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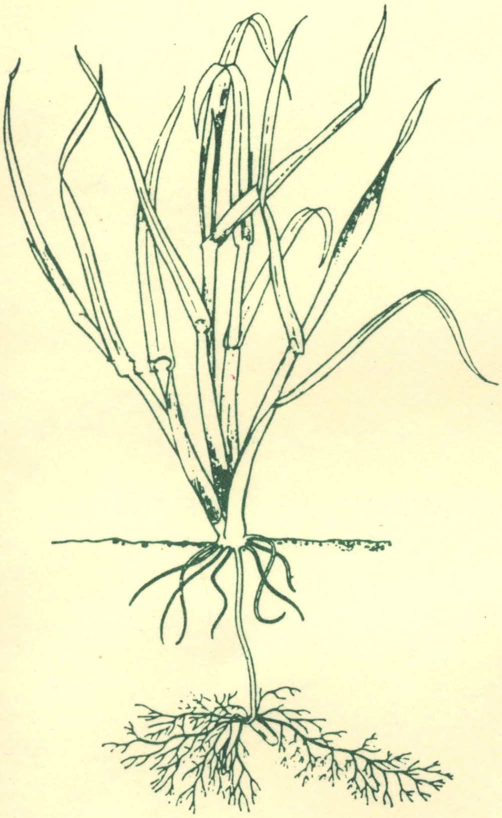

Productivity of 10 Warm - Season Perennial Grasses Over Several Years in Central Texas

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Productivity of 10 Warm-Season Perennial Grasses Over Several Years in Central Texas

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Abstract

Perennial warm-season grasses provide valuable forage during summer months in the southern Great Plains. Objectives of two 5-year studies were to compare 10 warm-season grasses for productivity and response to nitrogen (N) fertilizer over many environments. In Experiment 1, the yield response of 'Morpa' and 'Renner' lovegrass [*Eragrostis curvula* (Schrad.) Nees], 'Selection-75' kleingrass (*Panicum coloratum* L.), buffelgrass (*Cenchrus ciliaris* L., strain 18-35) and 'Coastal', 'Coastcross-1', and 'Alecia' bermudagrass [*Cynodon dactylon* (L.) Pers.] to four levels of N (0 to 500 lb per acre) was measured during 1972 and from 1974 to 1977. Plots were harvested three or four times each year. In Experiment 2, Selection-75 kleingrass, 'Llano' buffelgrass, PMT-587 bluestem (*Dicanthium* spp.), 'Pretoria-90' bluestem (*Dicanthium annulatum* Stapf.) and caucasian bluestem [*Bothriochloa caucasica* (Trin.) C.E. Hubb.] were evaluated for herbage yield from 1975 to 1979. Plots were harvested one to three times each year. In Experiment 1, bermudagrasses exhibited the greatest response to applied N and outyielded other species when rainfall was average or above average and N rate was high. Buffelgrass, kleingrass, and lovegrass produced well with limited N and rainfall; however, buffelgrass winterkilled after 3 years. In Experiment 2, Pretoria-90 bluestem produced very high yields from 1975 to 1978 before being severely winter damaged in the winter of 1978-1979. Buffelgrass yield was much reduced by winter injury during the winter of 1976-1977 and suffered complete stand loss the following winter. Caucasian bluestem, kleingrass, and lovegrass produced reliable yields over 5 years.

Introduction

Perennial warm-season grasses can meet a significant forage need during the summer months in the southern Great Plains and are well suited for revegetation of marginal lands. The establishment of the Conservation Reserve Program (CRP) in the 1985 Food Security Act (P.L. 99-198) has resulted in 30 million acres of highly erodible cropland being set aside, much of which has been planted to warm-season perennial grasses (Heimlich and Kula, 1989). In 1996, the first of the 10-year contracts will expire. This has prompted natural resource managers and farmers to consider the fate of these grasslands (Goetz, 1989; Heimlich and Kula, 1989). Thus, it is imperative to gather management information so that CRP lands can be integrated successfully into existing range and pasture land when the program expires. Producers desire information on persistence, productivity, nitrogen (N) requirements, and selection of species or varieties of warm-season grasses to design effective forage production systems.

