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Effect of Soil Fertility and Cultural Practices on Burr Yield of Buffalograss

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ABSTRACT

Successful production of buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] burrs is one of the greatest limitations to increased use of this native species as either a turfgrass or forage crop. The objective of this research was to determine the impact of soil fertility, planting rate, planting date, and harvest date on burr yields of buffalograss. Trials were conducted near Bronco, TX on a Portales fine sandy loam soil (fine-loamy, mixed superactive thermic Aridic Calciustolls) and at Lubbock, TX on an Amarillo fine sandy soil (fine-loamy, mixed thermic Aridic Paleustalfs). Under conditions where buffalograss had less than 47 in of available soil moisture, the application of 60 to 80 lbs N acre^{-1}, 20 to 40 lbs P_2O_5 acre^{-1}, and micronutrients did not enhance burr production. At lower levels of available moisture, soil nutrients did not appear to be a limiting factor. Cultivar, planting date, planting rate, and type of seed used for establishment had minimal impact on burr yield. Buffalograss appeared to be well adapted to a dual burr harvest regime in which the initial harvest was made in July, and the final harvest was made after the first frost.

KEYWORDS: Buchole dactyloides (Nutt.) Engelm., cultivar evaluation, planting rates, planting date, harvest date

Buffalograss [*Buchole dactyloides* (Nutt.) Engelm.] is a warm-season, long-lived, drought tolerant grass that forms a dense sod (Wenger, 1941). Because it is native to the Great Plains of North America, it is very tolerant to heat, drought, and pests that limit many turfgrass species introduced into this region (Hitchcock, 1936; Savage, 1934). These traits, combined with its slow growth rate, need for minimal levels of fertilization, and ability to withstand moderate traffic, have increased the use of buffalograss as a turfgrass (Leuthold, 1982; Riordan, 1991). Successful establishment of buffalograss by planting burrs has historically been difficult and expensive (Launchbaugh and Owensby, 1970; Hauser, 1986; Savage, 1934; Wu et al., 1989). Since buffalograss is dioecious, only female plants bear the seed-containing burrs which further limits yields. However, direct planting remains the most practical and cost effective means to establish large areas of buffalograss (Wu et al., 1989).

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Ahring and Todd (1977) extracted a water soluble compound from buffalograss burrs that reduced germination (Hauser, 1986). Removing the seeds from the burr eliminates this type of inhibition. Svoboda (1991) studied different types of burr decortication and compared the germination and establishment of seed with treated and untreated burrs. Burrs soaked in potassium nitrate had higher germination and establishment rates than nontreated burrs but were equivalent to seeds which had been removed from the burrs.

Successful stand establishment can also limit burr yields in this species. Since buffalograss seeds will not germinate at temperatures below 60°F, planting is often delayed until late spring (Leuthold, 1982). Wenger (1941) reported that planting from 10 to 20 April provided the highest plant establishment in undisturbed soils in Kansas. Planting prior to 15 May gave adequate establishment on fallow and cultivated soils, but successful stand establishment was achieved with all planting dates prior to 15 June. In addition, Gaitan-Gaitan et al. (1998) reported that planting seeds before mid-July gave optimum stand establishment at Lubbock, TX. The impact of initial stand establishment on burr yield in subsequent years has not been determined. The objectives of these studies were to determine impact of soil fertilization, planting rate, planting dates, and harvest dates on burr production in buffalograss in the lower Great Plains. This information could help growers produce economic yield of buffalograss burrs and seed.

MATERIALS AND METHODS

Soil Fertility

Three soil fertility trials were conducted in 1993 and 1994 on established stands of buffalograss near Bronco, TX (approximately 3 miles west of Plains, TX) on a Portales fine sandy loam soil (Fine-loamy, mixed superactive thermic Aridic calciustolls). The test site was at an altitude of 3788 ft and was located at 32° 15′ N latitude and 103° 03′ W longitude. The 1993 trials were conducted on established stands of the cultivar 'Texoka' (Voigt et al., 1975), and the 1994 trials on the cultivar 'Comanche' (Davis et al., 1978). Both of these cultivars have similar areas of adaptation. Six stratified soil samples from the top 36 in (0-6, 0-12, 12-24, 24-36 in) of the soil profile were taken across the plot area in both 1993 and 1994 prior to applying fertilizer treatments (Table 1). The samples from each soil depth were composited prior to laboratory analyses. Soil samples were taken 2 Feb. 1993 and 4 Feb. 1994. The 1993 samples were analyzed by the Texas A&M University Soil Laboratory and the 1994 samples by the High Plains Agricultural Laboratories, Inc. at Lubbock, TX for soil pH, nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), sodium (Na), sulfur (S), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), and boron (B).

