Fertilization and Deferment of a Native Hay Meadow in North Central Oklahoma

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Fertilizer has become less expensive through the years. The excellent responses obtained from using fertilizer on croplands has stimulated questions about rangeland fertilization. Native hay meadows are on the most productive range soils, yet their annual production averages little more than one ton/acre.

Studies of range fertilization in Oklahoma have been made by Murphy, 1933; Harper, 1957; Elder and Murphy, 1958; Huffine and Elder, 1960; Gay and Dwyer, 1965; and Graves and McMurphy, 1969. Forage yields generally increased but not enough to pay for the fertilizer. Occasionally fair yield responses were obtained at low rates of fertilizer application. The increase in cool season annual grasses and weeds resulting from fertilization has presented a problem (Elder and Murphy, 1958; Huffine and Elder, 1960). In the Northern Great Plains western wheatgrass (*Agropyron smithii* Rydb.) was encouraged with nitrogen fertilization (Rogler and Lorenz, 1957). Thus, it appears that nitrogen fertilization serves to promote cool season species. This is an advantage for the Northern Great Plains, but there are no aggressive cool season decreasers for Oklahoma ranges.

Gangstad (1958) reported 17 pounds of forage yield increase per pound of nitrogen from 'Coronado' and 'Vaughn' sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.). Other varieties gave less response. 'Coronado' sideoats grama was also the highest producer without nitrogen fertilization. Thus, the highest yielding variety without fertilization also appeared to have the greatest potential for response to fertilizer.

Native grasses are sensitive to clipping and a September harvest of native grass caused a ⅓ reduction in yield the next year, (Anderson, 1960). Deferment from use has long been a successful recommended range practice for improving production of depleted range.

The objectives of this study were to determine the effects of fertilization, deferment and the interaction upon a native grass hay meadow.

Procedure

The experimental area was a native hay meadow one mile north of the campus of Oklahoma State University, Stillwater, Oklahoma. Botanical composition determined by the point frame was 61 percent little bluestem (*Andropogon scoparius*) plus lesser amounts of big bluestem (*A. gerardi*), indiangrass (*Sorghastrum nutans*), and a trace of switchgrass (*Panicum virgatum*). These four decreasers comprised 86 percent of the total vegetation, thus it would be classified in excellent range condition.

The soil is a Zaneis loam with 3-5 percent slope and is a loamy prairie range site. The soil tests revealed low phosphorus, high potassium, 2.9 percent organic matter, and a pH of 5.6.

The long-time average annual precipitation is 32 inches and the monthly precipitation is shown in Table 1.

The experimental design used was a 2 x 2 x 2 factorial with 4 replications. The variables were nitrogen at 0 and 40 lb/acre, phosphorus (P_2O_5) at 0 and 40 lb/acre, and deferment vs. no deferment from summer harvest (Table 2). Individual plots were 9 x 25 ft. The fall harvest was taken after a killing frost. Fertilizer was broadcast on the soil surface in early May of each year using ammonium nitrate (33.5-0-0) and concentrated super phosphate (0-45-0).

Forage yields were taken by mowing a 3 x 16 ft. strip and are reported as oven dry forage.

The micro Kjeldahl was used for nitrogen determination of the forage samples. Recovery of nitrogen fertilizer was calculated as:

$$\frac{\text{N in fertilized forage} - \text{N from check}}{\text{N applied}} \times 100$$

Table 1. Monthly and annual precipitation at Stillwater.

Month	1965	1966	1967	1968	1969	Long Time Average
January	.99	1.07	2.32	1.68	.75	1.16
February	.71	1.98	.33	.25	2.27	1.35
March	1.38	.17	1.46	2.49	2.60	1.86
April	1.92	2.39	2.74	5.71	1.93	2.86
May	3.78	3.48	6.22	6.26	3.60	4.62
June	5.28	3.75	3.93	3.12	4.43	4.24
July	1.73	7.34	4.59	1.70	1.43	3.53
August	2.67	3.32	1.28	.99	3.11	3.21
September	6.50	1.34	4.60	1.88	3.77	3.38
October	.52	.40	2.58	2.73	2.63	2.78
November	.04	.13	.72	4.52	.08	1.85
December	2.26	1.41	.71	1.71	1.24	1.34
Total	27.78	26.78	31.48	33.04	27.84	32.18

Table 2. Total forage yields from a fertilized native hay meadow. Lb/acre, oven dry.