Revenues from forage-rangeland animal production systems comprise more than one-half of the annual $12 billion of agricultural income in Texas in 1989 (Anderson and Summerour, 1990). Livestock operations located in the 20- to 30-inch rainfall zone of the United States often combine rangeland with cropland and tame pastures. Much of the tame pasture and hayland areas are planted to warm-season perennial grasses.

The objectives of the 5-year studies reported here were to: (1) compare warm-season grasses for their productivity over several years in this region, and (2) to determine the response to N fertilizer over several years under the temperature and rainfall conditions of central Texas.

Materials and Methods

Experiment 1

The response of six warm-season grasses to four levels of N was evaluated during 1972, and 1974 to 1977. Strain 18-35 buffelgrass, Morpa lovegrass, Selection-75 kleingrass, and Coastal, Coastcross-1, and Alecia bermudagrass were planted in a Windthorst fine sandy loam (fine, mixed, thermic, Udic Paleustalf) soil at Stephenville, Texas, in spring of 1972. Renner lovegrass was seeded in spring of 1973. Lovegrass, buffelgrass, and kleingrass were seeded at 2 lb of pure live seed (PLS) per acre in rows 3 ft apart. Bermudagrasses were sprigged in rows 3 ft apart. Species whole plots were 17 ft by 40 ft in four randomized blocks.

Four N levels—none, low, medium, and high—were imposed on subplots of each species. In 1972, N was applied at 50, 100, and 200 lb/acre in March and after the first harvest for the low (100 lb), medium (200 lb), and high (400 lb) treatments, respectively. In 1974, 50 lb of N was applied on 22 March and 25 lb after Harvests 2 and 3 for the low (100 lb) rate. Medium (313 lb) and high (500 lb) rates of N were applied at 62.5 and 100 lb/acre, respectively, on 22 March and after each of the four harvests. From 1975 to 1977, one-third of the total N was applied in mid-April and after the first and second harvests for a total of 75, 188, and 300 lb N/acre for low, medium, and high treatments.

The experimental design was a randomized complete block with a split-plot arrangement of N treatments in four blocks. Grass entries were whole plots and N rates were subplots. Nitrogen effects were partitioned into linear, quadratic, and lack-of-fit terms. Because of different N rates in different years, years were analyzed separately.

Experiment 2

Selection-75 kleingrass, Llano buffelgrass, PMT-587 bluestem, Pretoria-90 bluestem, and caucasian bluestem were evaluated for herbage yield for 5 years. Plants of kleingrass, buffelgrass, and Pretoria-90 bluestem were started in pots in a glasshouse and then transplanted on 2-ft centers into 6 ft by 12 ft plots (12 plants per plot) on 27 May and 2 June,

1975. PMT-587 and caucasian bluestem were broadcast seeded at 2 lb PLS per acre in early June, 1975. All plots received 0.75 inches of water by solid-set irrigation sprinklers on 1 June, 30 June, 11 July, and 7 Aug., 1975 to ensure a stand. Rates of N, P_2O_5, and K_2O applied to plots were 50-40-0 lb/acre, respectively, in 1975, 150-80-160 in 1976, 300-40-0 in 1977, 200-80-160 in 1978, and 150-0-0 in 1979.

Herbage was cut 2 inches aboveground from a 3 ft by 12 ft section in each plot, weighed, and a subsample dried at 158°F to determine dry matter (DM) yield. Plants were harvested at boot or early flower stage. One harvest was made in 1975 and 1979, three in 1976 and 1977, and two in 1978.

In 1976 and 1977, herbage samples from each harvest of each species were analyzed for total N concentration via standard macro-Kjeldahl procedures. Crude protein was calculated as total N x 6.25.

The experimental design was a randomized complete block with four blocks. Grass entry differences were determined by a protected least significant difference test. Years were analyzed separately because of different entries in each year.

Results and Discussion

Experiment 1

Entry differences

Analysis of variance indicated significant species, N level, and species x N level effects on DM yield in each year except 1977 when species were not significantly different in yield (Table 3). Yield of all entries varied with year, primarily because of climatic differences (Tables 1 and 2). Buffelgrass yields declined progressively from 1972 to 1975 because of cumulative winter injury, and died out completely by 1976. Buffelgrass is not adapted to winter in central and north central Texas (Holt and Bashaw, 1976).

