Effect of Fertilization on Yield on an Irrigated Mountain Meadow[1]

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Ranchers utilizing mountain ranges in the Rocky Mountain region usually have areas of valley land on which they produce hay for winter feed. Approximately 3,800,000 acres of such land in the 11 Western States is classified as mountain meadows (Rouse et al. 1955). Commonly these meadows are pastured in the spring, cut for hay in the summer while the cattle are on higher ranges, and pastured again in the fall. Grasses predominate in these high altitude valleys.

Burton and DeVane (1952) reviewed the literature on the effect of nitrogen fertilization on growth and chemical composition of grasses in pastures in the southeast and Willhite et al. (1955) studied grasses in mountain meadows in Colorado. They all agreed that nitrogen on pure stands of grass increased the yields on most soils. Generally, yield increases were accompanied by increases in protein content.

Shipley and Headley (1948), working on the high altitude meadow areas of Nevada have shown that late harvesting reduced the nutritive value of hay. Miller et al. (1955) found that highest protein yields were obtained when the first harvest was at the end of June. Willhite et al. (1955) found that, in high mountain valleys in Colorado, hay cut the first of August was superior in feeding value to hay cut in early September. In their experiment, one pound of 43 percent crude protein cake supplement per animal per day was required to raise the feeding value of late cut hay ration to equal early cut hay. They also found a direct relationship between pounds of crude protein in the daily ration and the rate of animal gain. Many ranchers cut hay in the early stages of maturity to maintain the high protein content and then use the fall regrowth for pasture when the high mountain ranges are covered with snow.

This report summarizes a four-year study on an irrigated meadow in the Cimarron Valley one mile west of Cimarron in northern New Mexico. The valley at this location is 6500 feet above sea level. The average frost free period is 158 days (May 1 to October 11). The mean temperature for July is 70 degrees. Average annual precipitation is 15 inches. There is ample water for irrigation.

Materials and Methods

The field was leveled for irrigation in 1956 to a slope of 0.95 feet per 100 feet. Maximum cut in the experimental area was 1.10 feet; maximum fill was 0.70 feet. The soil was described as a well-drained, undifferentiated mountain alluvium. Barnyard manure, at the rate of five tons per acre, was spread on the whole field in 1956 following leveling. In 1957, 100 pounds of 8-32-0 and 100 pounds of 33-0-0 were spread, and the area was disk plowed. About July 1, 1957, a mixture of Kentucky 31 fescue *(Festuca arundinacea)*, orchardgrass *(Dactylis glomerata)*, tall wheatgrass *(Agropyron elongatum)*, and Madrid sweetclover *(Melilotus officinalis)* was planted. The area was irrigated before planting, and good rains followed planting. The grasses emerged to a good stand. The field was sprayed with 2,4-D about the middle of August. Most of the weeds and clover were killed but a good stand of grasses remained.

The treatments were initiated in 1958 and terminated in 1961. The main variables were time and rate of application of nitrogen as ammonium nitrate. One application was made early in the spring when the first growth was apparent (March 1); another was made when growth was well started (April 15); and a third was made after the first cutting of hay had been removed (July 1). The amounts of fertilizer applied at the various dates are shown in Figures 1, 2 and 3. All rates were doubled the last year.

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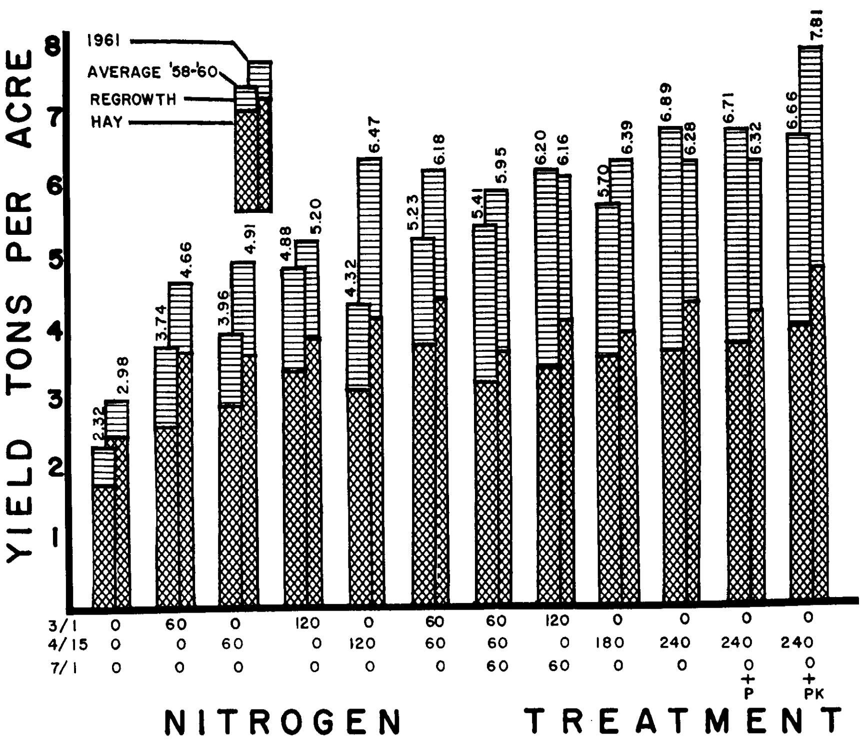

