THE EFFECTS OF NITRATES AND PHOSPHATES UPON FORAGE PRODUCTION

OF A SOUTHERN ARIZONA DESERT GRASSLAND RANGE

by

Barry N. Freeman

A Thesis

submitted to the faculty of the

Department of Agronomy and Range Management

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in the Graduate College, University of Arizona

1955

Approved: R R Humphrey, 5/5/55
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reseeding trials increased the chances of seedling survival and promoted initial growth. Fertilizer application has also been found to be effective in improving present vegetal cover for soil and moisture conservation (Hoglund, et al., 1952). Used in conjunction with brush control it greatly increased the chance for re-establishment of the native perennial grasses.

The application of commercial fertilizers may alter the chemical properties of the soil; this may or may not affect plant growth. This study has been carried out to determine some of the effects of commercial fertilizers upon range plants, with particular emphasis on quality and quantity of forage produced.

## CURRENT STUDY

This study was conducted during the summer of 1954 on the H. B. Thurber Singing Valley Ranch located in southeastern Pima County, Arizona. The experimental area was typical of the desert grassland ranges comprising much of southern Arizona; Cochise, Santa Cruz, and southeastern Pima Counties, in particular (Figure 1). The study site was a small livestock exclusion pasture in an open oak savanna.

Because the area selected contains most of the dominant and subdominant forage species typical of most desert grassland ranges of southern Arizona, the results may apply as well to other desert grassland regions with similar soil and precipitation.

The seasonal summer-winter precipitation pattern of this area is typical of the southwest. An annual rainfall of sixteen inches is

Figure 1. Typical southern Arizona desert grassland range near Sonoita, Arizona. Looking westward toward the Santa Rita Mountains.

normal for the area, slightly more than half (nine inches) of which falls during the summer months. Table 1 shows the rainfall pattern during the course of this study. As the bulk of forage in southern Arizona's desert grassland is produced during the summer rainy season the fertilizers were applied immediately prior to the first summer rains.

The soil of the study area is derived from residual granite. The rocks weather to form a reddish-brown granular sandy clay loam surface soil with a dull-red compact subsoil containing stones of various sizes throughout its profile. The soil is moderately acid throughout and is tentatively classified as a Shantung Brown soil of the Vista-Holland-Sierra series.

Perennial grasses were dominant on the study area. Two species, curly mesquite (*Hilaria belangeri*) and spruce top grama (*Bouteloua chondrosiodes*) predominated (Figure 2). Others occurring in significant amounts were: sideoats grama (*Bouteloua curtipendula*), slender grama (*Bouteloua filiformis*), blue grama (*Bouteloua gracilis*), poverty threeawn (*Aristida hamulosa*), and wolftail (*Lycurus phleoides*). Shrubby vegetation included false mesquite (*Calliandra eriophylla*), shrubby buckwheat (*Eriogonum wrightii*), and velvet-pod mimosa (*Mimosa dysocarpa*). Annual golden-eye (*Viguiera annua*) and wild-daisy (*Erigeron concinnus*) were abundantly distributed through all of the plots.

Figure 2. Typical fertilized plot showing slope and principal species. The dominant grasses are curly mesquite and sprucetop grama. Wild-daisy is the white-flowered forb; annual golden-eye is the tall forb.

Table 1. Weekly and total precipitation for the summer growing season of 1954 on the Singing Valley Ranch near Sonoita, Arizona.

| Week Ending | | Weekly Precipitation | Cumulative Precipitation |
|---|---|---|---|
| | | inches | inches |
| July | 1 | 0.42 | 0.42 |
| | 8 | 0.22 | 0.64 |
| | 15 | 0.18 | 0.82 |
| | 22 | 0.78 | 1.60 |
| | 29 | 0.27 | 1.87 |
| August | 5 | 0.93 | 2.80 |
| | 12 | 1.03 | 3.83 |
| | 19 | 0.38 | 4.21 |
| | 26 | 1.32 | 5.53 |
| Sept. | 2 | 1.00 | 6.53 |
| | 9 | 0.30 | 6.83 |
| | 16 | 0.55 | 7.38 |

## METHODS AND MATERIALS

The experimental area was divided into four series of ten plots each. The plots (each 8' X 24') were laid out with the 24-foot dimension extending downhill. There was a minimal distance of four feet between plots. The slope was gentle (approximately 45 percent) with an easterly exposure ( Figure 3). Of the ten plots within each series, nine were randomly treated with different commercial fertilizers at various rates. The tenth plot of each series was unfertilized and remained as a check plot. Due to the uniform nature of the soil and vegetation within each series, a single plot constituted an adequate check for each series.