Nitrogen × Phosphorus Trial. Five rates of N and P_2O_5 (0, 20, 40, 60, and 80 lbs/acre) in all possible combinations were applied to plots 6 ft wide and 24 ft long. Nitrogen was applied as urea (46-0-0) and P as triple superphosphate (0-46-0). Fertility treatments were preweighed for each plot and scattered by hand to ensure uniform distribution on 12 Mar. 1993 and 11 Mar. 1994. Fertilizer treatments were watered immediately after planting to minimize potential volatilization of the urea. Irrigation was provided by overhead sprinkler with a total of 41 and 20 in of water applied in

Table 1. Initial soil pH and nutrient status of buffalograss fields at Bronco, TX, where soil fertility trials on buffalograss burr yields were conducted.

	1993				1994			
	Soil depth, in				Soil depth, in			
Index	0-6	0-12	12-24	24-36	0-6	0-12	12-24	24-36
ph	8.7	8.7	8.6	8.9	8.5	8.2	8.0	8.2
Nitrogen (ppm)	1	1	1	1	14	7	7	12
Phosphorous (ppm)	169	118	21	5	12	13	12	12
Potassium (ppm)	571	508	539	256	203	166	105	90
Calcium (ppm)	8571	8571	8571	8571	2410	2500	2400	2200
Magnesium (ppm)	827	827	827	827	220	228	244	500
Zn (ppm)	0.2	0.3	0.1	0.1	0.3	0.2	0.2	0.2
Fe (ppm)	3.5	5.0	3.8	8.5	3.0	3.0	3.0	2.0
Mn (ppm)	3.0	3.0	0.9	0.3	3.0	2.0	2.0	.01
Cu (ppm)	0.4	0.4	0.3	0.1	0.4	0.4	0.4	0.4
Na (ppm)	115	158	498	139	70	152	171	143
Boron (ppm)	—	—	—	—	0.7	0.3	0.6	0.4

the 1993 and 1994 growing seasons, respectively. Total precipitation was 10 in and 11 in for 1993 and 1994.

Plots were harvested 9 Nov. to 4 Dec. of 1993 and 11 Nov. to 15 Dec. of 1994 using a rotary lawn mower with a rear bagging system. A swath 20 in wide and 23 ft long was cut 0.4 in above the soil surface from each plot and placed in individual polyweave sacks. The harvested area was then vacuumed and the recovered residue added to the clippings. Harvested clippings were dried for 5 d at 86°F in a forced air oven. Burrs were separated with a small plot thresher and a clipper seed cleaner to provide estimates of total seed yield.

This trial was arranged in a split plot, randomized complete block design with four blocks. The five N rates were assigned to main plots: (30 ft × 24 ft) and the five P rates to subplots (6 × 24 ft) to minimize the impact of N fertilizer movement between plots. Data from each year of the study were analyzed separately using analysis of variance. Fisher's Protected Least Significance Test was used to separate means (SAS, 1989).

Nitrogen Rate × Split Applications Trial. Five total rates of N (0, 20, 40, 60, and 80 lbs/acre) were applied in one, two, or three applications to buffalograss using the procedures described for the previous trial. The single application was applied on a single date (12 Mar. 1993 and 11 Mar. 1994). Fertilizer treatments for the double (split) application was placed on the plots on 12 Mar. and 20 Apr. 1993, and 11 Mar. and 20 Apr. 1994. Fertilizer treatments for the triple (split) applications were placed on the plots on 12 Mar., 20 Apr., and 13 May of 1993; and 11 Mar., 20 Apr., and 12 May of 1994. Fertilizer treatments were preweighed for each plot and scattered by hand to ensure uniform distribution. Fertilizer treatments were watered immediately after planting to minimize potential volatilization of the urea.

A randomized complete block design with four blocks was used. Data from individual years were subject to separate analysis of variance. Means for all analysis were separated with Fisher's Protected Least Significant Difference test (SAS, 1989).

