THE EFFECTS OF FERTILIZERS APPLIED TO A CHAPARRAL SOIL ON THE EMERGENCE, GROWTH, YIELD, AND NUTRIENT CONTENT OF LEHMANN LOVEGRASS

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The world's population explosion has created an increased demand for meat production. Experts estimate that meat requirements will be more than doubled in the United States within the next 50 years (Parker, 1961). It is, therefore, essential that forage production be increased if this need for meat production is to be realized.

A primary source of forage for livestock is rangeland. Range and pasture lands of the United States supply 55 percent (Sprague, 1952) of the feed requirement for livestock. While the need for increased forage production is a current problem, there are vast acreages of range lands throughout the world on which forage production is declining. A report written 15 years ago indicated that at that time in the United States alone approximately 80 million acres of range lands had been depleted so badly that they would have to be reseeded if they were to realize their forage-production potential (Pearse et al., 1948).

It is thus evident that proper management of range lands and development of their potential value for production of forage needs to be given primary consideration. Some of the major range improvement practices needed include: control of undesirable range plants, reseeding, and fertilization.

In Arizona most ranges are not producing the forage of which they are capable. Many of these ranges have been invaded by shrubs that produce much less feed than the grasses they have replaced. This invasion is due to a number of complex interrelated ecological factors such as cessation of fires, overgrazing, and drought (Humphrey, 1962).

Arizona has some six million acres of chaparral, constituting about eight percent of the state's land area (Nichol, 1952; Humphrey, 1959). These extensive chaparral areas once supported perennial grasses and may do so again if competition from shrubs can be effectively controlled (Cable, 1957; Humphrey, 1959).

Through burning, supplemented by mechanical and chemical techniques, the chaparral stands can be controlled sufficiently to make grass seeding feasible. Schmutz and Whitham (1962), from studies in the Arizona chaparral near Dewey, concluded that burning of the brush followed by reseeding to grasses and treatment with multiple applications of silvex or 2,4,5-T herbicide may be an economical means of reducing competing shrub growth and increasing forage production.

Reseeding adapted forage species is generally a necessary improvement practice following shrub control. Lehmann lovegrass (Eragrostis lehmanniana Nees), a species introduced from South Africa, has proven particularly valuable in reseeding burned-over chaparral areas in Arizona and California (Crider, 1945; Reynolds and Glendening, 1959). This grass has proven adapted to a wide range of environments, and has a further merit because of its self-reseeding ability once small strips have been established (Humphrey, 1958).

Although reseeding of rangelands is a common restoration practice, fertilization in conjunction with reseeding is a relatively new practice. The use of fertilizer may enhance the possibility of obtaining good stands and at the same time may increase the chance of seedling survival and subsequent plant establishment. There is little information on the effects of commercial fertilizers on grasses reseeded on chaparral lands of Arizona and no information is available on the effects of fertilizers on the establishment and growth of seedlings planted on these lands.

This study was designed to determine the effects of different kinds and rates of commercial fertilizer on the emergence, leaf-growth, yield, and nutrient content of Lehmann lovegrass seedlings grown on a typical chaparral soil in Arizona.

LITERATURE REVIEW

Effects of Fertilizers on Seedling Emergence

Maxton (1927) studied the effects of applying twelve kinds of fertilizers at variable, single, and heavy rates of application on the germination of grasses grown under greenhouse conditions. Two of the fertilizers used were ammonium nitrate and ammonium phosphate. Fertilizers applied in contact with the seeds resulted in a reduction in germination that varied with the kind of fertilizer used and the kind of seed planted. He concluded that low germination was due to contact effects of the fertilizer on the seeds that prevented germination rather than to seedling-injury immediately after germination. Germination injury was associated with solubility of the fertilizer salts. Fertilization before seeding was proposed as a means of preventing this type of injury.

Ward and Blasser (1961) applied nitrogen fertilizers to field plots at three rates of actual nitrogen (20, 40, and 80 pounds per acre) to determine the effect of this fertilizer on the emergence of various legumes and grass seedlings. The study was conducted over a period of two years. In 1956, the nitrogen was applied on the surface with inoculated seeds in a sawdust carrier. In 1957, the nitrogen fertilizer was applied before seeding. Ward and Blasser observed that regardless of the method of fertilizer application emergence per unit area decreased as the amount of nitrogen increased and that reduction was less under favorable moisture conditions than under low moisture conditions. The reduction of germination was attributed to the osmotic effects of the fertilizer salts on the seeds.

In Texas, Grumbles (1961) applied ammonium nitrate (33-0-0), superphosphate (0-45-0), a complete fertilizer (12-12-12), and a fortified compost. These fertilizers were applied to field plots both alone and in combination at 200- and 400-pound rates prior to planting sideoats grama, cane bluestem, switchgrass, silver bluestem, and little bluestem. He obtained successful stands and enhancement of germination in all fertilized plots for all species except sideoats grama. Switchgrass and silver bluestem were the most responsive to fertilizer treatments followed by cane bluestem, little bluestem, and sideoats grama. The greatest response was obtained from the higher rate (400 pounds per acre) of the complete mineral fertilizer alone. At the same time, switchgrass, silver bluestem, and sideoats grama were treated under greenhouse conditions. In the greenhouse study the combination of nitrogen and phosphorus applied at the 200-pound rate produced the greatest stimulation of germination of all kinds and rates of fertilizer applied. Sideoats grama again showed a very low response to fertilizer treatment.

