7.7	7.8	7.9
378	7.6	7.7	7.8	7.8	7.8
Cody	7.1	7.1	7.2	7.3	7.4
Texoka	6.6	6.6	6.6	6.8	6.9

LSD within cultivar is 0.1
LSD within nitrogen rate is 0.3
LSD for the culitvar x nitrogen rate interaction is 0.3
† Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Table 2.33 Mean buffalograss density for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 at the Nebraska site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss density[†]				
NE 91-118	6.8	7.6	8.1	8.7	8.8
378	7.6	7.9	8.1	8.4	8.5
Cody	6.6	7.3	7.4	7.7	7.8
Texoka	5.8	6.6	6.8	7.1	7.4

LSD within cultivar is 0.3
LSD within nitrogen rate is 0.6
LSD for the cultivar x nitrogen rate interaction is 0.6
[†] Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Table 2.34 Mean buffalograss density for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1998 at the Nebraska site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss density[†]				
NE 91-118	4.8	6.7	7.7	8.4	8.8
378	6.9	7.6	7.9	8.4	8.6
Cody	5.1	6.3	7.1	7.9	8.2
Texoka	4.2	5.3	6.0	6.8	7.8

LSD within cultivar is 0.6
LSD within nitrogen rate is 1.0
LSD for the cultivar x nitrogen rate interaction is 1.0
[†] Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Table 2.35 Analysis of variance table for buffalograss density at the Kansas site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 2WAT§	1997 4WAT(2nd)	1998 4WAT	1998 4WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	3	**	**	**	**	NS	**
W.P. Error	6						
Mowing height	2	**	NS	NS	*	NS	**
Cult. x Mow	6	NS	NS	NS	NS	NS	NS
S.P. Error	16						
N rate	4	NS	NS	**	**	**	**
Cult. x N	12	NS	NS	*	*	**	*
Mow x N	8	NS	NS	NS	NS	NS	NS
Cult. x Mow x N	24	NS	NS	NS	NS	NS	NS
Error	48						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
§ 2WAT = Two weeks after the first nitrogen application
*,**, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.36 Mean buffalograss density for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 at the Kansas site.

Cultivar	Nitrogen rate (kg N ha^{-1})				
	0	24	49	98	195
	Buffalograss density†				
NE 91-118	7.6	7.7	8.1	8.4	8.5
378	6.7	7.2	7.5	8.1	8.0
Cody	6.2	6.8	6.9	7.1	7.4
Texoka	5.4	5.9	6.3	6.8	6.9

LSD within cultivar is 0.3
LSD within nitrogen rate is 0.7
LSD for the cultivar x nitrogen rate interaction is 0.7
† Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Table 2.37 Mean buffalograss density for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1998 at the Kansas site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss density[†]				
NE 91-118	6.3	7.3	7.7	8.4	8.6
378	5.8	6.7	7.2	8.2	8.6
Cody	5.4	6.6	6.9	7.6	7.9
Texoka	4.4	5.6	6.7	7.1	7.7

LSD within cultivar is 0.5
LSD within nitrogen rate is 0.5
LSD for the cultivar x nitrogen rate interaction is 0.5
[†] Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

195 kg N ha^{-1} rates (Table 2.37). In 1997 and 1998, Texoka usually had the lowest density among cultivars and Cody had lower density than NE 91-118 and 378. For all cultivars the highest density in 1997 and 1998 was at the 98 and 195 kg N ha^{-1} rate.

Utah site

The cultivar x nitrogen rate interaction was significant at four weeks after the first nitrogen application in 1996 and 1997 (Table 2.38). In both years, NE 91-118 had the highest density when no nitrogen was applied and NE 91-118 and Cody had the highest density at the 24 kg N ha^{-1} rate (Table 2.39 and 2.40). There were no differences in density among cultivars at the 49, 98, and 195 kg N ha^{-1} rates. For NE 91-118 the highest density was at the 195 kg N ha^{-1} rate and for Cody and Texoka at the 98 or 195 kg N ha^{-1} rates.

Table 2.38 Analysis of variance table for buffalograss density at the Utah site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 4WAT	1997 4WAT(2nd)	1998 2WAT§	1998 2WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	2	*	*	*	**	NS	NS
W.P. Error	4						
Mowing height	2	**	**	**	**	**	**
Cult. x Mow	4	**	**	**	*	NS	NS
S.P. Error	12						
N rate	4	**	**	**	**	**	**
Cult. x N	8	**	NS	**	NS	NS	NS
Mow x N	8	NS	NS	NS	NS	NS	NS
Cult. x Mow x N	16	*	NS	*	NS	NS	NS
Error	36						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
§ 2WAT = Two weeks after the first nitrogen application
*,**, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.39 Mean buffalograss density for the cultivar x nitrogen rate interaction at four weeks after the first nitrogen application in 1996 at the Utah site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	Buffalograss density†				
NE 91-118	6.2	6.4	6.5	6.4	6.7
Cody	5.7	6.3	6.2	6.4	6.6
Texoka	5.8	5.9	6.2	6.2	6.4

LSD within cultivar is 0.2
LSD within nitrogen rate is 0.3
LSD for the cultivar x nitrogen rate interaction is 0.3
† Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Table 2.40 Mean buffalograss density for the cultivar x nitrogen rate interaction at four weeks after the first nitrogen application in 1997 at the Utah site.

Cultivar	Nitrogen rate (kg N ha^{-1})				
	0	24	49	98	195
	Buffalograss density[†]				
NE 91-118	6.2	6.4	6.5	6.4	6.7
Cody	5.7	6.3	6.2	6.4	6.6
Texoka	5.8	5.9	6.2	6.2	6.4

LSD within cultivar is 0.2
LSD within nitrogen rate is 0.3
LSD for the cultivar x nitrogen rate interaction is 0.3
[†] Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Density – Cultivar x Mowing Height Interaction

Nebraska site

There was a significant cultivar x mowing height interaction at four weeks after the second nitrogen application in 1997 and at four weeks after the first nitrogen application in 1998 (Table 2.31). In 1997, NE 91-118, 378, and Cody had the highest density at the 2.5 cm mowing height and NE 91-118 and 378 had the highest density at the 5.0 and 7.5 cm mowing height (Table 2.41). In 1997 and 1998, the lowest density within each cultivar was at the 2.5 cm mowing height. In 1998, 378 had the highest density at all mowing heights (Table 2.42). There were no differences in density between NE 91-118 and Cody at the 2.5 and 5.0 cm mowing height and among NE 91-118, Cody, and Texoka at the 7.5 cm mowing height. In 1998, Texoka had the lowest density at the 2.5 and 5.0 cm mowing height.