FIGURE 1. Average hay and regrowth yields for irrigated mountain meadow plots.

Each treatment was replicated six times in a randomized block design. The area was irrigated as necessary to prevent the grasses from wilting.

The experiment was not initiated in time for the early application the first year, and the late application was not made in the last year. In addition to the nitrogen variables, an N + P treatment and an N + P + K treatment were included. In these treatments N, P, and K rates were 240, 44, and 150 pounds per acre, respectively. P and K were applied in March and N in April.

Annual hay and regrowth yields were determined about July 1 and September 15, respectively, by weighing the forage clipped from a measured portion of each plot. A subsample of both hay and regrowth from three replicates was used to determine dry matter and N content. Protein content was determined by multiplying the nitrogen content obtained by Kjeldahl analysis by 6.25. The amount of nitrogen recovered in the forage was calculated for each year. The percentage of the applied nitrogen recovered in the crop was calculated as follows:

$$\left[\frac{\text{N in forage from fertilized plot—N in forage from check plot}}{\text{Total N applied}}\right] \times 100 = \text{percent N recovery.}$$

Results and Discussion

Hay Yields

Hay and regrowth yields are presented in Figure 1. Average yields of 1958-1960 are compared with 1961 yields because the fertilizer rates were doubled in 1961. Each year there was a statistically significant linear increase in yield with increasing amounts of nitrogen applied. The yield increases were not as great in 1958 as in the following years. The manure and fertilizer applied before the field was seeded apparently supplied enough nutrients for near maximum yields in 1958. In 1959, the 60-pound application gave the largest increase per pound of nitrogen. Rates greater than 60 pounds produced increases but they were less per pound of nitrogen applied. All 1960 yields were lower than other years, but the increase was more uniform over the range of nitrogen applied and the response curve was more linear than other years. The linear response indicated that maximum yield had not been attained so the fertilizer rates were all doubled in 1961. The response to the doubled rates was linear up to the 240-pound rate but was less per pound of nitrogen above that rate.

Protein Content

Protein content increased generally as nitrogen fertilizer rate increased. The averages of the protein percentages in the hay and regrowth are shown in Figure 2. Each hay crop gave a highly significant linear response to the nitrogen applied April 15. Neither the early application nor the split application varied significantly from the April application. The July application had no residual effect on the protein content of hay in the following year. Protein content of the regrowth increased linearly with the total amount of nitrogen applied. In all years except 1961, the protein content of regrowth on plots receiving 240 pounds of nitrogen per acre was above the line established by the lower rates of application. Nitrogen applied in the spring was as effective in maintaining the protein content of regrowth as nitrogen applied in mid-summer.

The two spring dates of application were equally effective, and splitting the nitrogen between the two dates was no better than applying the same total amount at either date. The July application of nitrogen tended to increase yield of regrowth but did not increase the total yield above that obtained when an equivalent amount of nitrogen

