EFFECTS OF RATES AND TIME OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON YIELD AND CHEMICAL COMPOSITION OF LAHOMA SUDAN GRASS FORAGE

By

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INTRODUCTION

Sudan grass has proven to be a valuable crop for warm season temporary pastures throughout the entire state. This crop is best adapted to fertile, well drained soils and has shown good response to proper fertilization for both increased yields and improved quality of forage (10).[1]

The objective of this study was to determine the effects of rates and time of nitrogen fertilizer application with various combinations of phosphorus and potassium fertility treatments on the yield and chemical composition of Lahoma sudan grass grown under field and greenhouse conditions.

[1] Figures in parenthesis refer to "Literature Cited."

REVIEW OF LITERATURE

The effects of fertilizing forages with nitrogen has received considerable attention by agronomists for many years. Ensminger and Pearson (12) state that nitrogen has been a deficient element in the cultivated soils of the world since the beginning of agriculture. They also report that there is a critical deficit in the nitrogen economy of southern soils. The amount of nitrogen that can be efficiently utilized as well as the best time for application differs widely according to the reports of several workers (2, 7, 12, 17, 23, 31). Burton and DeVane (7) suggested that the amount of nitrogen that a plant can efficiently use is dependent upon many factors including the yield potential of the plant in question.

There has been a continued increase in the rates of nitrogen fertilizer application considered adequate for efficient crop production. Ensminger and Pearson (12) report that recent research in the South has shown that corn will respond to higher nitrogen applications than was previously recognized. They also state that more nitrogen is necessary now to take advantage of improved crop varieties and better cultural methods.

Ramage, et al. (24) applied annual rates of 50, 100, 200 and 400 pounds of nitrogen per acre to orchard grass and reed canary grass grown on field plots of Duchess shaly loam in northern New Jersey for a three year period. Annual dry matter yields ranged from two tons per acre with 50 pounds of nitrogen to four and one-half tons with 400 pounds of

nitrogen per acre. The 100 pound rate produced the greatest yield of dry matter per pound of nitrogen applied.

Burton and DeVane (7) reported that annual hay yields of Bermuda grass ranged from one ton per acre with no nitrogen fertilizer to eight tons per acre when 400 pounds of nitrogen per acre were applied. Their largest hay yields per pound of nitrogen applied were obtained when 100 pounds of nitrogen per acre were used. They also found that rates of 200 pounds of nitrogen per acre produced hay the most economically with assumed costs and prices.

Pumphrey and Harris (23) suggested that during the year the nitrogen fertilizer was applied, grain yields of corn were influenced by the season and the productivity of the soil as well as by the time and rate of fertilizer application. They found yield increases to be higher on soils of low fertility than on soils of medium fertility.

Burton, Southwell and Johnson (8) found that applications of up to 1500 pounds of nitrogen per acre on Coastal Bermuda grass produced increases in yields and could find no evidence indicating that the palatability of the grass was reduced. Prine and Burton (22) found that increasing the nitrogen rate from 0 to 900 pounds per acre annually increased protein percentages, protein yield, stem length and leaf length, as well as increasing hay yields of Coastal Bermuda grass.

Stark, Hafenrichter and Klages (29), in working with mountain brome, found that an increase of one pound of nitrogen fertilizer produced an increase of slightly more than 20 pounds of dry matter. They also found the nitrogen applications increased forage yields more than seed yields by a ratio of 1.26:1. Slightly more than 30 pounds of nitrogen per acre were required to produce significant increases in forage yields.

Anderson, Krenzin and Hide (2) found that applications of nitrogen up to 100 pounds per acre produced significant increases in seed and forage yields of bromegrass in Kansas. With rates more than 100 pounds of nitrogen per acre, the yield increases were relatively small but the protein percentage increased.

Viets (30) grew sudan grass as a green manure crop on potato land in Washington and Oregon and found that nitrogen increased grass yields, but that more nitrogen was needed for the following potato crop. Chamblee, Lovvorn and Woodhouse (9) obtained an average annual increase of 689 pounds per acre with split applications of nitrogen of 100 pounds each on March 15 and June 15 on a permanent pasture mixture primarily of orchard grass, Dallis grass and white clover. Applications of 50 pounds of nitrogen per acre gave them increase growth for about six weeks while applications of 100 pounds increased growth for more than six weeks.

Robinson and Sprague (25) reported on an irrigated orchard grass-Ladino clover mixture on a Hagerstown silt loam and found greatly increased yields throughout the season with nitrogen fertilization on both irrigated and nonirrigated plots. They reported a greater actual as well as percentage increase in yield from nitrogen fertilization on their nonirrigated plots. The percentage increase in yield from nitrogen fertilizer was much greater during midsummer and fall than in the spring, particularly on the nonirrigated series. They also reported that nitrogen fertilization of nonirrigated orchard grass greatly increased the efficiency of water utilized during the dry part of the season.

Williams and Smith (31) reported increased hard red winter wheat

yields at all locations in Kansas by the use of nitrogen fertilizers. They also reported increases in yields with phosphorus applications but found that potash had no effect on yields.

Allison (1) stated that since nitrogen was easily lost from the soil, nitrate nitrogen should be applied only at the time the crop is ready to use it so as to minimize bacterial denitrification.

Foote and Batchelder (13) found that nitrogen produced a greater increase in yield of Hannchen barley when applied at seeding time and when the plants were 6 inches tall over applying nitrogen before plowing. They also reported nitrogen applications to be more effective if applied when the plants were 6 inches tall than later. Pumphrey and Harris (23) found nitrogen fertilization to be more efficient on irrigated corn when applied prior to planting, at planting time, or as a side dressing when the corn was 6 to 12 inches high than as a side dressing when the corn was 30 to 36 inches high. They also found the time of nitrogen fertilization to have little influence on yields during the year of application on soils of low productivity.

Nelson and Robins (17) in working with a Ladino clover-orchard grass pasture under irrigation reported that 50 pounds of nitrogen per acre was more effective when applied in April than when applied in June. Williams and Smith (31) found that nitrogen applied later gave a greater increase in yield than that broadcast before seeding hard red winter wheat in Kansas.

Burton and DeVane (7) found that splitting applications of nitrate of soda and ammonium nitrate on Bermuda grass gave significantly increased yields only in wet years.

Gingrich and Smith (14) suggested that time of application of nitro-

gen on wheat and oats in eastern Kansas generally had little influence on yields. From an economical standpoint, application of all nitrogen at seeding time might be preferable, they suggested.

