Fertilizer Experiments on Native Rangelands Using Increasing-Rate Spreader

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Highlight

The increasing-rate fertilizer spreader offers a method for overcoming variability of herbage stand and consequent difficulty of finding large uniform areas in fertilizer rate studies on rangelands.

In some native range areas, large uniform sites suitable for conventional soil fertility experiments are not available. Because of the variability in soils and in plant associations, a new method for conducting soil fertility studies on native rangelands is being investigated. Basically, curves showing plant responses to fertilizer are determined directly from plots to which fertilizer had been applied at continuously increasing rates.

Smith and Lutwick (1961) developed a spreader that applies fertilizer at rates continuously increasing from 0 to about 3,000 pounds per acre. The spreader thus provides a large number of rates, dependent upon the intensity of sampling along the strips, on a relatively small area. This may be of particular advantage on native range sites where large uniform areas are not available.

This is an initial report of the use of the machine in studies of the response of native range vegetation to fertilizer. Response patterns determined on small areas of a simple sward and of a more complex sward to increasing rates of nitrogen fertilizer and the possible conclusions from them are presented as the basis of discussion concerning the use of the machine in soil fertility studies.

Materials and Methods

Within areas of two representative plant covers, one on the Milk River Ridge and one in the Porcupine Hills of southwest Alberta, two adjacent experimental sites were chosen on uniform topography. The percent basal area and botanical composition of each sward were determined by the vertical point and point-yield methods (Campbell, 1958).

For each sward ammonium nitrate (33.5-0-0) was applied with the increasing-rate fertilizer spreader to one site in the fall of 1961 and to the other site in the fall of 1962. The fertilizer was applied in strips over the distance required for the spreader to change from completely closed to full opened. The strips, 4 feet wide, were laid out on 6-foot centers and were 150 feet long. To account for possible fertility gradients in the field, the strips were laid in opposite directions; in two replications the fertilizer rates increased in one direction, and in the other two they increased in the opposite direction. The fertilizer was applied once to each site.

The first-year sites were harvested in 1962 and 1963. The yields in 1963 represented the residual effect of the fertilizer. The second-year site was harvested in 1963. Square-yard samples were taken every 10 feet beginning 5 feet from the end of the strip. The yields for each rate of fertilizer were averaged across the four replications within each test. Square-yard samples were also harvested along untreated strips adjacent to the fertilized strips.

Results

Simple sward.—The botanical composition of the sward on the Milk River Ridge site was relatively simple. The dominant grass was rough fescue *(Festuca scabrella* Torr.) (Table 1). Other grass species, *Carex* spp., and forbs were of minor importance at this site.

The composition of the sward was affected by high rates of nitrogen fertilizer. At about 350 pounds of N per acre *Carex* spp. were killed out and at about 540 pounds of N per acre Idaho fescue *(Festuca idahoensis* Elmer) was killed out, leaving rough fescue and a few forbs as the only components of the sward.

The yields across the field where no fertilizer had been applied (Figure 1) were relatively constant, indicating a fairly uniform stand of herbage. Where nitrogen had been applied, the first-year yield patterns depended upon season. Thus, in 1963 the curve up to 180 pounds of N per acre was convex; beyond that point the curve was depressed. In 1962 the curve up to 123 pounds of N per acre was concave and beyond that point was essentially linear. The optimum rates appeared to be 180 pounds of N per acre in 1963 and 123 pounds of N per acre in 1962.

The second-year yield pattern, showing the effect of residual nitrogen, was similar to that of the first year, although maximum yield occurred at a higher rate of fertilizer. Also, the effect of residual nitrogen was nearly as great as the initial effect found in the preceding year. However, this effect of residual nitrogen was greater than the initial effect found in the same year on the plots fertilized in 1962. With yields for the two years combined, the optimum rate appeared to be 180 pounds of N per acre.

The optimum rate of fertilizer determined in one year may not be applicable as an optimum rate next year. Also, the response function obtained in one year may not be applicable next year. The residual effects of nitrogen on yield of herbage in the second year are as great or nearly as great as the effects obtained in the first year.

Mixed sward.—The botanical composition of the sward on the Porcupine Hills sites was more complex than that on the Milk River Ridge sites. Parry oatgrass *(Danthonia parryi* Scribn.) and rough fescue occurred as co-dominants with other grasses, carices, and forbs (Table 1). The forb component of the sward contained more species than occurred in the simple sward.

