RANGELAND FERTILIZATION FOR BALANCED FORAGE AND CATTLE NUTRITION [1/]

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Introduction

An important grazing resource in the United States is the big sagebrush-bunchgrass complex. It occupies nearly 94 million acres in southern Idaho, Utah, western Wyoming, Nevada, southeastern Oregon and south-central Washington. This area is often referred to as the Great Basin because of its precipitation pattern. Annual precipitation is generally less than 14 inches, and most of it falls during the winter and spring. The principal grasses are perennial bunch types, including species of wheatgrass, brome-grass, bluegrass, needlegrass and fescue.

Intensified management is converting much of this rangeland complex to higher producing grasses to increase forage production, to adjust the season of available forage, and on occasion to control insects and provide soil protection. Crested wheatgrass (Agropyron desertorum) has been selected for planting on such areas primarily because of its drought tolerance, ability to reseed, high yielding characteristics under these climatic conditions, and ability to initiate growth earlier than many other grasses.

The objectives of this paper are: (a) to review the effects of fertilization on crested wheatgrass forage yield in the big sagebrush-bunchgrass zone, (b) to review animal performance on crested wheatgrass, and (c) to discuss some special aspects of animal nutrition as related first to the monoculture grassland system and second to rangeland fertilization.

Forage Yield Versus Fertilization

Crested wheatgrass forage production is influenced not only by low amounts of precipitation, but by variable quantities from year to year which have a great influence in regulating plant population and forage yield. To a lesser extent forage yield may be restricted by low quantities of soil nutrients, particularly nitrogen. Available nitrogen may be low early in the year because of low nitrification activity when grasses are initiating rapid growth.

Nitrogen fertilization has increased crested wheatgrass forage yield in Oregon (20), Washington (13), and in extreme northeastern California (6). In one experiment, wheatgrass fertilized with 40 pounds of nitrogen per acre yielded 2300 pounds compared to 1220 pounds for check plots (13).

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These data represent average yield responses in the first year following fertilization for each of four years. Estimated cost of the increased forage was $12 per ton, assuming a cost of $0.15 per pound of applied nitrogen. Residual nitrogen studies reported by Sneva, Hyder and Cooper (20) demonstrated the decreasing response of crested wheatgrass forage yields in successive years following fertilization. Yield responses to 40 pounds of nitrogen per acre decreased each year until there was essentially no response in the third year following application.

Application costs may limit the economic returns from nitrogen fertilization. However, a recent proposal by J. F. Powers[3/] suggests that in some areas fertilizer nitrogen might be stored in a soil nitrate pool. Although his preliminary studies were conducted in the Northern Great Plains, such a pool might also be maintained in semiarid soils of the Great Basin. If this could be done, application costs could be reduced by fertilizing with amounts of nitrogen sufficient for a number of years.

Although nitrogen fertilization of some rangelands in the Great Basin states may be feasible, certain problems must be considered. The primary problem is that nitrogen fertilization may induce greater competition by annual weeds, including cheatgrass (Bromus tectorium). In some studies, competition for soil moisture and space has been sufficiently severe to depress the grass yields and, in some cases, has resulted in death of the wheatgrass (10, 23).

Annual yields of crested wheatgrass at Burns, Oregon, were directly related to nitrogen fertilization rate and to precipitation received in the preceding November 1 to June 1 period (20). Initiation of new growth is stimulated by nitrogen fertilization. Sneva, et al.(20) found that 44% of the seasonal growth had occurred by June 1 on check plots, compared to 69% on plots receiving 30 pounds of nitrogen. Such early growth enhancement could be utilized effectively in a management system where early grazing is desired.

A second desirable feature of nitrogen fertilization is that it increases water-use efficiency. Crested wheatgrass fertilized with 30 lb N/acre produced nearly 1.5 times the amount of dry matter per unit of water as did the unfertilized crested wheatgrass (20). Care must be taken in interpreting these data since they represent the relative water use in the first year following fertilization. Other studies have shown that nitrogen fertilization increases root activity in the deeper soil depths (17). Subsequently, moisture withdrawal increases because of the stimulated root growth and soil moisture may be extracted from zones of water accumulation previously unexplored by plants. Whether improved water-use efficiency would continue in subsequent years is not known. Increased water-use efficiency could also result from enhanced grass growth. In this case, water is used by the plants for dry matter production early in the season before the soil water is subjected to high evaporative demands.

3/ Workshop on Nitrogen Cycling in Semiarid Grasslands, Bismarck, North Dakota, March 25-26, 1969.