The commercial fertilizers used were ammonium nitrate (32-0-0), ammonium phosphate (16-20-0), and single superphosphate (0-20-0). These were applied in granular form at rates of 100,200, and 400 pounds per acre. Choice of fertilizer and rate of application to any particular plot were determined by random selection. Each of the rates of application was replicated four times.

Because of the small amounts of fertilizers to be applied on each plot, it was necessary to increase the bulk to facilitate even spreading. This was done by mixing a standard amount of river-bottom sand with each fertilizer application. An equal amount of sand was applied to each check plot to balance any effects that might arise as a result of using the sand in conjunction with the fertilizers.

Soil samples were taken from each plot prior to fertilization and again two months later. The samples were collected at twelve inch intervals to a depth of three feet, oven dried, and analyzed for avail-

Figure 3. General view of the study area showing plots and slope of land. Whetstone Mountains to the east.

able phosphate and soil nitrate. Nitrate determinations were made at each depth collected; phosphates only in the surface foot.

Available soil phosphate was determined by extraction with sodium bicarbonate (Olsen, et al., 1954). Soil nitrate was analyzed by the phenoldisulfonic acid method (Harper, 1924). Soil pH was determined by the Beckman pH indicator.

From the time of fertilizer application until harvest, the vegetation was observed regularly to note any visual effects of fertilization.

The amount of herbage produced during the summer growing season was determined by clipping, air drying, and weighing the current season's growth. At the end of the growing season all plants within three 9.6-square-feet quadrats on each plot were clipped to ground level. The two dominant grasses, curly mesquite and sprucetop grama, were packaged separately. After air drying the samples were thoroughly crushed and mixed to obtain uniformity. These were then passed through a 60-mesh sieve of a Wiley mill. The samples thus obtained were subsequently analyzed for available phosphorus and crude protein.

Nitrogen content of each plant sample was determined by the boric acid modification of the micro-Kjeldahl method. The nitrogen figure thus obtained was multiplied by the general protein factor of 6.25 (Triebold, 1946) to give crude protein. Phosphorus in plant material was determined by the molybdivanadophosphoric acid method (Kitson, 1944).

# RESULTS

## Forage Production

All applications of nitrogen fertilizers resulted in a marked increase in forage production (Table 2). The degree and trend of this increase varied with rate of application and source of nitrogen. Forage production on plots receiving ammonium nitrate was greatest at an application rate of 100 pounds per acre. Although all rates of ammonium nitrate fertilization resulted in increased forage production, there was a gradual decrease in production at the higher rates of 200 and 400 pounds per acre. A similar decrease, on the other hand, was not obtained with ammonium phosphate (Table 2). In this case, an increase in production was noted with each increase in application rate.

Phosphate fertilization at rates of 100 and 200 pounds per acre resulted in only slight increases in forage production. There was, however, a considerable increase at the 400-pound-per-acre rate.

In most instances the total herbage produced in the check plot of series one exceeded that of the other plots regardless of rate and type of fertilizer applied. This may be accounted for by a large amount of annual golden-eye that occured on most of the fertilized plots of this series, but that grew only sparsely on the check plot. Moisture competition from this weedy species appeared to effectively restrict growth of the perennial grasses.

Throughout the study area, the forage production on one of the fertilized plots occasionally fell below that produced on the check

Table 2. The effect of some commercial fertilizer applications on the total forage production of the study area.

| Fertilizer and Rate of Application | Forage Production of Four Replications | | | | | |
|---|---|---|---|---|---|---|
| | Series 1 | Series 2 | Series 3 | Series 4 | Average | Difference * |
| Pounds per Acre | lb/A | lb/A | lb/A | lb/A | lb/A | |
| No fertilizer | 1519 | 1374 | 1177 | 1063 | 1283 | |
| Superphosphate (0-20-0) | | | | | | |
| 100 | 1182 | 1871 | 1483 | 879 | 1354 | 71 |
| 200 | 1283 | 1288 | 1578 | 1098 | 1312 | 29 |
| 400 | 1833 | 1833 | 2090 | 1655 | 1594 | 311 |
| Ammonium Phosphate (16-20-0) | | | | | | |
| 100 | 1785 | 1645 | 1865 | 991 | 1572 | 289 |
| 200 | 1395 | 1149 | 2730 | 1527 | 1700 | 417 |
| 400 | 1355 | 1871 | 1920 | 2179 | 1831 | 548 |
| Ammonium Nitrate (32-0-0) | | | | | | |
| 100 | 1407 | 2560 | 1737 | 1123 | 1707 | 424 |
| 200 | 1095 | 2109 | 1945 | 1378 | 1632 | 349 |
| 400 | 1483 | 1414 | 2124 | 1363 | 1596 | 313 |

