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BENEFITS OF FERTILIZING ANNUAL RANGE IN A DRY YEAR

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Benefits of range fertilization include earlier range readiness, increased herbage production, and increased protein content of herbage. In addition, recent work (McKell, et al, 1959) indicate that fertilization of annual range provides for more efficient use of rainfall, which is of prime importance in a growing season of below average precipitation.

At the Forest Service's San Joaquin Experimental Range in the central Sierra Nevada foothills, the 1958-59 growing season was one of the driest and shortest growing seasons on record (Duncan and Reppert, 1960). The only substantial production of herbage occurred on nitrogen-fertilized areas and in swales. This paper reports on the growth, yield, palatability, and protein content of herbage produced on variously fertilized plots on hillside sites in the 1958-59 growing season.

Experimental Procedure

Soil of the experimental area is classified as Vista sandy loam, a permeable soil with an average depth of 21 to 36 inches, and it occurs extensively in the 10- to 20-inch rainfall zone of the Sierra Nevada foothills. The soil contains approximately 75 percent sand, 17 percent silt, and 8 percent clay. A laboratory analysis indicated the following: pH 6.2; organic matter 0.61 percent; P 12.1 ppm; K 0.20 ppm; Ca 0.50 ppm; Mg 0.35 ppm; total N 0.03 percent, and cation exchange capacity 4.16 me/100 g.

The study was established to test five levels of nitrogen, two levels of sulfur, and two levels of phosphorus in all possible combinations using a factorial experimental design. The individual plots,

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10 x 20 feet, were set out in randomized complete block arrangement with four replications.

Fertilizers, broadcast in October, were from the following sources at the indicated levels:

Element	Source		Rates of Application (lbs./acre)
Nitrogen	urea	N	0, 50, 100, 150, 200
Phosphorus	treble-super-phosphate	P_2O_5	0, 200
Sulfur	gypsum	S	0, 60

On March 3, 1959, and again on March 31, notes were made on the height of broadleaf filaree (Erodium botrys (Cav.) Bertol.) and grass. The percent of grass dominance of the herbaceous cover was also recorded. Near the end of the growing season before seed drop, an 18-inch x 20-foot strip was harvested from each plot with a small sickle-bar mower. The harvested samples were dried and herbage yield per acre was calculated. A total nitrogen analysis of herbage from the plots fertilized with nitrogen alone and of herbage from plots with nitrogen plus phosphorus and sulfur was made. In addition, nitrate nitrogen was determined for four replications of two treatments: $N_{200}P_0S_0$ and $N_{200}P_{200}S_{60}$.

On July 12 livestock were allowed free-choice grazing on the experimental plots and the adjacent unfertilized area. After 15 days of grazing, the degree of forage utilization was determined by visual estimates according to the method described by Hormay and Fausett (1942).

Weather

Total rain for the season was 10.12 inches as compared with an average of 19.53 inches and a 25-year high of 32.09 inches (Duncan and Reppert, 1960). The total effective precipitation was about 7 inches for the growing season. No effective rainfall occurred until after January 3, 1959. Germination and subsequent plant growth were slow because of low daily mean temperatures during January and February. As a result of the extended drought in March and the low water-holding capacity of Vista sandy loam, many forage plants had died by the time additional rain came on April 25. Herbage production for the 1958-59 growing season on the experimental range was 42 percent of the 25-year average.

Results

About 90 percent of the herbage in the late winter and early spring of 1959 consisted of grasses and broadleaf filaree. There were few legumes.

