Influence of Nitrogen on Irrigated Buffalograss Yield and Protein Content

R. D. PETTIT AND RICHARD E. FAGAN

Highlight: *Buffalograss (*Buchloe dactyloides*), a shortgrass dominant in many plant communities throughout the Great Plains, was irrigated and fertilized with four rates of ammonium nitrate. Yield and crude protein were determined on six dates throughout the growing season. The highest nitrogen level (120 kg/ha) increased dry matter yield 130% while 30 kg/ha of nitrogen only increased yield 23% over the control. Peak crude protein concentration (16.71%) of herbage from the 120 kg of N/ha treatment was observed on July 8, while maximum crude protein (9.26%) in nonfertilized herbage was found a month earlier. In all fertilized treatments, peak protein yield preceded peak herbage yields by at least 1 month. Loss of proteins from herbage was greater in those plots receiving the higher rates of nitrogen than on those plots receiving lower nitrogen applications. It is important that grassland managers be aware of the "quality vs quantity" interaction when making management decisions. Based on results from this study, we can not recommend fertilization and irrigation of buffalograss range.*

Many studies have reported the effects of fertilization on native forages. Usual objectives of these studies were to increase herbage yields or forage quality. Increased forage production, resulting from fertilization, may be due to a change in species composition which, in some cases, is toward more desirable species (Rumburg and Cooper, 1961) or in some cases to less desirable forage species (Johnston et al., 1967).

Burzlaff et al. (1968) reported that application of commercial fertilizer, especially nitrogen, increased yields of the dominant forage species. In addition to increased productivity and change in species composition, nitrogen and phosphorus fertilization also increased the crude protein content of native forages (Dee and Box, 1967). Rodgers and Box (1967) asserted that native grasses in the southern High Plains of Texas seldom contained adequate protein in the winter to sustain livestock production.

Dudley (1953) reported that when a nonirrigated buffalograss monoculture was fertilized with 30 and 60 lb of nitrogen per acre, yields ranged from 806 lb/acre of forage in the control plot to over 1,600 lb/acre of forage where 60 lb of N had been added.

Near Amarillo, Texas, ammonium nitrate was applied to a native bluegrama range at rates up to 800 lb of N/acre. Irrigation water was applied to facilitate maximum herbage response. In this study, Lehman et al. (1968) found that blue grama could produce at least 7,500 lb/acre/year of oven-dry forage. They maintained, however, that this species was a relatively inefficient user of water when compared to improved forages.

In an earlier study we found that irrigation and nitrogen fertilization were detrimental to carbohydrate reserve concentrations in root and crown tissues of buffalograss. These results showed that photosynthate was used to facilitate increased yields and stolon and seed development at the expense of the root and crown system. This study, then, reports on the productivity and crude protein content of buffalograss herbage as affected by differing nitrogen applications under irrigation treatments.

The reader should be aware that water for irrigation in this part of Texas is becoming a limiting resource. The authors in no way imply that rangeland fertilization and irrigation are economically feasible at this time. Current costs of fertilizer and the uncertainty of livestock prices make cultural practices seem impractical on this type of range. However, when more favorable price structures are a reality, data from research are needed to help land managers make good decisions.

Methods and Procedures

This study was conducted at the Texas Tech University Center located 24 km northeast of Amarillo, Texas. Plots were on a fair condition, deep hardland range site with buffalograss predominating.

The soil of the study area is a Pullman silty clay loam, which is the soil type of about 4/5 of Carson County and 4.8 million hectares in northwest Texas (Coover et al., 1953). Infiltration and water percolation rates are slow.

In early April, 1971, pelleted ammonium nitrate was broadcast with a "whirlwind" spreader at rates of 0, 30, 60, 90, and 120 kg/ha of N onto a 10 m^2 plots. Plots were in a completely random grid with three replications of each treatment.

The 1971 rainfall was periodically supplemented with sprinkler irrigation to facilitate a maximum herbage response. Throughout this study 70 cm of water were received on all plots.