Effects of Fertilizers on Leaf Growth

Honnas et al. (1959), in their study on a southern Arizona range, reported that the effects of applying ammonium phosphate (16-20-0, at rates of 100, 250, and 500 pounds per acre) on leaf length of blue, hairy, and sideoats grama were extremely varied. Blue grama responded with a slight increase in leaf length at the lower levels. Hairy grama yielded longer leaf lengths than the controls only under the highest level. Sideoats gave negative results under all three levels. It was observed, however, that fertilization at all levels increased the number of leaves of all species.

Johnsen (1954), as a result of studies also conducted in southern Arizona, reported that applications of 200 and 400 pounds of superphosphate per acre significantly increased the leaf-blade length of curly mesquite, but applications of nitrogen had no significant effect. He also observed that fertilized plants produced more leaves than those that were unfertilized.

Grumbles (1961) determined that with increased amounts of mineral fertilizer (NPK) there was a corresponding increase in leaf-blade length and width for each of five grasses tested.

Effects of Fertilizers on Grass Yield

Experiments have been conducted to determine the effects of superphosphate, ammonium nitrate, and ammonium phosphate upon the yield of various grasses in southern Arizona. In general, applications of ammonium nitrate and ammonium phosphate increased yields (Johnsen, 1954; Freeman and Humphrey, 1956; Dyer, 1958; Holt and Wilson, 1961). However, superphosphate did not increase yields as much as nitrogen or as a combination of nitrogen and phosphorus. Kilcher (1958), from studies in Saskatchewan, reported that none of three cultivated grasses used in his experiments responded to phosphorus fertilizers.

In Texas, Kap et al. (1949) found that nitrogen and combined nitrogen-phosphorus at rates of 50, 75, and 150 pounds per acre were highly effective in increasing yields of various range grasses.

Anklam (1962) conducted experiments on a central Arizona chaparral site where Lehmann lovegrass was the dominant grass. Ammonium nitrate and ammonium phosphate applied at 25, 50, and 75 pounds of active ingredient per acre resulted in significant increases in forage production of the grass.

Effects of Fertilizers on Nutrient Content

Studies have been conducted to determine the effects of different rates of nitrogen, phosphorus, and a combination of these fertilizers on the protein and phosphorus content of grasses in central and southern Arizona (Johnsen, 1954; Freeman and Humphrey, 1956; Dyer, 1958; Anklam, 1962). All of these studies indicated that protein content of the grasses was increased by all fertilizers that contained nitrogen or a combination of nitrogen and phosphorus. Phosphorus, however, had little or no effect upon the protein content, but did increase the phosphorus content. Nitrogen fertilizers, on the other hand, had no effect on phosphorus content.

In South Africa, Hall et al. (1937), reporting on work and studies conducted in the natural high veld pastures, noted a six-fold increase in the phosphorus content of grasses with the application of 200 pounds of superphosphate and 200 pounds of rock phosphate per acre.

MATERIALS AND METHODS

This study was conducted during the summer of 1962 at the Soil Conservation Service Plant Materials Center, Tucson, Arizona. Lehmann lovegrass seedlings were grown under partial shade in flats filled with soil collected from the Perry Henderson Ranch near Dewey, Arizona.

Description of Soil Collection Site

The soils were collected from a typical chaparral site at approximately five thousand feet in elevation (Figure 1).

The climate of the chaparral area is classed as semiarid with a summer and winter rainfall pattern. It has an average annual precipitation of 14.7 inches (U. S. Weather Bureau, 1942-1962) and a mean monthly temperature of 52° F. (Sellers, 1960).

A photograph of the burned and reseeded chaparral area from which the soil was collected is shown in Figure 2. As indicated in the picture, the area had been successfully reseeded with Lehmann lovegrass.

Figure 1. General view of chaparral area east of Dewey, Arizona. Typical untreated area is shown in the foreground; light-colored area in the background is the burned and reseeded soil collection site.

Figure 2. A portion of the chaparral area, burned and reseeded to Lehmann lovegrass. The picture was taken in October four months after the area was burned and reseeded.

The vegetation of the study area, as reported by Schmutz and Whitham (1962), includes the dominant shrub live oak (Quercus turbinella Greene), manzanita (Arctostaphylos pungens H.B.K.), skunkbush (Rhus trilobata Nutt.), wait-a-minute bush (Mimosa biuncifera Benth.), mountain mahogany (Cercocarpus breviflorus Gray), and ceanothus (Ceonothus greggii Gray). Dominant half-shrubs were broom snakeweed (Gutierrezia sarothrae (Pursh) Britt. and Rusby) and shrubby buckwheat (Eriogonum wrightii Torr.). Native perennial grasses included sideoats grama (Bouteloua curtipendula (Michx.) Torr.), black grama (B. eriopoda Torr.), blue grama (B. gracilis (H.B.K.) Lag.), sand dropseed (Sporobolus cryptandrus (Torr.) Gray) and red threeawn (Aristida longiseta Steud.).

The soils of the area have been classified as belonging to the Cordes and Gaddes series of the alluvial and noncalcic brown soil groups (Wendt, 1960). The soils, which were developed from granite, basalt, schist, and limestone parent materials, vary from shallow, residual, gravelly, and stony clay-loams on the uplands to deep, alluvial sandy-loams in the washes. At the surface they are brown or dark-brown in color; the subsoils range from reddish-brown to yellowish-red.