Coastal bermudagrass outyielded other bermudagrass cultivars except in 1977 when no differences among cultivars were observed. Alecia bermudagrass outyielded Coastcross-1 4 out of 5 years. Holt et al. (1978) also reported that Coastal bermudagrass generally outyielded other bermudagrass cultivars. Kleingrass outyielded all entries in 1976 when rainfall was much above average. Renner lovegrass generally outyielded Morpa lovegrass in each year.

Table 1. Rainfall (inches) during spring (March to May), summer (June to Aug.), fall (Sept. to Nov.), and winter (Dec. to Feb.) from 1972 to 1979 at Stephenville, Texas, compared with 40-year average.

Season	Average	1972	1974	1975	1976	1977	1978	1979
Spring	9.7	8.1	2.4	7.4	11.5	13.3	5.9	16.1
Summer	6.8	4.9	8.0	3.8	11.4	4.1	3.7	7.7
Fall	8.0	6.2	14.8	2.9	10.0	2.9	8.1	2.8
Winter	5.0	1.9	3.0	4.1	2.8	2.2	3.4	8.3
Total	29.5	21.1	28.2	18.2	35.7	22.6	21.1	34.9

Table 2. Average daily temperature (°F) during spring (March to May), summer (June to August), fall (Sept. to Nov.), and winter (Dec. to Feb.) from 1972 to 1979 at Stephenville, Texas, compared with 40-year average.

Season	Average	1972	1974	1975	1976	1977	1978	1979
Spring	63.0	67.6	68.2	61.9	62.6	56.8	62.9	61.5
Summer	81.2	79.7	80.4	81.9	79.3	82.7	81.9	78.0
Fall	65.2	65.1	64.7	64.7	61.8	68.4	64.4	63.8
Winter	45.9	47.9	47.7	43.9	49.8	44.4	38.6	39.0

Table 3. Analysis of variance and significance of F values for dry matter yields from 1972 to 1977 in Experiment 1.

Source of variation	df[++]	Significance level[+] 1972	1974	1975	1976	1977
Species (S)	5	***	***	***	***	NS
N rate (NR)	3	***	***	***	***	***
Linear	1	***	***	***	***	***
Quadratic	1	NS	NS	NS	NS	***
Lack-of-fit	1	NS	***	***	*	***
S X NR	15	***	***	***	***	***
S x Linear	5	**	***	***	**	**
S x Quad	5	NS	NS	***	NS	NS
S x LOF	5	NS	**	NS	NS	NS
CV %		21.5	20.3	17.6	20.0	17.0

[+] *** P<0.001; ** P<0.01; * P<0.05; NS = not significant.
[++] Degrees of freedom for 1974 were, S = 6, NR = 3, S X NR = 18 S X linear = 6, S X quadratic = 6, S X lack-of-fit (LOF) = 6.

Entry response to N

Species DM yield response to N level was linear in each year except in 1975 when there was a quadratic response by Renner and Morpa lovegrass (Tables 3, 4, 5, and 6). The species x linear and species x quadratic interaction indicated that species differed in their yield response to N application.

Buffelgrass, kleingrass, and Morpa lovegrass did not show a yield response to N in 1972, a dry year (Tables 1 and 5). Bunchgrasses increased in N responsiveness with age of stand with peak N response occurring in 1976 when excess rainfall occurred during the entire growing season (Tables 1 and 5). Although 1974 was near normal in total rainfall, spring rainfall was much reduced and may have limited bunchgrass and bermudagrass response to N. In 1975, however, adequate spring rain may have allowed an early N response even though total rainfall was 11 inches below normal.

Generally, the bermudagrasses showed the greatest response (larger regression slope) to applied N in each year with the greatest response occurring during years of average or above average rainfall (e.g., 1976). The bermudagrasses each responded to increased N application with Coastcross-1 and Alecia having a greater response (average slope = 16.98, 22.79, and 21.31 lb of DM/lb of N applied for Coastal, Coastcross-1, and Alecia, respectively, over 5 years).

