FERTILIZATION OF PASTURE AND RANGE IN THE UNITED STATES[1/]

H. F. Mayland[2/]

The importance of the forage resource in the United States is apparent from the 225-million ha of humid-region pasture, and 122-million ha of arid rangeland in the Great Plains and Western States.

The objective of this report is to briefly summarize the effect of fertilizer on yield and forage quality of pasture and range, particularly their effect on beef production.

In the past 25 years, beef cow herds have replaced both dairy cows and sheep on many forage-producing areas. The limited forage and range resources in the semiarid and arid Western States may restrict further expansion of cow-calf operations, except in areas where irrigated pasture can be developed or where forage productivity can be increased by fertilization.

Water is less limiting in the Eastern States, assuring more reliable supplies and potentially greater amounts of forage to support the beef industry. Thus, cow-calf numbers in some South-Atlantic and North-Central States have greatly increased.

Most of the cow-calf operation in the southern region and in the Midwest resemble ranch operations of old, in which inputs and costs are kept as low as possible. Implementing improved practices (i.e., improved forage varieties, fertilization, grazing management) would greatly increase beef production in these areas.

Warm-season grasses, like bermudagrasses (4-million ha), and paspalum, bahiagrass, and dallisgrass (1.4-million ha), are important forage resources in the southern U. S. The dry matter produced by some of these grasses, when grown under adequate soil moisture, increases linearly with annual N fertilization rates as high as 600 kg N/ha. Top yields of about 30 mT/ha-yr coastal bermudagrass can be obtained with about 1,200 kg N/ha-yr. Grass breeder, Glen Burton, has tremendously improved bermudagrass productivity (2). He reported beef production of 90, 170, 310, and 760 kg/ha-yr for common bermudagrass, common plus 34 kg N/ha, coastal plus 34 kg N/ha, and coastal plus 224 kg N/ha, respectively. Coastcross 1, when fertilized with 157 kg N/ha-yr plus P and K, produced 830 kg beef/ha-yr, and, when fertilized with 224 kg N plus P and K, produced 1120 kg beef/ha-yr (Burton, 1972).

As in other regions, split N applications are better than large single applications. The high yield potential of these N-responsive grasses may require a corresponding increase in S, K, and P fertilization to maintain yield and forage quality. Some of these grasses have especially high K requirements, e.g. intensively managed coastal bermudagrass may require 200 to

---

1/ Proceedings Twenty-eighth Annual Fertilizer Conference of the Pacific Northwest, Twin Falls, Idaho, July 12-14, 1977.

2/ Soil Scientist, Snake River Conservation Research Center, U. S. Department of Agriculture, Agricultural Research Service, Western Region, Kimberly, Idaho 83341.

400 kg K/ha-yr. Maintaining soil at 25- to 50-ppm dilute, double-acid soluble soil P and at 50- to 70-ppm exchangeable soil K should meet the P and K requirements of the warm-season grasses (Wilkinson and Langdale, 1974).

Cool-season grasses, like smooth bromegrass, orchardgrass, reed canarygrass, tall fescue, and perennial ryegrass, have great potential for increasing basic forage productivity in the areas where they are adapted. In areas with summer rainfall, application rates are often as large as 134 kg N/ha and N efficiency is high for cool-season grasses adequately fertilized before the cool season (Wedin, 1974). Single, as well as split, applications result in dry-matter production that is concentrated in the early part of the season.

Grass-legume mixtures are widely used in the U. S., especially in areas where natural rainfall or irrigation is adequate for maintaining the legume component. The forage mixtures consistently produce higher animal gains as compared with N-fertilized grasses, even though dry matter yields for the N-fertilized grasses are equal or slightly greater. Management practices, including fertilization, cutting height and frequency, and irrigation, influence the proportion of grass and legumes in the mix. Increasing the N-fertilization rate increases the grass component because the legume is intolerant of light and K stress. When all factors are considered (yield, legume content, seasonal distribution of production), applying N to grass-legume mixtures usually is not advisable until the legume component of the mixture decreases below 20 to 25% of the total herbage (Baylor, 1974).

Potassium fertilization of grass-legume mixtures is much more complicated than for pure species, especially on acid soils, partly because grass competes strongly with legumes for K. Thus, split K applications tend to improve both stand and yield of the legume component and be a more desirable management practice for reducing grass tetany in grazing animals.

