Effects of One Year's Nitrogen Fertilization on Native Vegetation Under Clipping and Burning

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Highlight

Burning and nitrogen fertilization in combination increased forage production significantly over any other treatment including fertilization alone. Forage production on plots burned and fertilized with 100 pounds of nitrogen increased forage production 59% over the control and 54% over plots unburned and treated with 100 pounds of nitrogen. Burning, fertilization, and their combination were effective in reducing forbs.

There are approximately 20 million acres of native grass rangeland in Oklahoma, and of this, some 415,000 acres are utilized as hay meadows. An economic picture which provides only a very narrow margin of profit has forced the rancher into more intensive management of his rangelands. Methods of increasing forage production are now being sought by the rancher. One of these methods may be the use of nitrogen fertilizers. In this study, the effects of ammonium nitrate fertilizer at two levels were considered on native prairie in north central Oklahoma. Forage production figures were obtained from fertilized plots on a hay meadow under combinations of burning and clipping.

A fertilization study by Mader (no date) on a native grass hay meadow in eastern Kansas showed an increase in production at two levels of nitrogen application. Elder and Murphy (1958) working on a native meadow in eastern Oklahoma, found some response to ammonium nitrate fertilizer. Unfavorable results were obtained by Huffine and Elder (1960) on eroded cropland when 300 lb. of superphosphate and 33 lb. of nitrogen per acre were applied annually 1952 through 1955. The fertilizer treatments caused an increase of weedy grasses and forbs. Wiliams (1953) found that 60 lb. of nitrogen per acre on native grass near Lincoln, Nebraska, returned 2.28 tons of forage in May, 2.38 tons in June, and 2.64 tons in August. The unfertilized check plots produced 0.50 tons in May, 0.76 tons in June and 1.20 tons in August.

First year data by Dwyer (1963) showed good response of native grass to nitrogen at two levels of application. A long-time study of native grass production under fertilization near Stillwater, Oklahoma, by Harper (1957) showed that the highest average yield of 4,039 lb. air-dry forage was obtained from a treatment of 42 lb. nitrogen, 20 lb. P_2O_5, and 12.5 lb. K_20 per acre applied annually in the spring. Using three levels of nitrogen, Nelson and Castel (1958) found that a point of diminishing returns was reached with heavy applications.

A burning and clipping study by Ehrenreich (1959) in northeastern Iowa showed no adverse effect on native vegetation when burned near the first of March. Growth of burned prairie plants began 2 to 3 weeks earlier than unburned plants. Frequent clippings during the growing season were more harmful than one clipping at the end of the growing season.

Experimental Area and Methods

This study was conducted on the 33,000 acre K. S. Adams Ranch located in northern Osage County, Oklahoma, and southern Chautauqua and Cowley County, Kansas. Mean annual precipitation is 32.81 inches. About three-fourths of this amount normally falls during the growing season from mid-April to late September. Summer temperatures are normally high, often exceeding 100 F. The mean annual temperature is 61 F, with the lowest monthly average of 37.5 occuring in January and the highest, 83.7 F in July. The dominant grasses of the region were little bluestem (*Andropogon scoparius* Michx.), big bluestem (*Andropogon gerardi* Vitmin), indiangrass (*Sorghastrum nutans* (L.) Nash), and switchgrass (*Panicum virgatum* L.) (Dwyer, 1958). These grasses often compose 70 to 90% of the vegetative composition on a climax loamy prairie range site. Tall dropseed (*Sporobolus asper* (Michx.) Kunth), sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), and scribner panicum (*Panicum scribnerianum* Nash) are also found in association with the four dominants.

The soils of the region have developed from limestones and clay shales of the Lower Permian and Upper Pennsylvanian Age (Gray and Galloway, 1959). The study area was on the loamy prairie range site. Loamy prairie sites are characterized by a deep (more than 36 inches) fertile soil of the Labette and Summit series (Gray and Galloway, 1959). These soils support a vegetative cover composed mostly of the four dominant grasses.