Kansas site

The cultivar x mowing height interaction was not significant but there was a significant mowing height effect in all years (Table 2.35). At four weeks after the second nitrogen application in 1997 and 1998, the 5.0 and 7.5 cm mowing heights had the highest density (Table 2.43).

Table 2.41 Mean buffalograss density for the cultivar x mowing height interaction at four weeks after the second nitrogen application in 1997 at the Nebraska site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss density[†]		
NE 91-118	7.6	8.3	8.2
378	7.5	8.5	8.2
Cody	7.2	7.5	7.4
Texoka	6.2	6.9	7.1

LSD within cultivar is 0.2
LSD within mowing height is 0.6
LSD for the cultivar x mowing height interaction is 0.6
[†] Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Table 2.42 Mean buffalograss density for the cultivar x mowing height interaction at four weeks after the first nitrogen application in 1998 at the Nebraska site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss density[†]		
NE 91-118	6.4	7.3	7.1
378	7.2	8.5	8.2
Cody	6.2	6.9	7.2
Texoka	5.1	6.0	7.0

LSD within cultivar is 0.5
LSD within mowing height is 0.8
LSD for the cultivar x mowing height interaction is 0.8
[†] Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Table 2.43 Mean buffalograss density for the mowing height effect at four weeks after the second nitrogen application at the Kansas site.

	Year		
Mowing height	1996	1997	1998
cm	Buffalograss density[†]		
2.5	6.9	6.9	6.3
5.0	6.9	7.3	7.3
7.2	6.7	7.3	7.4

LSD within year is 0.1

[†] Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Utah site

There was a significant cultivar x mowing height interaction in 1996 and 1997 (Table 2.38). At four weeks after the second nitrogen application in 1996, NE 91-118 had the highest density at the 2.5 cm mowing height and NE 91-118 and Cody had the highest density at the 5.0 cm mowing height (Table 2.44). There were no differences in density among cultivars at the 7.5 cm mowing height. In 1997, NE 91-118 had the highest density at the 2.5 and 5.0 cm mowing height and NE 91-118 and Cody had the highest density at the 7.5 cm mowing height (Table 2.45). In 1997, for NE 91-118 there were no differences in density among the mowing heights but for Cody and Texoka the highest density was at the 5.0 and 7.5 cm mowing height.

Density – Nitrogen Rate x Year Interaction

There was a significant nitrogen rate x year interaction at all sites. The interaction was similar to the nitrogen rate x year interaction for quality and color that revealed the 98 kg N ha^{-1} rate sustained quality and color over the three year period but the 0, 24, and 49, kg N ha^{-1} rates had declining quality and color over time.

Nebraska site

There were no differences in density among the 24, 49, 98, and 195 kg N ha^{-1} rates in 1996 (Table 2.46). In 1997, the 98 and 195 kg N ha^{-1} rates had the highest density and in 1998 the 195 kg N ha^{-1} rate had the highest density.

Table 2.44 Mean buffalograss density for the cultivar x mowing height interaction at four weeks after the second nitrogen application in 1996 at the Utah site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss density[†]		
NE 91-118	5.9	6.5	5.6
Cody	5.3	6.2	5.8
Texoka	4.8	5.7	5.5

LSD within cultivar is 0.4
LSD within mowing height is 0.4
LSD for the cultivar x mowing height interaction is 0.4
[†] Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Table 2.45 Mean buffalograss density for the cultivar x mowing height interaction at four weeks after the second nitrogen application in 1997 at the Utah site.

	Mowing height (cm)		
Cultivar	2.5	5.0	7.5
	Buffalograss density[†]		
NE 91-118	6.5	7.0	6.5
Cody	4.9	5.9	6.1
Texoka	4.4	5.7	5.7

LSD within cultivar is 0.6
LSD within mowing height is 0.6
LSD for the cultivar x mowing height interaction is 0.6
[†] Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

Table 2.46 Mean buffalograss density for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Nebraska site.

	Year		
Nitrogen rate	1996	1997	1998
— kg N ha^{-1} —	Buffalograss density[†]		
0	7.2	6.7	5.2
24	7.3	7.3	6.5
49	7.3	7.6	7.2
98	7.4	8.0	7.9
195	7.5	8.1	8.4

LSD within nitrogen rate is 0.2
LSD within year is 0.2
LSD for the nitrogen rate x year interaction is 0.2
[†] Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