Phosphorus applications should resemble those recommended for legumes grown by themselves and should be based on soil tests.

Irrigated pastures have increased in popularity in several Great Plains and Western States. The major benefit from irrigating is stabilized forage production, which results in a better balanced, and flexible forage system.

The grass-only systems, although representing a small proportion of the total acreage, are justified by the high potential productivity of N-fertilized grasses and the fear of bloat when some legumes are included in an irrigated grass-legume mixture. However, the legume component can be an effective source of symbiotic N. Gomm (1969) concluded that pastures with at least 40% legume in the stand produced dry-matter yields similar to grasses fertilized with 236 kg N/ha. Also, the advantages of increased beef production from grass-legume mixtures generally outweigh both the difficulties in maintaining a desirable mixture and the bloat hazard. The use of antibloating agents and cultivars or legumes with low bloating hazard may also be considered.

Much of the literature indicates that forage dry-matter and beef production is increased by fertilizing irrigated grass-legume mixtures with up to 224 kg N/ha (Moline, Rehm, and Nichols, 1974). Grazing trials on irrigated grass-legume pastures, where N and stocking rates have been controlled, have not been sufficient to fully evaluate the efficiency of high forage productivity. Benefits derived from N fertilization decrease as the proportion of legume in the mixed stands increases and become negative as the legume component approaches 50%. To maintain stand composition, it is important to use split applications when fertilizing with N.

The P fertilization levels should be chosen to adequately meet the needs of the legume component. The bicarbonate-extractable soil P should be maintained above 10 ppm P.

Legumes on some irrigated pastures along the Pacific Coast States have responded to additions of P, K, S, and/or B. As in other forage resource areas, soil tests should be used to identify potential areas of legume forage production responses to fertilizer applications.

Midcontinent range grasses in the central and northern Great Plains include cool-season native grasses (i.e., western wheatgrass, needleandthread, prairie june grass, and needlegrass), and warm-season grasses (especially bluegrama). Popular introduced cool-season grasses include smooth brome, russian wildrye, and intermediate wheatgrass. Warm-season grasses (i.e., grama, buffalo-grass, and bluestem) predominate in the area south and west of the Nebraska-Kansas border.

In the northern Great Plains, N fertilization results in significant and often economical benefits. However, N fertilization favors the growth of the cooler-season component at the expense of the most desirable warm-season grasses. Nevertheless, researchers (7) have obtained 56, 109, and 140 kg beef production/ha from a mixed-prairie rangeland fertilized with 0, 45, and 90 kg N/ha, respectively, for an 11-year period. Rogler and Lorenz (1969) found that cool-season crested wheatgrass in the northern Great Plains fertilized with 0, 45, and 90 kg N/ha produced 113, 189, and 197 kg beef/ha, respectively. A crested wheatgrass-alfalfa mixture (65:35) produced 152 kg beef/ha-yr over an 11-year period.

The warm-season grasses of the west central Great Plains generally respond poorly and often insignificantly to N fertilization. However, early spring growth, especially of introduced cool-season species, may respond significantly to N fertilization (Rogler and Lorenz, 1974).

Nitrogen fertilization of introduced warm-season grasses in the southern Great Plains shows promise. Weeping lovegrass, for example, yielded profitable returns when fertilized in western Oklahoma and other areas where it is adapted. Beef production and net profit from fertilized weeping lovegrass were increased 31 and 30%, respectively, by applying 39 kg N/ha (Rogler and Lorenz, 1974).

The annual grasslands of the Pacific Coast States are nearly always N-deficient. To obtain early winter feed and to increase total production, N must be added either by a legume or as N fertilizer. Phosphorus and S are applied to legume systems to obtain maximum productivity. In some areas, Mo deficiencies are quite common. Sometimes K, B, and lime are deficient on acid soils, but this is not widespread. Usually, the K and B deficiencies become evident only after adequate amounts of P and S have been applied on grass-legume mixed pastures.

Nitrogen applications are not profitable in central and southern California where rainfall is below 30 cm/yr, because drought restricts plant growth. In the 30- to 75-cm rainfall zone, N is generally applied in the fall to increase winter growth and lengthen the green-feed period (Jones, 1974). Nitrogen is generally not recommended when rainfall exceeds 75 cm, since leaching losses are high.