Phosphorus fertilization of crested wheatgrass has been reported in the Great Basin area in only one study (6). Phosphorus applied at 44 pounds per acre did not give significant yield response in any of five years. These authors (6) did not evaluate the available phosphorus status of the soil. The lack of forage yield response may mean that there was sufficient soil phosphorus for forage production.

Animal Performance on Unfertilized Range

Animals are generally turned out on foothill ranges and crested wheatgrass pastures about May 1. At this time the grass generally has initiated growth, but minimum air temperatures may be lower than 35 F. Animal gains are low until temperatures begin to increase grass growth and animals have adjusted to the change in feed. Figure 1 shows the trend in average daily gain made by ten groups of yearling and two-year-old Hereford cattle (mostly heifers) during eight summers at Knoll Creek, Nevada (15). Weight gains on actively growing forage are high, but begin to decrease as the forage matures and cures. This decline in animal gains results from a decline in nutrient concentrations in the forage. Crude protein decreases in maturing grass forage (Figure 2) and generally falls below the minimum levels established for beef cows by the National Research Council (12, 22). Phosphorus levels likewise decrease (Figure 3) as the season progresses and fall below the minimum level near the same time as crude protein (12, 22). *In vitro* studies of cellulose digestibility indicate a general decline as forage matures (22), demonstrating a decline in forage quality. Protein and energy supplements to animals during this period should be considered to maintain suitable animal performance (9). Seasonal gains of 125 pounds for supplemented beef cows were reported by Harris, et al. (8) in Utah compared to only 50 pounds for nonsupplemented animals. However, animal nutritionists have cautioned against broad statements concerning supplementation in every case (5, 9). It can be seen, though, from the chemical data that we should be concerned about nutritional quality of forage as it matures and cures.

Plant nutrient content, especially in the semiarid areas, decreases because of the downward transfer and leaching of minerals in standing vegetation as a result of the maturation process (11). Considerable leaching or transfer of various constituents - especially nitrogen, phosphorus, magnesium and potassium - occurs in the crop before deposition of litter. A novel idea to arrest the loss of nutrients in crested wheatgrass was examined by Sneva (19). He applied low concentrations of paraquat[4/] to crested wheatgrass at anthesis. This effectively arrested the redistribution of nutrients in the herbage portions during curing. In wet summers, herbage yield from treated plots was less than yield from check plots because of fall regrowth on check plots, but in dry summers, yields of treated and check plots were equal. Herbage yields were not reduced on

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4/ 1, 1'-dimethyl-4, 4'-bipyridylium-(dimethylsulphate).

plots sprayed with paraquat the previous year. A further check on the usefulness of this approach included the measurement of animal responses (14). Animal responses shown in Figure 4 indicate significant increases in daily gains on paraquat-cured crested wheatgrass. However, this approach to pasture management has not yet been approved in the United States.

Animal Performance on Fertilized Crested Wheatgrass Ranges

Limited information is available on animal performance on fertilized crested wheatgrass ranges in the Great Basin. Sneva, et al. (20) report 12.7, 14.0, and 16.7% crude protein in forage following fertilization with 0, 20, and 40 pounds of nitrogen per acre, respectively. Nitrogen and nitrogen plus phosphorus fertilization studies conducted in the Northern Great Plains under the influence of the summertime precipitation may help to illustrate what might happen to forage quality following fertilization. Nitrogen fertilization increased crude protein levels of forage above that required by beef animals (12, 18). Phosphorus concentrations were decreased by nitrogen fertilization and required phosphorus fertilization for forage-P to be above minimum levels (12, 18). A ten-year summary of animal response to crested wheatgrass as influenced by nitrogen fertilization and alfalfa (*Medicago Sativa*) should help define good animal management on crested wheatgrass pastures, particularly on the Northern Great Plains (16).

Nutrient Deficiencies

Deficiencies of phosphorus and nitrogen for animal performance have already been discussed. Figures 2 and 3 illustrate the steady decline in nutrient content of these two elements with seasonal maturity in crested wheatgrass. Only recently have we identified problems arising from deficiencies of other elements.

Selenium in excess has long been known to be toxic. However, minimal levels of 0.03 to 0.10 ppm, depending upon the level of vitamin E, are required to prevent white muscle disease (4). Ranchers in some geographical areas of the big sagebrush-bunchgrass zone should be prepared to handle such cases by injecting calves and lambs with selenium.