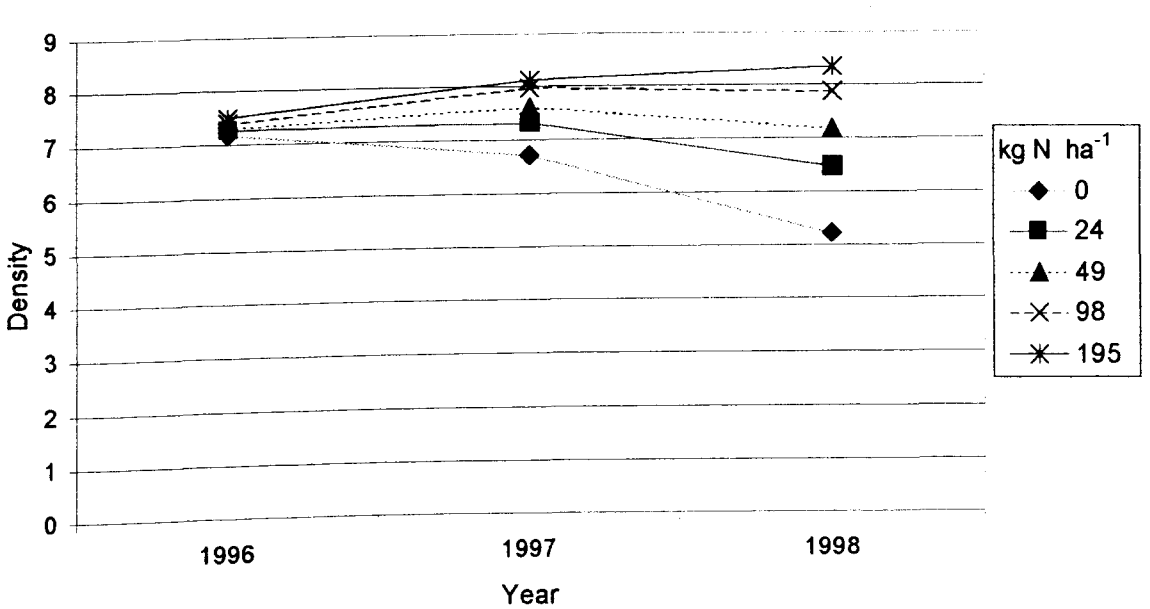

Figure 2.17. Buffalograss density for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Nebraska site.

Density decreased each year from 1996 to 1998 when no nitrogen was applied and decreased from 1997 to 1998 when 24 kg N ha^{-1} was applied (Figure 2.17). At the 49 kg N ha^{-1} rate, density was highest in 1997 and not significantly different between 1996 and 1998. For the 98 kg N ha^{-1} rate, density increased from 1996 to 1997 and was not significantly different between 1997 and 1998. Density increased each year from 1996 to 1998 at the 195 kg N ha^{-1} rate. The 98 kg N ha^{-1} rate sustained density over the three year period. It could be argued that the 49 kg N ha^{-1} rate sustained density over time because there was no difference in density between 1996 to 1998. However, in lieu of the results from the nitrogen rate x year interaction for quality and color, the 49 kg N ha^{-1} rate would not be recommended.

Kansas site

At the Kansas site, there were no differences in density among the nitrogen rates in 1996 (Table 2.47 and Figure 2.18). Similar to the Nebraska site, in 1997, the 98 and 195 kg N ha^{-1} rates had the highest density and in 1998 the 195 kg N ha^{-1} rate had the highest density. For the 0, 24, and 49 kg N ha^{-1} rates, density decreased from 1996 to 1998. For the 98 kg N ha^{-1} rate there were no differences in density from 1996 to 1998. For the 195 kg N ha^{-1} rate, density increased each year from 1996 to 1998.

Table 2.47 Mean buffalograss density for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Kansas site.

	Year		
Nitrogen rate	1996	1997	1998
— kg N ha^{-1} —	Buffalograss density†		
0	7.7	6.5	5.5
24	7.7	6.9	6.5
49	7.8	7.2	7.1
98	7.8	7.6	7.8
195	7.8	7.7	8.2

LSD within nitrogen rate is 0.2
LSD within year is 0.2
LSD for the nitrogen rate x year interaction is 0.2
† Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

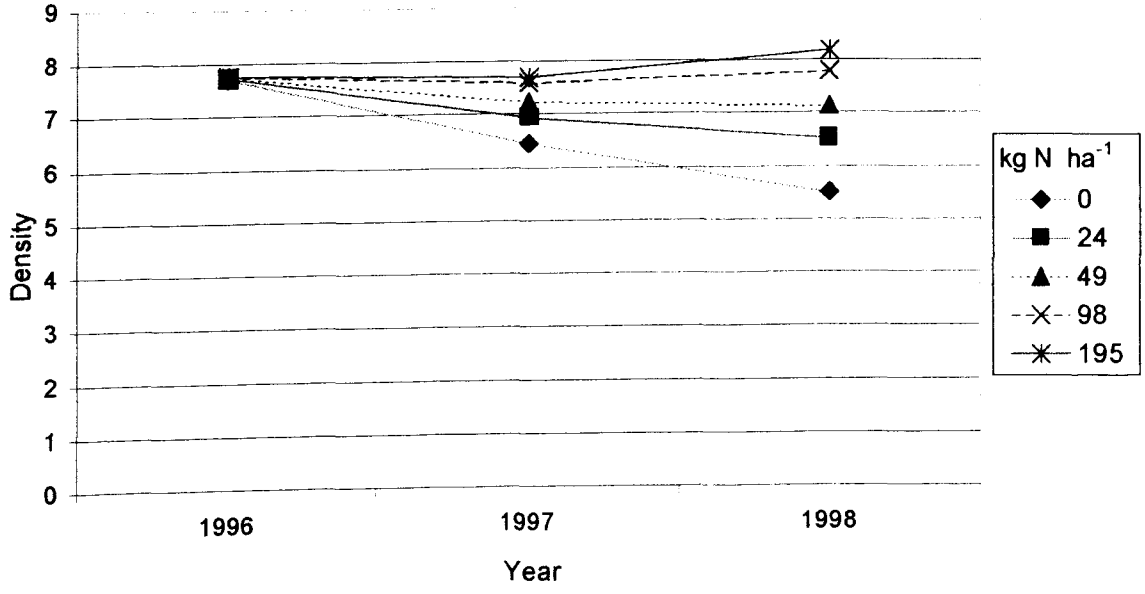

Figure 2.18. Buffalograss density for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Kansas site.

Utah site

The 98 and 195 kg N ha^{-1} rate had the highest density in 1996 and the 195 kg N ha^{-1} rate had the highest density in 1997 and 1998 (Table 2.48 and Figure 2.19). Density decreased each year from 1996 to 1998 when no nitrogen was applied and decreased from 1996 to 1998 at the 24 kg N ha^{-1} rate. For the 49 kg N ha^{-1} rate, density decreased from 1997 to 1998. At the 98 kg N ha^{-1} rate, density was highest in 1997 and not different between 1996 and 1998. Density increased from 1996 to 1997 for the 195 kg N ha^{-1} rate and was not different between 1997 and 1998.

