The Effect of Commercial Fertilizers on Forage Production and Utilization on a Desert Grassland Site

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Although many studies have been made in southern Arizona on nearly all phases of range management (ecology, noxious plant control, reseeding and stocking rates), little information is yet available concerning the effects of commercial fertilizers on rangeland. The limited number of studies conducted in southern Arizona have shown that forage production usually can be increased on these ranges (Freeman and Humphrey, 1956). These studies, however, were made on a small number of species and did not show the effect of range fertilization on forage utilization by cattle.

The current study was conducted to determine the effects of two commercial fertilizers on (1) forage production, and (2) on forage utilization by cattle on a desert grassland range.

The application of nitrogenous fertilizers on ranges supporting annuals not only increases quantity and quality of forage produced (Retzer, 1954), but also is a means of improving the vegetative cover for soil and moisture conservation (Hoglund, Miller and Hafenrichter, 1952).

The response of perennial grasses to nitrogenous fertilizers has been rather apparent. Freeman and Humphrey (1956) found that an increase in the amount of fertilizer applied resulted in an increase in the crude protein content of perennial grasses and that the green-feed period, important in the Southwest, can be extended by fertilization. Smith and Lang (1958) found that nitrogenous fertilizers were effective in facilitating uniform livestock distribution and that good utilization was obtained on areas previously only lightly grazed.

Rogler and Lorenz (1957), in studies conducted in the northern Great Plains, obtained an immediate response to nitrogen fertilizer by cool-season grasses as reflected by darker color and increased growth. One of the evident advantages of the use of nitrogen was a beneficial effect on the vegetation in heavily-grazed pastures. It was determined that two years of fertilization with 90 pounds of nitrogen (N) per acre each year did more to improve the condition and increase the yields of the heavily-grazed pasture than six years of complete isolation from grazing. This suggests that fertilization may prove effective as one of the main tools in bringing back some depleted ranges to near-original productivity.

The Study Area
The study was conducted during the summer of 1958 on the Santa Rita Experimental Range in southeastern Pima County, Arizona. The study area was typical of many southern Arizona desert grassland ranges. The site selected was at an elevation of 4100 feet in a pasture of approximately 700 acres that had received no grazing during the summer of 1958.

Average annual precipitation on the area, based on the six-year period of record from 1952 to 1958, was 15.52 inches. The average precipitation for July and August, during this six-year period, was 9.86 inches. This indicates that 60 percent of the total annual precipitation normally falls during these two summer months. Precipitation in the amount of 14.34 inches was recorded during the period of July 16-September 10, 1958.

The soil on the area has been developed from granite or syenite. These rocks have weathered to form a coarse, gritty parent soil material. Depth to bedrock ranges from zero to more than one foot. There is a definite topsoil consisting of a few inches of reddish-brown or dark reddish-brown coarse, sandy loam. The topsoil underlain by a red, gritty clay loam or heavy loam subsoil overlaying soft, crumbling granite or syenite, into which red colloidal material has penetrated. The soil is slightly acid and is considered good for grasses. It has been classified as a stony, coarse, sandy loam of the Coronado series (Youngs et al., 1931).

The vegetative cover on the study area was composed almost entirely of perennial grasses. Lehmann lovegrass (Eragrostis lehmanniana Nees), which had been seeded in 1949, and Santa Rita threeawn (Aristida glabrata (Vasey) Hitch.) were the two dominant forage species (Figure 1). Other perennial grasses making up the rest of the vegetative cover were: spruce-top grama (Bouteloua chondrosioides (H.B.N.) Benth.) sideoats grama (Bouteloua curtipendula (Michx.) Torr.), slender grama (Bouteloua filiformis (Fourn.) Griffiths), Arizona cottontop (Trichache californica (Benth.) Chase), poverty threeawn (Aristida divisorica Humb. and Bonpl.), Boer lovegrass (Eragrostis chloromelas Swartz), and sixweeks threeawn (Aristida adscensionis L.).
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FIGURE 1. Area fertilized with 50 pounds of nitrogen per acre, applied as ammonium phosphate, showing the slope and principal grasses. The dominant grasses are Lehmann lovegrass and Santa Rita threeawn.