Micronutrient Trial. Four micronutrients (Mn, Fe, Zn, and B) were applied as foliar sprays on 10 May 1993 and 12 May 1994 to buffalograss using the procedure described for the N × P trial. Chelated Mn Sulfonate was applied at two rates (0.21 lbs Mn/acre + 0.16 lbs S/acre and 0.41 lbs Mn/acre + 0.32 lbs S/acre). Chelated Zn Chloride was applied at two rates (0.13 lbs Zn $acre^{-1}$ and 0.24 lbs Zn $acre^{-1}$). Chelated Fe Sulfonate was applied at two rates (0.19 lbs Fe/acre + 0.10 lbs S/acre and 0.38 lbs Fe/acre + 0.19 lbs S/acre). Boron was applied as mixed borate at the rate of 8.3×10^{-4} lbs B/acre. All micronutrients were applied by a hand sprayer after dissolved in solution equivalent to 40 gal H_2O/acre to ensure uniform coverage. The entire plot area in which the micronutrients were applied was uniformly treated with 36 lbs N/acre as urea on 12 Mar. 1993 and 11 Mar. 1994. This trial was conducted as a randomized complete block design with four blocks. Data from each year of the study were analyzed using analyses of variance and means were separated with Fisher's Protected Least Significant Difference test (SAS, 1989).

Cultural Practices

Additional trials were conducted in 1993 and 1994 at Lubbock, TX on an Amarillo fine sandy soil (fine-loamy, mixed thermic Aridic Paleustalfs). The test site was at an altitude of 3290 ft and was located at 33° 35′ N latitude and 101° 58′ W longitude. Buffalograss was fertilized with 20 lbs N $acre^{-1}$ as ammonia sulfate (21:0:0:24) on 11 May of 1993 and 10 May of 1994. Additional nutrients were not added. During the establishment year, these plots were evaluated for seedling establishment and turf quality (Gaitan-Gaitan et al., 1998; 1999). Treatments were evaluated for their impact on burr production during the second year of establishment.

Planting Rate Study. Burrs from a 1991 lot of 'Comanche' (Davis et al., 1978) were dehulled by Frontier Hybrids (Abernathy, TX) in early 1992 to provide the seed used in both years of this study. Burrs of the same seed lot were commercially treated with a 0.5% potassium nitrate solution for 24 h prior to the initiation of the study in 1992 (Wenger, 1941). Both treated burrs and seed were stored at room temperature (72 to 81°F).

Planting rates of 626, 939, 1253, and 1566 burrs or seeds/yd^2 were used to establish the plots used in this study. This seed lot required 0.26, 0.39, 0.52, and 0.67 oz/yd^2 of burrs and 0.04, 0.06, 0.08, and 0.10 oz. per yd^2 of seeds to provide rates equivalent to 626, 939, 1253, and 1566/yd^2. These planting rates assumed only one seed per burr would establish.

The studies were planted 17 June 1992 and 17 May 1993. Burrs and seed were scattered by hand to ensure even distribution and immediately covered with approximately 0.24 in of sand to reduce desiccation. A micro set sprinkler system applied approximately 2.0 in of water immediately after planting and an additional 0.5 in of water every 3 d during the first 14 d of the study. During weeks 3 and 4 of the study, the irrigation rate was decreased to 0.5 in every 4 d. This irrigation schedule provided adequate moisture to ensure optimum germination and establishment for the initial 4 wks after planting. Subsequent irrigations during the remainder of the establishment year were scheduled on the basis of estimated evaporation as determined by published estimates provided by the Texas A&M Center at Lubbock, TX.