* This is the difference in pounds of average forage produced on the fertilized plots and that produced on the unfertilized (check) plots.

plot. This may be due in part, to the fact that in spite of similar densities within the plots, there is a difference in species size and weight that can be outstanding if one species dominates a plot.

Soil Nitrate Content

The application of single superphosphate had no effect on soil nitrogen. After addition of nitrogen-source fertilizers, on the other hand, the nitrate content of the soil was significantly increased after two months at all depths to three feet (Table 3).

There was a slight increase in soil nitrate at the three-foot level when superphosphate was applied at 100 pounds per acre. This increase was small and presumably due to a slight soil variation not resulting directly from phosphorus fertilization.

Because soils in general have slight capacity for preventing nitrate leaching, one might expect to find a higher amount of soil nitrate at greater depths after applying ammonium nitrate. This might account for the large increase (375) percent of soil nitrate at the three foot level when ammonium nitrate was applied at 400 pounds per acre. A similar application rate of ammonium phosphate, on the other hand, gave only a 75 per cent increase at the three foot level. This difference can be accounted for by the presence or absence of the nitrate form of nitrogen in the additive. When ammonium phosphate and ammonium nitrate were applied at this same 400 pound per acre rate, the percentage increase of soil nitrate at the two-foot level was the same (200 percent). This similar percentage increase of soil nitrogen at the two-foot level is apparently directly attributed to the ammonium form of nitrogen in each fertilizer. Nitrogen in the ammonium form is not readily leached from the soil upon application. However, under good soil conditions of moisture and aeration, the soil microorganisms necessary for the conversion of ammonium to nitrate speed this conversion. This converted nitrate is then readily leached to greater soil depths. The rainfall of the study area for the first six or seven weeks after fertilization, apparently was sufficient to stimulate the soil microorganisms and affect the speed of the nitrate conversion from ammonium, thus allowing it to be leached to the depth of two feet. The large increase in soil nitrate at the three foot level when ammonium nitrate was applied at 400 pounds per acre, was presumably due to the nitrate form of nitrogen in the ammonium nitrate.

## Crude Protein Content of Grasses

Results from this one-season study indicate that phosphate fertilization at all rates of application had no significant effect on the crude protein content of the grasses. Nitrogen fertilization, however increased the crude protein content of both curly mesquite and sprucetop grama (Table 4). These crude protein increases were directly proportional to the rate of nitrogen fertilizer application. They appear, therefore, to be a direct result of the influence of increased available nitrogen in the treated soils. Although the nitrogen content of the ammonium nitrate was twice that of the ammonium phosphate, the slight increase in crude protein content of the grasses tested does not warrant the use of ammonium nitrate rather than a similar amount of ammonium phosphate.

## Available Soil Phosphate

Table 3. The content of soil nitrate as affected by three commercial fertilizers.

| Fertilizer and Rate of Application in Pounds Per Acre | Soil Nitrate Content at Different Depths | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Prior to Application | | | Two Months After Application | | | Percentage Increase After Two Months | | |
| | 0-3" | 12-15" | 24-27" | 0-3" | 12-15" | 24-27" | 0-3" | 12-15" | 24-27" |
| | ppm | ppm | ppm | ppm | ppm | ppm | Percent | | |
| No fertilizer | 7.0 | 3.5 | 2.0 | 7.5 | 3.5 | 2.0 | 7.1 | 0.0 | 0.0 |
| Superphosphate (0-20-0) | | | | | | | | | |
| 100 | 6.5 | 3.5 | 1.5 | 7.0 | 3.5 | 2.0 | 7.7 | 0.0 | 33.3 |
| 200 | 7.5 | 4.0 | 2.0 | 7.5 | 4.0 | 2.0 | 0.0 | 0.0 | 0.0 |
| 400 | 7.0 | 3.5 | 2.0 | 7.0 | 3.5 | 2.0 | 0.0 | 0.0 | 0.0 |
| Ammonium Phosphate (16-20-0) | | | | | | | | | |
| 100 | 7.0 | 3.5 | 1.5 | 7.5 | 5.5 | 3.0 | 7.1 | 57.1 | 100.0 |
| 200 | 7.5 | 3.5 | 2.0 | 8.5 | 8.5 | 3.5 | 13.3 | 142.8 | 75.0 |
| 400 | 7.5 | 4.0 | 2.0 | 11.5 | 12.0 | 3.5 | 53.3 | 200.0 | 75.0 |
| Ammonium Nitrate (32-0-0) | | | | | | | | | |
| 100 | 6.5 | 3.0 | 1.5 | 7.0 | 5.0 | 3.5 | 7.7 | 66.6 | 133.3 |
| 200 | 7.0 | 3.5 | 2.0 | 11.0 | 6.0 | 4.5 | 57.7 | 71.4 | 125.0 |
| 400 | 7.0 | 3.5 | 2.0 | 14.0 | 10.5 | 9.5 | 100.0 | 200.0 | 375.0 |

