Effect of Range Fertilization on Growth of Three Southern Arizona Grasses[1]

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The use of commercial fertilizers on dryland ranges is a practical means of increasing forage production in many areas. Several investigators have studied the effects of fertilizers on forage production and chemical composition of the vegetation. Relatively little is known, on the other hand, of the ecological and phenological effects. In this study a commercial fertilizer (ammonium phosphate) was applied at 3 rates on a southern Arizona desert grassland range. The effects of this application on forage response, ecology, and growth characteristics of three native grasses were recorded.

Numerous workers have reported that the influence of commercial fertilizers advanced the stage of range readiness several weeks (Dickey, Hoglund and Madson, 1948; Hoglund, Miller and Hafenrichter, 1952). Others observed an extension of the growing period (Johnsen, 1954; Freeman and Humphrey, 1956). Johnsen concluded that this prolongation of the growing season was a typical nitrogen effect, *i. e.*, that of delaying plant maturity. He also noted that the addition of ammonium phosphate did not increase the number of flowering stalks per plant and had no apparent effect on leaf length. He did observe an increase in leaf numbers.

The seed setting characteristics of a grass influence its natural distribution, ease of establishment and usefulness in range improvement. Burton (1943) in studying some of the factors pertaining to seed set in southern grasses, found that commercial fertilizers had no significant effect on the percentage of florets that set seed. He later noted that seed yields may be increased by moderate applications of nitrogen (Burton, 1944). Retzer (1954) reported that range fertilization in conjunction with reseeding operations enhanced initial seedling survival and subsequent growth.

Experimental Area

The current study was conducted on the Vaca Ranch, located in San Rafael Valley, Santa Cruz County, in southeastern Arizona.[2] The experimental area, at 5,000 feet elevation, is typical of high-potential semidesert grassland ranges in southern Arizona. Precipitation, most of which falls as rain during the summer and winter seasons, has averaged approximately 18 inches per annum over the 30-year period of record. High winds, high temperatures, and low humidity make evaporation rates excessive during the summer growing season. Because of low temperatures which prevent much winter or early spring growth, most of the forage is produced during the late spring and summer months.

Soils of the area are derived from Quaternary and Tertiary sands and gravels. The parent materials weather to form a heavy clay-loam surface with a compact subsoil. Soils on the study plots were slightly acid, and have been tentatively classified as a Reddish Brown soil of the Whitehouse-Tumacacori series.

Vegetation of the area is dominated by perennial grasses. Blue grama (*Bouteloua gracilis*), hairy grama (*B. hirsuta*), and sideoats grama (*B. curtipendula*) are the species most frequently encountered. Others found in significant quantities are poverty three-awn (*Aristida divaricata*), curly mesquite (*Hilaria belangeri*), Rothrock grama (*B. rothrockii*) and Texas timothy (*Lycurus phleoides*). Two species of annual forbs, wild daisy (*Erigeron concinnus*), and goldeneye (*Viguiera annua*) were abundant throughout the area at the time the study was made.

The study site was a 40-acre livestock-exclusion pasture that had received aerial applications of ammonium phosphate fertilizer in the early summer of 1956. This was applied in granular form at rates of 100, 250, and 500 pounds per acre. The applications were flown on in strips 33 ft. wide and approximately one-eighth mile long. Due to extremely deficient summer rainfall, the fertilizer was not leached into the ground until after the onset of the winter rains in December 1956.