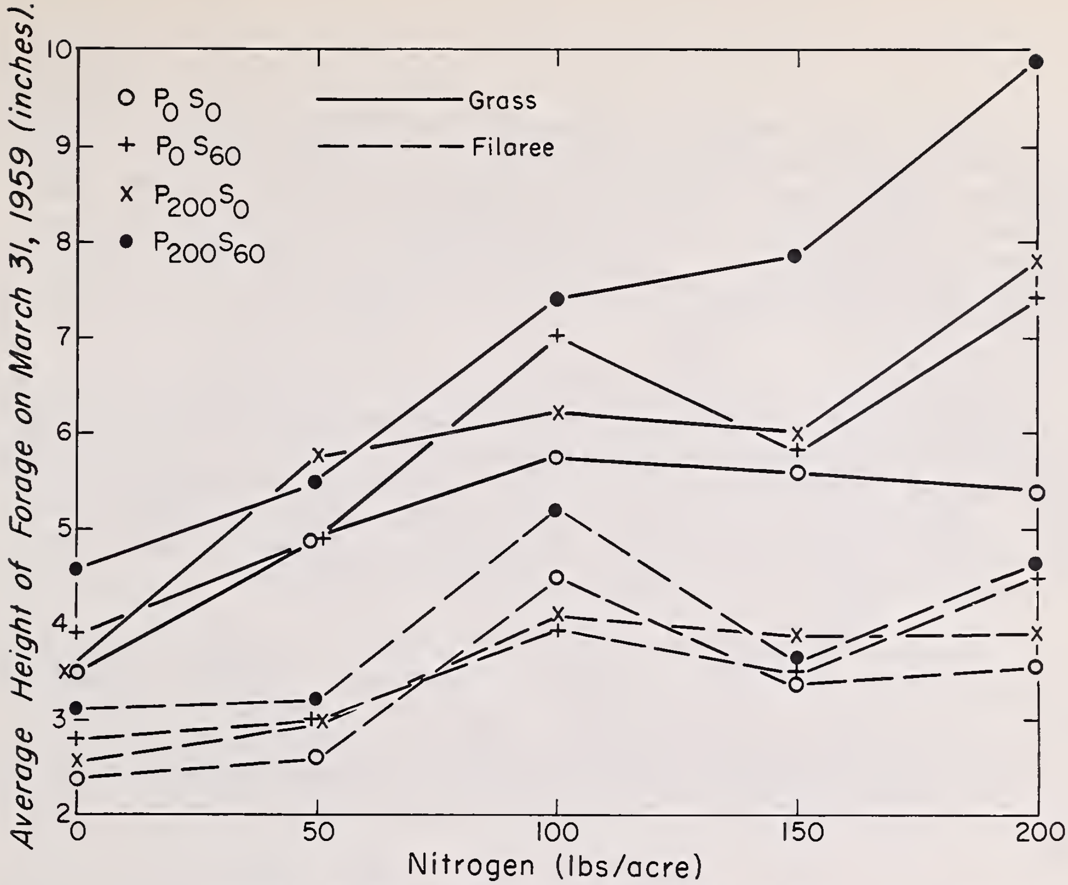

Figure 1.--Average filaree and grass heights on March 31, 1959, in response to various nitrogen fertilization rates in combination with phosphorus and sulfur.