L.S.D. at 5% level is 1.6
L.S.D. at 1% level is 2.6

Table 4. Crude protein content of two grass species as a result of application of phosphate and nitrate fertilizers.

| Fertilizer and Application rate in Pounds per Acre | Crude Protein by Grass Species | | | |
|---|---|---|---|---|
| | Curly Mesquite * | | Sprucetop Grama ** | |
| | Crude Protein Content | Increase or Decrease | Crude Protein Content | Increase or Decrease |
| | Percent | Percent | Percent | Percent |
| No fertilizer | 5.15 | | 5.98 | |
| Superphosphate (0-20-0) | | | | |
| 100 | 5.20 | + .97 | 6.05 | + 1.17 |
| 200 | 5.12 | - .58 | 6.10 | + 2.01 |
| 400 | 5.45 | + 5.83 | 5.93 | - .84 |
| Ammonium Phosphate (16-20-0) | | | | |
| 100 | 6.30 | + 22.33 | 6.95 | + 16.22 |
| 200 | 7.55 | + 46.60 | 10.33 | + 72.74 |
| 400 | 8.80 | + 70.87 | 11.65 | + 95.18 |
| Ammonium Nitrate (32-0-0) | | | | |
| 100 | 5.50 | + 6.80 | 7.85 | + 31.27 |
| 200 | 8.45 | + 64.08 | 9.16 | + 53.18 |
| 400 | 9.64 | + 87.18 | 12.32 | + 100.60 |

* L.S.D. at 5% is 1.1; at 1% is 1.7
** L.S.D. at 5% is 0.7; at 1% is 0.8

The application of phosphate fertilizers increased the available phosphate considerably in the surface foot of soil two months after application (Table 5). The percentage increases in soil phosphate were essentially similar from applications of either superphosphate or ammonium phosphate. One unexplained exception will be noted when superphosphate was applied at 200 pounds per acre.

The only increase of soil phosphorus upon application of ammonium nitrate was at the 200 pound per acre rate. This was a small percentage increase and was not significant.

Phosphorus Content of Grasses

The percentage of plant phosphorus in curly mesquite and sprucetop grama from phosphate fertilized plots was considerably increased in all instances (Table 6). The percentage increase was slightly greater in samples of sprucetop grama than curly mesquite when phosphorus was applied as ammonium phosphate. This may possibly be attributed to the capacity of phosphorus in ammonium phosphate to penetrate the soil at a faster rate than when applied as superphosphate. Except for this slight difference, there was little variation in the increases of plant phosphorus from applications of ammonium phosphate and single superphosphate.

The phosphorus content of grass samples from the unfertilized plots was slightly less than might have been expected for grasses clipped at the mature stage. This may be accounted for by the fact that after clipping the grass samples were allowed to air dry for two months prior

Table 5. Available soil phosphate as affected by phosphate and nitrate fertilizers applied at different rates.

| Fertilizer and Rate of application in Pounds Per Acre | Phosphorus Available in the Surface Foot of Soil | | |
|---|---|---|---|
| | Prior to Application | Two Months After Application | Percent Increase After Two Months |
| | ppm | ppm | percent |
| No Fertilizer | 3.5 | 3.5 | - |
| Superphosphate (0-20-0) | | | |
| 100 | 3.5 | 4.5 | + 28.57 |
| 200 | 3.0 | 5.0 | + 66.66 |
| 400 | 3.5 | 6.0 | + 85.71 |
| Ammonium Phosphate (16-20-0) | | | |
| 100 | 3.0 | 4.0 | + 33.33 |
| 200 | 3.5 | 4.5 | + 28.57 |
| 400 | 3.5 | 6.0 | + 85.71 |
| Ammonium Nitrate (32-0-0) | | | |
| 100 | 3.5 | 3.5 | 0.0 |
| 200 | 3.5 | 4.0 | + 14.28 |
| 400 | 3.5 | 3.5 | 0.0 |