As this area is similar in vegetation and topography to many other desert grassland ranges, the results obtained may be applicable to other ranges with similar soil and climate.

Methods

Four replications of seven 50 x 70 foot plots were established in the study area. The plots were laid out on the contour to insure uniform slope and prevent washing of fertilizer from one plot to the next. Treatment for plots within each replication were randomized. Two commercial fertilizers, ammonium phosphate (16-20-0) and ammonium nitrate (32-0-0) were broadcast in pelletized form on six of the plots in each replication at rates of 25, 50 and 100 pounds of nitrogen (N) per acre. The seventh plot was unfertilized and constituted the check plot. Because most of the forage in the desert grassland is produced during the summer growing season, three 9.6-square-foot quadrats (Frischknecht and Plummer, 1949) were randomly selected in each plot. All the vegetation within each quadrat was clipped to a 1-inch stubble height, and air dried. Because of the high density and lodging of the vegetation, annual and perennial grasses were combined and weighed as a unit.

Utilization of the vegetation on the area by cattle was determined by observing the grazing use of the first 25 perennial grass plants encountered on a 1-foot-wide belt transect placed in the center of each plot. Thus 100 plants were examined for each treatment. Grazing use was rated in one of three categories: grazed, and ungrazed (Canfield, 1944).

Results

Forage Production

Both ammonium phosphate and ammonium nitrate gave significant increases over the check in total forage produced at all three rates of application (Table 1). Comparison of the means by the Duncan multiple range test utilizing a standard error of the mean of 267.6, shows that ammonium phosphate provided significant increases in forage through the range of 100 pounds of nitrogen per acre. In addition, 100 pounds of nitrogen per acre from the ammonium phosphate source provided significantly more forage than did the similar rate from the ammonium nitrate source.

Ammonium nitrate gave significant increases only through the range of 50 pounds of nitrogen per acre. The 50-pound plot in replication 3 gave yields that greatly exceeded those of the other three plots fertilized at the same rate. This high yield may have been because the fertilizer was applied in an almost pure stand of Lehmann lovegrass. Thus, difference in size and weight of one species over another may have accentuated the increase in forage production.

Forage yields obtained from fertilizing with ammonium phosphate exceeded those obtained from ammonium nitrate at each rate of nitrogen application. The ammonium phosphate fertilized plots showed a linear response in forage production. The increase in forage production at the 100-pound rate was much greater and had not reached a point of diminishing return as

<table>
<thead>
<tr>
<th>Fertilizer and rate</th>
<th>Total Forage Production¹</th>
<th>Difference²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pounds (N) per acre</td>
<td>Pounds per acre</td>
<td></td>
</tr>
<tr>
<td>No fertilizer</td>
<td>2475</td>
<td>.............</td>
</tr>
<tr>
<td>Ammonium Phosphate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>4578</td>
<td>2103</td>
</tr>
<tr>
<td>50</td>
<td>5420</td>
<td>2946</td>
</tr>
<tr>
<td>100</td>
<td>6380</td>
<td>3905</td>
</tr>
<tr>
<td>Ammonium Nitrate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>4113</td>
<td>1638</td>
</tr>
<tr>
<td>50</td>
<td>5290</td>
<td>2816</td>
</tr>
<tr>
<td>100</td>
<td>5368</td>
<td>2889</td>
</tr>
</tbody>
</table>

Least significant range value—796
¹Mean of four replicates.
²Additional forage produced per unit area on fertilized over unfertilized plots.
was the case with ammonium nitrate at the same rate.

**Forage Utilization**

Approximately 20 head of mother cows were turned into the pasture on October 1, 1958. This stocking rate (18 head per section) constituted light grazing for the area. Utilization on the study area was first noted in December, but measurements were not made until February, 1959.