Clipping weights

Nebraska and Kansas sites

The results of statistical analysis of clipping weights from the Nebraska and Kansas sites were similar. At the Nebraska site there was a significant cultivar x mowing height x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 (Table 2.49). At the Kansas site there was a significant cultivar x mowing height x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 and 1998 (Table 2.50). Interpretation of the three way interaction does not reveal any important information and since the interaction was only significant one time at the Nebraska site and twice at the Kansas site, interpretation of the cultivar x nitrogen rate and mowing height x nitrogen rate interaction will be of primary concern.

Table 2.48 Mean buffalograss density for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Utah site.

	Year		
Nitrogen rate	1996	1997	1998
— kg N ha^{-1} —	Buffalograss density†		
0	5.2	4.6	3.1
24	5.5	5.2	4.0
49	5.7	5.9	4.8
98	5.9	6.4	6.0
195	6.2	7.2	7.5

LSD within nitrogen rate is 0.3
LSD within year is 0.3
LSD for the nitrogen rate x year interaction is 0.3
† Buffalograss density was rated from 1 to 9, with 1 = lowest density and 9 = highest density.

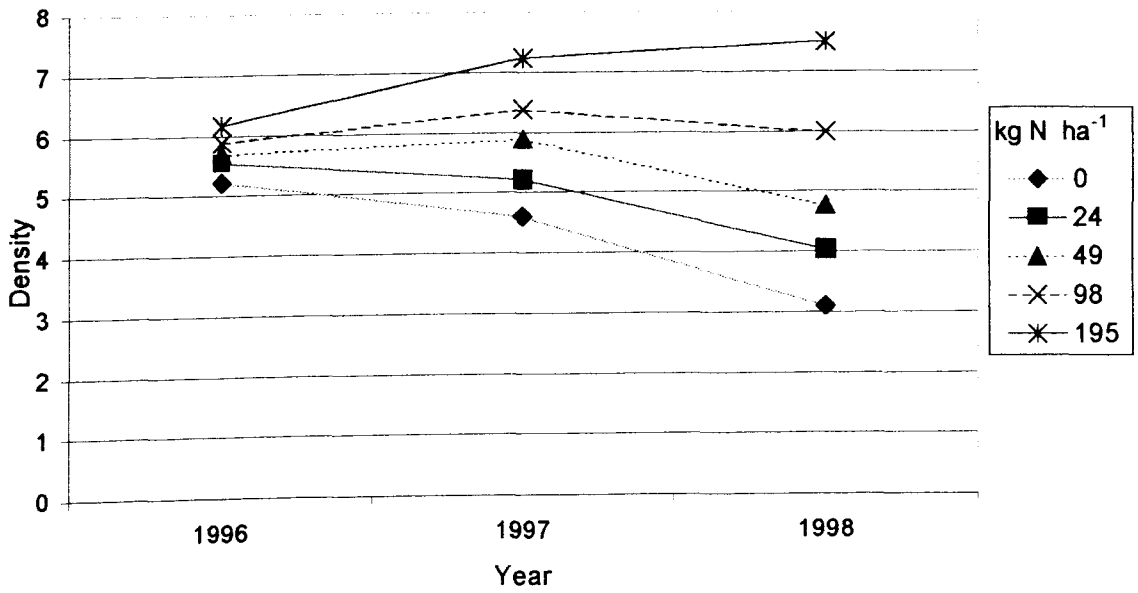

Figure 2.19. Buffalograss density for the nitrogen rate x year interaction at four weeks after the second nitrogen application at the Utah site.

Table 2.49 Analysis of variance table for buffalograss clipping weights at the Nebraska site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 4WAT	1997 4WAT(2nd)	1998 4WAT	1998 4WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	3	NS	*	NS	*	NS	**
W.P. Error	6						
Mowing height	2	**	**	**	**	NS	NS
Cult. x Mow	6	**	*	NS	NS	NS	*
S.P. Error	16						
N rate	4	**	**	**	**	**	**
Cult. x N	12	NS	NS	**	**	**	**
Mow x N	8	*	*	NS	**	NS	NS
Cult. x Mow x N	24	NS	NS	*	NS	NS	NS
Error	48						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
*,**, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.50 Analysis of variance table for buffalograss clipping weights at the Kansas site.

Source	df	1996 4WAT†	1996 4WAT(2nd)‡	1997 6WAT	1997 4WAT(2nd)	1998 4WAT	1998 4WAT(2nd)
		Pr > F					
Rep.	2						
Cultivar	3	*	NS	NS	NS	NS	NS
W.P. Error	6						
Mowing height	2	**	**	**	**	**	**
Cult. x Mow	6	*	*	NS	NS	NS	NS
S.P. Error	16						
N rate	4	**	**	**	**	**	**
Cult. x N	12	NS	NS	NS	**	**	**
Mow x N	8	NS	*	NS	NS	**	NS
Cult. x Mow x N	24	NS	*	NS	NS	NS	*
Error	48						

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application
*,**, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Utah site

Due to poor establishment of NE 91-118, clippings were not harvested at four weeks after the first nitrogen application in 1996. There were no significant interactions at the Utah site in 1996 and 1998 but there was a significant nitrogen rate effect on clipping weight (Table 2.51). At both times in 1998, the 195 kg N ha^{-1} rate had the highest clipping weight and there were no differences in clipping weights among the other nitrogen rates (Table 2.52).

Clipping Weights – Mowing Height x Nitrogen Rate Interaction

Nebraska and Kansas sites

There were significant mowing height x nitrogen rate interactions at the Nebraska and Kansas sites. Results from the sites were similar, although the clipping weights at the Kansas site were greater than at the Nebraska site. At four weeks after the second nitrogen application in 1996, there was no difference in clipping weights among nitrogen rates at the 2.5 cm mowing height at the Kansas site (Table 2.53). At the Nebraska site the lowest clipping weight was at the 2.5 cm mowing height when no nitrogen was applied (Table 2.54). At the 5.0 cm mowing height, the highest clipping weight at both sites was at the 195 kg N ha^{-1} rate. At the Kansas site, the highest clipping weight at the 7.5 cm mowing height was at the 98 and 195 kg N ha^{-1} rate and at the Nebraska site at the 195 kg N ha^{-1} rate. The significance of the mowing height x nitrogen rate interaction is questionable because the interaction is not separating the cultivar effects. The results of the interaction suggest that there is little difference in clipping weights

Table 2.51 Analysis of variance table for buffalograss clipping weights at the Utah site.