The bunchgrasses typically yielded more at zero-N (larger regression intercepts) than did bermudagrasses. During 1975, a very dry year, lovegrass and kleingrass yields at zero-N were two to three times greater than those of buffelgrass and bermudagrass. Lovegrasses outyielded other grasses in 1974, 1975, and 1976 at low N inputs (75 to 100 lb/acre). Only at N fertilizer levels greater than 200- to 300-lb/acre did bermudagrass outyield bunchgrasses. Renner lovegrass responded more to applied N than did Morpa in 1974, 1976, and 1977. The yield response of kleingrass in 1976, a wet year, was nearly as great as bermudagrass responses.

In our study, environment and species as well as cultivar influenced yield-N relationships in warm-season grasses. Read (1982) reported no differences among three warm-season bunchgrasses [Selection-75 kleingrass, plains bluestem (*B. ischaemum* L. King)] and 'Alamo' switchgrass (*Panicum virgatum* L.) in response to various N levels. Jung et al. (1990), however, reported year, cultivar, and N rate interac-

Table 4. Total season dry matter yields of bunchgrasses and bermudagrasses in response to nitrogen fertilizer over 5 years at Stephenville, Texas. Experiment 1.

Nitrogen Rate	BG	KG	MLG	RLG	CBG	ABG	CCBG⁺
	Dry matter yield (lb/acre)						
(lb/acre)				1972			
0	4425	4715	3003		3547	2994	1454
100	4614	5319	3157		4956	3629	3866
200	4810	5282	3146		7646	6338	4699
400	4582	5932	3445		8813	6207	5415
Mean	4608	5312	3188		6240	4792	3858
				1974			
0	513	1127	1635	1894	721	272	446
100	1472	1610	2374	2909	1573	992	1460
313	3253	2512	2192	3221	4239	4134	3858
500	3316	2528	2644	3589	5390	5431	4032
Mean	2138	1944	2211	2903	2981	2707	2449
				1975			
0	656	1564	2122	3191	645	371	456
75	919	2257	3671	5612	2062	1934	2023
188	2709	4423	6351	8325	5912	6069	4837
300	3138	5919	6645	7966	9370	7462	6116
Mean	1856	3540	4697	6273	4497	3959	3358
				1976			
0		3171	2020	3485	2013	1251	1499
75		6910	4986	6716	4441	3625	5609
188		12519	6264	9072	10598	8255	8899
300		12971	7130	11153	12758	12185	11615
Mean		8893	5100	7606	7452	6329	6905
				1977			
0		1593	2834	1955	842	728	1282
75		3382	3057	3566	3014	3091	4104
188		5845	5104	5202	6364	6254	6074
300		5620	5909	5706	7537	7996	6275
Mean		4110	4107	4226	4439	4517	4434

⁺BG = Strain 18-35 buffelgrass; KG = Selection-75 kleingrass; MLG = Morpa lovegrass; RLG = Renner lovegrass; CBG = Coastal bermudagrass; ABG = Alecia bermudagrass; CCBG = Coastcross-1 bermudagrass.

Table 5. Regression equations describing response of bunchgrasses to applied nitrogen in Experiment 1. Equation form is Yield = A + b (Nitrogen rate)[1]. r^2 = coefficient of simple or multiple determination. REMS=root error mean square. P=probability level.

Year	Equation	r^2	REMS	P
	Buffelgrass			
1972	4524+ 0.44 x	0.01	602	NS
1974	810+ 5.82 x	0.76	683	0.001
1975	563+ 9.18 x	0.59	928	0.005
	Kleingrass			
1972	4820+ 2.62 x	0.12	1126	NS
1974	1279+ 2.92 x	0.53	568	0.001
1975	1410+15.14 x	0.85	777	0.001
1976	4113+33.96 x	0.78	2202	0.001
1977	2139+14.00 x	0.79	867	0.001
	Morpa lovegrass			
1972	3005+ 0.97 x	0.05	675	NS
1974	1866+ 1.51 x	0.29	489	0.03
1975	1956+31.68 x +0.05 x^2	0.87	796	0.025
1976	2870+15.84 x	0.75	1097	0.001
1977	2641+11.26 x	0.69	924	0.001
	Renner lovegrass			
1974	2228+ 2.96 x	0.55	555	0.001
1975	3076+44.14 x -0.09 x^2	0.83	1033	0.005
1976	4143+24.60 x	0.78	1591	0.001
1977	2352+12.47x	0.81	729	0.001

[1]The parameter "A" is the intercept of the equation and estimates the average yield response to zero N. The parameter "b" is the slope of the line or the change in yield per unit of N applied.