Forage production data were recorded from plots in a native grass hay meadow near the ranch headquarters. Hazell (1964) found that little bluestem was the dominant species in this meadow comprising 62.4% of the total grass composition. Big bluestem made up 23.5%, indiangrass 5.5, and switchgrass 2.2%

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of the grass composition. Other grasses found in association with these major four were buffalograss, (*Buchloe dactyloides* (Nutt.) Engelm.), tall dropseed, and sideoats grama.

Plots were laid out in an randomized complete block design with five replications April 11, 1963. Each replication contained six 30 x 15 feet plots separated by a 6 foot strip. Three plots in each replication were burned prior to fertilization at the season recommended by Anderson (1961). Three plots were left unburned.

All plots were burned against a northeasterly wind with a velocity of 10 to 15 miles per hour. The soil surface was moist and the sky was overcast. Air temperature was 68.5 F and the relative humidity 33%, when burning began at 1:30 P.M. Air temperature and relative humidity were 64 F. and 38%, respectively at the termination of burning. Approximtely 1,500 to 1,800 lb. of dead vegetation per acre were burned. Moisture content of this material was 18.5%. Rhizomes of the major four grass species were breaking dormancy with some green shoots about 0.5 inch high. Average burning time per plot was 12 minutes with a range of 10 to 14 minutes.

Soil surface temperatures were recorded using asphalt plates scribed with temperature indicating crayons. These plates were placed on the soil surface just under the mulch layer.

Two of the burned and two of the unburned plots within each replication were fertilized with prilled ammonium nitrate fertilizer May 11, 1963, at the rates of 50 and 100 lb./acre of active nitrogen.

Each plot was divided and one-half was clipped once at the end of the growing season, August 25, 1963. At that time the samples were separated into big bluestem, little bluestem, indiangrass, switchgrass, other grasses, and forbs. The remaining half was clipped twice in identical locations on June 18 and August 25, 1963. No separations were made in these samples.

Five subsamples 11.5 x 24 inches were clipped at ground level within each of the plot halves. The forage was oven-dried and weighed in grams and this weight was multiplied by the factor 50 to determine lb./acre of forage.

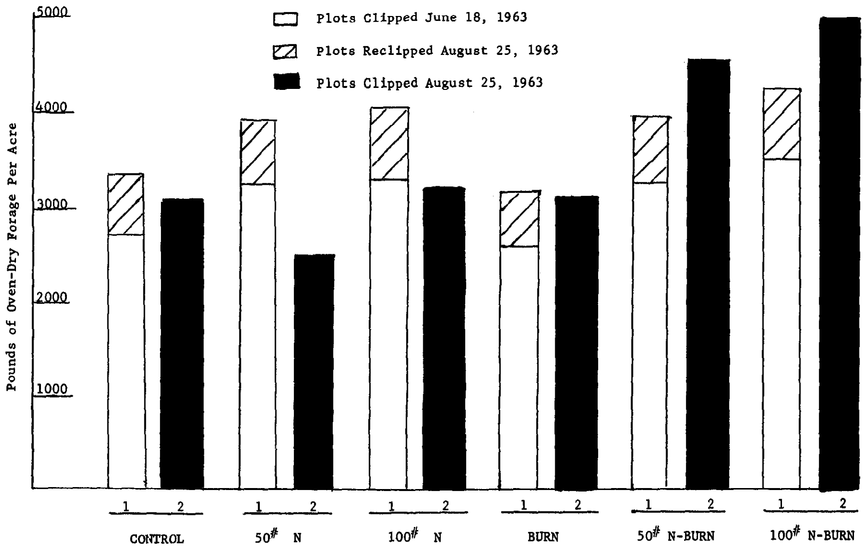

FIGURE 1. Forage production by treatments comparing two seasonal clippings with one seasonal clipping.