Methods

Each application rate was sampled by three randomly selected 100-foot line transects. There was a total of 4 series of 3 transects—one series in each application rate and one in an adjacent unfertilized area. Five plants each of blue, hairy, and sideoats grama were located along each transect; the same plants were used throughout the

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study. Species growth response to fertilization was evaluated by measurements of the studied plants taken at weekly intervals throughout the 1957 spring and summer growing seasons. Measurements began when the old stems of each plant first greened up in the spring and ended when the plants completed setting seed and cured in the fall. The length of the three longest leaves and stems was measured on each plant. The time of initiation of growth, flower stalk emergence, flowering, and seed set was noted for each species studied on each transect. At the close of the summer growing season, the number of stems per plant was counted. Clippings were made on ten randomly selected 9.6 square-foot quadrats in each application rate and in the check area. These were oven-dried and weighed to determine total forage production in pounds per acre. Seed fill per seed unit was determined by the method described by Wolff (1950).

Results

Leaf Length

The effect of all rates of fertilizer application on leaf length was rather inconsistent (Table 1). Blue grama responded with a slight increase; however, this was in inverse proportion to the rate of application. Hairy grama yielded longer leaf lengths than the controls only under the high level of fertilization. Sideoats grama, on the other hand, gave negative results under all three levels of treatment. It was noted that all species on the treated transects appeared to be more vigorous than those that were not fertilized, and although no count was made, it was evident that the fertilized plants were producing more leaves than the untreated controls. The same phenomenon was noted by Johnsen (1954) who concluded that any increased production due to fertilization was the result of an increase in leaf numbers rather than in leaf length.

Stem Length

Stem length of blue grama was increased by fertilization but inversely to the amount of fertilizer applied (Table 1). Although the increase was appreciable at all application rates, the response at the high rate was considerably less than at either the medium or low levels. Hairy grama increased its stem length at the low and high levels by about one-fourth, but showed no change at the medium level of treatment. Sideoats grama followed the same pattern as it did in leaf-length response; negative results were obtained under all levels of fertilization.

Number of Stems

There was a general tendency for stem number to increase under fertilization. This effect was most marked with blue grama. Although significant increases were noted for blue grama at all application rates, the highest rates gave the greatest stem number increase; the lowest rate gave the least increase. Although stem numbers of hairy grama also increased under all application rates, the results were variable and apparently rather inconsistent. A marked increase was noted at the low rate, a slight increase at the medium rate, and the greatest increase at the high rate. Sideoats grama responded only at the high rate, a slight decrease being recorded at the low and medium rates.

Forage Production

Forage production as a response to fertilization proved to be erratic. Of the three species evaluated, only blue grama responded rather consistently. Although increases were marked at all fertilization levels, more than 400 percent increase was noted at the high rate. Hairy grama produced about twice as much forage at the low fertilization rate as on the check area, but 40 percent less than the check at the medium rate, and only slightly more than the check on the high rate area. Sideoats grama showed slight increases at the low and high rates and a slight decrease at the medium rate, figures which were rather inconclusive at all rates.

It will be noted that these two latter species gave little or no response under the medium level of fertilization for leaf length, stem length and number of stems per plant. This would account at least in part for the negative forage-production results.

Forage produced by the three species combined was doubled at the low and medium fertilization rates and increased a little more than four times at the high rate. These results are in essential agreement with those of Freeman and Humphrey (1956) who

Table 1.—Effect of ammonium phosphate on growth of range grasses.

Fertilizer Application Rate lbs./acre	Leaf Length % change			Stem Length % change			Number of Stems % change			Forage Production % change			Seed Yield % change		
	Bgr.[1]	Bhi.	Bcu.	Bgr.	Bhi.	Bcu.	Bgr.	Bhi.	Bcu.	Bgr.	Bhi.	Bcu.	Bgr.	Bhi.	Bcu.
Low 100	+15	0	—14	+34	+22	—13	+ 33	+37	— 4	+187	+110	+16	+36	+10	+26
Medium 250	+11	0	—29	+30	0	—24	+106	+ 5	—10	+166	— 40	—21	+ 6	—31	+20
High 400	+ 4	+23	0	+19	+28	— 2	+166	+52	+50	+447	+ 20	+23	— 7	—31	+24

[1] Bgr. = blue grama. Bhi. = hairy grama. Bcu. = sideoats grama.

noted an increase in total forage production at each fertilizer increment up to 400 pounds of 16-20 per acre. They agree only roughly with those of Johnsen (1954) who, although noting an increase under fertilization, did not record a rate of increase that was correlated with rate of fertilization.