Carex spp. and Idaho fescue were killed out at high rates of nitrogen fertilizer as they were in the simple sward (Figure 2). Oatgrass, a co-dominant, was killed out at about 580 pounds of N per acre. Other grass species such as northern wheatgrass *(Agropyron dasystachyum* (Hook.) Scribn.), western wheatgrass *(A. smithii* Rydb.), and northern awnless brome *(Bromus pumpellianus* Scribn.), which had occurred in trace amounts, increased in growth and assumed greater importance in the sward as the rates of nitrogen fertilizer increased. None of the forbs were killed out at high rates of nitrogen fertilizer. Some species, such as scarlet globe mallow *(Sphaeralcea coccinea* (Pursh.) Rydb.) and narrow-leaved goosefoot *(Chenopodium leptophyllum* Nutt.), which tolerate relatively high salinity, appeared at the high rate of nitrogen end of the strips. They may be considered invaders when other species are killed out.

Where no fertilizer had been applied (Figure 3), the yield of total herbage across the field was variable, indicating that the stand of native grasses and forbs was not uniform. The one exception was the second-year harvest. These plots were clipped twice, once before fertilizer was applied and once for yield in 1962. Clipping and removing the herbage may tend to even out the yield of native herbage in succeeding years.

Table 1. Percent basal area and composition of vegetation at two study sites and response of species to high rates of nitrogen.

Species	Milk River Ridge basal area	Milk River Ridge composition	Porcupine Hills basal area	Porcupine Hills composition	Reaction to high rates of N[1]
Festuca scabrella	14.80	80	3.12	31	R
Danthonia parryi	—	—	7.25	37	K
Festuca idahoensis	1.40	4	1.35	5	K
Stipa spartea	0.95	3	0.72	4	K
Agropyron smithii	0.40	2	0.42	3	R
Agropyron dasystachyum	—	—	0.32	2	R
Calamagrostis montanensis	—	—	0.28	2	K
Bromus pumpellianus	—	—	0.70	4	R
Other grasses	1.33	4	0.73	4	—
Carex spp.	2.52	5	1.48	5	K
Forbs and shrubs	3.56	2	3.41	3	—
Total	24.96	100	20.78	100	

[1]K — killed out at high rates of N; R — responded to high rates of N.

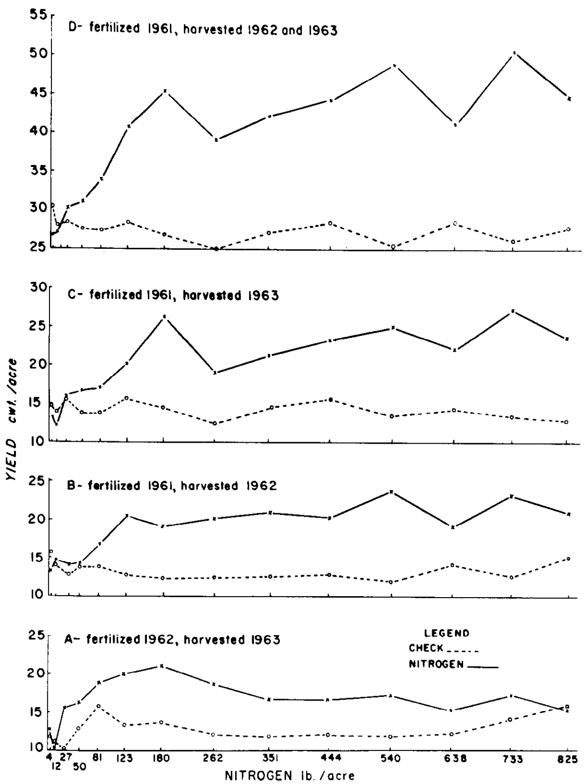

FIGURE 1. Yields of dry matter in hundredweights per acre of unfertilized and fertilized strips at the Milk River Ridge study site.