Anderson, Krenzin and Hide (2) in working with nitrogen fertilizer on bromegrass in Kansas found that rates of nitrogen up to 100 pounds per acre did not increase the protein percentage of fairly mature forage appreciably. However, rates of nitrogen from 140 to 200 pounds per acre did increase protein percentage by appreciable amounts. Burton and DeVane (7) obtained increases in protein content from 7 percent with no nitrogen to 13 percent with 400 pounds of nitrogen per acre on Bermuda grass. They found that rates of 200 to 400 pounds per acre produced the most protein per pound of nitrogen applied and that 400 pounds of nitrogen per acre produced the cheapest protein.

Burton, Southwell and Johnson (8) found that the protein content of Coastal Bermuda grass increased with increasing nitrogen applications up to 1500 pounds of nitrogen per acre.

Hobbs (16) reported increased protein content with spring applications of 37 pounds of nitrogen per acre on winter wheat in Kansas. However, fall nitrogen applications decreased the protein content of the grain.

Bartholomew and Hiltbold (4) suggested that addition of any plant residues, particularly from corn, lowers the recovery percentage of the nitrogen applied. Higher recovery percentages can be achieved with higher rates of application. Uptake of the fertilizer nitrogen almost ceases by the time oats reach the boot stage.

Burleson, Cowley and Otey (6) in a field experiment with grain sorghums obtained recovery percentages of 83.2 and 89.6, respectively, when

60 and 120 pounds of nitrogen per acre was applied. Viets (30) found in working with sudan grass that about 40 percent of the applied nitrogen was recovered in the tops. Ohlrogge, Krantz and Scarseth (18) obtained average recovery rates of 45 to 50 percent of the applied nitrogen in working with corn in Indiana.

Prine and Burton (22) found that increasing the clipping interval from one to eight weeks for Coastal Bermuda grass increased hay yield, stem length, leaf length, plant height, seed-head frequency, internode length and internode number; had little effect on protein yield and percent of nitrogen recovery and decreased the protein percent and leaf percent. Peterson and Hagan (20) in working with an irrigated pasture mixture in California found that all mixtures increased in yields as growth intervals were extended from two to five weeks. They reported a decrease in percent of ash, crude protein, and ether extract with wider intervals between cutting while crude fiber increased and nitrogen - free extract was not greatly affected.

EXPERIMENTAL PROCEDURE

Description of Soil Used in Experiments

The field experiment was located on a Norge fine sandy loam soil at the Paradise Station, approximately ten miles south and seven miles west of Stillwater, Oklahoma on the NW¼ NW¼ SE¼ Section 34, T 18 N, R 1 E.

The Norge fine sandy loam soil was developed from old alluvium. It is a well developed Reddish Prairie soil developed under grass. A complete profile description is presented in the Appendix.

The soil for the greenhouse experiment was obtained from a check plot in the field experiment.

Results of some chemical and physical analyses of the soil used in the field and greenhouse experiments are listed in Table I. The mechanical analysis was determined by the Bouyoucos (5) hydrometer method. Soil pH was determined by the glass electrode method suggested by Peech and English (19). Exchange capacity and exchangeable potassium were determined as suggested by A. O. A. C. (3), using neutral normal ammonium acetate as the extracting agent. The ferrous ammonium sulfate titration method proposed by Schollenberger (26) was used to determine organic matter. The Kjeldahl method suggested by Piper (21) was used to determine total nitrogen. Easily soluble phosphorus was determined by the method presented by Harper (15).

TABLE I

SOME PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE SOIL USED IN THE FIELD AND GREENHOUSE EXPERIMENTS, NORGE FINE SANDY LOAM, STILLWATER, 1957-1958.

Texture	
Percent sand	75.0
Percent silt	21.5
Percent clay	3.5
Cation exchange capacity (Meq./100 gms.)	4.12
pH	6.3
Percent organic matter	0.89
Percent nitrogen	0.036
Easily soluble phosphorus (lbs./acre)	28.16
Exchangeable potassium (lbs./acre)	94.00

Field Experimental Procedure

Lahoma sudan grass was grown on Norge fine sandy loam at the Paradise Station to determine effects of rates and time of nitrogen application with different phosphorus and potassium combinations. The experimental design was a randomized block with three replications. It was a split plot factorial for phosphorus and potassium with four rates of nitrogen applied with two methods of application.

The fertility treatments and fertilizer materials used are listed in detail in Table II. Each plot was fifty feet long and ten feet wide. The fertilizer was placed in bands about two inches below the soil surface with a 15 x 7 John Deere grain drill. On June 7, 1957, the plots were planted to Lahoma sudan grass with the same drill. On August 3, 1957, three rows 25 feet in length, were harvested from each plot for yield data. After the excess crop material had been removed, the additional nitrogen (B) was applied with the 15 x 7 John Deere grain drill. On November 11, 1957, a three foot swath for twenty feet was harvested from each plot and weighed for second cutting yield data. Samples were taken during each harvest for moisture determination. Both cuttings were harvested when the sudan grass was in the boot stage.

Greenhouse Experimental Procedure

The soil used in the greenhouse experiment was obtained from the location of the field experiment at the Paradise Station.

The air-dry Norge fine sandy loam soil was screened through a .25 inch screen and 9000 grams were weighed into each of 60 two gallon glazed earthenware pots. The fertilizer was placed one and one-half inches deep and one inch in from the pot walls. The fertility treatments

TABLE II

FERTILITY TREATMENTS, RATES AND FERTILIZER MATERIALS USED IN THE FIELD EXPERIMENT, PARADISE STATION, NORGE FINE SANDY LOAM, STILLWATER, 1957.

Symbol	Treatment
Check	No fertilizer
P	40 pounds of P_2O_5 per acre as treble superphosphate (45% P_2O_5)
K	40 pounds of K_2O per acre as KCL (60% K_2O)
N_1	40 pounds of N per acre as $NH_4 NO_3$ (33.5% N)
N_2	80 pounds of N per acre as $NH_4 NO_3$ (33.5% N)
N_3	160 pounds of N per acre as $NH_4 NO_3$ (33.5% N)
A	All nitrogen applied at planting time
B	½ nitrogen at planting and ½ nitrogen after the first cutting

and fertilizer materials used are shown in detail in Table III. Lahoma sudan grass was planted one-half inch above and one inch in from the fertilizer bands on October 7, 1957. The experiment was arranged in a randomized block arrangement with three replications. After the plants were established, the stands were adjusted to ten plants per pot. The soil in each pot was watered periodically with distilled water. Enough moisture was supplied to keep the soil moisture at a high level and approximately the same in each pot.