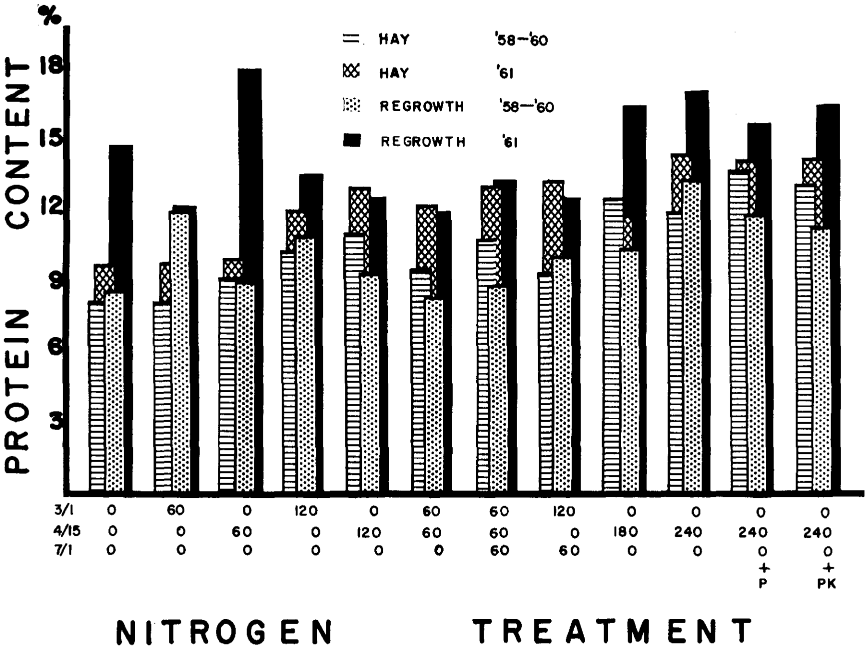

FIGURE 2. Average protein content of hay and regrowth from irrigated mountain meadow plots.

was applied in the spring. There was no residual effect of the July application on hay yield the following year. Neither phosphorus nor phosphorus with potassium gave statistically significant increases in yield of hay during the four years.

Regrowth Yields

The yields of regrowth (Figure 1), like the hay yields, showed a statistically significant linear response to nitrogen. The manure and previous fertilizer maintained high yields on the untreated plots through 1958. Low yields in subsequent years reduced the average for the check plots. Regrowth yields were not affected by the date of application of nitrogen. A total of 180 pounds per acre applied April 15 was as effective as the same total split in any of the ways included in the experiment. There was a tendency in each year (except 1961) for the 120-0-60 treatment to give the highest regrowth yield; however, this trend was not statistically significant. Neither phosphorus nor potassium gave consistent increases in regrowth yields.

Protein Yield

The amount of protein produced is a reliable measure of the effectiveness of a meadow management program. There is a direct relationship between the pounds of crude protein in a feed ration and the pounds of animal gain (Willhite 1955). The increases in yield and protein content of forage from nitrogen fertilization resulted in linear increases of protein yield. Average protein yields from both hay and regrowth are shown in Figure 3. Protein yields increased with the amount of nitrogen applied, with no consistent differences between dates of application of the same total amount of nitrogen.

Small but consistent increases in protein yield in regrowth were obtained from nitrogen application rates through 120 pounds per acre. Yields of protein in regrowth from 180 and 240 pounds of nitrogen per acre were greater than those from lower rates. This is not consistent with the results reported by Rouse et al. (1955), who found that nitrogen applied in the spring at rates up to 160 pounds per acre resulted in no increase in protein yield in regrowth after an early initial harvest.

Nitrogen Recovery

Accumulative nitrogen recovery in forage is shown in Figure 4. The percentage recovered increased in each of the first three

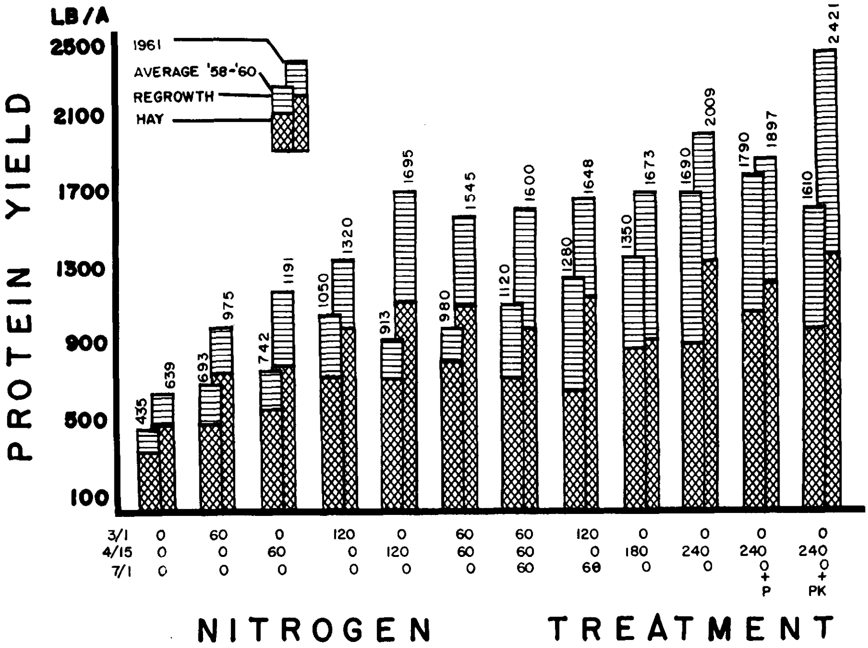

FIGURE 3. Average protein yield in hay and regrowth from irrigated mountain meadow plots.