Seed Yield

Seed yield of blue grama was increased by one-third at the low fertilization level. At the medium and high levels, seed yields were not markedly different from those of the check. Hairy grama seed production showed an insignificant 10 percent increase at the low level but a 31 percent decrease at the medium and high levels. In contrast, sideoats grama produced approximately one-fourth more seed under all fertilization levels than on the unfertilized check plots. These varied results are difficult to explain and should be verified by additional studies.

Growth Period

Initiation of spring growth was not affected by fertilization. Growth of the three perennial grasses studied began at about the same time on both fertilized and unfertilized plots. Range readiness and length of green-feed period of both blue and hairy grama, on the other hand, were affected at all fertilization levels. At the high fertilization level blue grama was ready to graze 6 weeks ahead of the check and cured 2 weeks ahead, thus lengthening the green-feed period by 4 weeks. At the medium level of treatment, range readiness was 4 weeks earlier, and the grasses cured 2 weeks before the check plants, thus extending the period of green feed by 2 weeks. The blue grama plants at the low fertilization rate were ready for grazing 4 weeks before the controls and cured at the same time, thus producing an additional 4 weeks of green feed.

Range readiness for hairy grama was advanced by 4 weeks at both the high and medium fertilization levels. These plants cured 2 weeks before the controls, lengthening the green-feed periods by 2 weeks. At the low level of fertilization hairy grama reached readiness 6 weeks before the unfertilized plants and cured at the same time, providing 6 weeks additional green feed.

Conversely, the date of range readiness for sideoats grama was not advanced by fertilization. On the other hand, the plants of this species cured 2 weeks earlier at the high and medium application rates than at the low level and unfertilized. High and medium level fertilization rates therefore appear to have reduced the green-feed period of sideoats grama by 2 weeks.

All three species began flowering at an earlier date on all fertilized plots than on the unfertilized areas. Flowering was initiated first at the high fertilization level, next at the medium level and last at the low level. Despite the difference in time of initiation of flowering, the plants at the high fertilization rate and those that were not fertilized set seed at about the same time. At the time this seed had set, seed was in the process of forming on those plants fertilized at the low rate, while those at the intermediate rate were still flowering.

Summary

A study was made of the effects of range fertilization on several growth characteristics of three native forage grasses in southern Arizona. Ammonium phosphate in granular form was applied at rates of 100, 250 and 400 pounds per acre. The fertilizer remained on top of the soil for approximately 6 months before precipitation was adequate to leach it down.

The growth response to this fertilization by blue, hairy and sideoats grama was extremely varied.

There was no difference in the time of beginning growth on treated and untreated plots. Subsequent to growth initiation, however, grasses on the fertilized areas made more rapid growth than those that were not fertilized. The date of range readiness was advanced and length of the green-feed period was increased for blue and hairy grama under all levels of treatment. The green-feed period was lengthened from 2 to 4 weeks for blue grama, and 2 to 6 weeks for hairy grama. Range readiness of sideoats grama was not affected, and fertilization at the high and medium levels appeared to reduce the green-feed period of this species by 2 weeks.

All species on the fertilized areas initiated flowering earlier, and remained in the flowering stage longer than the untreated plants. All species at the high level of treatment set seed at the same time as those on the controls; they were followed by those on the low level and medium level of treatment respectively. With the exception of hairy and sideoats grama at the medium level of fertilization, all species increased total forage production over the controls under all levels of treatment.

It appears that adequate precipitation immediately following application of the fertilizer is essential to obtaining the optimum benefits from range fertilization. More work in this line is needed before any recommendations pertaining to such a range-improvement practice in southern Arizona can be proposed.

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