Results and Discussion

Twice Clipped vs. Once Clipped.—Two seasonal clippings significantly[2] increased forage production over one seasonal clipping for all unburned treatments (Figure 1). The control plots clipped twice during the growing season averaged 3,329 lb./acre of oven-dry forage while the control plots clipped once, at the termination of growth, produced 3,088 lb. of forage. Yield from plots treated with 50 lb. of nitrogen and clipped once was 2,457 lb./acre of forage, but increased to 3,875 lb. when clipped twice. Those plots which received 100 lb. of nitrogen showed an average yield of 3,197 lb. of forage for the single clipping and 4,041 lb. when clipped twice.

The addition of fertilizer to the unburned plots clipped twice significantly increased their yields over the control. Those treated with 50 lb. of nitrogen increased production 16.4% and plots treated with 100 lb. of nitrogen showed an increase of 21.4% over the control.

When the above treatments were coupled with burning, a different trend was observed. Clipping twice did not significantly increase forage on plots that were burned and unfertilized. Those plots burned and clipped twice produced 3,178 lb. of forage, an increase of only 106 lb./acre over the plots burned and clipped once (Figure 1). Plots treated with nitrogen fertilizer and burned produced more forage than all other treatments when clipped once. Those burned, treated with 50 lb. of nitrogen, and clipped twice produced 3,918 lb. of oven-dry forage compared to the same treatment, clipped once which produced 4,492 lb., an increase of 14.7% over the double clipping. One hundred lb. of nitrogen combined with burning and one clipping produced 4,921 lb. of forage, a 17.4% increase over the 4,194 lb. for the twice clipped plots.

There was no significant difference in forage produced between the first and second clipping among treatments in those plots clipped twice. The range of forage produced after the first clipping was 578 to 778 lb./acre for all treatments. Neither was there a significant difference in total forage production between burned and unburned plots when fertilized equally and clipped twice.

Moisture conditions probably had a great influence on results. Precipitation for the study period of April through August, 1963, was approximately 60% below normal. Total rainfall for these months was 9.46 inches and the longtime average is 19.34 inches. During the early part of the growing season, soil moisture was adequate for good growth and

[2] *Significance established at the 1% level by analysis of variance unless otherwise indicated. See Table 1 for detailed analysis.*

trends in production due to treatments were established at the time of the first clipping. Drouth conditions prevailed the remainder of the season and very little growth response was observed in any treatment, presumably due to limiting moisture.

Mulch appeared to play a role in the forage production of the plots. There was a large quantity of mulch on the unburned plots which aided early growth by preventing moisture loss from the soil. However, when moisture was depleted and precipitation occurred only as light summer showers, the mulch layer prevented rainfall from reaching the soil, thus causing a decreased response of forage growth to treatments.

Nitrogen Fertilization. — In this study, fertilization alone showed little value for increasing yields of forage. Only the plots treated with 100 lb. of nitrogen showed an increase in yield over the controls (Figure 1). This increase of 109 lb. was not significant. Plots treated with 50 lb./acre of nitrogen were significantly different from the control plots, producing 25.6% less than the control (Table 1).

When unburned, the 50 and 100 lb. nitrogen treatments produced less forage with a single clipping at the end of the season than the same treatments clipped once June 18 (Figure 1 and Table 2). The reasons for these decreases in production are only speculative. These data were recorded under drouth conditions and forage production in a single season may decline after a peak is reached, when moisture is limiting. Soil moisture was near field capacity in the early spring and fertilization gave added impetus to forage production. As drouth conditions became severe, growth appeared to halt and dormancy began as moisture was exhausted. Fertilized plots reached this point sooner than the controls.

Nitrogen Fertilization and Burning in Combination.—Certain measurements were made at the time of burning. The beginning soil temperature was 59 F at one-half inch. The soil temperature at the same depth, taken in the center of each burned plot immediately after the line of flame has passed, averaged 67.1 F with a range of 61 to 72 F. The peak soil surface temperature while burning averaged 400 F with a range of 350 to 500 F. The temperatures recorded at the rhizome level (0.5 inch below the surface) were not sufficient to cause injury to the plant.