On June 10, July 8, August 11, September 18, October 19, and November 27, herbage yields were taken at ground level from two, 0.1 m^2 plots in each replication. Samples were dried in a forced air oven at 70°C for 24 hours prior to weighing. They were then ground in a Wiley Mill to pass through a 40-mesh screen and stored in air-tight containers.

The authors are assistant professor and graduate research assistant, Department of Range and Wildlife Management, Texas Tech University, Lubbock. Richard Fagan is presently natural resource specialist, Bureau of Land Management, Kanab, Utah.

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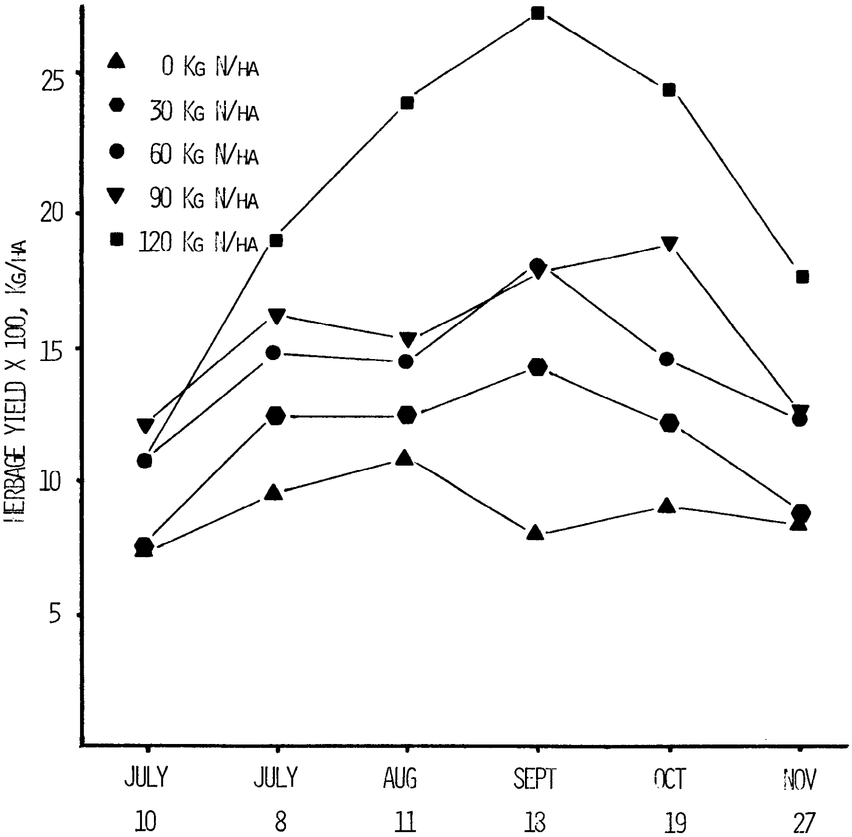

Fig. 1. *Herbage yield of nitrogen treated and irrigated buffalograss on a deep hardland range site in the Texas High Plains near Amarillo, Texas.*

Nitrogen determinations for crude protein were obtained by the automatic Dumas Combustion method using a Coleman Model 29 A Nitrogen Analyzer. This method of N determination yields results comparable to the more conventional Kjeldahl Method (Morris et al., 1969).

Data were analyzed as a split-plot factorial with sampling dates as whole units and fertilizer rates as the subunit in this analysis. Duncan's multiple range test was used to compare all means. Level of precision used was 0.05.

Results

Herbage Production

Nitrogen fertilization increased yields at all application rates and on nearly all sampling dates (Fig. 1). The highest N level–120 kg of N/ha–increased dry matter yield 130% over the control, while the lowest N rate–30 kg of N/ha–increased yields 23%. There was no difference in average yields for the August and October sampling dates, while yields on all other dates were different from each other. Peak standing crop in the 120 kg of N/ha treatment–2,787 kg/ha–was obtained on September 18. Peak standing crop on the nonfertilized plots, however, was obtained 5 weeks earlier.