Source	df	1996 4WAT(2nd)†	1998 4WAT‡	1998 4WAT(2nd)
		Pr > F		
Rep.	2			
Cultivar	3	**	NS	NS
W.P. Error	6			
Mowing height	2	**	**	NS
Cult. x Mow	6	**	NS	NS
S.P. Error	16			
N rate	4	**	**	**
Cult. x N	12	NS	NS	NS
Mow x N	8	NS	NS	NS
Cult. x Mow x N	24	NS	NS	NS
Error	48			

† 4WAT(2nd) = Four weeks after the second nitrogen application
‡ 4WAT = Four weeks after the first nitrogen application
*,**, and NS indicate significance at P=0.05, 0.01 and not significant at P=0.05, respectively

Table 2.52 Mean buffalograss clipping weight for the nitrogen rate effect at the Utah site in 1998.

Nitrogen rate	1998 4WAT†	1998 4WAT(2nd) ‡
— kg N ha^{-1} —	kg ha^{-1}	
0	333	290
24	337	288
49	378	334
98	401	367
195	497	455
LSD (P=0.05)	76	79

† 4WAT = Four weeks after the first nitrogen application
‡ 4WAT(2nd) = Four weeks after the second nitrogen application

Table 2.53 Mean buffalograss clipping weights for the mowing height x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Nebraska site.

	Mowing height (cm)		
Nitrogen rate	2.5	5.0	7.5
— kg N ha^{-1} —		kg ha^{-1}	
0	244	344	267
24	323	401	302
49	366	430	312
98	408	530	364
195	395	728	510

LSD within mowing height is 106
LSD within nitrogen rate is 109
LSD for the mowing height x nitrogen rate interaction is 109

Table 2.54 Mean buffalograss clipping weights for the mowing height x nitrogen rate interaction at four weeks after the second nitrogen application in 1996 at the Kansas site.

	Mowing height (cm)		
Nitrogen rate	2.5	5.0	7.5
— kg N ha^{-1} —		kg ha^{-1}	
0	436	801	783
24	454	763	789
49	491	788	786
98	524	1022	1005
195	515	1276	1194

LSD within mowing height is 106
LSD within nitrogen rate is 109
LSD for the mowing height x nitrogen rate interaction is 109

among nitrogen rates at the 2.5 cm mowing height. However, if as discussed previously, the density of the cultivars is different at the 2.5 cm mowing height the significance of the interaction is diminished. For example, Texoka had the lowest density among cultivars at the 2.5 cm mowing height at the Nebraska site and therefore it could be inferred that Texoka would have low clipping weights at all nitrogen rates at the 2.5 cm mowing height. Therefore, Texoka would essentially reduce the clipping weight values in the mowing height x nitrogen rate interaction and diminish the importance of analyzing the interaction. The interaction that revealed more information about clipping weight response to the nitrogen rate treatments was the cultivar x nitrogen rate interaction.

Clipping Weights – Cultivar x Nitrogen Rate Interaction

Nebraska site

The cultivar x nitrogen rate interaction was significant in 1997 and 1998. At four weeks after the second nitrogen application in 1997, there were no differences in clipping weights between the 98 and 195 kg N ha^{-1} rate for NE 91-118 and among the 49, 98, and 195 kg N ha^{-1} rate for 378 (Table 2.55). For Cody and Texoka, the highest clipping weight was at the 195 kg N ha^{-1} rate. There were relatively few differences among the cultivars at the different nitrogen rates but at the 195 kg N ha^{-1} rate, Texoka had the highest clipping weight and NE 91-118 and 378 had the lowest.

Table 2.55 Mean buffalograss clipping weights for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 at the Nebraska site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
			kg ha^{-1}		
NE 91-118	113	175	241	392	421
378	215	260	344	367	393
Cody	132	230	204	448	622
Texoka	179	259	303	499	746

LSD within cultivar is 110
LSD within nitrogen rate is 120
LSD for the cultivar x nitrogen rate interaction is 120

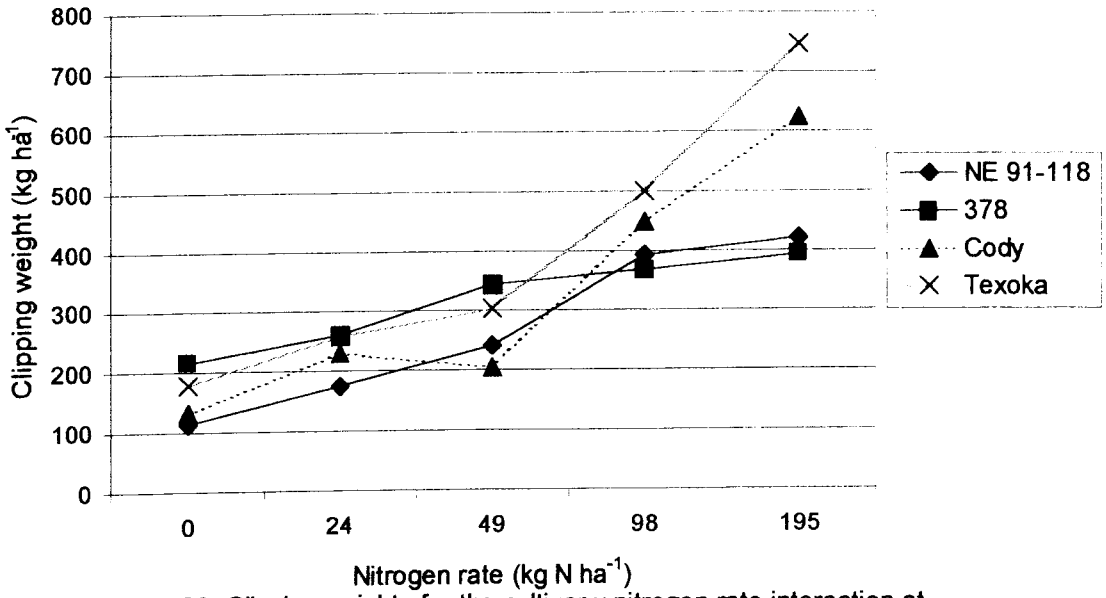

Figure 2.20. Clipping weights for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 at the Nebraska site.