The preference exhibited by cattle for fertilized over unfertilized grass was very apparent (Table 2). Utilization was approximately three, four and five times greater, respectively, on the 25, 50 and 100 pounds-per-acre rate of nitrogen application as on the unfertilized plots. Utilization on plots fertilized with ammonium phosphate at the 50-pound rate, on the other hand, was less than on those where only 25 pounds of the same kind of fertilizer had been applied. This was apparently due to the fact that two of these plots had not been discovered by the cattle at the time the utilization measurements were made, and thus did not give representative utilization data for that rate of fertilization.

**Table 2. Effect of two commercial fertilizers on forage utilization, Santa Rita Desert Grassland**

<table>
<thead>
<tr>
<th>Fertilizer and rate</th>
<th>Partially Grazed</th>
<th>Partially Grazed</th>
<th>(Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Stubble Height 2&quot;)</td>
<td>(Stubble Height more than 2&quot;)</td>
<td></td>
</tr>
<tr>
<td>Pounds (N) per acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No fertilizer</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Ammonium Phosphate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>41</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>38</td>
<td>19</td>
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<tr>
<td>100</td>
<td>63</td>
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<tr>
<td>Ammonium Nitrate</td>
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<td>33</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>42</td>
<td>22</td>
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</tr>
<tr>
<td>100</td>
<td>65</td>
<td>15</td>
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</tr>
</tbody>
</table>

**Figure 2.** Area fertilized with 50 pounds of nitrogen per acre, applied as ammonium phosphate, showing increased growth and darker green color than on the unfertilized area in the foreground.

Utilization where 25 pounds of nitrogen per acre had been applied as ammonium phosphate was greater than where an equivalent amount of nitrogen had been applied as ammonium nitrate.

**Green-Feed Period and General Observations**

Application of the nitrogenous fertilizers, even at the lowest rates, extended the green-feed period of the grasses. The length of extension was dependent on rate of application and source of nitrogen. For example, 25 pounds of nitrogen obtained from ammonium nitrate extended the green-feed period one week. The same amount of nitrogen from ammonium phosphate, on the other hand, extended the green-feed period by three weeks. Fifty pounds of nitrogen from ammonium nitrate provided green feed for an additional four weeks and 50 pounds from ammonium phosphate, five weeks. One hundred pounds of nitrogen per acre applied either as ammonium phosphate or ammonium nitrate extended the green-feed period six weeks.

Two weeks after the first effective rain, vegetation on the fertilized plots showed an increase in growth and a darker green color than on the unfertilized plots (Figure 2). Grasses on the fertilized plots had considerable lodging as compared to no lodging in the unfertilized area. Degree of lodging increased with increasing rate of fertilization, irrespective of the kind of fertilizer, except at the 25-pound rate where grasses fertilized with ammonium phosphate lodged more heavily.

**Discussion and Conclusions**

Although not statistically significant, grasses fertilized with ammonium phosphate gave higher yields at all three application rates than those fertilized with ammonium nitrate. Due to above-normal rainfall during the period of this study, nitrate-nitrogen losses by leaching may have occurred, thus reducing the amount of nitrogen readily available for plant growth. This would suggest the advisability of applying nitrogen as ammonium-nitrogen which is initially tied up in the soil complex and becomes available gradually upon the action of soil microorgan-
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FIGURE 3. Cattle use on plot fertilized with ammonium phosphate at 100 pounds of nitrogen per acre. This plot was grazed to a 1-inch stubble height. Cattle showed no preference for one grass species over another.

Another possible reason for the relatively high yields obtained from ammonium phosphate at all three rates of application and the diminishing effect of ammonium nitrate at the 100-pound rate may be the availability of phosphorus. Olsen and Fried (1957) found a close correlation between soil moisture and phosphorus availability. When dry conditions prevail, as they commonly do in the Southwest, phosphorus is tied up in the soil and is not available to the plant. With an increase in soil moisture the phosphorus is released and becomes available for plant growth. Under these conditions phosphorus may have a long-time residual effect on the vegetation.