Chemical analyses of the soil used for growing the Lehmann lovegrass seedlings yielded the following data: pH 6.1; total soluble salts, 210 ppm; nitrate, 10 ppm; phosphate, 4 ppm.

Experimental Procedure

Four inches of soil was taken from the surface of the burned and reseeded chaparral area. This was thoroughly mixed and sifted to obtain uniformity and placed in 14x20x4-inch metal pans. These flats were then placed upon a cement bench in a lath house under partial shade (Figure 3).

Ammonium nitrate (33-0-0), superphosphate (0-45-0), and combinations of these fertilizers were used in this experiment. The combination ammonium nitrate-superphosphate fertilizer was made up by weighing each of the ingredients to the desired rate, combining the two, and thoroughly mixing the compounds. In order to assure uniform application of the small quantity of fertilizer used in each pan, the fertilizer pellets were finely ground.

After each pan was filled with soil to a depth of 3 inches, the fertilizers were broadcast in the powdered form at per-acre rates of 25, 50, and 75 pounds of active ingredients. The fertilizer was then covered by a one-inch layer of unfertilized soil.

The experiment was set up using a randomized block design with four replicates of ten treatments each inclusive of the control flats.

The Lehmann lovegrass seeds used in this experiment were tested by the New Mexico State Seed Laboratory. Results of these tests

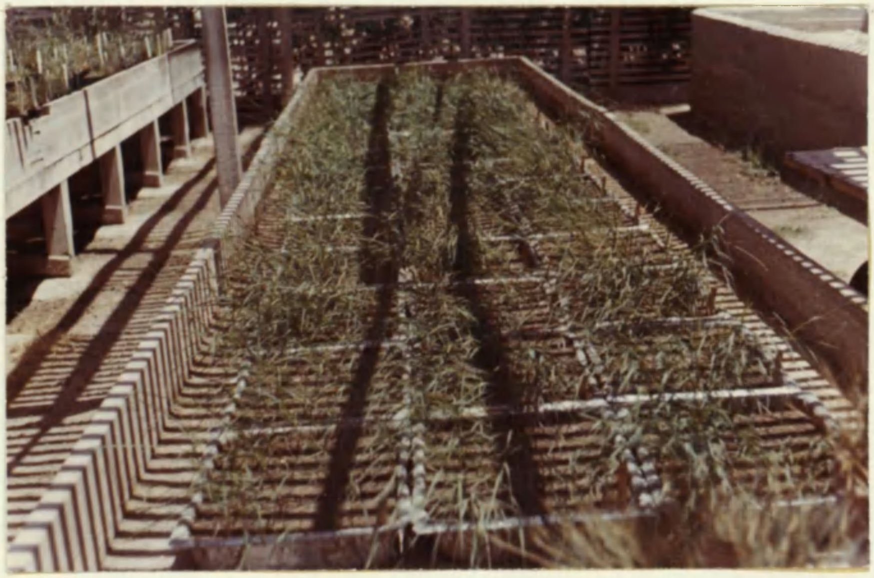

Figure 3. General view of Lehmann lovegrass seedlings in flats under partial shade at Soil Conservation Service Plant Materials Center, Tucson, Arizona.

were as follows: purity 99 percent, inert material 0.60 percent, crop (dropseed) 0.02 percent, germination 90 percent.

The seeding method was designed to provide equal spacing and use of soil nutrients. Four rows of forty seeds each were planted in each pan at a depth of one-half inch. Based on the above purity and germination this would provide 144 live seeds in each pan, or four rows, each containing 36 live seeds.

The quantity of the seeds used was small and the seeds are of minute size (approximately 5,000,000 per pound). In order to obtain a sufficient volume to permit sowing the seeds evenly in each row of flats, the seeds were mixed with a small amount of soil in a test tube. This mixture of seed and soil was poured uniformly in each row. After seeding, the soil was compacted to simulate field conditions and watered. During the course of the study, care was taken to apply sufficient and equal amounts of water to each pan.

Temperature and relative humidity data were collected during the period of plant growth. Temperature data were recorded by the Plant Materials Center personnel. Relative humidity data were obtained from the U. S. Weather Bureau at the Tucson Airport Weather Station (Figure 4).

Emergence data were recorded each day after planting for 21 days. Leaf-growth measurements were made during seedling growth