The increase in clipping weights as nitrogen rate increased varied among the cultivars. There appears to be a significant increase in clipping weights from the 49 to 98 kg N ha^{-1} rate for all cultivars except 378 (Figure 2.20). Regression analysis from the 0 to 49 kg N ha^{-1} rate and from the 49 to 195 kg N ha^{-1} rate revealed different slopes among the cultivars and within each cultivar over the different range of nitrogen rates. From the 0 to 49 kg N ha^{-1} rate, the slopes of NE 91-118, 378, and Texoka ranged from 62 to 65 (Figure 2.21). The fitted line for Cody had a slope of 36 but the fit was poor, with an R-squared value of only 0.50. The slopes for NE 91-118, Cody, and Texoka increased for the 49 to 195 kg N ha^{-1} rate. The slope of NE 91-118 increased from 64 for the 0 to 49 kg N ha^{-1} rate to 90 for the 49 to 195 kg N ha^{-1} rate (Figure 2.22). The slopes for Cody and Texoka increased from 36 and 62 to 209 and 222, respectively. The slope for 378 actually decreased from 65 for the 0 to 49 kg N ha^{-1} rate to 25 for the 49 to 195 kg N ha^{-1} rate. Two important conclusions can be made from these results. At the 195 kg N ha^{-1} rate, the vegetative cultivars NE 91-118 and 378 had significantly lower clipping weights than the seeded cultivars Cody and Texoka. Cody and Texoka had a greater increase in clipping weights from the 49 to 195 kg N ha^{-1} rate than NE 91-118 and 378.

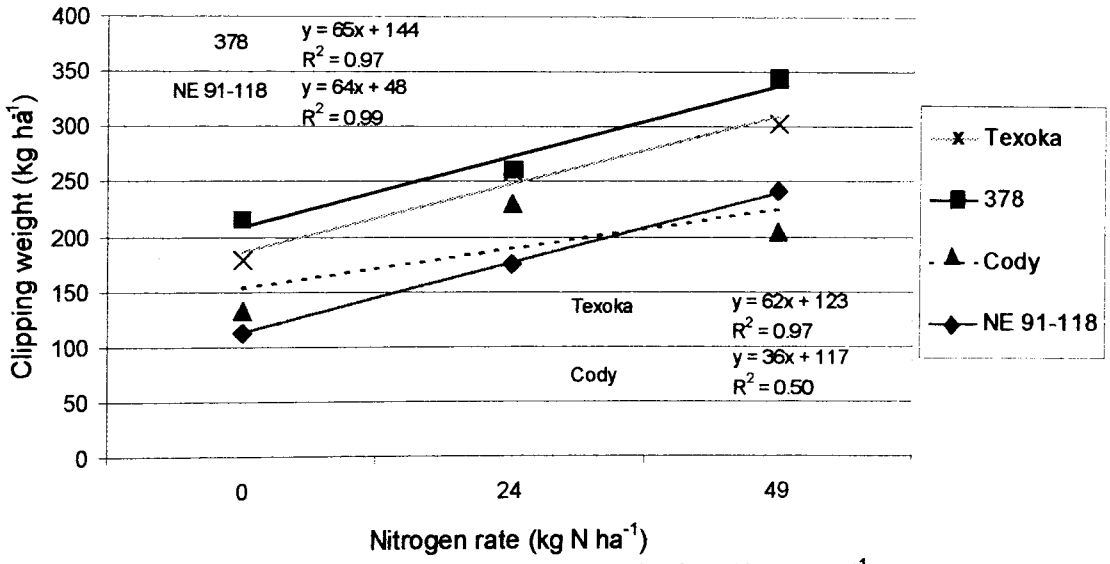

Figure 2.21. Regression of clipping weights on the 0 to 49 kg N ha^{-1}rates for buffalograss cultivars at four weeks after the second nitrogen application in 1997 at the Nebraska site.

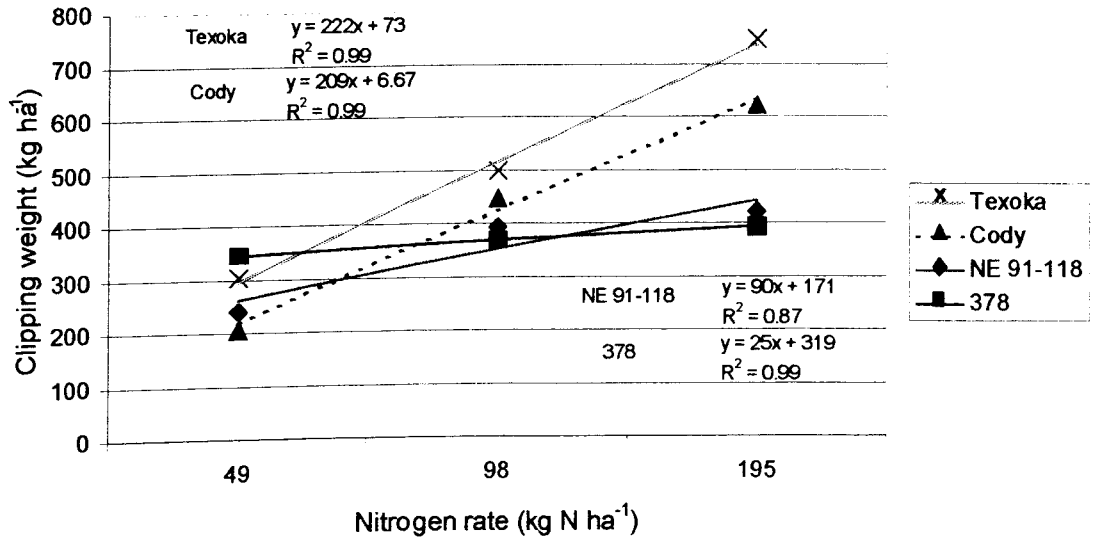

Figure 2.22. Regression of cliping weights on the 49 to 195 kg N ha^{-1} rates for buffalograss cultivars at four weeks after the second nitrogen application in 1997 at the Nebraska site.