Table 6. Regression equations describing response of three bermudagrasses to applied nitrogen in Experiment 1. Equation form is Yield = A + b (Nitrogen rate). r2 = coefficient of simple or multiple determination. REMS = root error mean square. P = probability level.

Year	Equation	r^2	REMS	P
	Coastal			
1972	2158+ 9.07 x	0.68	1017	0.001
1974	719+ 7.58 x	0.88	589	0.001
1975	622+19.43 x	0.92	712	0.001
1976	2306+32.68 x	0.77	2160	0.001
1977	2158 +16.16 x	0.70	1280	0.002
	Coastcross-1			
1972	3686+13.62 x	0.62	1712	0.003
1974	757+ 9.74 x	0.91	647	0.001
1975	293+29.87 x	0.94	929	0.001
1976	2127+37.84 x	0.89	1613	0.001
1977	1217+22.89 x	0.86	1145	0.001
	Alecia			
1972	3085+ 9.10 x	0.48	1549	0.0031
1974	210+10.94 x	0.91	719	0.001
1975	433+25.05 x	0.93	857	0.001
1976	1115+37.04 x	0.95	1024	0.001
1977	1080+24.42 x	0.93	820	0.001

tions in various warm-season bunchgrasses in the Northeast. They grouped warm-season grasses into three categories: (i) those that responded early to applied N, (ii) those that showed a delayed response (2 to 3 years), and (iii) those with little or no response. Thus, the warm-season bunchgrasses used in our study would fit in Category 2, delayed response types, because the greatest N response occured after 2 to 3 years, whereas bermudagrasses, which responded in each year, would fit in Category 1.

Kleingrass and lovegrass should be excellent grasses to grow in dry areas with limited N fertilizer inputs. Our data indicate that the N requirements of kleingrass and lovegrass could be met by including an adapted warm-season legume with moderate or high N-fixing potential at low stands or establishing a good stand of a legume with a low N-fixing potential. Thus, legume and grass management to enable such a legume stand to persist may not be critical.

Experiment 2

There were no differences in DM yield among species in 1975 (Fig. 1a) probably because of limited rainfall (Table 1). The greatest yields occurred in 1976 when rainfall was 6 inches above normal. Pretoria-90 bluestem outyielded other species from 1976 to 1978 (Fig. 1b-d). Buffelgrass yields were very high in 1976, then declined greatly in 1977. Buffelgrass eventually died out during the winter of 1977-1978. Pretoria-90 bluestem was weakened during the winter of 1978-1979 as evidenced by the low yield in 1979 confirming its lack of winterhardiness in northcentral Texas. There were 1, 9, and 8 days in the winters of 1975-1976, 1976-1977, and 1977-1978, respectively, during which minimum temperatures of 7 to 15°F were recorded.

Caucasian and PMT-587 bluestems and kleingrass yields were similar during 1976 to 1978. In 1979, caucasian bluestem yielded the most, whereas PMT-587 bluestem and kleingrass were similar in yield. Yield for each species was distributed similarly throughout each season (data not shown). Most production occurred in late spring to early summer. Yields were least in summer and moderate in late summer to early fall. Pretoria-90 bluestem yield was distributed mostly toward the fall. Although stand density data were not collected, yield data and visual observations made at the end of the trial indicated little loss of stand among surviving bunchgrasses.

Kleingrass and buffelgrass had the highest crude protein concentration in 1976, whereas there was no clear pattern of crude protein differences among species in 1977 (Table 7). Lowest crude protein concentrations occurred in the last harvest, likely because the forage was more mature.

Table 7. Crude protein concentrations (percent of dry matter) of six warm-season perennial grasses at three harvest dates in 1976 and 1977. Data are the means of four replicates. Experiment 2.

	1976			1977		
Species	1	2	3	1	2	3
Caucasian bluestem	9.3	9.3	6.1	9.7	7.6	5.8
Buffelgrass	11.1	11.6	8.0		8.6	8.4
PMT-587 bluestem	7.8	7.9	6.0	11.2	9.1	6.8
Pretoria-90 bluestem	7.8	7.9	6.0	9.9	7.0	5.5
Kleingrass	11.0	10.9	6.4	10.6	11.2	7.8
L.S.D[1]	1.6	1.6	1.1	0.9	1.3	0.8

[1]Least significant difference at the 0.05 probability level.