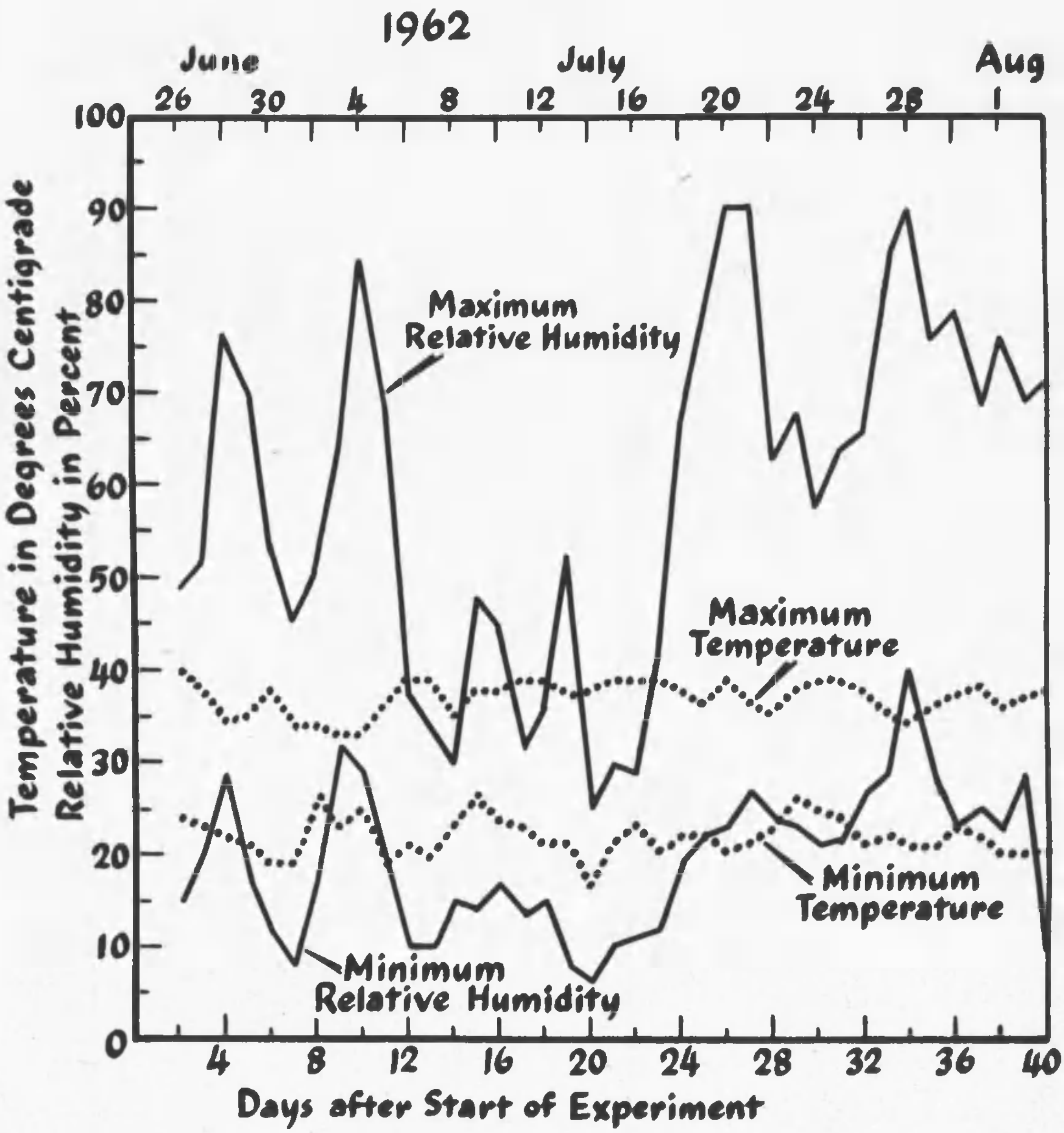

Figure 4. Maximum and minimum temperatures and relative humidity during the period of the experiment.

on 10 Lehmann lovegrass seedlings selected at random in each flat and marked with a toothpick. Leaf measurements were made by measuring the longest leaf of each plant every three days, commencing with the 26th day until the harvesting date.

On the 41st day after planting, the seedlings were harvested by clipping at ground level, sacked, oven-dried at 66° C for four days, and weighed. The samples were then analyzed for their nitrogen and phosphorus content.[1] The nitrogen in the seedlings was determined by the Kjeldahl method outlined by the Association of Official Agricultural Chemists (1955). A colorometric method, a minor modification of the Toth et al. (1948) method, was used to determine the phosphorus content.

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[1] Chemical analyses for both nitrogen and phosphorus were determined by the Animal Science Department, University of Arizona, Tucson.

RESULTS AND DISCUSSION

Effects of Fertilizers on Seedling Emergence

The emergence of Lehmann lovegrass seedlings from flats receiving 25 pounds of ammonium nitrate was fifty-five percent greater than from unfertilized flats (Table 1). Increasing the amount of nitrogen fertilization above the 25-pound-per-acre level did not result in any further substantial increase.

Application of phosphorus did not significantly increase seedling emergence.

The combination nitrogen-phosphorus fertilizer resulted in significant increases in seedling emergence at all rates of application. The minimal 25-pound rate produced the greatest seedling emergence (61 percent) but this was not significantly greater than from the higher rates of application (60 and 43 percent).

Effects of Fertilizers on Leaf Growth

The effects of fertilizers upon early and late leaf growth are graphically presented in Figure 5. These present a pattern equivalent to a portion of an S-shaped growth curve.

Table 1. The effect of fertilizer treatments on the emergence of Lehmann lovegrass 21 days after planting.

Fertilizers and rates of application	Seedling emergence: Plants per flat	Seedling emergence: Increase or decrease over check
(pounds per acre)	(avg. number)	(percent)
No fertilizer	44.75	0
Ammonium nitrate (33-0-0)		
25	68.75	55
50	57.50	28
75	71.50	59
Superphosphate (0-45-0)		
25	44.25	-1
50	46.00	2
75	45.25	1
Ammonium nitrate-superphosphate combination		
25-25	72.25	61
50-50	71.75	60
75-75	64.25	43
Average fertilizer effect		
O	44.75	
N	65.87	
P	45.12	
NP	69.37	
Standard error	7.07	
5% L.S.D.	20.50	

Analysis of variance

Source of variation	Degrees of freedom	Mean squares
Replications	3	44.96
Treatments	9	620.68**
Error	27	199.79