The sudan was harvested on February 7, 1958, just as the first heads began to appear by clipping the plants about one inch above the soil. Since a large percentage of the plants did not recover after clipping, all the plants were destroyed and the pots were replanted to Lahoma sudan grass and a stand of ten plants per pot was established as before.

On May 9, 1958, the sudan was again harvested by clipping about one inch above the soil. The sudan was in the early boot stage when the second crop was harvested. All the plant material from each pot was oven-dried immediately after each clipping and weighed for yield data. Chemical analyses in duplicate for percent nitrogen, phosphorus and potassium were run on the ground oven-dry samples of the first cutting. Total nitrogen was determined by the Kjeldahl process as outlined by Piper (21). Potassium was determined with a Perkin-Elmer Flame Photometer and phosphorus was determined by the procedure outlined by Shelton (27).

Statistical Analysis

The yield data from the field and greenhouse experiments and the results of the chemical analysis were analyzed statistically. Analysis

of variance for significant differences and coefficients of variation were determined as outlined by Snedecor (28). When significant differences were determined by analysis of variance, a multiple range test proposed by Duncan (11) was used to aid in interpreting the data.

TABLE III

FERTILITY TREATMENTS, RATES AND FERTILIZER MATERIALS USED IN THE GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, 1958.

Symbol	Treatment
Check	No fertilizer
K	80 pounds of K_2O per acre as KCL (C.P.)(60% K_2O)
P	80 pounds of P_2O_5 per acre as $Ca(H_2PO_4)_2 \cdot H_2O$ (56% P_2O_5)
N_1	80 pounds of Nitrogen per acre as $NH_4 NO_3$ (33.5% N)
N_2	160 pounds of Nitrogen per acre as $NH_4 NO_3$ (33.5% N)
N_3	240 pounds of Nitrogen per acre as $NH_4 NO_3$ (33.5% N)
N_4	320 pounds of Nitrogen per acre as $NH_4 NO_3$ (33.5% N)

RESULTS AND DISCUSSION

Field Experiment

Results from the field experiment are reported in Tables IV, V and VI. These data show effects of: (1) rates of nitrogenous fertilizer application, (2) different times of nitrogenous fertilizer application and (3) the different phosphorus and potassium combinations on yield of sudan grass forage obtained from two cuttings during the 1957 growing season. Significant F values and multiple range tests are included with these tables. Individual plot yields are reported in detail in Tables XIII, XIV and XV.

Yield results from the first cutting, reported in Table IV, show the highest significant differences in yield due to the phosphorus fertilizer treatments. The plots receiving phosphorus produced an average yield of 3236 pounds per acre while those receiving no phosphorus produced an average of only 1380 pounds per acre. Response to nitrogen fertilization was not significant; however, the mean yields varied from 1825 pounds of forage per acre with no nitrogen to 2790 pounds of forage per acre with 160 pounds per acre of nitrogenous fertilizer applied at planting. The potassium fertilizer treatments apparently had little effect on yields of sudan grass hay. The highest mean yield was produced with the 160-40-0 treatment and the lowest mean yield was produced with the 20-0-40 treatment.

Results from the second cutting are presented in Table V. Signifi-

TABLE IV

EFFECTS OF RATES AND TIME OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON YIELD OF LAHOMA SUDAN GRASS, FIELD EXPERIMENT, PARADISE STATION, NORGE FINE SANDY LOAM, STILLWATER, FIRST CUTTING, AUGUST 3, 1957.

Treatments[1] / Pounds N/A	Pounds fertilizer per acre 0-0-0	0-40-0	0-0-40	0-40-40	Average
	Pounds dry forage per acre[2]				
None	1330	2020	1427	2522	1825
20 B	1149	2871	747	3199	1991
40 A	2047	3058	1099	2634	2209
40 B	1834	3883	929	4601	2812
80 A	1854	2012	1486	4223	2394
80 B	1079	2697	1838	2937	2138
160 A	809	6086	1693	1572	2790
Average	1443	3232	1317	3241	2308

F Values: C.V. = 45.89%

Treatments 4.229**

Phosphorus 64.53**

Multiple Range Test[3]: Sm = 611.56 1% level

Symbol	N_3PA	N_2PKB	N_2PKA	N_2PB	N_1PKB	N_1PA	N_3PKB	N_1PB	N_3PB	N_1PKA	N_3PKA	PK	N_1A	P	N_2PA	N_2A	N_3KB	N_2B	N_3KA	N_2KA	K	Ck	N_1B	N_1KA	N_3B	N_2KB	N_3A	N_1KB
Average Yield	6086	4601	4223	3883	3199	3058	2937	2871	2697	2634	2572	2522	2047	2020	2012	1854	1838	1834	1693	1486	1427	1330	1149	1099	1079	929	809	747

[1] See Table II for details of treatments. The plots indicated with B treatments received one-half of the added nitrogen after the first cutting.

[2] Yield figures are the mean of three replications expressed as hay with 14% moisture content.

[3] Any two means not underlined by the same line are significantly different at the 1% level.

**Significant difference at the 1% level.

TABLE V

EFFECTS OF RATES AND TIME OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON YIELD OF LAHOMA SUDAN GRASS, FIELD EXPERIMENT, PARADISE STATION, NORGE FINE SANDY LOAM, STILLWATER, SECOND CUTTING, NOVEMBER 8, 1957.

Treatments[1] / Pounds N/A	Pounds fertilizer per acre 0-0-0	0-40-0	0-0-40	0-40-40	Average
	Pounds dry forage per acre[2]				
None	1241	976	1597	1077	1223
40 at planting	2559	1510	1936	1599	1901
20 at planting and 20 after first cutting	1628	1582	1581	1787	1644
80 at planting	1971	1737	2124	1293	1781
40 at planting and 40 after first cutting	1434	1386	1872	1654	1586
160 at planting	1229	2108	2546	2244	2032
80 at planting and 80 after first cutting	1837	1853	1529	2362	1895
Average	1700	1593	1884	1717	1724

F Values: C.V. = 34.03%

Nitrogen 4.474*

Multiple Range Test[3]: Sm = 338.93 1% level

Symbol	N_1A	N_3KA	N_3PKB	N_3PKA	N_2KA	N_3PA	N_2A	N_1KA	N_2KB	N_3PB	N_3B	N_1PKB	N_2PA	N_2PKB	N_1B	N_1PKA	K	N_1PB	N_1KB	N_3KB	N_1PA	N_2B	N_2PB	N_2PKA	Ck	N_3A	PK	P
Average Yield	2559	2546	2362	2244	2124	2108	1971	1936	1872	1853	1837	1787	1737	1654	1628	1599	1597	1582	1581	1529	1510	1434	1386	1293	1241	1229	1077	976

[1] See Table II for details of treatments.
[2] Yield figures are the mean of three replications expressed as hay with 14% moisture content.
[3] Any two means not underlined by the same line are significantly different at the 1% level.
* Significant difference at the 5% level.

cant differences in forage yields were obtained due to the rates of nitrogenous fertilizer applied. The average yield from plots receiving no nitrogen was 1223 pounds of hay per acre. The high mean yield obtained from plots receiving 160 pounds of nitrogenous fertilizer per acre was 2032 pounds of hay per acre. This cutting was harvested following a heavy frost and some plants had been blown over by strong winds. Plots receiving the entire rate of nitrogen at planting outyielded those receiving the same rate of nitrogen fertilizer with one-half of the nitrogen applied at planting and one-half after the first cutting.