A nutritional disorder in ruminants known as hypomagnesaemia, or grass tetany, occurs in temperate regions throughout the world. It is frequently observed in the Great Basin area in the early spring for a two- to three-week period following turnout on crested wheatgrass pastures. It is prevalent in seasons when lush grass is available, but seldom occurs during dry years. The symptomology is exhibited by low blood serum magnesium levels (sometimes accompanied by low serum calcium), loss of appetite, twitching, and tremors. Acute severe symptoms consist of rapidly developing tetanic convulsions terminating with coma and death (1). Death is generally the only noticeable evidence of grass tetany under rangeland conditions, but it is suspected that animal performance may suffer because of this nutritional disorder. Many complicated interactions in addition to low forage magnesium are involved (7). Changes in weather, increases in the potassium to calcium plus magnesium ratio in plants (3), endocrine factors in the animal (1), and the occurrence of high levels of *trans* aconitate in plants (2) have been implicated in this nutritional disorder. In addition, magnesium absorption by the animal is lower from spring grass relative to hay supplying the same amount of magnesium (21).

Magnesium fertilization of tetany-prone pastures is common in humid regions. Response of forage to magnesium fertilization on semiarid rangelands is being studied by our laboratory. The magnesium status of rangeland grasses in the western United States is inherently low, even though soils may contain 10 to 20% exchangeable magnesium. High potassium to calcium plus magnesium ratios occur in plants in addition to high levels of trans aconitate at the time tetany occurs. The actual causes of hypomagnesaemia are not yet fully understood, but animals stricken with tetany will often respond to injections of calcium-magnesium gluconate. Oral supplementation of magnesium may be used to prevent this nutritional disorder. Block or meal supplements containing magnesium oxide have been used. Magnesium alloy capsules are available for implantation in the rumen and have reportedly given protection in Great Britain. Little use has been made of these capsules in the United States, however.

Animal Nutrition and Fertilizer Interactions

Nitrogen and phosphorus: it was pointed out earlier that nitrogen fertilization may result in lowering forage phosphorus concentration. Information on this possible interaction is not available for the big sagebrush-bunchgrass zone now covered with crested wheatgrass.

Nitrogen and nitrate poisoning: High levels of forage nitrate-nitrogen, which is converted by ruminant animals to nitrite, can accumulate following nitrogen fertilization. However, very few such incidences have been reported on semiarid pastures.

Nitrogen and magnesium: Nitrogen fertilization of rangelands which results in higher plant nitrogen could increase the occurrence of grass tetany. Experimental findings have shown that increases in forage nitrogen are accompanied by a decrease in the magnesium availability to ruminants (21).

Phosphorus and calcium: Calcium to phosphorus ratios of 1.5 to 2.5 are desirable for efficient utilization of both of these elements by ruminant animals. The actual ratio depends on the quantity of either calcium or phosphorus present in the diet. Calcium interferes with phosphorus utilization, especially at low phosphorus concentrations in forage. High calcium to phosphorus ratios increase vitamin D requirements. Since vitamin D is synthesized in the sunlight by animals, there should be little problem experienced on crested wheatgrass ranges, and so there is at the present time little evidence available to support concern for calcium to phosphorus ratios.

Summary

Intensified management on western rangelands is raising questions not previously considered. The feasibility of fertilization is certainly one of these questions.

While nitrogen fertilization has been shown to increase yields of crested wheatgrass in some cases, problems from stimulation of annual weeds and grasses such as cheatgrass can occur. Variability in amount and distribution of precipitation governs the effectiveness of nitrogen fertilization. Early maturation of forage is advantageous in management systems where early spring grazing is desired. Nitrogen fertilization has also been shown to increase water-use efficiency. This may result from more rapid growth before soil water becomes subject to high evaporation losses. Very little information is available on phosphorus fertilization of crested wheatgrass.

Animal performance has been improved when protein and energy are supplemented during certain periods when animals are grazing crested wheatgrass. Animal performance is also improved in instances where nutrient losses from grass have been chemically arrested. Nutrient deficiencies of nitrogen, phosphorus, selenium and magnesium can occur, but fertilization to correct these deficiencies is still questionable. Animal supplementation may be the more feasible method and in the long run more economical than applying the nutrient to the soil-plant system. If fertilization is done, we should be aware of possible occurrences of nutrient imbalances in the forage. It is obvious that we need more information on rangeland fertilization for forage that provides balanced cattle nutrition.

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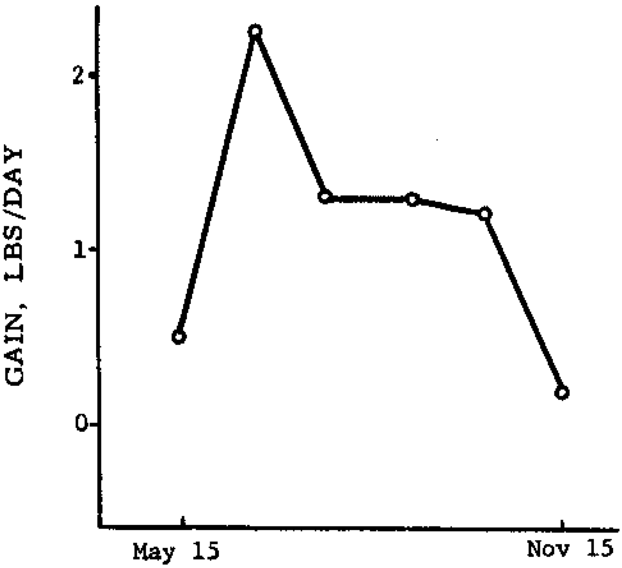

Figure 1. Average cattle gains during eight summers at Knoll Creek, Nevada (15).