** Significant at the 1-percent level of probability.

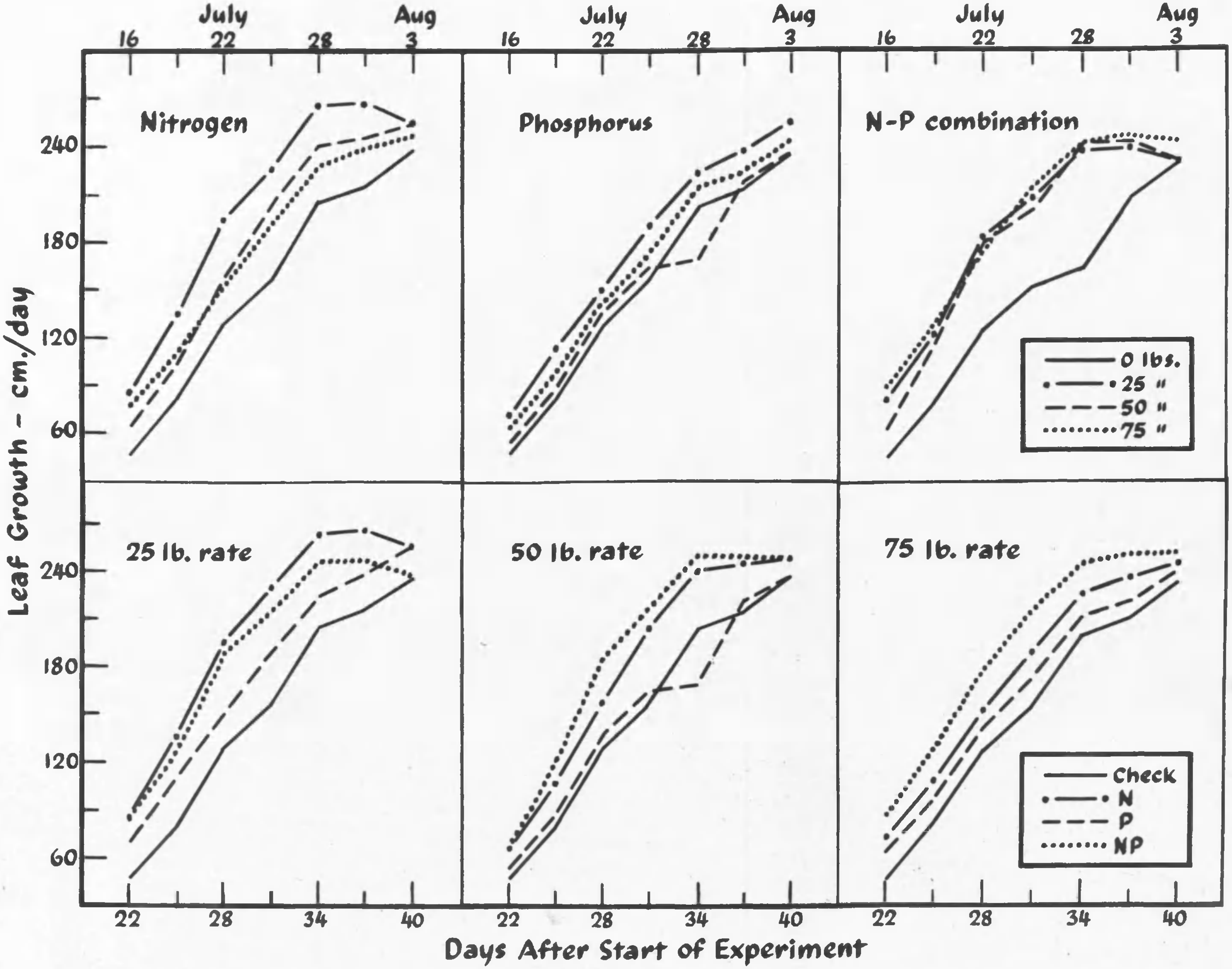


Figure 5. Fertilizer effects on leaf growth of Lehmann lovegrass. Top, comparison of a given fertilizer at different rates of application; bottom, comparison of different fertilizers at the same rates of application.

Although nitrogen at all rates of application increased the rate of leaf growth, the minimal 25-pound application gave the greatest increase.

Phosphorus treatments resulted in little increase in leaf growth, although again the 25-pound rate produced the greatest increase in rate of growth.

The combination nitrogen-phosphorus fertilizer, at all levels, increased the rate of leaf growth. There were, however, no apparent differences between the different rates of application.

A comparison of the effects of the different fertilizers at the same rates of application (lower half, Figure 5) showed that at the 50- and 75-pound application levels the combination nitrogen-phosphorus fertilizer produced a greater increase in leaf growth than either nitrogen or phosphorus alone. At the 25-pound rate, nitrogen alone produced the greatest increase in leaf growth. However, this increase was not appreciably greater than the combination nitrogen-phosphorus treatment.

It is a well-established fact that nitrogen and phosphorus play a fundamental role in metabolism and that a deficiency of either element retards the metabolic rate, and thereby limits growth (Allison, 1957; Black, 1960). The results of this study indicate that the 25-pound rate supplied the minimal amounts of nitrogen and phosphorus needed which presumably would account for the fact that the higher rates of application yielded no increase in rate of growth.

Effects of Fertilizers on Grass Yield

All rates of ammonium nitrate application produced significant increases in yield per flat and in weight per plant (Table 2). The addition of amounts beyond the 25-pound-per-acre level did not, however, substantially increase the yield per flat or per plant.