Yield results of the first and second cuttings combined are presented in Table VI. Phosphorus fertilization treatments produced differences in yields significant at the 1% level. The plots that received phosphorus fertilization produced an average of almost one ton more hay per acre than those plots that received no phosphorus. Most of this difference occurred with yields for the first cutting. Plots that received the entire rate of nitrogen fertilization at planting generally produced more hay than those plots with the same rate of nitrogen applied one-half at planting and one-half after the first cutting. The highest total mean yield of 8194 pounds of hay per acre was produced with the 160-40-0 treatment with all nitrogen fertilizer applied at planting.

These data indicate that phosphorus is apparently the first limiting factor on this soil for sudan grass forage production (Figure 1). When adequate phosphorus is supplied, available nitrogen is a governing factor in determining sudan grass yields on this soil (Figure 2).

Greenhouse Experiment

Yield data for the first crop, second crop and for the total dry

TABLE VI

EFFECTS OF RATES AND TIME OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON TOTAL YIELD OF LAHOMA SUDAN GRASS, FIELD EXPERIMENT, PARADISE STATION, NORGE FINE SANDY LOAM, STILLWATER, 1957.

Treatments[1]	Pounds fertilizer per acre				
Pounds N/A	0-0-0	0-40-0	0-0-40	0-40-40	Average
	Pounds dry forage per acre[2]				
None	2571	2996	3024	3599	3047
40 at planting	4607	4568	3036	4234	4111
20 at planting and 20 after first cutting	2777	4452	2328	4985	3636
80 at planting	3825	3749	3610	5517	4175
40 at planting and 40 after first cutting	3268	5269	2801	6254	4398
160 at planting	2038	8194	4238	4816	4822
80 at planting and 80 after first cutting	2916	4550	3367	5299	4031
Average	3143	4825	3201	4958	4032

F Values: C.V. = 30.64%

Treatments 3.510** Phosphorus 40.69** Nitrogen 3.831*

Multiple Range Test[3]: Sm = 713.33 1% level

Symbol	N_3PA	N_2PKB	N_2PKA	N_3PKB	N_2PB	N_1PKB	N_3PKA	N_1A	N_1PA	N_3PB	N_1PB	N_3KA	N_1PKA	N_2A	N_2PA	N_2KA	PK	N_3KB	N_2B	N_1KA	K	P	N_3B	N_3KB	N_1B	Ck	N_1KB	N_3A
Average Yield	8194	6254	5517	5299	5269	4985	4816	4607	4568	4550	4452	4238	4234	3825	3749	3610	3599	3367	3268	3036	3024	2996	2916	2801	2777	2571	2328	2038

[1] See Table II for details of treatments.

[2] Yield figures are the mean of three replications expressed as hay with 14% moisture content.

[3] Any two means not underlined by the same line are significantly different at the 1% level.

* Significant difference at the 5% level.

** Significant difference at the 1% level.

forage produced with Lahoma sudan grass in the greenhouse experiment are summarized in Tables VII, VIII and IX, respectively. Significant F values and multiple range tests are presented with these data. Individual pot yields from the greenhouse experiment are presented in Tables XVI, XVII and XVIII.

The first crop of sudan grass forage, as shown in Table VII, produced highly significant yield differences from both nitrogen and phosphorus treatments. The highest mean yield was produced by the 240-80-80 treatment. The lowest mean yield was produced by no fertilization. A noticeable reduction in yield was observed at the highest rate of nitrogen application.

The second crop, as shown in Table VIII, grown without additional fertilizer, produced a significant yield response from the residual effects of both the nitrogen and the phosphorus fertilizations. The residual effects of nitrogen were much the same as those observed on the first crop. All nitrogen rates increased yields except the highest rate where a slight decrease was noted. The residual effects of the phosphorus were a reversal of the results on the first crop. The pots that had received a previous phosphorus treatment yielded an average of about three grams less per pot than those that had not received a previous phosphorus fertilizer application. The highest yielding treatment was the 160-0-80 treatment. The lowest yielding treatment was no fertilization.

Yields of the two individual crops combined are shown in Table IX. Nitrogen and phosphorus treatments produced highly significant effects on the yields. The higher rates of nitrogen increased yields although a decrease was noted at the highest rate. The phosphorus treatments

TABLE VII

EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON YIELD OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, FEBRUARY 7, 1958.

Treatments[1]	Pounds fertilizer per acre				
Pounds N/A	0-0-0	0-80-0	0-0-80	0-80-80	Average
	Grams dry forage per pot[2]				
None	7.77	12.13	10.30	10.47	10.17
80	11.87	19.20	11.90	18.90	15.47
160	11.47	19.17	10.07	20.10	15.20
240	11.57	20.13	11.10	20.37	15.79
320	10.43	17.10	11.77	18.83	14.53
Average	10.62	17.55	11.03	17.73	14.23

F Values:

Treatments	12.15**	C.V. = 15.12%	
		Nitrogen	13.94**
		Phosphorus	150.54**

Multiple Range Test[3]: Sm = 1.242 1% level

Symbol	N_3PK	N_3P	N_2PK	N_1P	N_2P	N_1PK	N_4PK	N_4P	P	N_1K	N_1	N_4K	N_3	N_2	N_3K	PK	N_4	K	N_2K	Ck
Average Yield	20.37	20.13	20.10	19.20	19.17	18.90	18.83	17.10	12.13	11.90	11.87	11.77	11.57	11.47	11.10	10.47	10.43	10.30	10.07	7.77

[1] See Table III for details of treatments.
[2] Yields are the mean of three replications.
[3] Any two means not underlined by the same line are significantly different at the 1% level.
**Significant difference at the 1% level.