Kansas site

The cultivar x nitrogen rate interaction was significant in 1997 and 1998 (Table 2.50). There were no differences in clipping weights between the 98 and 195 kg N ha^{-1} rate for NE 91-118, but for 378, Cody, and Texoka the 195 kg N ha^{-1} rate had the highest clipping weight (Table 2.56). For NE 91-118, 378, and Cody there were no differences in clipping weights among the 0, 24, and 49 kg N ha^{-1} rates. There were no differences in clipping weights among cultivars at the 0 and 24 kg N ha^{-1} rate. At the 49 kg N ha^{-1} rate, NE 91-118 had the lowest clipping weight and at the 98 kg N ha^{-1} rate Texoka had the highest clipping weight. There were no differences in clipping weights among NE 91-118, 378, and Cody at the 98 kg N ha^{-1} rate. At the 195 kg N ha^{-1} rate, Texoka had the highest and NE 91-118 had the lowest clipping weight.

The increase in clipping weights among cultivars as nitrogen rate increased at the Kansas site was similar to the results at the Nebraska site. There appeared to be a large increase in clipping weights from the 49 to 98 kg N ha^{-1} rate (Figure 2.23). Regression analysis from the 0 to 49 kg N ha^{-1} rate revealed relatively gradual slopes for all cultivars except Texoka (Figure 2.24). In fact, the slope of the line for NE 91-118 was –11, but there were no significant differences in clipping weights among the 0, 24, and 49 kg N ha^{-1} rates indicating that the negative slope is not of real significance (Table 2.56). The slopes for 378, Cody, and Texoka were 15, 28, and 66, respectively. All cultivars except Texoka had no differences in clipping weights between the 0, 24, and 49 kg N ha^{-1} rate. There were no differences in clipping weights between the 0 and 24 kg N ha^{-1}

Table 2.56 Mean buffalograss clipping weights for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 at the Kansas site.

	Nitrogen rate (kg N ha^{-1})				
Cultivar	0	24	49	98	195
	kg ha^{-1}				
NE 91-118	150	134	129	185	231
378	139	191	168	256	356
Cody	140	180	196	246	380
Texoka	128	168	259	382	505

LSD within cultivar is 92
LSD within nitrogen rate is 122
LSD for the cultivar x nitrogen rate interaction is 122

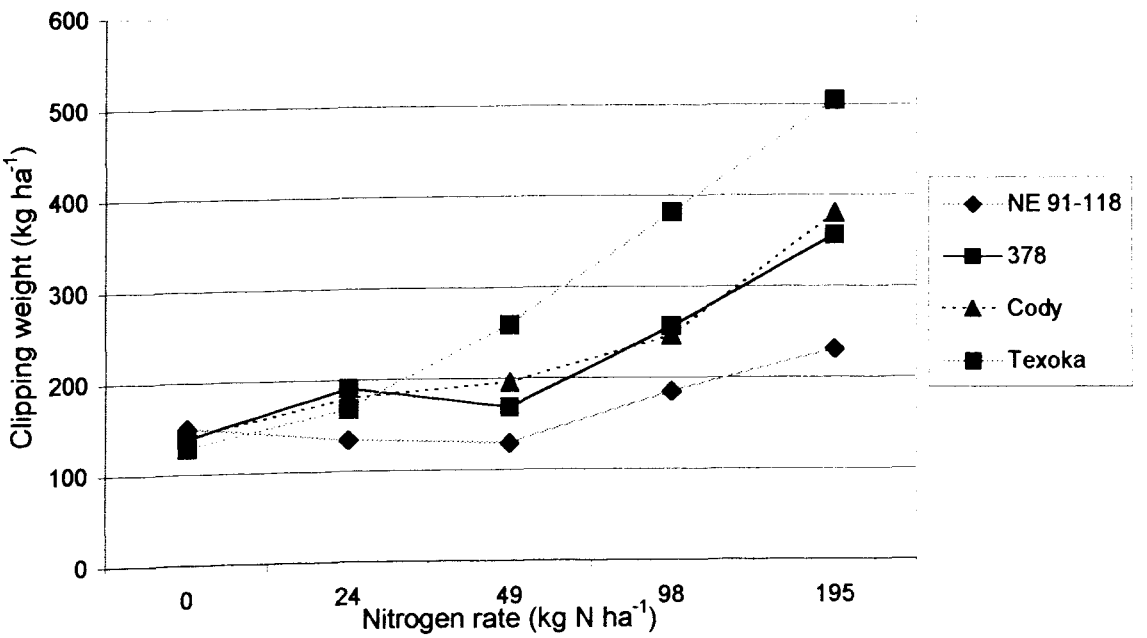

Figure 2.23. Clipping weights for the cultivar x nitrogen rate interaction at four weeks after the second nitrogen application in 1997 at the Kansas site.

rate for Texoka but the 49 kg N ha^{-1} rate had greater clipping weight than when no nitrogen was applied. From the 49 to 195 kg N ha^{-1} rates, the slopes for all cultivars increased (Figure 25). Texoka had the steepest and NE 91-118 had the flattest slope. Similar to the Nebraska site, there was little difference in the slopes of the lines from the 0 to 49 kg N ha^{-1} rate, but all cultivars had steeper slopes for the 49 to 98 kg N ha^{-1} rate. At the Kansas site the slopes were not as steep as at the Nebraska site and the distinction between the vegetative and seeded cultivars was not as clear. At the Kansas site, Texoka had the steepest slope and NE 91-118 had the most gradual slope but there was relatively no difference in the slopes of 378 and Cody. The result common to both sites is that there is a significant increase in clipping weight from the 49 to 195 kg N ha^{-1} rate and for most cultivars from the 49 to 98 kg N ha^{-1} rate.

The implications of the increased clipping weight are that although the 195 kg N ha^{-1} rate may result in the highest quality, color, and density ratings, it also results in the highest clipping weight and thereby would eliminate the low maintenance claim of reduced mowing frequency for buffalograss.