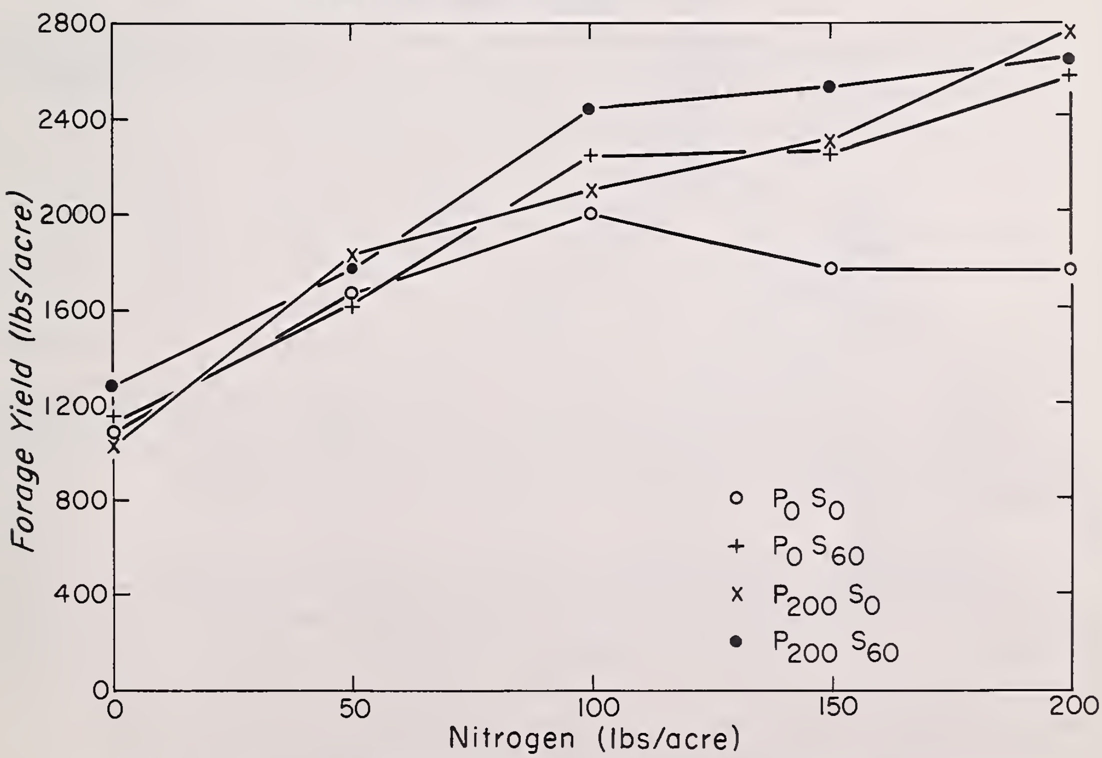

Figure 2.--Herbage production at various nitrogen fertilization rates in combination with phosphorus and sulfur.

Plots fertilized with 150 and 200 pounds per acre of nitrogen were at range readiness by February 20. On March 3 many of the plots fertilized with 50 and 100 pounds of nitrogen per acre were at range readiness. Plots receiving no nitrogen did not appear to be at range readiness until March 31. Thus, plots fertilized with high rates of nitrogen were ready for grazing about six weeks earlier than plots not receiving nitrogen fertilizer.

Plant height generally increased as the rate of nitrogen application increased (fig. 1). On March 31, plant heights on plots fertilized with 50 and 100 pounds of nitrogen per acre were up to 2 inches greater than those on unfertilized plots. The combination of phosphorus and sulfur with nitrogen resulted in taller plants than nitrogen alone, particularly at the higher rates of nitrogen application, where plants were up to 4 inches taller than on unfertilized plots.

Dominance of grass increased as the rate of nitrogen application increased (table 1). The addition of sulfur and phosphorus to the nitrogen fertilizer also increased grass dominance inasmuch as few legumes were in the vegetation to respond to sulfur and phosphorus. Bentley and Green (1954) discussed the stimulation of annual clovers by application of sulfur but did not make any comparison with nitrogenous fertilizers.

Table 1.--Percent dominance of grass on March 31, 1959 on plots fertilized with various rates of nitrogen

Rates of nitrogen plus phosphorus and/or sulfur (lbs./acre)	Average percent grass (visual estimate)
0	42
50	58
100	61
150	62
200	64

There was an obvious contrast in the greenness of the herbage on March 31. Plants were darker green at the higher levels of nitrogen application. Addition of phosphorus and sulfur to nitrogen fertilizer resulted in additional dark green coloring of the herbage.