As nitrogen is increased, the metabolic rate of the plant is accelerated. The speed-up in metabolism increases the amount of phosphorus and other minerals required by the plant. Consequently, when nitrogen from ammonium phosphate was applied at increasing rates, the amount of phosphorus needed for the added growth was applied. When nitrogen was applied as ammonium nitrate, on the other hand, phosphorus already in the soil was apparently present only in sufficient quantity to take care of the plants' requirement up to the 50 pounds of nitrogen per acre rate of application. Thus when 100 pounds of nitrogen was applied as ammonium nitrate, the amount of phosphorus in the soil was insufficient to provide the increased phosphorus required by the plant (Allison, 1957).

Ranchers in most areas have a problem in obtaining uniform distribution of livestock in the range. Range fertilization appears to provide a good tool for alleviating this problem. Through fertilization of forage, it has been found possible to attract livestock into areas that previously had been utilized lightly or not at all (Smith and Lang, 1958). As has been noted earlier in this paper, cattle showed a marked preference for the grasses that had been fertilized. This preference indicates that fertilization with adequate rainfall may be used as an important tool in attaining better livestock distribution on Arizona ranges.

Another problem in range management is that of selective grazing. It is a well-known fact that some grass species are more palatable than others. The re-

FIGURE 4. Cattle use on plot fertilized with ammonium nitrate at 100 pounds of nitrogen per acre. Vegetation here consisted primarily of Santa Rita thresawn and Lehmann lovegrass. Note heavy utilization of both species.
results from this study indicate that range fertilization can be used to increase forage palatability, thus reducing selective grazing on ranges that support a mixture of highly palatable and slightly palatable species. Cattle showed on preference for one grass species over another on plots that had been fertilized with either ammonium phosphate or ammonium nitrate (Figure 3). Lehmann lovegrass, which is considered to be much less palatable than most native perennial grasses (Humphrey, 1958), was grazed on the fertilized plots to the same degree as the native perennial grasses associated with it (Figure 4).

Extension of the green-feed period is of extreme importance in most range operations. By extending the green-feed period, the amount of supplemental feed required to maintain animals at an optimum nutritional level is reduced. Another advantage of extending the green-feed period involves the relationship of green-feed to Vitamin A. Green forage is fairly high in carotene, and this carotene in turn is converted to Vitamin A by animals. As cattle are generally inefficient in this process, they require large amounts of carotene and the longer they are without green-feed the lower becomes their supply of Vitamin A. Lengthening of the green-feed period, therefore, shortens the carotene-deficient period.

**Summary**

Two commercial fertilizers, ammonium phosphate and ammonium nitrate, were applied in pelleted form on a typical desert grassland site at rates providing 25, 50 and 100 pounds of nitrogen (N) per acre. A marked response was obtained for all rates of application. The forage-yield response was apparently facilitated by the 14.34 inches of rainfall (5 inches above normal) that fell during the summer.

Total forage production, grazing use and length of green feed period were measured as indicators of the effectiveness of fertilization.

Results and conclusions can be summarized as follows:

1. At all three rates of application, plots fertilized with either ammonium phosphate or ammonium nitrate showed significant increase in total forage produced over the unfertilized plots.

2. Both fertilizers, even at the lowest rates, almost doubled the forage production over that produced on the unfertilized areas.

3. Plots fertilized with ammonium phosphate showed a linear response in forage production. Plots fertilized at the rates of 25, 50 and 100 pounds of nitrogen per acre produced significantly different means of 4578, 5420 and 6380 pounds of air dry forage respectively.

4. Plots fertilized with ammonium nitrate reached a point of diminishing return near the 100 pounds of nitrogen per acre application.

5. Cattle utilization at the 25, 50 and 100 pound nitrogen application rates was approximately three, four and five times as great respectively as on the check plots.

6. Cattle showed no preference for one grass species over another on plots fertilized with either ammonium phosphate or ammonium nitrate as contrasted with marked preferences on unfertilized range.

7. Application of the two commercial fertilizers extended the green-feed period of the forage up to six weeks.

The highly significant results obtained from this one-year study indicate that range fertilization has a definite possibility of becoming one of the most valuable tools of range management in southern Arizona.

**LITERATURE CITED**