Burning in combination with nitrogen fertilizer was of great significance as a treatment. Burning alone was not different from the control plots, but with the addition of nitrogen, production increased markedly above all other treatments.

When burned, forage showed the greatest response to the first 50 lb. of nitrogen added. An increase of 45.5% was noted in these plots over the control, with forage production increasing from 3,088 lb./acre to 4,492 lb. The second 50 lb. increment of nitrogen increased yield an additional 13.9% over the control (Figure 1). This combination of treatments also increased yield 54% over the unburned plots treated with 100 lb. of nitrogen (3,197 lb./acre).

Here again the effect of moisture and the influence of mulch was clearly shown. Burning grasslands causes earlier initiation of growth by plants from winter dormancy (Aldous, 1934). This fact coupled with fertilizer and the early season moisture caused greater early differences between treatments in the burned plots and the unburned plots as shown by the data from the June 18 clipping. Unburned plots treated with fertilizer showed a decline in production after the June 18 clipping.

The removal of mulch by burning was an important factor in causing increased yields in the burned plots in this study. By opening the grass stand, light summer rains were allowed to penetrate into the soil. It was noted that puddles were formed after showers in the burned plots, while the soil of unburned plots remained dry. Because of this, green growth was found in burned plots long after unburned plots had become dormant.

Response by Species. — Little change in forage production

Table 1. Analysis of variance for the forage production plots[1]

Source	df	Sum of Squares	Mean Squares	F
Total	59	65,311,892.5		
Mean	1	798,056,963.3		
Blocks	4	9,325,615.1	2,331,403.8	3.602*
Treat.	11	27,507,051.1	2,500,641.0	3.863**
Fert.	2	8,541,143.4	4,270,571.7	6.598**
Burn	1	5,981,504.8	5,981,504.8	9.241**
Clip	1	714,168.6	714,168.6	1.034
F x B	2	3,860,306.4	1,930,153.2	2.987
F x C	2	345,083.2	172,541.6	0.267
B x C	1	5,693,811.4	5,693,811.4	8.797**
F x B x C	2	12,270,234.3	6,135,117.2	9.479**
Error	44	28,479,226.3	647,255.1	

* Significant at the 0.05 level.
** Significant at the 0.01 level.
[1] Follows Steel and Torrie (1960).

Table 2. Oven dry forage lb/acre by species for plots with one seasonal clipping.

Species	Control	50 lb-N	100 lb-N	Burned	Burn 50 lb-N	Burn 100 lb-N
Age[1]	1,082.0	1,180.8	1,153.1	1,037.2	1,369.0	2,199.2
Asc	637.0	436.3	484.4	535.1	1,008.0	675.6
Snu	633.6	456.3	718.5	935.3	967.1	1,305.4
Pvi	258.3	24.4	245.0	291.5	542.3	237.1
O	254.1	230.7	374.7	126.0	304.3	297.1
F	223.4	136.9	221.6	146.8	182.8	206.9
Total	3,088.3	2,456.8	3,197.4	3,071.8	4,492.0	4,921.4

[1] Age=*Andropogon gerardi*, Asc=*Andropogon scoparius*, Snu=*Sorghastrum nutans*, Pvi=*Panicum virgatum*, O=Other grasses, F=Forbs.

from fertilization on unburned plots was noted. Application of 50 lb./acre of nitrogen increased production of big bluestem from 1,082 lb./acre in the control to 1,181 lb. (Table 2). With the addition of 100 lb. of nitrogen big bluestem produced 1,153 lb.

Little bluestem, indiangrass, and switchgrass showed decreases in forage production when unburned and fertilized with 50 lb./acre of nitrogen. Little bluestem dropped from 637 lb. of forage to 436 pounds, indiangrass fell from 634 to 456 lb., and switchgrass decreased from 258 to 24 lb. There was no apparent reason for this decline.