TABLE VIII

RESIDUAL EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON YIELD OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, MAY 9, 1958.

Treatments[1]	Pounds fertilizer per acre				
Pounds N/A	0-0-0	0-80-0	0-0-80	0-80-80	Average
	Grams dry forage per pot[2]				
None	2.93	3.53	3.03	3.47	3.24
80	11.10	4.33	10.70	4.73	7.72
160	15.83	12.33	19.10	10.97	14.56
240	16.33	13.40	16.03	14.10	14.97
320	14.57	12.70	13.20	13.10	13.39
Average	12.15	9.26	12.41	9.27	10.78

F Values: C.V. = 22.21%

Treatments	16.35**
Nitrogen	64.02**
Phosphorus	27.78**

Multiple Range Test[3]: Sm = 1.280 1% level

Symbol	N_2K	N_3	N_3K	N_2	N_4	N_3PK	N_3P	N_4K	N_4PK	N_4P	N_2P	N_1	N_2PK	N_1K	N_1PK	N_1P	P	PK	K	Ck
Average Yield	19.10	16.33	16.03	15.83	14.57	14.10	13.40	13.20	13.10	12.70	12.33	11.10	10.97	10.70	4.73	4.33	3.53	3.47	3.03	2.93

[1] See Table III for details of treatments.
[2] Yields are the mean of three replications.
[3] Any two means not underlined by the same line are significantly different at the 1% level.
**Significant difference at the 1% level.

TABLE IX

EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON TOTAL YIELD OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, 1958.

Treatments[1]	Pounds fertilizer per acre				
Pounds N/A	0-0-0	0-80-0	0-0-80	0-80-80	Average
	Grams dry forage per pot[2]				
None	10.70	15.67	13.33	13.93	13.41
80	22.97	23.53	22.60	23.63	23.18
160	27.30	31.50	29.17	31.07	29.76
240	27.90	33.53	27.13	34.47	30.76
320	25.00	29.80	24.97	31.93	27.92
Average	22.77	26.81	23.44	27.01	25.01

F Values: C.V. = 11.59%

Treatments	17.17**
Nitrogen	72.18**
Phosphorus	25.79**

Multiple Range Test[3]: Sm = 1.673 1% level

Symbol	N_3PK	N_3P	N_4PK	N_2P	N_2PK	N_4P	N_2K	N_3	N_2	N_3K	N_4	N_4K	N_1PK	N_1P	N_1	N_1K	P	PK	K	Ck
Average Yield	34.47	33.53	31.93	31.50	31.07	29.80	29.17	27.90	27.30	27.13	25.00	24.97	23.63	23.53	22.97	22.60	15.67	13.93	13.33	10.70

[1] See Table III for details of treatments.
[2] Yields are the mean of three replications.
[3] Any two means not underlined by the same line are significantly different at the 1% level.
**Significant difference at the 1% level.

increased yields significantly. The highest mean yield was produced by the 240-80-80 treatment. The lowest mean yield was produced by no fertilization.

The plant material from the first crop was analyzed chemically for percent nitrogen, phosphorus and potassium. The results of these analyses are reported in Tables X, XI and XII. These summary tables show the effects of (1) nitrogen rates and (2) different phosphorus and potassium combinations. Significant F values and multiple range tests are shown with these tables. A detailed report of the results of the chemical analysis is presented in Tables XIX, XX and XXI.

Nitrogen and phosphorus treatments produced significant differences in nitrogen percentages (Table X). The nitrogen treatments increased the nitrogen content and the phosphorus treatments decreased the nitrogen content of the plant material. The highest mean nitrogen percentage was 2.60% produced by the 240-0-0 treatment. The lowest mean nitrogen percentage was 0.76% produced by the 0-80-80 treatment.

The nitrogen and phosphorus treatments produced significant differences in the phosphorus content of the plant material (Table XI). The phosphorus applications increased the phosphorus percentage and the nitrogen treatments decreased the phosphorus content. The highest mean phosphorus percentage was 0.204% produced by the 0-80-80 treatment. The lowest mean phosphorus percentage was 0.090% produced by the 320-0-80 treatment.

All three fertilizer materials produced significant differences in the potassium percentage of the sudan. The phosphorus and nitrogen treatments decreased the potassium content and the potassium treatments increased the potassium percentage of the plant material. The highest

TABLE X

EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON NITROGEN COMPOSITION OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, FEBRUARY 7, 1958.

Treatments[1] / Pounds N/A	Pounds fertilizer per acre 0-0-0	0-80-0	0-0-80	0-80-80	Average
			Percent[2]		
None	1.33	0.81	1.08	0.76	1.00
80	2.16	1.12	2.18	1.38	1.71
160	2.29	1.77	2.25	1.71	2.00
240	2.60	2.08	2.29	2.04	2.25
320	2.46	2.03	2.33	2.02	2.21
Average	2.17	1.56	2.02	1.58	1.83

F Values: C.V. = 14.12%

Treatments	14.03**
Nitrogen	44.35**
Phosphorus	57.45**

Multiple Range Test[3]: Sm = .1495 1% level

Symbol	N_3	N_4	N_4K	N_3K	N_2	N_2K	N_1K	N_1	N_3P	N_3PK	N_4P	N_4PK	N_2P	N_2PK	N_1PK	Ck	N_1P	K	P	PK
Average Yield	2.60	2.46	2.33	2.29	2.29	2.25	2.18	2.16	2.08	2.04	2.03	2.02	1.77	1.71	1.38	1.33	1.12	1.08	0.81	0.76

[1] See Table III for details of treatments.
[2] Percentages are the mean of three replications.
[3] Any two means not underlined by the same line are significantly different at the 1% level.
**Significant difference at the 1% level.

TABLE XI

EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON PHOSPHORUS COMPOSITION OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, FEBRUARY 7, 1958.

Treatments[1] / Pounds N/A	Pounds fertilizer per acre 0-0-0	0-80-0	0-0-80	0-80-80	Average
			Percent[2]		
None	.143	.185	.118	.204	.162
80	.121	.126	.120	.126	.123
160	.118	.143	.117	.139	.129
240	.137	.118	.118	.122	.124
320	.114	.141	.090	.140	.121
Average	.127	.143	.113	.146	.132

F Values: C.V. = 10.47%

Treatments	9.85**
Nitrogen	18.84**
Phosphorus	48.04**

Multiple Range Test[3]: Sm = .007979 1% level

Symbol	PK	P	Ck	N_2P	N_4P	N_4PK	N_2PK	N_3P	N_1PK	N_3PK	N_1K	N_1K	N_2	K	N_3K	N_3P	N_2K	N_4	N_4K
Average Yield	.204	.185	.143	.143	.141	.140	.139	.137	.126	.126	.122	.121	.120	.118	.118	.118	.117	.114	.090

[1] See Table III for details of treatments.
[2] Percentages are the means of three replications.
[3] Any two means not underlined by the same line are significantly different at the 1% level.
**Significant difference at the 1% level.