L.S. D. at 5% level is 1.2
L.S.D. at 1% level is 1.5

Table 6. The effect of some commercial fertilizers upon the phosphorus content of two grass species.

| Fertilizer and Application Rate in Pounds per Acre | Plant Phosphorus by Grass Species | | | |
|---|---|---|---|---|
| | Curly Mesquite * | | Sprucetop Grama ** | |
| | Phosphorus Content | Increase | Phosphorus Content | Increase |
| | Percent | Percent | Percent | Percent |
| No Fertilizer | .15 | | .13 | |
| Superphosphate (0-20-0) | | | | |
| 100 | .17 | 13.33 | .16 | 23.07 |
| 200 | .21 | 40.00 | .19 | 46.15 |
| 400 | .26 | 73.33 | .23 | 76.92 |
| Ammonium Phosphate (16-20-0) | | | | |
| 100 | .18 | 20.00 | .15 | 15.38 |
| 200 | .21 | 40.00 | .21 | 61.53 |
| 400 | .26 | 73.33 | .25 | 92.30 |
| Ammonium Nitrate (32-0-0) | | | | |
| 100 | .16 | 6.66 | .13 | 0.00 |
| 200 | .15 | 0.00 | .14 | 7.69 |
| 400 | .15 | 0.00 | .13 | 0.00 |

* L.S.D. at 5% level is .03
** L.S.D. at 5% level is .05

to analyzation. Although the samples were stored in a closed room, this air drying period may have acted much as would mild weathering, thus lowering the phosphorus content of the plants.

**Green Feed Period of Grasses**

It was observed that many of the grasses from plots treated with nitrogenous fertilizers were green into the first week of September, on the other hand, grasses on the unfertilized and superphosphate treated plots, with the exception of those on the plots treated with 400 pounds of superphosphate, were well into the curing stage by the middle of August. It would appear, therefore, that phosphorus had some effect on the length of the green feed period. Phosphorus when applied with nitrogen as ammonium phosphate prolonged the green feed period more than any other fertilizer. Ammonium nitrate when applied at 400 pounds per acre extended the green feed period considerably. When applied at the lower rates of 100 and 200 pounds per acre, however, though there was some response, the effect was less marked.

Further observations made during the following spring showed that the basal leaves of grasses from nitrogen fertilized plots began greening up as early as the last week in March. Similar basal growth on grasses from unfertilized and superphosphate treated plots was not noted until the middle of April.

## DISCUSSION

In commercial fertilization of our native grassland ranges, the stockman is interested primarily in practical results as are reflected in increased forage production, increased palatability and nutritousness of the forage, or more effective erosion control. At the same time he wants to maintain or increase the inherent fertility of the soil. Though the soil fertility of the area on which this study was made was not predetermined, the responses of the forage plants to fertilization indicated that the prior fertility status of the soil was either low or unbalanced, or that in spite of the necessary elements being present, they were in an unavailable form.

On a basis of the criteria given in the preceding paragraph, the results from this study have proven beneficial in all cases where nitrogenous fertilizers were used. However, the degree of increase in quantity and quality of forage produced was found to depend upon the particular nitrogen fertilizer used and the rate of application.

Ammonium phosphate, though containing less actual nitrogen than ammonium nitrate, appeared to have definite advantages over ammonium nitrate. This may be due to two factors (1) that nitrogen is present in the ammonium form and consequently is not readily leached from the soil, but combines with the soil colliods until it is converted by soil microorganisms to the available nitrate form, (2) the added phosphate is an important factor especially in a dry soil. Phosphorus is difficult for plants to obtain under arid conditions, hence an increase in available phosphate by the addition of a fertilizer makes more phosphorus available during a prolonged drought. If there is sufficient moisture so that the phosphorus present is available, the addition of more phosphorus does not mean that the surplus is lost as there is a carryover effect with the added phosphorus (Taylor and Haddock, 1955). The addition of ammonium phosphate therefore, would seem to benefit the forage plants in two ways; by increasing soil nitrogen which becomes available under favorable conditions of aeration and moisture, and by increasing phosphorus which in drought periods benefits the plants more than does nitrogen.