Plots unburned and treated with 100 lb./acre of nitrogen tended to produce little bluestem, indiangrass, and switchgrass at a level comparable with the controls. Of the three grasses, only indiangrass surpassed the production of the control plots. Indiangrass produced 718 lb. of forage, when treated with 100 lb. of nitrogen as compared to 634 lb. of forage in the control plots.

Burning combined with 50 lb. of nitrogen increased production in all cases (Table 2). Big bluestem produced 1,369 lb., an increase of 26.6% over the controls, little bluestem produced 1,008 lb., a 36.8% increase, indiangrass produced 967 lb., an increase of 52.5% and switchgrass increased 11.0%.

Big bluestem and indiangrass were the most efficient users of nitrogen of the species studied. These two grasses continued to increase in production when burned and treated with 100 lb. of nitrogen. Big bluestem reached a total figure of 2,199 lb./acre of forage, a 103% increase over the control plots. Indiangrass increased 105% over the control.

Both little bluestem and switchgrass appeared to reach their most efficient use of nitrogen at the 50 lb. level under burning. Little bluestem's production dropped when treated with 100 lb. of nitrogen and burned. The 676 lb. of forage produced was still a 6.1% increase over the control. Switchgrass responded similarly with forage production of 237 lb. for the 100 lb. of nitrogen and burned treatment. These decreases may have been due to increased competition from big bluestem and indiangrass at the 100 lb. level.

Other grasses also showed increases in production when burned and fertilized. Forbs decreased when burned and fertilized. This may have resulted from increased grass competition.

Summary and Conclusions

The effects of nitrogen fertilization on native vegetation under the conditions of clipping and burning were studied on the Adams Ranch in Osage County, Oklahoma. Forage production plots were established in a randomized complete block design with 5 replications in a native grass hay meadow in excellent range condition. Half the plots were burned. Plots were fertilized at rates of 50 lb. and 100 lb./acre of nitrogen with ammonium nitrate.

Following are the important findings of the study:

1. Unburned plots clipped twice during the season produced more forage than unburned plots clipped once.

2. When treated with 50 lb. of nitrogen and clipped once, yield was 2,457 lb./acre of forage, but the yield increased to 3,875 lb. when clipped twice. These yields were 3,197 and 4,401 lb. per acre, respectively, for the plots treated with 100 lb. of nitrogen. This implies that the grass recovered more quickly from clipping when fertilized with nitrogen since there was no significant difference between the once-clipped and twice-clipped controls.

3. When burned and fertilized with nitrogen, however, yields were greater from plots clipped once at the end of the season than from those clipped twice.

4. Plots burned and fertilized with 100 lb. of nitrogen and clipped once at the end of the season produced significantly more forage than any other treatment—4,921 lb./acre compared to 3,088 lb./acre for the control.

Big bluestem and indiangrass were the most efficient users of nitrogen, especially under burning.

6. Both burning, fertilization, and a combination of the two were effective in reducing forbs.

These data are preliminary and the effects of longtime treatments on the vegetation are not known. However, some significant responses have been noted which should be studied by others working in different regions. A startling interaction of nitrogen fertilization and burning has been shown which caused a remarkable increase in forage growth that nitrogen alone did not cause.

Spring moisture in this region is fairly certain even during drouth years. A combination of burning and nitrogen fertilization allows the grass to better utilize this spring moisture for extra early growth. Burning plus 100 lb. nitrogen produced 800 lb./acre more forage than the control by June 18. There was very little difference in additional growth from June 18 to August 25 due to the drouth conditions which prevailed. If drouth follows during the rest of the season, the additional growth made early becomes all the more valuable.

Longtime effects of these treatments need to be studied, but these early data indicate the production of meadows in the eastern half of Oklahoma could be increased markedly through the judicious use of controlled and prescribed burning and nitrogen fertilization.

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