Herbage Protein Concentration

The crude protein concentration within the herbage increased with each increase in N rate (Table 1). When considering the seasonal averaged protein concentration, no difference was found between the 30 and 60 kg of N/ha treatments. All other N rates produced herbage with higher protein levels. Similarly, all fertilized buffalograss herbage contained more protein than did the control treatment. No difference was found in herbage protein on the June and July sampling dates, while protein levels in herbage collected on all other dates were significantly different.

Peak crude protein concentration–16.71%–of herbage from the 120 kg of N/ha treatment was observed on July 8; maximum crude protein in the nonfertilized herbage–9.26%–was a month earlier. Protein levels of herbage from all treatments declined after July 8.

Fertilization, under optimum soil moisture conditions, dramatically increased the herbage protein yield on this site (Fig. 2). The 120, 90, 60, and 30 kg of N/ha rates produced 263, 134, 80, and 46% more protein, respectively, than did the control.

Discussion

Results from this study demonstrate that the quantity and quality of buffalograss herbage can be increased with N and water applications. Efficiency of dry matter production was also increased with N additions. However, maximum herbage yields were not obtained with our rates of application as evidenced by luxuriant growth on the borders of plots where fertilizer had spilled in the weighing process.

The loss of herbage protein from August 11 to September 18 was of major concern. It is generally assumed that maturing short grass species do not lose proteins as readily as taller grasses. Our data show that nearly 100% decrease in nitrogen concentration occurred in this time period when 90 or more kg of N/ha were applied. In the control and 30 kg of N/ha treatments, only 17% of the protein was lost in this same period. This differential loss of nitrogen from the herbage poses an important

Table 1. Average crude protein concentration (%) of irrigated and fertilized buffalograss herbage sampled throughout the growing season near Amarillo, Texas.

Nitrogen application rate[1]	Crude protein						
	June 10	July 8	Aug. 11	Sept. 18	Oct. 19	Nov. 27	Avg
0	9.26	8.47	7.98	6.64	4.84	2.68	6.65 a
30	11.83	11.88	8.13	6.57	5.53	2.66	7.77 b
60	12.33	11.62	8.31	5.72	5.51	2.80	7.78 b
90	12.08	13.62	12.80	6.57	5.97	3.24	9.05 c
120	13.25	16.71	15.30	7.68	6.26	4.56	10.63 d
Avg	11.75 a[2]	12.46 a	10.50 b	6.71 c	5.62 d	3.19 e	

[1] Fertilizer applied as NH_4NO_3, April, 1971.
[2] Protein concentrations in rows or columns followed by same letter are not different at the 0.05 level of significance.

question–why? Perhaps the most tenable answer is that this area received about 15 cm of rainfall between August and September 18. Until this date most water was artificially applied by irrigation. Phenologically the plants had progressed from the early to hard seed stage of development with little change in leaf tissue coloration. It seems logical, then, that substantial portions of the nitrogen passed into the atmosphere or into the soil. The Lehman et al. (1968) study with irrigated and fertilized blue grama on the same soil series disregarded soil N accumulation or leaching losses.

Other avenues of N losses are as gases into the atmosphere, accumulation of N in root material, and other chemical reactions. Wullstein and Gilmour (1964) warned that interpretations regarding soil N losses are incompletely understood. They further asserted that gas analysis was needed in nitrogen balance studies.

To support the hypothesis that gaseous loss of N was high in this study, unpublished data of microbial populations on a site near our study area showed the soil fauna to dramatically increase after the heavy, late summer precipitation. In addition, we have found blue grama-buffalograss litter decomposition rates to exceed net photosynthesis for this time period. Thus, denitrification and the gaseous loss of N as molecular nitrogen (N_2), nitrous oxide (N_2O) or nitric oxide (NO) are assumed to be major contributors to low N recovery rates in grassland ecosystems. Further testing of this hypothesis is needed.

In the control (0 N), peak protein and herbage yield occurred on the same date whereas all fertilizer treatments showed maximum protein yield occurring at least 1 month earlier than maximum herbage yield. Whitehead (1970), in England, similarly reported the rate of N uptake by grasses to be greatest in the vegetative state. Further, he stated that N yield in the herbage reached a peak just before ear emergence. Our data revealed that peak protein yield of buffalograss fertilized with 30, 60, and 90 kg of N/ha corresponded to the male flowering stage of development. In the nonfertilized and 120 kg of N/ha treatment, peak protein yield was obtained 1 month later or at the early seed stage of development. Reasons for this lag are not known.