At all levels of application the superphosphate fertilizer when applied alone showed no significant difference in yield per flat as compared with the untreated flats (Table 2). Similarly, phosphate fertilization at the 25- and 50-pound rates of application did not result in a significant increase in weight per plant. However, the 75-pound rate did result in a significant increase in weight per plant.

At all levels of application the combined nitrogen-phosphorus fertilizer produced a significant increase in yield per flat and weight per plant (Table 2). These increases were two and one-half to four times the yield obtained from the unfertilized flats. From the standpoint of both weight per flat and weight per plant, applications of combined fertilizer at the 50- and 75-pound rates produced significant increases over those receiving only nitrogen or phosphorus. Except for the weight-per-plant response at the 25-pound rate of fertilizer application, increases for both yield per flat and weight per plant represent an interaction or synergistic response over the nitrogen and phosphorus alone.

Table 2. The effects of fertilizers on the forage yield of Lehmann lovegrass seedlings.

Fertilizers and rates of application	Average yield of lovegrass: Per flat, Oven-dry weight	Per flat, Increase over check	Per plant, Oven-dry weight	Per plant, Increase over check
(pounds per acre)	(grams)	(percent)	(grams)	(percent)
No fertilizer	3.53	0	.078	0
Ammonium nitrate (33-0-0)				
25	10.43	198	.159	103
50	9.03	155	.149	92
75	10.69	203	.146	87
Superphosphate (0-45-0)				
25	4.86	36	.106	35
50	3.96	12	.082	5
75	5.16	46	.113	44
Ammonium nitrate-superphosphate combination				
25-25	12.12	243	.167	114
50-50	14.00	296	.200	156
75-75	12.99	268	.206	164
Average fertilizer effect				
O	3.53		.078	
N	10.04		.151	
P	4.65		.100	
NP	13.02		.191	
Standard error	1.20		.012	
5% L.S.D.	3.48		.035	

Analysis of variance

Source of variation	Degrees of freedom	Mean squares: Per flat	Mean squares: Per plant
Replications	3	7.83	.00314
Treatments	9	62.98**	.00815*
Error	27	5.80	.00055

* Significant at the 5-percent level of probability.

** Significant at the 1-percent level of probability.

Representative effects of the various kinds and rates of fertilizers on the seedlings may be seen in Figure 6. It is visually evident that the flats receiving the combined nitrogen-phosphorus fertilizer had the thickest stands and made most vigorous growth.

Effects of Fertilizers on Nutrient Content

Protein Content

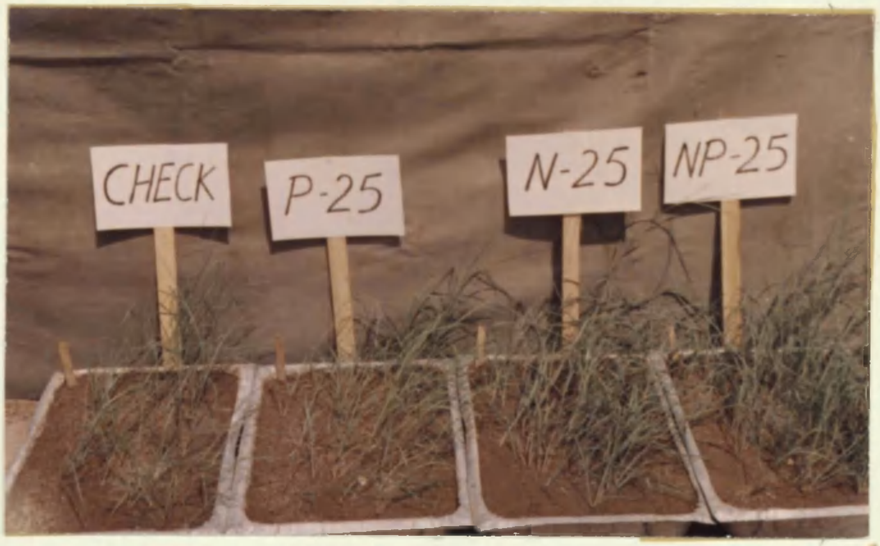
The protein content of the Lehmann lovegrass seedlings was significantly increased by the application of nitrogen at all rates (Table 3). In addition, the seedlings receiving the 75-pound application of nitrogen showed a significantly greater increase in protein content than those receiving the 25- and 50-pound rates. Phosphorus did not significantly affect the protein content of the seedlings.