Analysis of the herbage yield data indicated a significant difference between application rates of 100 pounds per acre of nitrogen and no nitrogen (fig. 2). Further increases in forage yield were not obtained from 150 and 200 pounds per acre of nitrogen. Nitrogen at 150 and 200 pounds per acre in combination with 200 pounds per acre of phosphorus and 60 pounds per acre of sulfur gave higher yields than nitrogen alone. In general, greater forage yields were obtained when nitrogen was applied in combination with phosphorus and sulfur than when applied alone. No

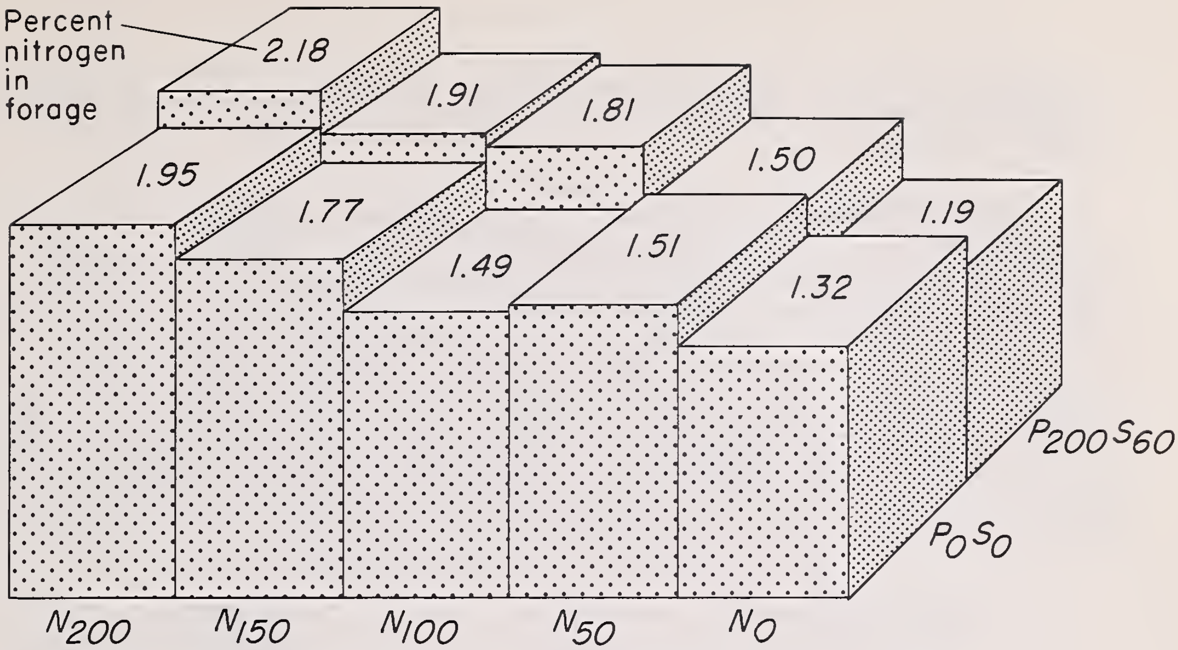

Figure 3.--Nitrogen in annual-range herbage resulting from fertilization with various rates of nitrogen in combination with phosphorus and sulfur and without either.