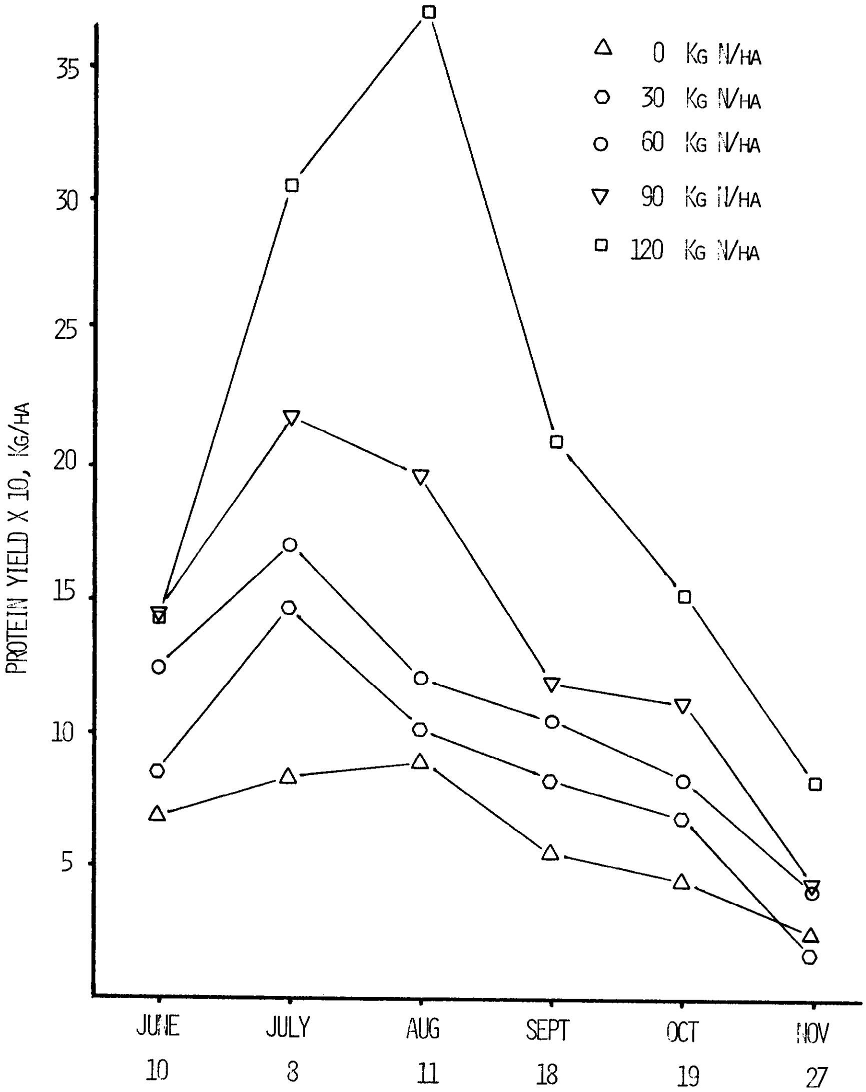

Fig. 2. *Total crude protein yield of irrigated and nitrogen treated buffalograss harvested from a deep hardland range site near Amarillo, Texas.*

Table 2. Total available carbohydrate concentration (mg/g) of irrigated buffalograss reserve tissues[1] sampled on six dates in 1971.

Nitrogen application rate[2]	Sampling date June 16	July 16	Aug. 18	Sept. 17	Oct. 19	Nov. 27	Avg
0	101[3]	165	113	111	118	132	120 ab[4]
30	85	151	102	110	118	132	113 acd
60	84	131	93	99	118	137	106 cd
90	81	132	80	102	132	129	106 d
120	79	104	71	95	130	138	99 e
Avg	86 ab	136 cd	91 ab	103 e	123 f	133 cd	

[1] Reserve tissues include living crown and root tissue to a depth of 10 cm.
[2] Kg/ha of actual nitrogen applied in April, 1971.
[3] Averaged total available carbohydrate concentration expressed as mg/g of dry plant tissue.
[4] Means in any column or row not sharing a common letter are significantly different ($P < 0.05$) from all others.