TABLE XII

EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON POTASSIUM COMPOSITION OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, FEBRUARY 7, 1958.

Treatments[1]	Pounds fertilizer per acre				
Pounds N/A	0-0-0	0-80-0	0-0-80	0-80-80	Average
			Percent[2]		
None	3.55	2.87	3.35	2.83	3.15
80	3.42	2.43	3.43	2.76	3.01
160	3.27	2.44	3.44	2.83	3.00
240	3.27	2.20	3.39	2.62	2.87
320	3.01	2.11	3.12	2.68	2.73
Average	3.30	2.41	3.35	2.74	2.95

F Values: C.V. = 5.95%

Treatments	18.98**
Nitrogen	9.70**
Phosphorus	273.70**
Potassium	17.21**

Multiple Range Test[3]: Sm = .1013 1% level

Symbol	Ck	N_2K	N_1K	N_1	N_3K	K	N_2	N_3	N_4K	N_4	P	N_2PK	PK	N_1PK	N_4PK	N_3PK	N_2P	N_1P	N_3P	N_4P
Average Yield	3.55	3.44	3.43	3.42	3.39	3.35	3.27	3.27	3.12	3.01	2.87	2.83	2.83	2.76	2.68	2.62	2.44	2.43	2.20	2.11

1/ See Table III for details of treatments.
2/ Percentages are the mean of three replications.
3/ Any two means not underlined by the same line are significantly different at the 1% level.
**Significant difference at the 1% level.

mean potassium percentage was 3.55% produced by no fertilizer treatment. The lowest mean potassium percentage was 2.11% produced by the 320-80-0 treatment.

SUMMARY

The objective of this study was to compare the effect of different rates and time of nitrogen fertilizer application with various combinations of phosphorus and potassium on the forage production of Lahoma sudan grass.

A field experiment was conducted at the Paradise Station on a Norge fine sandy loam soil. Lahoma sudan grass was grown with twenty-eight different soil fertility treatments. Two cuttings were made on this field experiment. Results from the field experiment may be summarized as follows:

1. Significantly higher yields of the first cutting were produced by the plots which received phosphorus fertilization.
2. Nitrogen treatments produced significant yield increases of sudan grass hay in the second cutting.
3. There was an increase due to both nitrogen and phosphorus fertilizer applications in the combined hay yields from the two cuttings. The effect due to phosphorus was the most significant.
4. Higher yields were obtained on those plots that received nitrogen in a single application than on those that received split applications of nitrogen. However, the difference was not significant.

Two crops of Lahoma sudan grass were grown on Norge fine sandy loam in the greenhouse experiment; the first to compare effects of rates of

nitrogen fertilizer application with various combinations of phosphorus and potassium on forage yields and the second to measure residual effects of these fertility treatments. Results of the greenhouse experiment may be summarized as follows:

1. Nitrogen and phosphorus treatments produced significant yield increases in the first crop. The phosphorus treatment increased mean yields approximately seven grams per pot or seventy percent.
2. Nitrogen produced significant increases and phosphorus produced significant decreases in mean yields of sudan grass forage from the residual study.
3. Nitrogen and phosphorus treatments produced significant increases in total yields of Lahoma sudan grass from the greenhouse experiment.
4. Yields from the 320 pounds of nitrogen per acre treatment were lower than those from the 160 and 240 pounds of nitrogen per acre treatment.
5. Yields from the check pots were consistently lower than those from pots that received fertility treatments.
6. Percent nitrogen was higher in forage grown in pots receiving nitrogen treatments than in forage grown in pots not receiving nitrogen. Phosphorus treatments produced decreases in the nitrogen percentage of the forage material.
7. Percent phosphorus was significantly higher in forage from pots that received phosphorus fertilization than in forage grown without phosphorus fertilization. Nitrogen fertilization signigicantly decreased the phosphorus percentage in the sudan grass.

8. Percent potassium was significantly higher in forage that received potassium fertilization than in forage from pots that received no potassium treatments. Nitrogen and phosphorus fertilization significantly decreased the potassium percentage.

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APPENDIX

PROFILE DESCRIPTION OF NORGE FINE SANDY LOAM

The following profile description was prepared June 2, 1958 by Mr. Ruel Bain, Instructor of Agronomy, Oklahoma State University. The entire profile was moist when the description was prepared. There was a one percent slope at the site.

A_1	0-8"	Dark-brown (7.5 YR 4/2, m) fine sandy loam to loamy sand; weak fine to medium granular; friable, permeable.
B_1	8-11"	Dark-brown (7.5 YR 4/2, m) sandy clay; weak medium subangular blocky; firm; permeable; an abundance of quartz grains.
B_{2-1}	11-18"	Reddish-brown (5 YR 4/4, m) some dark brown (7.5 YR 4/2, m) along natural cleavege planes. Sandy clay; firm; permeable, very few fine pores; few fine roots; grades to layer below.
B_{2-2}	18-36"	Yellowish-red (5 YR 4/6, m) sandy clay; weak medium subangular blocky; firm; permeable; much like above but not as compact.
C_1	36-44"	Yellowish-red (6 YR 5/6, m) fine sandy loam; very weak medium granular to structureless; loose.
C_2	44-54"	Strong brown (7.5 YR 5/6, m) loamy sand structureless; loose.

TABLE XIII

EFFECTS OF RATES AND TIME OF NITROGEN FERTILIZER APPLICATIONS WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON YIELD OF LAHOMA SUDAN GRASS, FIELD EXPERIMENT, PARADISE STATION, NORGE FINE SANDY LOAM, STILLWATER, FIRST CUTTING, AUGUST 3, 1957.