Clipping Date[1]	Fertility Treatments							
	0-0	$40P_2O_5$	40N	40-40	0-0	$40P_2O_5$	40N	40-40
July 14	1930c	1740c	2310b	2840a	Deferred for winter harvest			
Dec. 17	190d	170d	220d	230d	1730c	1820bc	2270ab	2510a
1965 Total	2120bcd	1910cd	2530b	3070a	1730d	1820d	2270bc	2510b
July 12	1090f	1080f	1680d	2350b	1420e	1570de	1910c	2790a
Nov. 3	830a	810a	990a	890a	710a	920a	1170a	970a
1966 Total	1920f	1890f	2670cd	3230b	2130ef	2500de	3070bc	3760a
June 22	590c	590c	1050b	1690a	Deferred for winter harvest			
Nov. 22	660e	710e	1310c	1050d	1520b	1750b	2500a	2730a
1967 Total	1240d	1310d	2350b	2740a	1520cd	1750c	2500ab	2730ab
July 11	1480d	1660cd	2500b	3350a	1620cd	1930c	2770b	3520a
Nov. 22	210a	220a	210a	250a	200a	320a	240a	190a
1968 Total	1690d	1880cd	2710b	3600a	1820d	2250c	3010b	3710a
July 3, 1969	1208c	1378c	2001b	3353a	Deferred for winter harvest			

[1]Within each clipping date, average yields followed by the same letter are not significantly different at the .05 level of probability.

Forage yields in 1967 were undoubtedly influenced by an accidental fire on November 7, 1966. The plants and the soil were very dry at the time of the fire, but only the mowed stubble plus some mulch was available for fuel. The plots were accidently burned again in April, 1968, but this fire occurred under ideal conditions for burning (McMurphy and Anderson, 1965).

Results

Forage yield. — All nitrogen fertilization treatments produced significant increases in forage yield over that from the check plots each July and for the total years harvest (Table 2). The nitrogen plus phosphorus treatment often produced a further significant yield increase, but phosphorus alone did not increase forage yields. The 5-year average for normal summer hay harvest was a 1460 lb increase in forage production for the $40N\text{-}40P_2O_5$ treatment (Figure 1).

Response to nitrogen in terms of amount of forage produced/lb of nitrogen applied are given in Table 3. The nitrogen-phosphorus combination produced 19 to 53 pounds of forage/lb of nitrogen applied. Thus, low levels of fertilization would be justified.

Deferment. — In 1965 two harvests produced more hay than a single harvest after frost (Table 4), but significant forage yield increases in 1966 and 1967 resulted from the deferment. On a practical basis the annual early July hay harvest had a rather small influence on total forage

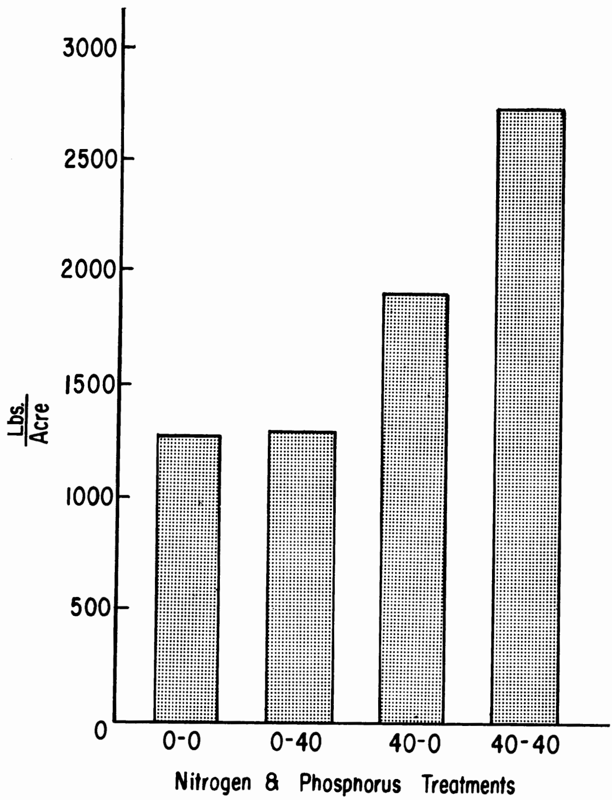

Figure 1. Forage Production from Normal Hay Meadow Summer Harvest, 5-year Average.

Table 3. Forage produced (in lbs) per lb of N applied.

Clipping	Fertility Treatments			
Date	40N	40N + 40 P_2O_5	40N	40N + 40 P_2O_5
July 14	10	23	Deferred for winter harvest	
1965 Total	10	24	13	19
July 12	15	31	12	34
1966 Total	19	33	24	41
June 22	12	28	Deferred for winter harvest	
1967 Total	28	38	25	30
July 11	26	47	29	48
1968 Total	26	48	30	47
July 3	20	53	Deferred for winter harvest	
1969				

yield. Apparently any harvest during the growing season will tend to reduce forage yield the next year.

Crude protein content of the forage. – The addition of nitrogen alone nearly always increased crude protein content of the forage when cut in early July (Table 5). The lower crude protein content of forage from the nitrogen plus phosphorus plots reflects the dilution caused by a higher total forage yield.

After frost there was no difference in protein content of regrowth as compared to mature plants. In all treatments through the four years of study the protein content varied from 2.01 - 3.66 after frost. The fertilizer treatments had little practical effect upon crude protein content of the cured forage.

Nitrogen recovery. – Recovery of the nitrogen fertilizer in the total forage harvested ranged from 8 to 39 percent (Table 6). These values are similar to those of Lehman et al. (1968) who reported 28 to 34 percent nitrogen recovery by irrigated blue grama (*Bouteloua gracilis*). Drawe and Box (1969) reported 1 to 3 percent nitrogen recovery

Table 4. The effect of deferment upon total forage yield.