Management Implications

Range managers traditionally have assumed that a moderate grazing intensity is necessary to sustain both plant and animal vigor. Maximum livestock profits/ha are usually lower at this intensity than when heavy grazing is used. Our data (Figs. 1 and

2) show that grassland managers can not generally obtain maximum protein and herbage yields simultaneously on fertilized and irrigated buffalograss range.

If Fig. 2 was superimposed on Fig. 1, we would see that all fertilizer treatment herbage and protein yield curves intersect. It is apparent that where these curves intersect, we have optimized the quantity vs quality of forage concept. Unfortunately, buffalograss was approaching the hard seed stage of development which corresponded to low carbohydrate reserves (Table 2). When over 30 kg of N/ha was added, reserve carbohydrates decreased an average of 33% from the early seed to hard seed growth stage. The concept of optimizing the quantity vs quality of forage can not be achieved without possibly damaging the plant by harvesting at this time. To solve this dilemma, and if maintenance of plant vigor as measured by these reserves is considered important, we believe it is necessary to either delay the harvest until herbage is mature–mid October–or harvest the herbage in mid July at the late anthesis-early seed stage of development.

The ultimate question, then, must be asked. Can we justify fertilizing irrigated or dryland buffalograss range? First, our observations of fertilized but nonirrigated buffalograss show little herbage production response. Similarly, nonfertilized and irrigated buffalograss yields are not substantially increased. Second, if irrigation and fertilizers are available, more productive forages are available to the ranchman. Third, in this part of the state, cool season perennial forages are needed to complement the native-warm season blue grama-buffalograss ranges. In view of this, we can not recommend the treatments used in this research on those sites dominated by buffalograss. Perhaps on other soils or in other locations, these treatments might be feasible.

Literature Cited

Burzlaff, D. F., G. W. Fick, and L. R. Rittenhouse. 1968. Effect of nitrogen fertilization on certain factors of a western Nebraska range ecosystem. J. Range Manage. 21:21-24.

Coover, J. R., C. E. Van Doren, and C. J. Whitfield. 1953. Some characteristics of the Pullman soils on the Amarillo experiment station. Texas Agr. Exp. Sta. Misc. Pub. 97. 11 p.

Dee, R. F., and T. W. Box. 1967. Commercial fertilizers influence crude protein content of four mixed-prairie grasses. J. Range Manage. 20:96-99.

Dudley, D. I. 1953. Buffalograss. Progress Rep. 1579. Texas Agr. Exp. Sta., College Station, Texas. Mimeo. 3 p.

Johnston, A., S. Smoliak, A. D. Smith, and L. E. Lutwick. 1967. Improvement of southeastern Alberta range with fertilizers. Can. J. Plant Sci. 47:671-678.

Lehman, D. R., J. J. Bond, and H. V. Eck. 1968. Forage potential of irrigated blue grama with nitrogen fertilization. J. Range Manage. 21:71-73.

Morris, G. F., R. B. Carson, and W. T. Jopkiewicz. 1969. Comparison of the automatic Dumas and Kjeldahl Methods for the determination of total nitrogen in fertilizers. J. Amer. Org. Agr. Chem. 52:943-945.

Rodgers, J. D., and T. W. Box. 1967. Seasonal protein content of four southern Mixed Prairie grasses. J. Range Manage. 20:177-178.

Rumburg, C. B., and C. S. Cooper. 1961. Fertilizer-induced changes in botanical composition, yield, and quality of native meadow hay. Agron. J. 53:255-258.

Whitehead, D. C. 1970. The role of nitrogen in grassland productivity. Commonwealth Agr. Bur. Bul. 48. Farnham Royal, Bucks, England. 202 p.

Wullstein, L. H., and C. M. Gilmour. 1964. Gaseous nitrogen losses and range fertilization. J. Range Manage. 17:203.