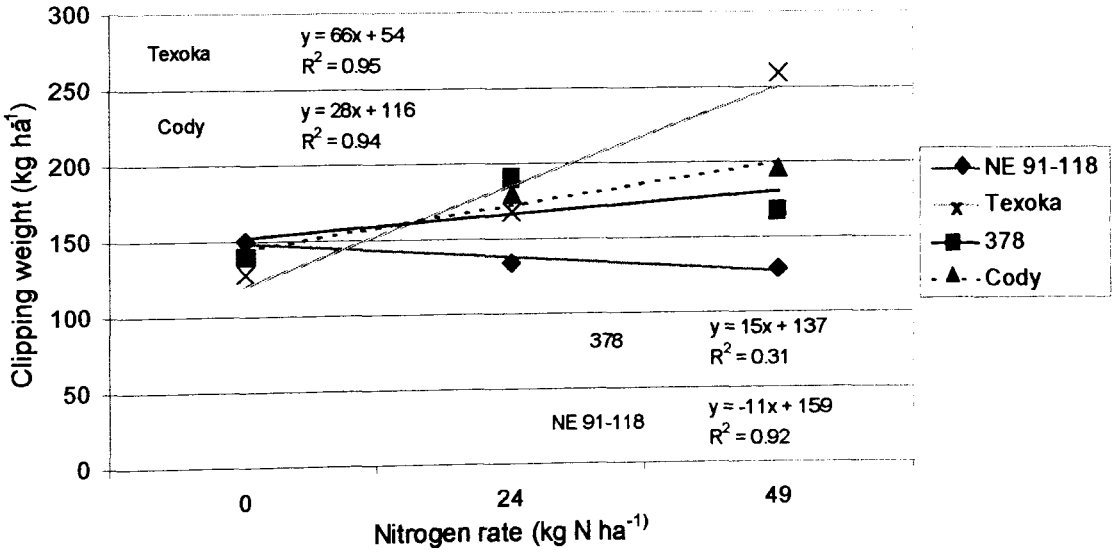

Figure 2.24. Regression of clipping weights on the 0 to 49 kg N ha^{-1} rates for buffalograss cultivars at four weeks after the second nitrogen application in 1997 at the Kansas site.

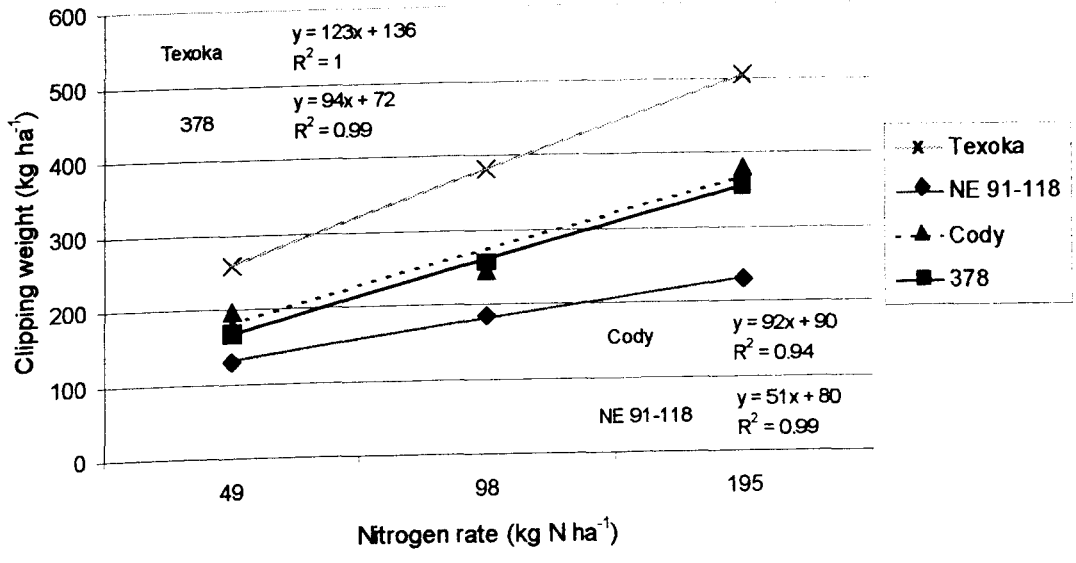

Figure 2.25. Regression of clipping weights on the 49 to 195 kg N ha^{-1} rates for buffalograss cultivars at four weeks after the second nitrogen application in 1997 at the Kansas site.

CONCLUSIONS

Due to differences in cultivar response to the nitrogen and mowing height treatments at the three sites, making specific management recommendations for the buffalograss cultivars is difficult. However, some of the results of the nitrogen and mowing height treatments were similar at all sites. The nitrogen rate x year interaction was significant at all sites for buffalograss quality, color, and density. The interaction revealed that the 98 kg N ha^{-1} rate sustained quality, color, and density over the three year period but that lower nitrogen rates resulted in decreases in quality, color, and density. The 195 kg N ha^{-1} rate increased quality, color, and density over the three year period but in many cases for the individual cultivars did not result in better quality, color, or density than the 98 kg N ha^{-1} rate. Furthermore, analysis of clipping weights revealed that the 195 kg N ha^{-1} rate had significantly greater clipping weights for most of the cultivars at the three sites. Although the 195 kg N ha^{-1} rate increased quality, color, and density over time, the higher clipping weights associated with this nitrogen rate along with the high amount of nitrogen applied reduce the low maintenance characteristic of buffalograss.

Management Recommendations

The management recommendations that will be made are relevant to irrigated buffalograss that was mowed weekly with clippings removed. Buffalograss maintained in this manner is not considered to be low maintenance but rather representative of common lawn management practices. Buffalograss

that is not irrigated nor mowed regularly would have lower quality expectations and therefore, different management recommendations.

Under the management protocol of this research, the nitrogen rate that is recommended to sustain quality, color, and density of buffalograss over time while avoiding excessive clipping production is 98 kg N ha^{-1} $year^{-1}$.

Depending on the desired use, the mowing height recommendation for NE 91-118 is 2.5 to 5.0 cm. The 2.5 cm mowing height would only be recommended for golf course fairways. The mowing height recommendation for 378 is 2.5 to 7.5 cm. The mowing height recommendation for Cody and Texoka is 5.0 to 7.5 cm.

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