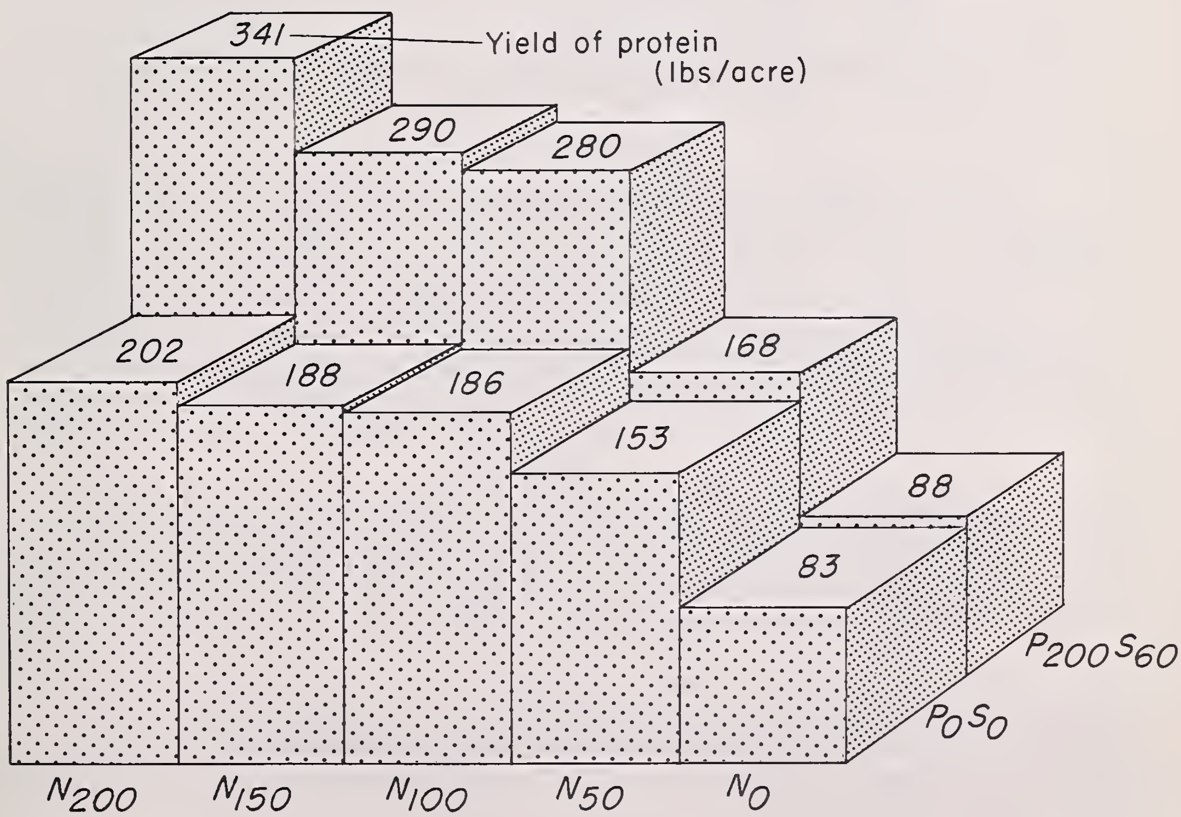

Figure 4.--Crude protein yields resulting from fertilization with nitrogen alone as compared with fertilization with nitrogen plus phosphorus and sulfur.

significant response was obtained from sulfur alone or from phosphorus alone although yield differences with each element approached significance at the 5 percent level.

The percentage of nitrogen in the herbage increased as the level of nitrogen fertilization was increased (fig. 3). However, nitrogen content of the forage on plots fertilized with nitrogen alone was not significantly different from that on plots receiving nitrogen in combination with phosphorus and sulfur. A conversion of nitrogen percentage to crude protein content (percent N x 6.25) reveals that the crude protein content of the fertilized plants is as high or higher than crude protein content reported by other workers in dry (Martin, et al., 1957) and wet years (Martin and Berry, 1956), averaging from 9.43 percent on plots fertilized with 50 pounds per acre of nitrogen to 12.88 percent on plots fertilized with 200 pounds per acre of nitrogen:

Nitrogen fertilizer (lbs./acre)	Percent protein
0	7.84
50	1/9.43
100	1/10.31
150	11.49
200	12.88

1/ Not significantly different at the 5 percent level.

Protein production per acre increased as the rate of nitrogen application increased (fig. 4). Fifty pounds of nitrogen per acre resulted in about the same amount of protein in plants as 50 pounds of nitrogen plus phosphorus and sulfur. Plants receiving an application of phosphorus and sulfur without nitrogen contained about the same amounts of protein as unfertilized plants. Protein production was increased by the combination of nitrogen, phosphorus, and sulfur when the nitrogen application rate was 100 pounds per acre or higher.