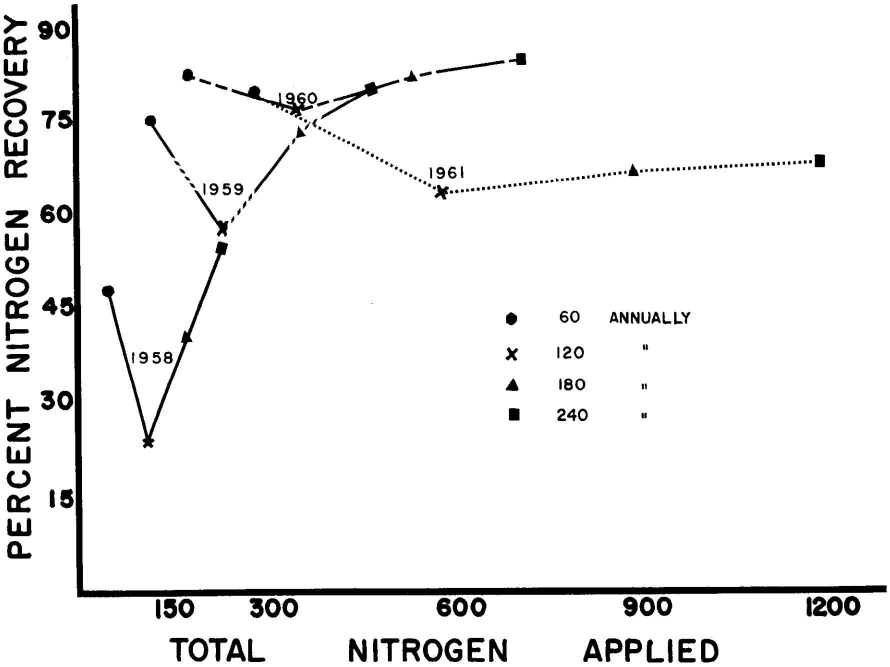

FIGURE 4. Accumulative nitrogen recovery in forage from annual nitrogen applications to irrigated mountain meadow plots.

years from all rates of application. The low recovery from the 120-pound rate in 1958 affected the accumulative recovery to the end of the experiment although the difference decreased each year. Recovery from the doubled rates in 1961 dropped at all rates.

Nitrogen recovery in this experiment was in agreement with others using the net recovery value. Legg and Allison (1959), using N^{15}, showed that the net recovery (the method used here) was considerably higher than the actual recovery of tagged N. The differences were especially marked at the lower rates of N application. Cooper, Klages, and Schulz-Shaeffer (1962) reported recovery up to 107 percent by both orchardgrass and smooth bromegrass. They postulated that fertilized grass had a larger root system and utilized more soil N than unfertilized. Lewis and Lang (1957) reported average nitrogen recovery of 78.8 per cent of 160 pounds on N per acre. Grable and Johnson (1961) obtained an average recovery of 77 percent with ryegrass in pots fertilized with 200 and 600 pounds N per acre. They found the amount of soil N removed by fertilized and unfertilized ryegrass from pots was equal. Dotzenko (1960) reported highly significant differences between grass species, nitrogren levels, and nitrogen level X variety interaction in the percent N recovery in Fort Collins soil. He concluded that rhizomatous species, e.g. smooth bromegrass and intermediate wheatgrass, have an inherent ability to use higher nitrogen rates more efficiently, presumably because of the proliferation of their root system throughout the soil profile.

The increases to a high level of N recovery followed by a drop in 1961 for all treatments suggests that, in the absence of other limiting factors, the plants developed an equilibrium with nitrogen supply through such factors as density of stand or relative vigor to each level of nitrogen in the three-year period. The doubled rates of fertilization provided more nitrogen than the plants could utilize; therefore, the percent recovery decreased. The experiment was terminated before a new equilibrium was established.

Summary

Fertilizer was applied to an irrigated meadow in a mountain valley in northern New Mexico annually for four years. Hay yields cut July 1 and regrowth sampled September 15 increased linearly with the amount of nitrogen applied. Applications made March 1 were as effective as those made April 15. Split applications (half on March 1 and half April 15) showed no advantage over single applications. The protein content and total protein yield followed the same linear response pattern to the total amount of nitrogen applied. Yield and protein content of regrowth were increased by a July 1 fertilization, but the increase in protein was less than the increases in yield and protein content in the hay crop when all the nitrogen was applied in the spring.

Neither phosphorus nor potassium increased the yield or protein content of grasses grown.

Recovery of applied nitrogen increased in successive years. However, when nitrogen rates were doubled in 1961, the percentage of recovery decreased.

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