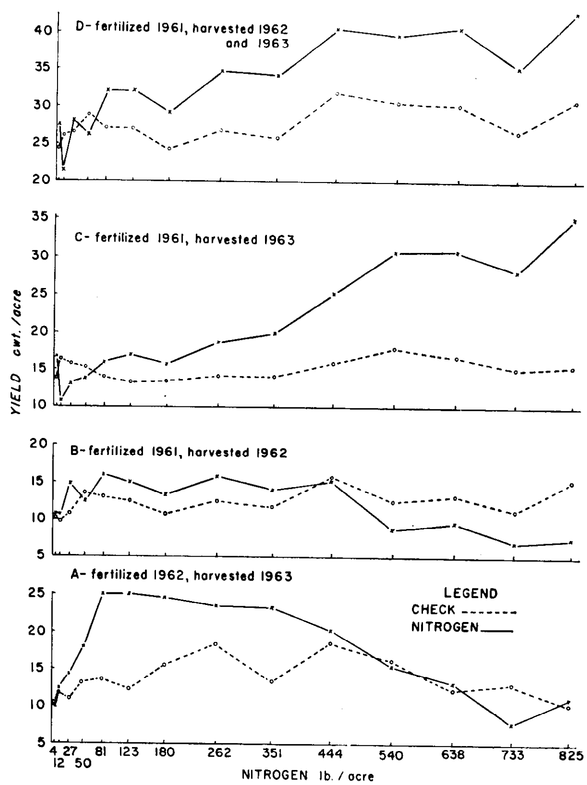

FIGURE 3. Yields of dry matter in hundredweights per acre of unfertilized and fertilized strips at the Porcupine Hills study site.

FIGURE 2. Fertilized strip at Porcupine Hills study site showing toxic effect of high applications of N. Surviving plants are *Festuca scabrella.*

Where nitrogen fertilizer had been applied, the first-year response patterns depended upon season. Thus, in 1963 maximum response occurred at about 80 pounds of N per acre; in 1962 yields increased only slightly from nitrogen fertilizer. In both years as noted above some components of the sward were killed out. Thus, at rates higher than 440 pounds of N per acre yields of herbage were equal to or less than the yields of the check plots.

In the second year after fertilization, yields increased with the rate of nitrogen up to about 540 pounds of N per acre and thereafter were relatively constant. The increase over the check was not large until rates higher than about 350 pounds of N per acre had been applied. Thus, the residual effect of nitrogen was most marked where some species had been killed out the previous year.

With the two years combined, the differences between check and nitrogen plots were similar at all rates above 260 pounds of N per acre. The most apparent effects of nitrogen fertilizer on the complex sward were: (a) a season-dependent increase in yield in the first year; (b) a change in botanical composition of the sward at high rates of nitrogen in the first year; and (c) a marked increase in yield over the check in the second year by those species not killed out in the first year.

The full effect of nitrogen on native herbage cannot be assessed in one year. Also, the residual effect of nitrogen, especially at high rates, may not have dissipated after two years of growth.

Discussion

It is often stated that three rates of a given plant nutrient are sufficient for calculating a plant-nutrient yield-response function. However, some previously obtained information is required when selecting the three rates. In this study of the effect of nitrogen on native grassland swards, the response patterns appear much more complex than can be described by three rates of nitrogen fertilizer. Also, even with more than three rates, relatively simple regression equations, such as quadratic and logarithmic functions, would not reflect the complexity of the response patterns shown in some of the curves in Figures 1 and 3.

Some of the complexity of the response patterns may be attributed to the native grasslands themselves. They are mostly mixtures of species and do not grow in orderly patterns as do cultivated crops. Also, cattle do not graze in geometrical patterns. The irregular grazing would contribute to the complexity of the sward or unevenness of stand. It would therefore be impractical to establish completely randomized, replicated, and orthogonal factorial experiments on such complex swards. With several rates of fertilizer in the study, the complexity of the sward would force a large experiment, thus posing a considerable labor problem, in order to have adequate control of error.

Many of the questions concerning the response of native grasslands to nitrogen fertilizer can be answered from studies of the type reported here. Small areas of relatively uniform stand can be obtained. The problem of establishing experiments involving several rates of fertilizer on such sites, especially where basic information is lacking, becomes one of selecting the rates and fitting them into the area. The increasing-rate spreader used in this study applies fertilizer from 0 to about 3,000 pounds per acre in a non-random manner. Each strip, 150 feet long and 4 feet wide, comprises 600 square feet of area, and as many replications as will fit the area could be used. In this study, four replications were used. From the strips a large number of rates can be selected after the crop has grown in response to the fertilizer. In this study, sampling along the strips was done at regular intervals. This need not be so and sampling may be done at any intensity according to the desires of the person conducting the study.

The mathematical treatment of the data to show significance of responses and magnitude of errors has not been worked out. Statisticians are presently engaged with the problem and will be reporting separately.

Summary

Nitrogen fertilizer was applied at increasing rates from 0 to over 800 pounds of N per acre to strips of native rangeland vegetation. Sub-plots for yield measurement were chosen at intervals along the strips. Because of variability of stand of herbage on native rangelands and the consequent difficulty of finding relatively large uniform areas, the increasing-rate fertilizer spreader offers a method of overcoming these difficulties in fertilizer rate studies on these rangelands.

LITERATURE CITED

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