Analysis for nitrate nitrogen in herbage produced on plots fertilized with 200 pounds per acre of nitrogen alone and on plots fertilized with 200 pounds per acre of nitrogen plus phosphorus and sulfur revealed values below the 1.5 percent KNO_3 level known to be toxic to livestock (Kendrick, et al., 1955).

Grazing use on the range adjacent to the experimental plots was rated very light; on fertilized plots, it was moderate, close, and very close. Palatability of the herbage appeared to be increased by each increment of nitrogen applied and by the addition of phosphorus and sulfur (fig. 5).

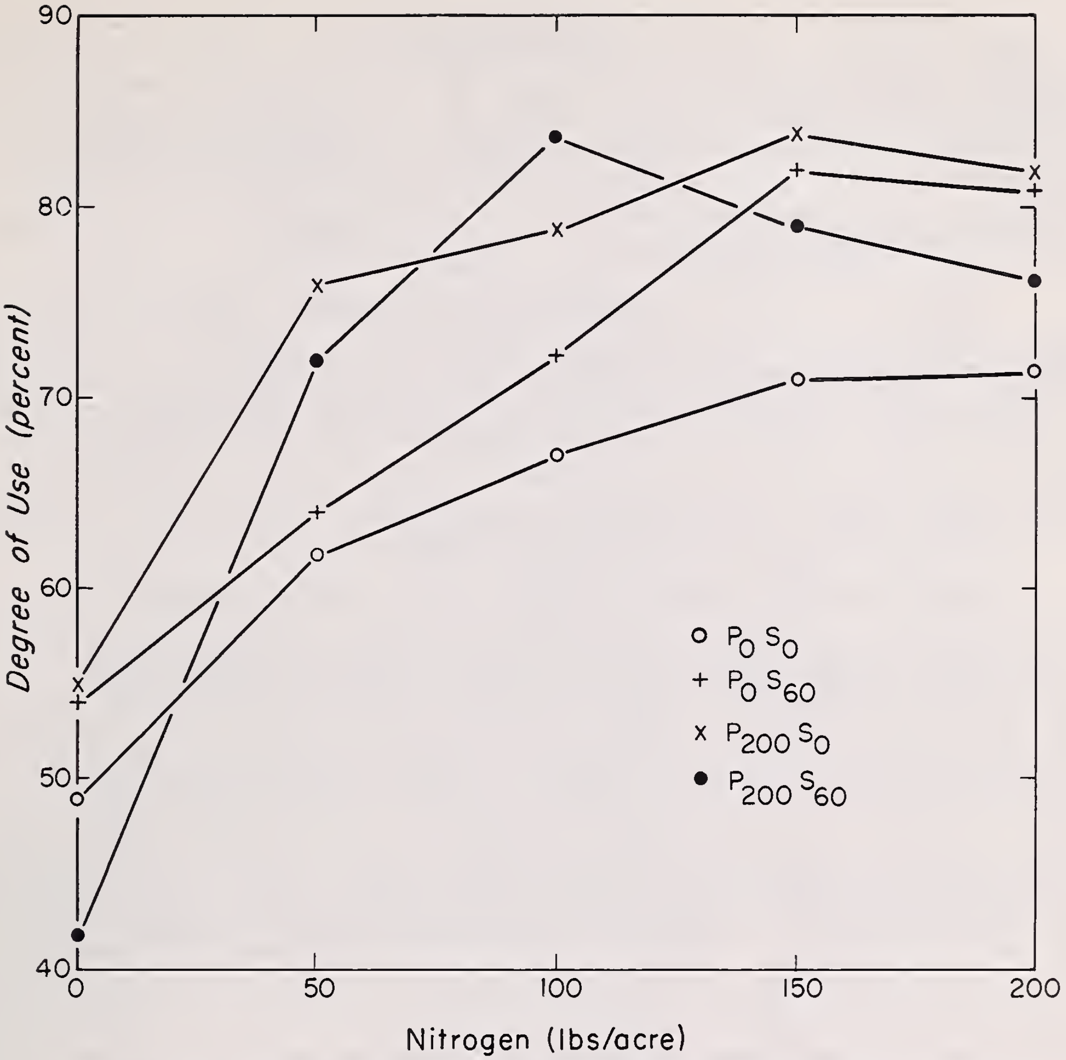

Figure 5.--Grazing use of annual-range fertilized with various combinations of phosphorus and sulfur and increasing rates of nitrogen.

Discussion

Limited and erratic moisture distribution in the 1958-59 growing season was one of the main causes for the relatively low production of grazeable herbage. Many plants that were fertilized at relatively high rates of nitrogen did not mature but "cured green" when they depleted the soil moisture.

Range readiness occurs when enough new forage plants reach a height that will provide an adequate diet of nutrients and dry matter for grazing animals. Most of the forage intake may be made up of the past year's leached dry herbage on moderately used range, but the new forage plants provide most of the nutrients necessary for a balanced diet. Supplemental feeding can be reduced or eliminated as soon as feed is available. Therefore, early production of green feed is economically important to a range livestock operation.

The amount of nitrogen fertilizer applied is an important factor in range readiness. Nitrogen stimulates most range plants, particularly grasses, to grow under cool conditions and as a result the range is ready for grazing earlier when fertilized. In comparison with unfertilized range the date of range readiness was advanced six weeks by the application of 150 or 200 pounds of nitrogen per acre. A four-week advance in range readiness was obtained by the application of nitrogen at 50 to 100 pounds per acre.

Vegetation height is one evidence of abundant herbage. In general, each 50-pound increment of nitrogen fertilizer resulted in a height increase of one inch for grasses and about one-half inch for filaree. Height of filaree in its leafy vegetative state is not as responsive to nitrogen fertilization as grasses. Filaree responds to increased fertility by greater leafiness and lateral spread. In the spring of 1959, earlier range readiness of the nitrogen fertilized plots appeared to be due to taller vegetation and increased grass dominance.