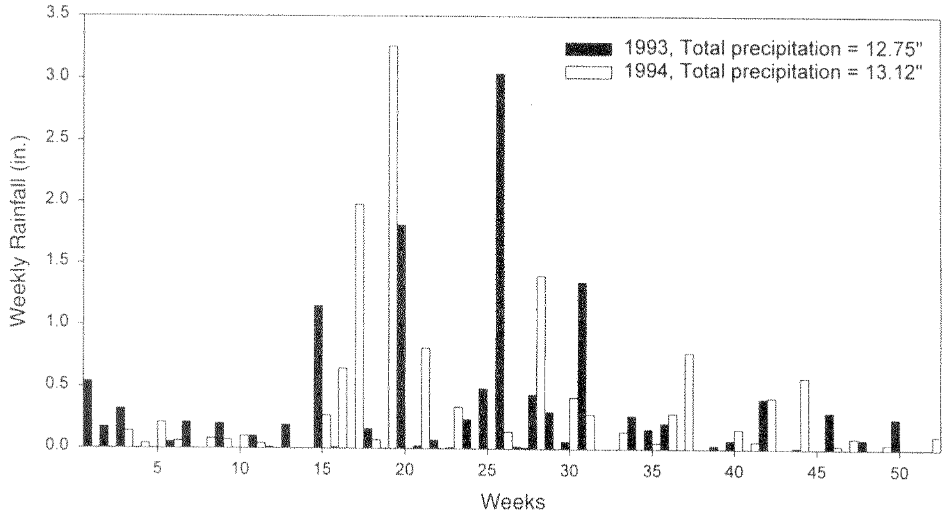

Figure 1. Rainfall distribution at Lubbock, TX during 1993 and 1994.

During the winter following establishment, the plots were mowed to a height of 2 in above the soil surface to remove accumulated thatch to stimulate burr production. During the seed production year, plots were irrigated twice each week to replace soil moisture lost through estimated evapotranspiration. An additional 20 in of irrigation water were applied in 1993 and 27 in 1994. Rainfall at this site was 127 in in 1993 and 13 in in 1994 (Fig. 1).

Treatments were planted in a randomized complete block design with a split-plot treatment arrangement and five blocks. The main plots were seed types (burrs or seed), and the four planting rates were subplots. Main plots were 43.2 ft^2 in 1992 and 96.8 ft^2 in 1993 and 1994. Subplots were 10.8 ft^2 in 1992 and 24.2 ft^2 in 1993 and 1994. Data were analyzed using analyses of variance and means separated by Fisher's Protected Least Significant Difference Test at the 0.05 level of probability (SAS, 1989).

Planting Date Study. This study was conducted using procedures described for the planting rate study with the following exceptions: Seven planting dates evaluated in this study ranged from mid-June (Day of Year 165) to mid-September (Day of Year 250) in 1992 and 1993. The experiment was conducted as a randomized complete block design with a split-split plot arrangement of treatments and five blocks. The seven planting dates were assigned to main plots, the two seed types (burrs and seed) were assigned to subplots, and cultivars (Comanche and Texoka) to sub-subplots. Data were analyzed using analyses of variance and mean separations were performed using Fisher's Protected Least Significant Differences Test at the 0.05 level of probability.

Date of Harvest Study. This study was conducted using procedures described for the planting rate study except all plots were seeded in early spring of 1993. The experiment was conducted as a randomized complete block design with four blocks and a split plot arrangement of treatments. Cultivars (Commanche and Texoka) were assigned to main plots (96.8 ft^2) and harvest dates were assigned to subplots (24.2 ft^2). Harvest dates were 1 July 1994, 15 July 1994, 27 July 1994; and 11 January 1995. Data were analyzed using analyses of variance and mean separations were performed using Fisher's Protected Least Significant Differences Test at the 0.05 level of probability.

RESULTS AND DISCUSSION

Soil Fertility

Initial soil analyses conducted at both Bronco, TX test sites showed the soil had a high pH of 8.6 to 8.9 in 1993 and 8.0 to 8.5 in 1994 (Table 1). Both sites had low levels of residual N and most micronutrients based on soil tests. The 1994 site had very low levels of available P. These soil analyses suggest that the application of nutrients should have improved the yields of most cereal and forage crops. The low burr yields observed in 1994 trials were probably the result of an extreme drought and limited irrigation at the site which provided only 31.0 in of total moisture compared to 60.6 in of total moisture in 1993 (Fig. 1).

Nitrogen × Phosphorus Trial. In 1993 and 1994, there was no N × P interaction in burr yield (Table 2). The main effect of P did not influence burr yield in either year of these trials, but the addition of N increased burr yield in 1993. Under dry conditions such as in 1994, soil nutrients did not appear to limit burr production. Under conditions where moisture is not limiting, growers would probably obtain increases in burr yield with applications of 20 to 40 lbs of N/acre.

Nitrogen Rate × Split Applications Trial. In 1993, average burr yield of buffalograss increased from 198 lbs/acre with no N application to 356 lbs/acre with 80 lbs of N $acre^{-1}$ (Table 3). The increase in burr yield with increasing N rates was less dramatic in 1994 when moisture stress limited burr production. Splitting N application in one, two, or three applications had no measurable impact on burr yield. This could be expected under the dry conditions under which these trials were conducted, when growth was limited by moisture availability. Once again, applications of 60 to 80 lbs of N/acre would probably increase burr yield in environments where moisture did not limit burr production.