In the 30- to 75-cm rainfall zone, N fertilization of grass increased average daily gains and produced 1.19 kg beef/kg N. When S was included with N, 1.48 kg beef/kg N, and when S and P were included with N, 2.00 kg beef/kg N were produced, showing the value of correcting multiple nutrient deficiencies (Jones, 1974).

As in other areas, soil tests for P and K availability are necessary. Plant-tissue tests are reliable for evaluating S status, but not P status of the legume components in the mixed grass-pasture systems. Liming is recommended if the pH is below 5.5 to assist in establishing subterranian clover, and Ca may be helpful for stand establishment on the serpentine soils. Boron deficiencies occur in perennial legumes, but are rare in annual clovers (Jones, 1974).

General Comments: Where lime is required, dolomitic limestone is preferred to calcitic sources to maintain soil Mg supplies. Splitting N and K fertilizer applications is recommended to reduce the incidence of grass tetany, a Mg deficiency of ruminants, which occurs throughout the U. S.

Corrective measures must be taken to avoid Mo deficiency of legumes in parts of the Pacific States region, and Zn and Fe deficiencies on some of the annual forages grown in the Great Plains and Mountain States. Alfalfa, however, absorbs Zn from soils considered to be markedly Zn-deficient for other crops. Boron deficiency may be a problem in legume production in all but the South Atlantic States. Selenium in forage may be inadequate for animal requirements in the Ohio Valley, New England, and Pacific States. Copper deficiencies in animals have been noted in many areas, but these are often induced by high dietary intakes of Mo. Direct animal supplementation of Se and Cu, rather than fertilization, is recommended. However, inadequate soil Cu may restrict forage growth on the peaty-type soils, like those in Florida and Oregon, and small amounts of Cu fertilizer are necessary.

Conclusions: Fertilizers will continue to play an increasing role in forage produced for grazing animals. Careful management will be needed to maintain optimum production, especially in grass-legume systems to maintain the desired proportion of each component. Split applications of N and K (when needed) will receive increasing attention to optimize yields and maintain animal health. Direct animal supplementation with Se, Cu, and, in some areas, with Mg and Zn may be preferred to fertilizing pastures with these minerals.

REFERENCES

1. Baylor, J. E. 1974. Satisfying the nutritional requirements of grass-legume mixtures, p. 171-188. *In:* Mays, D. A., Editor, Forage fertilization. Am. Soc. Agron., Madison, WI, 621 p.

2. Burton, G. W. 1972. Can the South become one of the world's great grasslands? Progressive Farmer 87(3):22-24.

3. Gomm, F. B. 1969. Evaluation of grasses, legumes, and grass-legume mixtures for irrigated pastures grazed by sheep under various fertility and management practices. Mont. Agric. Exp. Stn. Bull. 618.

4. Jones, M. B. 1974. Fertilization of annual grasslands of California and Oregon, p. 255-275. *In:* Mays, D. A., Editor, Forage fertilization. Am. Soc. Agron., Madison, WI, 621 p.

5. Moline, W. J., G. W. Rehm, and J. T. Nichols. 1974. Fertilizer responses of irrigated grasslands, p. 213-229. *In:* Mays, D. A., Editor, Forage fertilization. Am. Soc. Agron., Madison, WI, 621 p.

6. Rogler, G. A., and R. J. Lorenz. 1969. Pasture productivity of pasture wheatgrass as influenced by N fertilization and alfalfa. USDA Tech. Bull. 1402.

7. Rogler, G. A., and R. J. Lorenz. 1974. Fertilization of mid-continent range plants, p. 231-254. *In:* Mays, D. A., Editor, Forage fertilization. Am. Soc. Agron., Madison, WI, 621 p.

8. Wedin, W. F. 1974. Fertilization of cool-season grasses, p. 95-118. *In:* Mays, D. A., Editor, Forage fertilization. Am. Soc. Agron., Madison, WI, 621 p.

9. Wilkinson, S. R., and G. W. Langdel. 1974. Fertility of the warm-season grasses, p. 119-145. *In:* Mays, D. A., Editor, Forage fertilization. Am. Soc. Agron., Madison, WI, 621 p.