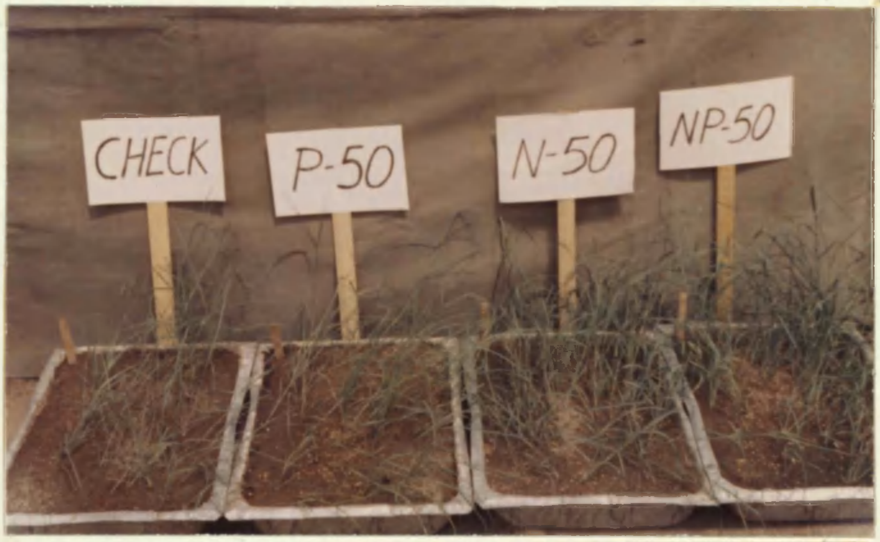
All rates of combined nitrogen-phosphorus fertilizer increased the protein content of the seedlings significantly. However, there was no significant difference in the protein content of the seedlings treated with combination nitrogen-phosphorus fertilizer and those treated with only ammonium nitrate.

Phosphorus Content

Phosphorus content of the grass was not significantly increased by applications of ammonium nitrate (Table 4). In fact, the phosphorus content of the seedlings receiving 50 and 75 pounds of nitrogen fell below

Figure 6. Fertilized and unfertilized flats showing effects of different kinds and rates of commercial fertilizers on Lehmann lovegrass seedlings.


CHECK
P-25
N-25
NP-25


CHECK
P-50
N-50
NP-50

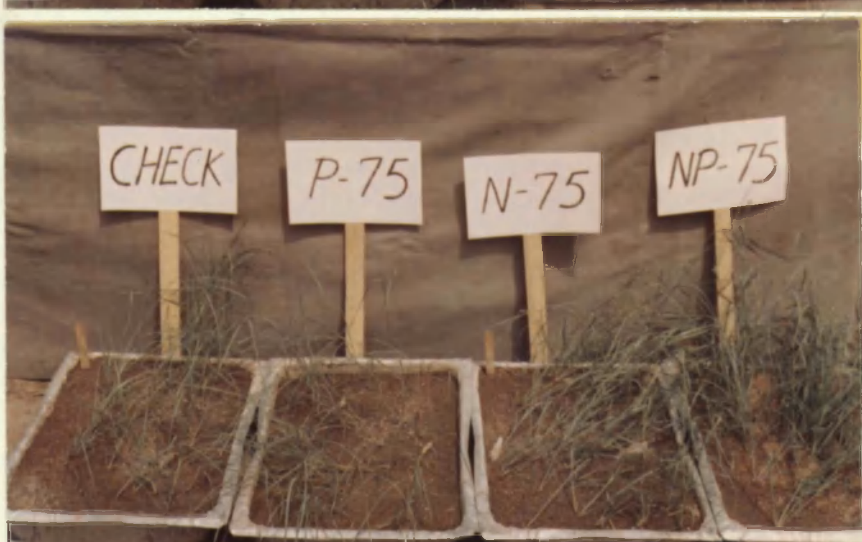

CHECK
P-75
N-75
NP-75

Table 3. The effects of fertilizers on the protein content of Lehmann lovegrass seedlings.

Fertilizers and rates of application	Protein analyses	
	Crude protein	Increase or decrease over check
(pounds per acre)	(percent)	(percent)
No fertilizer	14.80	0
Ammonium nitrate (33-0-0)		
25	18.09	22
50	18.39	24
75	21.78	47
Superphosphate		
25	14.77	0
50	16.06	9
75	15.68	6
Ammonium nitrate-superphosphate combination		
25-25	17.14	16
50-50	18.96	28
75-75	20.86	41
Average fertilizer effect		
O	14.80	
N	19.40	
P	15.48	
NP	18.97	
Standard error	.83	
5% L.S.D.	2.41	

Analysis of variance

Source of variation	Degrees of freedom	Mean squares
Replications	3	14.95
Treatments	9	23.46**
Error	27	2.77

** Significant at the 1-percent level of probability.

Table 4. The effects of fertilizers on the phosphorus content of Lehmann lovegrass seedlings.

Fertilizers and rates of application	Phosphorus analyses: Phosphorus	Phosphorus analyses: Increase or decrease over check
(pounds per acre)	(percent)	(percent)
No fertilizer	.405	0
Ammonium nitrate (33-0-0)		
25	.458	13
50	.258	-36
75	.380	- 6
Superphosphate (0-45-0)		
25	.388	- 4
50	.442	- 9
75	.445	10
Ammonium nitrate-superphosphate combination		
25-25	.415	2
50-50	.415	2
75-75	.535	32
Average fertilizer effect		
O	.40	
N	.37	
P	.40	
NP	.46	
Standard error	.043	
5% L.S.D.	.125	

Analysis of variance

Source of variation	Degrees of freedom	Mean squares
Replications	3	.0248
Treatments	9	.0199*
Error	27	.0074

* Significant at the 5-percent level of probability.

the level of the check flat. This decrease was statistically significant at the 50-pound rate but not at the 75-pound rate. Similar effects were noted by Dyer (1958) on ryegrass seedlings and by Anklam (1962) on mature Lehmann lovegrass plants.

This decrease in phosphorus content of the plants fertilized with nitrogen may be explained as follows: The increased rate of growth due to nitrogen application required more available phosphorus than the soil could provide. In other words, addition of nitrogen fertilizer produced greater yield per flat and weight per plant and diluted the phosphorus available to the seedlings, resulting in a lower phosphorus content (Allison, 1957; Black, 1960).