Year	Not Deferred	Deferred	Defer. Value
1965	2410	2090	—320**
1966	2420	2870[1]	450**
1967	1920	2120	210*
1968	2470	2670[1]	200

[1]Harvested on same dates as the non deferred plots in 1966 and 1968.
*Indicates a significant difference (P=.05)
**Indicates a significant difference (P=.01)

Table 5. Protein content[1] of hay from a fertilized hay meadow.

Clipping Date[1]	Fertility Treatment 0-0	$40P_2O_5$	40N	40-40	0-0	$40P_2O_5$	40N	40-40
				1965				
July 14	5.13b	5.21b	6.54a	5.43b	Deferred for winter harvest			
December 17	2.77ab	2.56bc	2.96a	2.83ab	2.38c	2.58bc	2.73ab	2.91a
				1966				
July 12	4.60bc	4.10cd	5.81a	4.70b	4.20bcd	3.93d	5.61a	4.67bc
November 3	3.19a	3.66a	2.85a	2.89a	2.55a	2.99a	2.74a	2.72a
				1967				
June 22	6.37bc	5.72c	8.64a	6.53b	Deferred for winter harvest			
November 22	2.28ab	2.31ab	2.44a	2.38a	2.01b	2.18ab	2.54a	2.54a
				1968				
July 11	5.81a	5.69a	5.31a	5.31a	5.69a	4.75a	5.44a	5.19a
November 22	3.02cd	3.02cd	3.55ab	3.38abc	2.88d	3.28bcd	3.75a	3.58ab

[1]Within each clipping date, averages followed by the same letter are not significantly different at the .05 level of probability.

at 100 and 300 lb nitrogen/acre on a coastal prairie range. These nitrogen recovery values of native grass are low when compared with those of other forage species.

Tall fescue (*Festuca arundinacea*) forage recovered at least 60 percent of the nitrogen applied at rates up to 320 lb nitrogen/acre, and 'Midland' bermudagrass (*Cynodon dactylon*) recovered 69 to 82 percent of the nitrogen applied at rates up to 400 lb/acre (Elder and Tucker, 1964). Six cool season species were able to recover 39 to 71 percent of applied nitrogen at rates up to 160 lb nitrogen/acre (Dotzenko, 1961).

Weed production. — Some of the plots had an abundance of forbs in 1966. These were mostly the weedy species, Louisiana sagewort (*Artemisia ludoviciana*) and western ragweed (*Ambrosia psilostachya*). The nitrogen-phosphorus combination treatment produced significantly more weeds than any other treatment (Table 7). The forb production in subsequent harvests was negligible and no further separations were made.

Discussion. — One problem which developed in earlier native grass fertilization studies was the invasion of fertilized plots by cool season annual grasses and weeds (Elder and Murphy, 1958). Controlled burning has been shown to control these undesirable species (McMurphy and Anderson, 1965).

The plots reported in this study were burned twice. No cool season species were present in these plots and very few forbs remained. This was an excellent stand of native grass free of undesirable species.

Table 6. Recovery (in percent) of applied N from the total year's forage production.

	No Deferment		Deferred	
Year	40N	40N + 40P_2O_5	40N	40N + 40P_2O_5
1965	22	23	8	13
1966	20	24	25	32
1967	28	33	13	16
1968	19	38	25	39

Table 7. Weed production in July harvest, 1966. Lb/acre.

Fertility Treatments			
0-0	40P_2O_5	40N	40N + 40P_2O_5*
	Not Deferred in 1965		
54	58	98	257
	Deferred in 1965		
73	193	96	484

*Produced significantly more than any other fertility treatment.

The excellent forage yield responses to nitrogen and phosphorus are in sharp contrast to the long time study reported by Harper (1957). There is also a big difference in the forage yields from the unfertilized plots. Forage yields from the unfertilized plots in this study averaged 1260 lb/acre while those in the Harper (1957) plots averaged 3097 lb/acre. In 1965 the unfertilized plots in this study produced 1930 lb forage/acre and the increased yield on the fertilized plots was not as great as in subsequent years when the unfertilized plots produced much less. It appears that fertilization will give greater responses when hay meadow production is normally much less than one ton/acre.

Summary and Recommendations

The effect of low levels of nitrogen and phosphorus fertilization on a native hay meadow near Stillwater were tested for five years. Significant increases in forage yield were attributed to nitrogen fertilization and a further significant increase resulted from the phosphorus-nitrogen combination. Deferment from the July harvest until after frost had a small influence on total yield.

Although increases in crude protein were detected, these were small increases. By December there were no practical differences in crude protein content of the regrowth or the mature forage on all plots. Recovery of applied nitrogen from the forage ranged from 8 to 39 percent.

The results of this experiment indicate that low levels of nitrogen and phosphorus (on phosphorus deficient soil) will produce satisfactory forage yield increases from hay meadows if weeds and other undesirable plants are controlled.

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