Interpretive Summary

Federal conservation programs mandated by the 1985 Food Security Act have as their goal removing highly erodible land from cultivated crop production and changing its use to include permanent cover. Perennial grasses requiring limited inputs work well as permanent cover and, in the southern Great Plains, warm-season grasses would work well because they are adapted to the hot, dry summers typical of the region. Ten warm-season grasses were evaluated in two 5-year experiments in our study.

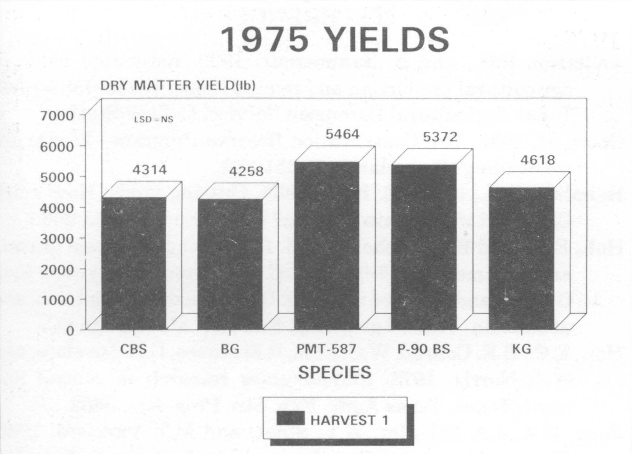

Figure 1a

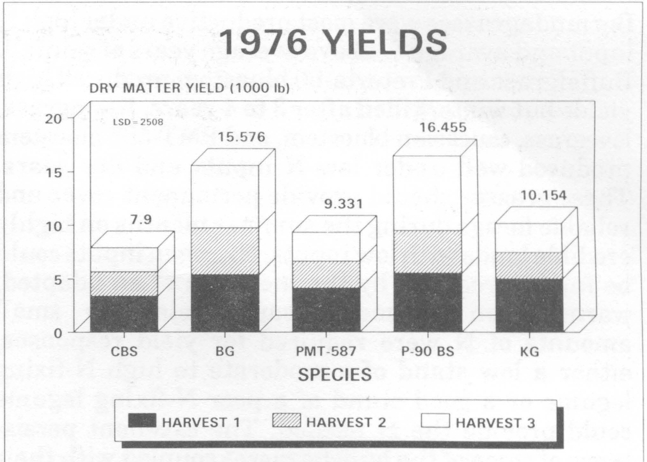

Figure 1b

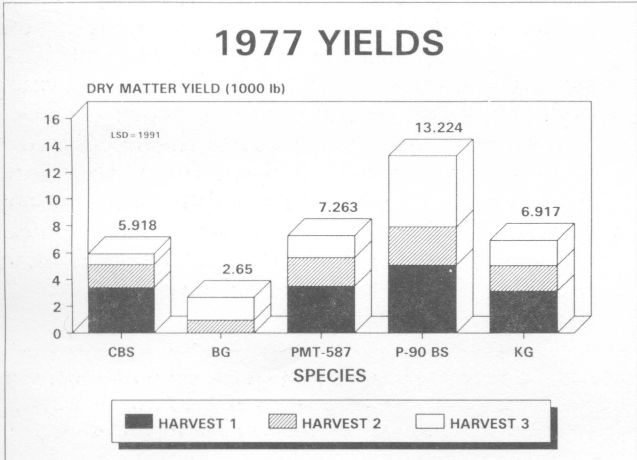

Figure 1c

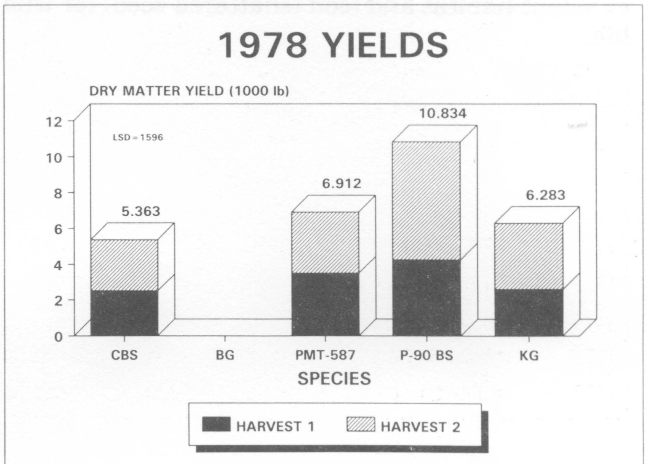

Figure 1d

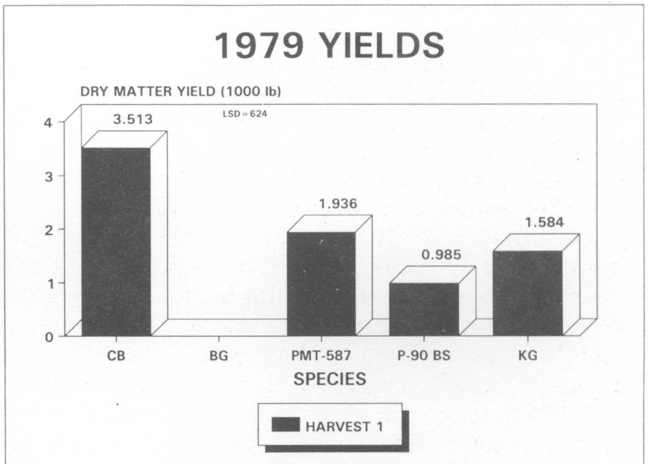

Figure 1e

Figures 1a - e. Yields of caucasian bluestem (CBS), buffelgrass (BG), PMT-587 bluestem (PMT-587), Pretoria-90 bluestem (P-90 BS), and kleingrass (KG) over 5 years at Stephenville, Texas. Experiment 2. L.S.D. = least significant difference at the 0.05 probability level. NS = not significant. Buffelgrass winterkilled during 1977-1978

Bermudagrasses were most productive under high N input and average or above average years of rainfall. Buffelgrass and Pretoria-90 bluestem produced high yields but winterkilled after 3 to 4 years. Kleingrass, lovegrass, caucasian bluestem, and PMT-587 bluestem produced well under low N inputs and dry years. These grasses should provide permanent cover and reliable forage during the summer months on highly erodible lands with low inputs. Nitrogen inputs could be further reduced by the inclusion of an adapted, warm-season legume. Because