Treatments[1]	Pounds of hay per acre[2]			
	Rep I	Rep II	Rep III	Mean
Check	1195	380	2414	1330
P	1655	1705	2701	2020
K	1929	498	1854	1427
PK	1842	1966	3759	2522
N_1A	1786	1232	3124	2047
N_1PA	3124	1369	4680	3058
N_1KA	2016	261	1021	1099
N_1PKA	1817	1307	4779	2634
N_1B	1879	523	1045	1149
N_1PB	3062	1269	4281	2871
N_1KB	1108	597	535	747
N_1PKB	1643	1481	6472	3199
N_2A	324	1767	3472	1854
N_2PA	1381	1307	3348	2012
N_2KA	875	871	2713	1486
N_2PKA	3485	3908	5277	4223
N_2B	485	2203	2813	1834
N_2PB	2601	2302	6746	3883
N_2KB	834	448	1506	929
N_2PKB	2676	4505	6621	4601
N_3A	1008	199	1220	809
N_3PA	3609	3945	10703	6086
N_3KA	311	2290	2477	1693
N_3PKA	1493	2029	4194	2572
N_3B	1294	361	1581	1079
N_3PB	2775	2141	3174	2697
N_3KB	871	1805	2838	1838
N_3PKB	1406	2962	4443	2937

[1] See Table II for details of treatments.
[2] Yield figures represent pounds of hay containing 14% moisture.

TABLE XIV

EFFECTS OF RATES AND TIME OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON YIELD OF LAHOMA SUDAN GRASS, FIELD EXPERIMENT, PARADISE STATION, NORGE FINE SANDY LOAM, STILLWATER, SECOND CUTTING, NOVEMBER 8, 1957.

Treatments[1]	Pounds of hay per acre[2]			
	Rep I	Rep II	Rep III	Mean
Check	1580	1098	1045	1241
P	807	825	1295	976
K	2236	1475	1080	1597
PK	831	1040	1359	1077
N_1A	2497	1830	3351	2559
N_1PA	1284	1632	1615	1510
N_1KA	1528	732	3549	1936
N_1PKA	1586	1487	1725	1599
N_1B	1388	1458	2039	1628
N_1PB	1853	1713	1179	1582
N_1KB	1591	1562	1591	1581
N_1PKB	993	1771	2596	1787
N_2A	1504	1417	2991	1971
N_2PA	2248	1713	1249	1737
N_2KA	2143	1934	2294	2124
N_2PKA	1731	987	1162	1293
N_2B	865	1620	1818	1434
N_2PB	2538	1109	511	1386
N_2KB	2341	929	2346	1872
N_2PKB	2033	1249	1679	1654
N_3A	1545	1069	1074	1229
N_3PA	2329	1777	2219	2108
N_3KA	1638	3014	2985	2546
N_3PKA	1766	1760	3206	2244
N_3B	1574	1725	2213	1837
N_3PB	1859	1766	1934	1853
N_3KB	1260	1655	1673	1529
N_3PKB	1255	3357	2474	2362

[1] See Table II for details of treatments.
[2] Yield figures represent pounds of hay containing 14% moisture.

TABLE XV

EFFECTS OF RATES AND TIME OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON TOTAL YIELD OF LAHOMA SUDAN GRASS, FIELD EXPERIMENT, PARADISE STATION, NORGE FINE SANDY LOAM, STILLWATER, 1957.

Treatments[1]	Pounds of hay per acre[2]			
	Rep I	Rep II	Rep III	Mean
Check	2775	1478	3459	2571
P	2462	2530	3996	2996
K	4165	1973	2934	3024
PK	2673	3006	5118	3599
N_1A	4283	3062	6475	4607
N_1PA	4408	3001	6295	4568
N_1KA	3544	993	4570	3036
N_1PKA	3403	2794	6504	4234
N_1B	3267	1981	3082	2777
N_1PB	4915	2982	5460	4452
N_1KB	2699	2159	2126	2328
N_1PKB	2636	3252	9068	4985
N_2A	1828	3184	6463	3825
N_2PA	3629	3020	4597	3749
N_2KA	3018	2805	5007	3610
N_2PKA	5216	4895	6439	5517
N_2B	1350	3823	4631	3268
N_2PB	5139	3411	7257	5269
N_2KB	3175	1377	3852	2801
N_2PKB	4709	5754	8300	6254
N_3A	2553	1268	2294	2038
N_3PA	5938	5722	12922	8194
N_3KA	1949	5304	5462	4238
N_3PKA	3259	3789	7400	4816
N_3B	2868	2086	3794	2916
N_3PB	4634	3907	5108	4550
N_3KB	2131	3460	4511	3367
N_3PKB	2661	6319	6917	5299

[1] See Table II for details of treatments.
[2] Yield figures represent total pounds of hay, containing 14% moisture, produced from two cuttings.

TABLE XVI

EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON YIELD OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, FEBRUARY 7, 1958.

Treatments[1]	Grams of dry forage per pot[2]			
	Rep I	Rep II	Rep III	Mean
Check	9.0	7.9	6.4	7.77
P	15.2	12.3	8.9	12.13
K	10.9	8.2	11.8	10.30
PK	11.8	11.2	8.4	10.47
N_1	12.6	11.2	11.8	11.87
N_1P	19.1	20.4	18.1	19.20
N_1K	14.6	11.4	9.7	11.90
N_1PK	19.7	17.6	19.4	18.90
N_2	15.0	12.5	6.9	11.47
N_2P	20.2	17.1	20.2	19.17
N_2K	9.4	10.7	10.1	10.07
N_2PK	22.1	19.9	18.3	20.10
N_3	10.4	11.9	12.4	11.57
N_3P	21.4	19.1	19.9	20.13
N_3K	10.0	11.3	12.0	11.10
N_3PK	19.5	20.7	20.9	20.37
N_4	10.4	12.0	8.9	10.43
N_4P	23.5	18.3	9.5	17.10
N_4K	11.9	13.3	10.1	11.77
N_4PK	19.1	18.6	18.8	18.83

[1]/See Table III for details of treatments.
[2]/Each figure represents grams of oven-dry forage per pot.

TABLE XVII

RESIDUAL EFFECTS FROM RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON YIELD OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, MAY 9, 1958.

Treatments[1]	Grams of dry forage per pot[2]			
	Rep I	Rep II	Rep III	Mean
Check	2.6	2.9	3.3	2.93
P	3.0	3.4	4.2	3.53
K	2.4	2.7	4.0	3.03
PK	2.7	3.6	4.1	3.47
N_1	8.8	14.5	10.0	11.10
N_1P	4.2	4.5	4.3	4.33
N_1K	6.2	11.9	14.0	10.70
N_1PK	4.4	3.8	6.0	4.73
N_2	13.5	15.5	18.5	15.83
N_2P	11.1	10.1	15.8	12.33
N_2K	18.2	17.8	21.3	19.10
N_2PK	11.1	9.0	12.8	10.97
N_3	14.9	14.8	19.3	16.33
N_3P	14.5	15.5	10.2	13.40
N_3K	9.6	21.9	16.6	16.03
N_3PK	11.9	15.6	14.8	14.10
N_4	16.2	13.5	14.0	14.57
N_4P	9.1	13.9	15.1	12.70
N_4K	11.2	13.8	14.6	13.20
N_4PK	12.6	13.9	12.8	13.10

[1] See Table III for details of treatments.
[2] Each figure represents grams of oven-dry forage per pot.