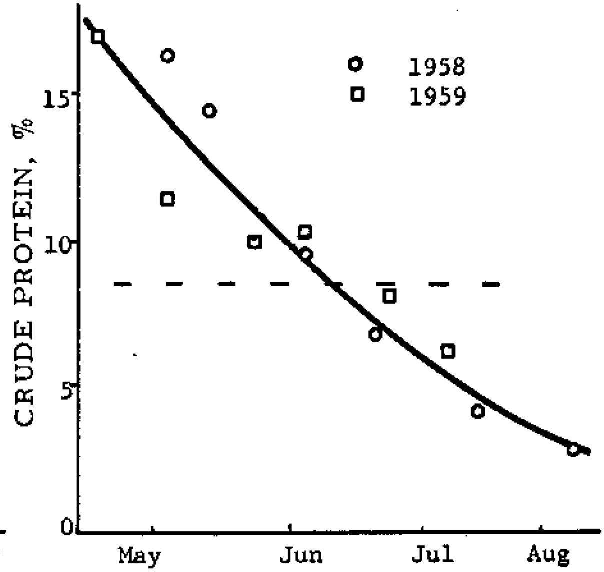

Figure 2. Crude protein content of crested wheatgrass, Burns, Oregon (22). Minimum level for beef cattle is 8.3% (12).

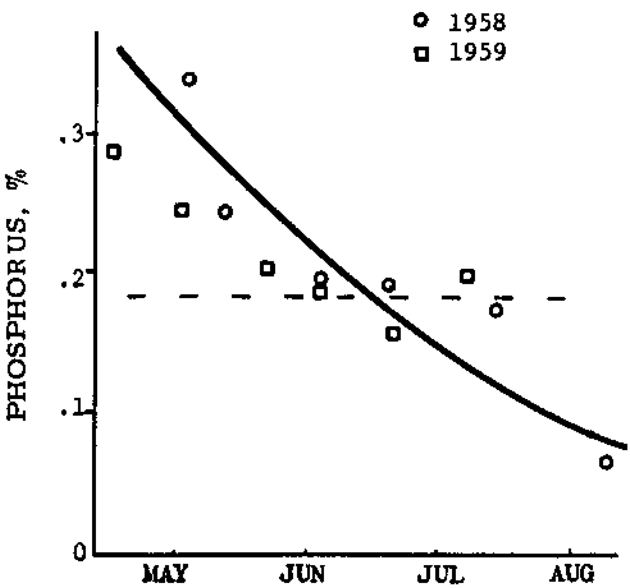

Figure 3. Phosphorus content of crested wheatgrass, Burns, Oregon (22). Minimum level for beef cattle is 0.18% (12).

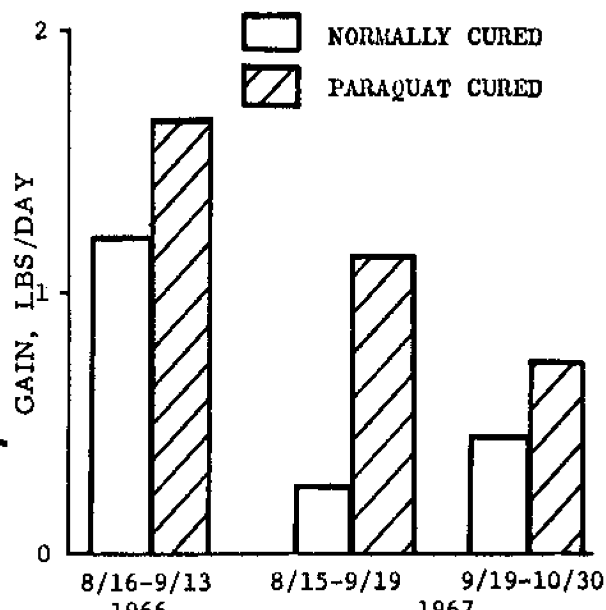

Figure 4. Average cattle gains grazing normal and paraquat-cured crested wheatgrass, Burns, Oregon (17).

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