Micronutrient Trial. In 1993, there was no significant response in burr yield to the foliar application of micronutrients even with the high soil pH's (8.0 to 8.9) measured at this site (Table 4). Under the dry conditions of 1994, a slight but statistically significant response in burr yields to application of micronutrients was observed. Because this response was highly variable, no consistent recommendation on micronutrient fertility could be made based on these limited data.

Table 2. Effect of nitrogen (N) and phosphorous (P) fertilization on buffalograss burr yield at Bronco, TX in 1993 and 1994.

	lbs N/acre					
lbs P_2O_5/acre	0	20	40	60	80	Avg
1993	----------------	----------------	lbs/acre	----------------	----------------	----------------
0	238	236	368	353	394	**318 a**[†]
20	249	347	380	347	380	**341 a**
40	295	312	322	416	380	**345 a**
60	300	336	322	347	286	**318 a**
80	348	314	409	317	436	**365 a**
Avg	**286 c**[†]	**309 bc**	**360 ab**	**356 ab**	**375 a**	
CV = 27.2%						
1994	----------------	----------------	lbs/acre	----------------	----------------	----------------
0	96	96	71	130	100	**99 a**[†]
20	87	88	85	94	119	**95 a**
40	87	91	100	90	122	**98 a**
60	73	86	139	121	105	**105 a**
80	108	127	111	123	104	**113 a**
Avg	**90 a**[†]	**98 a**	**101 a**	**112 a**	**110 a**	
CV = 34.7%						

[†] Means of average N or P rates not followed by the same letter differ at 0.05 level of probability by Fisher's Protected Least Significant Difference Test.

Cultural Practices

Planting Rate Study. During the initial year of establishment, buffalograss usually does not produce significant burr yields. Consequently, burr yields were not determined until the second year of establishment. No differences in burr yields were measured among seeding rates or between plots established with either burrs or seed. No interaction was present among these factors during either 1993 or 1994 (Table 5). These data indicate that establishment of buffalograss for burr production can be achieved across a wide range of seeding rates using both burrs and seed removed from the burrs. The stolons of this warm-season grass, with appropriate irrigation and weed control, quickly produce uniform stands. Higher burr yields were observed in 1994 than in 1993 probably reflect the additional irrigation water applied in 1994.

Planting Date Study. No differences in burr yield were detected between planting dates (1993); cultivars (1993 and 1994); planting burrs vs. seed (1993 and 1994); and the interactions of these factors (Table 6). The mid-September planting date in the 1994 harvested trial had lower burr yields than all earlier planting dates. All other factors did not impact burr yield. These results indicate that buffalograss fields grown for burr production could be established as late as midsummer using either burrs or seed. This would facilitate rapid seed increase of improved varieties of buffalograss.

Table 3. Effect of split applications of nitrogen (N) on burr yield of buffalograss at Bronco, TX in 1993 and 1994.

Total N applied	Number of applictions	Burr weight 1993	Burr weight 1994
—lbs/acre—	—No.—	—lbs/acre—	
0	**0**	**198 de**[†]	**74 b**[†]
20	1	264 cde	113 ab
	2	237 cde	126 a
	3	176 e	94 ab
	Avg	**226**	**111**
40	1	244 cde	117 ab
	2	224 cde	105 ab
	3	265 cde	111 ab
	Avg	**244**	**111**
60	1	294 bcd	106 ab
	2	265 cde	102 ab
	3	405 a	115 ab
	Avg	**322**	**108**
80	1	369 ab	116 ab
	2	316 abc	100 ab
	3	384 ab	113 ab
	Avg	**356**	**110**
CV		25.5%	33.7%

[†] Means not followed by the same letter differ at 0.05 level of probability by Fisher's Protected Least Significant Difference Test.

Table 4. Effect of foliar-applied micronutrients and sulfur on burr yield of buffalograss at Bronco, TX in 1993 and 1994.

Nutrients	Application rate	Burr weight 1993	Burr weight 1994
	-- lbs/acre --	------------ lbs/acre ------------	
Manganese/Sulfur	0.41/0.32	121 a[†]	56 cd[†]
Iron/Sulfur	0.19/0.10	125 a	113 a
Iron/Sulfur	0.38/0.19	123 a	64 bcd
Manganese/Sulfur	0.21/0.16	112 a	63 bcd
Zinc	0.13	109 a	95 ab
Boron	0.83	109 a	92 abc
Control	0.00	91 a	43 d
Zn	0.24	84 a	117 a
CV		29.5%	43.0%

[†] Means not followed by the same letter differ at 0.05 level of probability by Fisher's Protected Least Significant Difference Test.