Applications of superphosphate did not produce significant increases in phosphorus content of the seedlings, although the analysis showed a 10-percent increase in phosphorus content at the higher rates. This nonsignificant response may be explained by availability of the phosphorus in the soil. Even though the phosphorus level in the soil was low (4 ppm) the availability was probably high due to the favorable pH of the soil (6.1), which is within the range of pH (5.6 to 6.5) noted by Olsen and Fried (1957) as the range for high phosphorus availability.

The combination nitrogen-phosphorus fertilizer did not increase the phosphorus content of the Lehmann lovegrass seedlings significantly at the 25- and 50-pound level of application but did at the 75-pound level.

Possible explanations for the increased phosphorus content in the plant at the high 75-pound level of application may be (1) the result of a better balance of phosphorus with other minerals (Olsen and Fried, 1957; Black, 1960), or (2) an accumulation of surplus phosphorus in the plant.

CONCLUSIONS

Studies have shown that the nutritive value of grasses may be greatly influenced by differences of season, location, and other climatic and edaphic factors (Stanley and Hodgson, 1938; Young and Otagaki, 1958). Since this study was conducted under environmental conditions which were quite different from those at the site where the soil was collected, it is logical to assume that the results obtained from the studies of Lehmann lovegrass grown in Tucson at the Soil Conservation Service Plant Materials Center may be somewhat different from results that might be obtained from studies made at the chaparral-soil site. However, an attempt was made to simulate, as far as possible, the conditions prevailing at the collection site by placing the flats under partial shade. As a result it is believed that the differences in climatic effects, such as those due to temperature and humidity, would not be great and that information of practical importance to the rancher can be deduced from the result of this study. It is believed that when reseeding chaparral ranges these results can be used to predict the responses of certain grasses to commercial fertilizers, and particularly the response of Lehmann lovegrass.

As already reported, the application of nitrogen alone generally produced responses equivalent to or higher than those due to phosphorus alone or to the combination nitrogen-phosphorus fertilizers. These responses included equivalent or greater emergence, rate of leaf growth, and protein content of Lehmann lovegrass. Also, the nitrogen-phosphorus combination produced significantly greater increases in yield and phosphorus content of the foliage over nitrogen or phosphorus applied alone, and phosphorus applied alone resulted in no significant increase in any of the plant responses studied. These results indicate that nitrogen alone will result in good establishment and growth but that the combination nitrogen and phosphorus treatments will generally result in greater yield and higher nutrient content of forage than nitrogen alone.

Since the 25-pound rates of fertilizer application generally produced equivalent or greater responses than the 50- or 75-pound rates in emergence, rate of leaf growth and yield of Lehmann lovegrass, and significantly greater responses were obtained from the higher rates of fertilizer applications only in protein and phosphorus content of the forage, it can be concluded that, in general, the most effective rates of fertilizer application for establishment and growth of Lehmann lovegrass would be approximately 25 pounds per acre. However, where increases in nutrient content of the grass are desired the higher rates of fertilizer application would generally be more effective.

To evaluate the economics of fertilizer effects, increases in forage yield and nutrient quality, savings in seeding rates, increases in erosion control, and increases in soil fertility would need to be evaluated against fertilization costs.

SUMMARY

Lehmann lovegrass (*Eragrostis lehmanniana* Nees) seedlings were grown in flats under partial shade on soils taken from a typical chaparral site in central Arizona. The experiment was conducted for a period of six weeks at the Soil Conservation Service Plant Materials Center, Tucson, Arizona, during the summer of 1962. Flats were fertilized with ammonium nitrate, superphosphate, and a combination of equivalent amounts of these two. All fertilizers were applied at rates of 25, 50, and 75 pounds of active ingredient per acre and compared with unfertilized check plots. Results were as follows:

1. Superphosphate treatments at all levels failed to produce significant increases in emergence, yield, or nutrient content of the seedlings.

2. The application of ammonium nitrate produced significant increases in seedling emergence, 55 to 59 percent at the 25- and 75-pound rates, respectively, but emergence was not significantly greater at the 50-pound rate. All rates of the combination fertilizer significantly increased emergence, approximately 50 percent.

3. Marked increases in leaf growth were obtained at all rates of application of ammonium nitrate and combination fertilizers. The minimal 25-pound application of the three fertilizers produced as great or greater leaf growth than the higher rates.

4. All rates of application of ammonium nitrate and combination fertilizer resulted in significant increases in yield of grass per flat (155 to 296 percent) as well as weight per plant (87 to 164 percent). The increases in yield at the 50- and 75-pound rates of the combination fertilizer represented significant synergistic increases in both weight per plot and weight per plant as compared to applications of ammonium nitrate and phosphate alone.

5. All rates of ammonium nitrate and combination fertilizer significantly increased the protein content of the seedlings. The increase at the 75-pound rate was significantly greater than at the lower rates.

6. The 75-pound application of the combination nitrogen-phosphorus fertilizer was the only application that produced a significant increase in the phosphorus content of the seedlings.

It was concluded that nitrogen alone will result in good establishment and growth, but that the combination fertilizer would generally result in greater yield and higher nutrient content of the forage. It was also concluded that the 25-pound rates of fertilizer application would be most effective in establishment and growth of Lehmann lovegrass, but where increases in nutrient content are desired the higher rates would generally be more effective.

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