TABLE XVIII

EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON TOTAL YIELD OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, 1958.

Treatments[1]	Grams of dry forage per acre[2]			
	Rep I	Rep II	Rep III	Mean
Check	11.6	10.8	9.7	10.70
P	18.2	15.7	13.1	15.67
K	13.3	10.9	15.8	13.33
PK	14.5	14.8	12.5	13.93
N_1	21.4	25.7	21.8	22.97
N_1P	23.3	24.9	22.4	23.53
N_1K	20.8	23.3	23.7	22.60
N_1PK	24.1	21.4	25.4	23.63
N_2	28.5	28.0	25.4	27.30
N_2P	31.3	27.2	36.0	31.50
N_2K	27.6	28.5	31.4	29.17
N_2PK	33.2	28.9	31.1	31.07
N_3	25.3	26.7	31.7	27.90
N_3P	35.9	34.6	30.1	33.53
N_3K	19.6	33.2	28.6	27.13
N_3PK	31.4	36.3	35.7	34.47
N_4	26.6	25.5	22.9	25.00
N_4P	32.6	32.2	24.6	29.80
N_4K	23.1	27.1	24.7	24.97
N_4PK	31.7	32.5	31.6	31.93

[1] See Table III for details of treatments.
[2] Each figure represents grams of oven-dry forage per pot. Each figure is the total of two cuttings.

TABLE XIX

EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON NITROGEN CONTENT OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, FEBRUARY 7, 1958.

Treatments[1]	% Nitrogen[2]			
	Rep I	Rep II	Rep III	Mean
Check	.95	1.13	1.91	1.33
P	.66	.72	1.06	.81
K	.96	1.23	1.04	1.08
PK	.65	.72	.92	.76
N_1	2.06	2.21	2.22	2.16
N_1P	1.14	1.20	1.03	1.12
N_1K	1.82	2.43	2.29	2.18
N_1PK	1.18	1.43	1.52	1.38
N_2	2.08	2.34	2.45	2.29
N_2P	1.67	1.76	1.88	1.77
N_2K	2.21	2.25	2.29	2.25
N_2PK	1.50	1.66	1.96	1.71
N_3	2.66	2.46	2.67	2.60
N_3P	2.64	1.76	1.83	2.08
N_3K	2.15	2.26	2.45	2.29
N_3PK	1.71	1.74	2.67	2.04
N_4	2.51	2.35	2.53	2.46
N_4P	1.88	2.14	2.08	2.03
N_4K	2.19	2.43	2.36	2.33
N_4PK	1.85	2.01	2.19	2.02

[1] See Table III for details of treatments.
[2] Percentages represent the average of two subsamples.

TABLE XX

EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON PHOSPHORUS CONTENT OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, FEBRUARY 7, 1958.

Treatments[1]	% Phosphorus[2]			
	Rep I	Rep II	Rep III	Mean
Check	.126	.142	.162	.143
P	.151	.176	.228	.185
K	.102	.134	.118	.118
PK	.184	.192	.235	.204
N_1	.096	.134	.132	.121
N_1P	.128	.114	.136	.126
N_1K	.090	.136	.133	.120
N_1PK	.114	.138	.126	.126
N_2	.086	.117	.152	.118
N_2P	.134	.164	.132	.143
N_2K	.104	.111	.136	.117
N_2PK	.117	.138	.161	.139
N_3	.132	.136	.142	.137
N_3P	.109	.122	.124	.118
N_3K	.098	.134	.123	.118
N_3PK	.108	.132	.126	.122
N_4	.092	.111	.140	.114
N_4P	.117	.154	.151	.141
N_4K	.072	.098	.100	.090
N_4PK	.128	.124	.168	.140

[1] See Table III for details of treatments.
[2] Percentages represent the average of two subsamples.

TABLE XXI

EFFECTS OF RATES OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON POTASSIUM CONTENT OF LAHOMA SUDAN GRASS, GREENHOUSE EXPERIMENT, NORGE FINE SANDY LOAM, STILLWATER, FEBRUARY 7, 1958.

Treatments[1]	% Potassium[2]			
	Rep I	Rep II	Rep III	Mean
Check	3.42	3.45	3.78	3.55
P	2.58	2.73	3.30	2.87
K	3.42	3.39	3.24	3.35
PK	2.58	2.85	3.06	2.83
N_1	3.52	3.51	3.24	3.42
N_1P	2.49	2.42	2.37	2.43
N_1K	3.21	3.60	3.48	3.43
N_1PK	2.76	2.85	2.67	2.76
N_2	3.12	3.15	3.54	3.27
N_2P	2.43	2.52	2.37	2.44
N_2K	3.66	3.21	3.46	3.44
N_2PK	2.67	2.78	3.03	2.83
N_3	3.42	3.16	3.24	3.27
N_3P	2.16	2.25	2.19	2.20
N_3K	3.45	3.48	3.24	3.39
N_3PK	2.67	2.64	2.55	2.62
N_4	3.06	3.12	2.85	3.01
N_4P	1.92	2.14	2.28	2.11
N_4K	2.91	3.22	3.24	3.12
N_4PK	2.79	2.55	2.70	2.68

[1] See Table III for details of treatments.
[2] Percentages represent the average of two subsamples.

80-0-0 80-40-40

Figure 1. Effects of Phosphorus Fertility Treatments on Growth of Lahoma Sudan Grass, Norge Fine Sandy Loam, Paradise Station, Field Experiment, Stillwater, 1957. (See Table II for treatment details and Tables IV and XIII for yield data.)

40-40-0 160-40-40

Figure 2. Effects of Rates of Nitrogen Application on Growth of Lahoma Sudan Grass, Norge Fine Sandy Loam, Paradise Station, Field Experiment, Stillwater, 1957. (See Table II for treatment details and Tables IV and XIII for yield data.)

VITA

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Master of Science

Thesis: EFFECTS OF RATES AND TIME OF NITROGEN FERTILIZER APPLICATION WITH VARIOUS COMBINATIONS OF PHOSPHORUS AND POTASSIUM FERTILITY TREATMENTS ON YIELD AND CHEMICAL COMPOSITION OF LAHOMA SUDAN GRASS FORAGE

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