Table 5. Burr yield of Comanche buffalograss established the previous year at four seeding rates of burrs or seed at Lubbock, TX in 1993 and 1994.

Treatment	Burr yield 1993	1994
	---------------------lbs/acre---------------------	
Seeding Rate:		
Burrs or Seed yd^2		
626	257 a	481 a†
939	249 a	473 a
1253	245 a	454 a
1566	194 a	592 a
Seed Treatment:		
Burrs	283 a	465 a†
Seed	187 a	485 a
Interactions:		
Rate x Treatment	ns	ns

† Means within a treatment column not followed by the same letter differ at the 0.05 level of probability by Fisher's Protected Least Significant Difference Test.

Table 6. Burr yield of buffalograss established the previous year at seven planting dates, two cultivars, and two seed treatments at Lubbock, TX in 1993 and 1994.

Treatment	Burr yield 1993	1994
	--------------------lbs/acre--------------------	
Planting Date:		
Mid-June	214 a	472 a†
Late June	288 a	540 a
Mid-July	228 a	552 a
Late July	245 a	489 a
Mid-August	203 a	472 a
Late August	172 a	445 a
Mid-September	185 a	259 b
Cultivar:		
Comanche	230 a†	477 a†
Texoka	209 a	447 a
Seed Treatment:		
Burr	207 a†	443 a†
Deburred	231 a	480 a
Coefficient of Variation	32.4%	33.4%

† Means within a treatment column not followed by the same letter differ at the 0.05 level of probability by Fisher's Protected Least Significant Difference Test.

Table 7. Total and percent burr yield of post frost (PF) harvest of Comanche and Texoka buffalograss at four dates with dual and single harvest regimes at Lubbock, TX in 1994.

Treatment	Total burr yield	Final harvest
	---- lbs/acre -----	-------%-------
Cultivar:		
Comanche	581 a†	48 a†
Texoka	443 b	47 a†
Harvest Dates:		
1 July / PF	447 a†	
	28 a†	
15 July / PF	591 a	33 a
27 July / PF	551 a	31 a
PF	459 a	100 b
Interactions:		
Cultivar × Harvest Date	ns	ns
CV%	29.5%	60.4%

† Means within a treatment column not followed by the same letter differ at the 0.05 level of probability by Fisher's Protected Least Significant Difference Test.

Date of Harvest Study. In the 1994 growing season, Texoka produced slightly lower total burr yields than Comanche (Table 7). The four harvest dates and the cultivar × harvest date were not significantly different. The percentage of seed recovered in the final harvest of the three dual harvest date regimes ranged from 28 to 33% indicating that a large proportion of the burrs of buffalograss was produced in the early summer. The burrs harvested at the three midsummer dates appeared to be physiologically mature, but no attempt was made to determine seed quality of the dual harvest regime. Based on this study, it would appear that buffalograss burrs can be grown under a wide range of harvest regimes.

CONCLUSION

These studies attempted to optimize production of buffalograss burrs on the Texas High Plains. They indicated that soil fertility requirements of buffalograss are highly dependent upon available soil moisture. Under dry conditions, the addition of soil nutrients did not significantly increase burr yield. In conditions where total available moisture was less than 47 in, burr production had a positive response from applications of 60 to 80 lbs of N/acre and 20 to 40 lbs of P_2O_5/acre. These studies did not provide adequate information to provide recommendations in sulfur or micronutrients. The factors of planting burrs vs. seed, planting date, planting rate, and cultivar had a minimal impact on burr yield of buffalograss in the year following establishment. Based on these studies, it appears that buffalograss is adapted to a dual harvest regime. Under this type of harvest management, almost 70% of the total burr yield was obtained in the initial mid-July harvest. In some situations, it might be more profitable to use the fall growth of buffalograss on burr production fields for forage instead of as a second burr crop.

Future research should concentrate on better defining the interaction of soil moisture and soil nutrition on burr yield of buffalograss. It would also be important to better define the impact of different harvest regimes on germination and emergence of the harvested burrs and the seed they contain.

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