Ammonium nitrate has the definite advantage of having nitrogen immediately available to the plants upon application. There is an added advantage of a possible residual effect on forage production from the ammonium form of nitrogen. This nitrogen may not become available the year of application due to unfavorable moisture conditions, yet the following year with good precipitation it becomes available and benefits the plants.

The crude protein content of all grass samples taken from nitrogen fertilized plots showed a marked increase. This increase was directly proportional to the rate of fertilizer application. It is of interest to note, that even though the grasses were well into the curing stage at the time they were clipped and analyzed, the crude protein content of those from nitrogen fertilized plots was as much as double that of the same species from unfertilized plots. This is of great importance in the nutritional value of the grasses as there is normally a lag and gradual decrease in the crude protein content of grasses as they mature and approach the winter season. The nitrogen fertilizers do not necessairly increase the protein content at this time, but do check the usual rapid drop in protein content with the approach of winter (Hall <u>et al</u>., 1937).

Phosphorus when applied to the soil, has a tendency to revert to less soluble and available forms, especially under or above a pH range of 5.6 to 6.5 (Lyon and Buckman, 1943). Therefore, it can be of major importance to predetermine the pH value of the soil prior to fertilizing with phosphorus. This would prevent the application of large amounts of phosphorus to the soil without getting desired results. There is some indication that phosphorus in the form of ammonium phosphate, when applied to the soil surface, has a greater penetrating capacity than does the soluble portion of superphosphate (Bear, 1953). Under the arid conditions of southern Arizona, it is of importance to know that phosphorus in the form of ammonium phosphate will penetrate to the root zone of the grasses and not all be tied up in the surface inch or two of a dried out soil.

The marked increase noted in phosphorus content of the grasses is especially important as the plants enter the curing stage. Grasses at this stage of growth have their lowest palatability, and an increase in plant phosphorus increases both palatability and nutritional value of the forage, although it has little effect upon volume of forage produced.

The extension observed in the green feed period is of major importance in the arid Southwest. Southwestern range grasses decrease rapidly in palatability during the early fall months. Under normal rainfall conditions during the growing season, there is an abundance of feed at the end of the summer's growth; however, its palatability and nutritional value is waning. Nitrogen fertilization, by extending the green feed period, provides palatable and nutritious feed during a longer period. This additional green feed period shortens the supplemental feed period that is necessary during the fall and winter months when the range forage is at its lowest nutritional level. Similar extensions of the green feed period of grasses due to nitrogen fertilization were noted by Hoglund, et al., (1952) and Johnsen, (1954).

The early greening of the basal leaves, as noted in the spring of 1955, does not necessarily mean that those grasses treated with nitrogen fertilizers will be ready for summer grazing earlier than those untreated. It may, however, be a factor of considerable importance in the spring, a time when Southwest ranges are usually short of green feed.

## SUMMARY

The commercial fertilizers- single superphosphate, ammonium phosphate, and ammonium nitrate were applied in granular form to a typical southern Arizona desert grassland range. Varying responses were obtained from their application at rates of 100, 200, and 400, pounds per acre. Range response was also affected by the summer rainfall of 7½ inches.

Forage production was determined by clipping, air drying, and weighing the current season's growth. Samples of curly mesquite and sprucetop grama thus obtained were subsequently analyzed for available phosphorus and for crude protein. Soil samples were taken to a depth of three feet prior to fertilization and again after two months. These samples were analyzed for available soil phosphate and soil nitrate. The green feed period was determined by regular observation of the study site during the course of the study.

Super phosphate fertilization, except at the 400-pound-per-acre rate, resulted in only slight increases in forage production and green feed period. There was a considerable increase in available soil phosphate in the surface foot of soil, and a corresponding increase in the phosphorus content of curly mesquite and sprucetop grama after phosphate fertilization. Ammonium phosphate fertilization gave significant increases in forage production and the green feed period of grasses. It increased the available phosphate and nitrate content of the soil. The use of ammonium phosphate also gave considerable increases in the phosphorus and crude protein content of curly mesquite and spruce-top grama. Ammonium nitrate produced significant increases in forage production and the green feed period, in nitrate content of soils and in crude protein content of curly mesquite and spruce top grama.

Results from this one season study indicate that range fertilization is beneficial under the arid conditions of southern Arizona.

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