relatively small amounts of N were required for yield responses, either a low stand of a moderate to high N-fixing legume or a good stand of a poor N-fixing legume could provide the N needed. The excellent persistence of some of the bunchgrasses coupled with their low N requirement provide additional benefits in potentially reducing nonpoint source pollution. Additionally, species such as kleingrass provide excellent habitat and food (shattered seed) for wildlife.

References

Anderson, C.G., and B. Summerour. 1990. Estimated value of agricultural production and related items, Texas, 1986-1989. Texas Agricultural Extension Service, College Station.

Goetz, H. 1989. The Conservation Reserve Program—Where are we heading? Rangelands 11:251-252.

Heimlich, R.E., and O.E. Kula. 1989. Grazing lands: How much CRP land will remain in grass? Rangelands 11:253-256.

Holt, E.C., and E.C. Bashaw. 1976. Developing improved grasses and legumes. pp. 7-9. *In*: E.C. Holt and R.D. Lewis (ed.) Grasses and legumes in Texas: Development, production, and utilization. Texas Agric. Exp. Stn. Res. Monograph 6C.

Holt, E.C., B.E. Conrad, W.C. Ellis, R.M. Jones, D.A. Lovelace, and W.J. Norris. 1978. Bemudagrass research in central and north Texas. Texas Agric. Exp. Stn. Prog. Rpt. 3482.

Jung, G.A, J.A. Schaffer, W.L. Stout, and M.T. Panciera. 1990. Warm-season grass diversity in yield, plant morphology, and nitrogen concentration and removal in Northeastern USA. Agron. J. 82:21-26.

Read, J.C. 1982. Response of kleingrass, switchgrass, and plains bluestem to nitrogen fertility. Agron. Abstr. p. 127.

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