Production of grazeable herbage is the main benefit of range fertilization. During the period 1953 to 1957, in a series of field-scale beef grazing trials (Martin, et al., 1957) on annual range fertilized with nitrogen at rates varying from 40 to 144 pounds per acre and including sulfur and phosphorus, the value of extra meat produced was greater than or equal to the cost of the fertilizer in 29 of 36 tests. The grazing trials were conducted over a series of average, wet, and dry years and indicate the favorable economics of fertilizing annual range. In the present study forage plants failed to show any significant response in yield and crude protein content to application of nitrogen higher than 100 pounds per acre. Although the 50-pound-per-acre nitrogen rate did not significantly increase forage yield, it did increase the nitrogen percentage and the per acre yield of protein. At the 50- and 100-pound nitrogen rates the total yield of protein appears to be limited by the available nitrogen rather than by phosphorus and sulfur. Where the nitrogen application rate was low the addition of phosphorus and sulfur gave no increase in total nitrogen uptake. Where nitrogen was not the limiting factor in plant growth, the addition of phosphorus and sulfur resulted in an upward trend in the amount of protein produced.

A range operator in the annual-type range assumed there will be some growing seasons with a limited amount of rainfall when plant responses to fertilization will not be as high as expected. Nevertheless, fertilizer investments in a dry year are not a loss. Adequate levels of nitrogen, even with a limited moisture supply, will produce earlier forage and substantially more forage and protein than will non-fertilized range. In addition, because of the incomplete utilization of the fertilizer and the low probability of leaching losses in a drought year, fertilizer carryover and plant responses in the following season may be expected unless unseasonally late spring or early fall rains leach fertilizer elements out of the root zone. Further study is underway to evaluate carryover of fertilizer elements.

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