THE EFFECTS OF DIFFERENT RATES OF NITROGEN FERTILIZER ON FOUR STRAINS OF BERMUDAGRASS

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TABLE OF CONTENTS

LIST OF TABLES

Tables | Page

Tables Page

LIST OF ILLUSTRATIONS

Figures | Page

INTRODUCTION

The effects of nitrogen fertilization on forage grasses are of major concern and have been studied by many investigators. Maximum production of high quality forage with adapted grasses throughout the growing season cannot be attained without an adequate supply of nitrogen. Oklahoma soils, in general, are deficient in organic matter and the problem of soil nitrogen is directly related to the status of soil organic matter.

Warm season grasses differ in their response to application of nitrogen fertilizer. Four strains of Bermudagrass, particularly adapted to Oklahoma conditions, were selected for this study. Bermudagrass has the capability to produce high yields of good quality forage and also has good soil binding properties. In 1906, John Fields, (15)* an early director of the Oklahoma Agricultural Experiment Station, stated, "Of all the grasses tried on the station farm, Bermudagrass alone has shown the qualities which must be possessed by a pasture grass in Oklahoma."

The purpose of this study was to obtain additional information on the effect of different rates of nitrogen fertilizer on the forage production, chemical composition, and efficiency of nitrogen utilization of four strains of Bermudagrass.

* Figures in parenthesis refer to literature cited.

REVIEW OF LITERATURE

Nitrogen Rates

Woodhouse, Chamblee, and Dobson (37) reported that Coastal Bermudagrass fertilized with 100 pounds of nitrogen per acre produced 9,208 pounds of dry forage per acre while the check plots produced 3,597 pounds. Burton and Devane (6) found annual hay yields of Bermudagrass ranged from one ton of hay per acre without nitrogen to eight tons where 400 pounds of nitrogen were used. They stated that 100 pounds of nitrogen per acre produced the most economical yield of hay. In another experiment by Burton, Southwell, and Johnson, (7) it was found that yields of Coastal Bermudagrass hay increased with added increments of nitrogen up to 600-900 pounds per acre and then decreased. They concluded that the heavy rates affected growth adversely.

Smith and Kapp, (33) who worked with Coastal Bermudagrass, found that applications of nitrogen fertilizer produced highly significant increases in yields of forage. They found that combinations of phosphorus and potassium, when used with nitrogen, further increased yields. Prophet (27) concluded in his study on Coastal Bermudagrass that increased rates of nitrogen fertilizer did not result in corresponding increases in yields of forage. Holt, Potts, and Fudge (18) found proper fertilization would greatly increase yields of Bermudagrass. They stated that the lack of nitrogen is most often the factor limiting plant growth.

Elder, (12) who used Midland Bermudagrass, reported hay yields of 3,759, 6,448, 7,356, and 8,580 pounds of dry forage per acre when fertilized with 0, 50, 100, and 200 pounds of nitrogen per acre, respectively.

McCloud (21) found that Coastal Bermudagrass forage fertilized with 540 pounds of nitrogen per acre contained 16 percent protein while the plots that did not receive the nitrogen fertilizer contained only 7.0 percent protein. Burton (4) found that Coastal Bermudagrass hay contained 7.0 percent protein when no nitrogen fertilizer was applied, and 800 pounds of nitrogen per acre produced hay containing 16.0 percent protein. In other studies, Burton (7) found that protein content of Coastal Bermudagrass hay increased with increasing increments of nitrogen up to 1,500 pounds per acre. Coastal Bermudagrass grown under this high nitrogen rate contained 25.5 percent protein. Burton and Devane (6) concluded that nitrogen applications had no significant effect upon the fat, calcium, phosphorus, and potassium content of Coastal Bermudagrass hay. Coastal Bermudagrass hay contained 0.28 to 0.32 percent phosphorus, and 0.84 to 1.02 percent potassium.

Brown and Munsell (3) found that yields from timothy were increased markedly by annual applications of 28 to 56 pounds of nitrogen per acre. Russell, Bourg, and Rhoades (30) noted that Lincoln bromegrass declined in percentage of all elements throughout the growth period. Nitrogen percentage in the forage was higher for fertilized bromegrass than the non-fertilized. Data reported by Eheart and Ellett (11) showed that 100 to 200 pounds of nitrogen per acre applied on bluegrass sod increased the protein and had no effect upon the phosphorus. Brown (2) reported that 56 pounds of nitrogen per acre decreased the potassium but had no effect upon the phosphorus content of pasture grasses. Data obtained from an experiment conducted on bluegrass sod

(22) indicated that increases in the amount of nitrogen fertilizer gave a corresponding increase in the yield of protein.

An average recovery of 23.0 percent of the nitrogen applied was obtained on two bluegrass pastures in West Virginia. This experiment was conducted over a seven-year period by Robinson and Pierre (28). In 1929, Welton and Salter (36) reported on efficiencies of nitrogen utilization from timothy hay. They used sodium nitrate as the nitrogen carrier and reported efficiencies of 7.0, 48.7, 33.9, and 39.0 percent when timothy plots were fertilized with 50, 100, 200, and 400 pounds of sodium nitrate per acre, respectively.

Nitrogen Carriers

Eheart and Ellett (11) concluded that sodium nitrate was superior as a nitrogen carrier over ammonium sulfate and urea on Kentucky bluegrass sod.

McClure, (22) who used nine nitrogen carriers, reported that only cyanamide caused a decrease in yield on Kentucky bluegrass. In his observations he noted that the decrease in yield was caused by the toxic effect of this material on the grass. Burton and Devane (6) found relative yields of 100, 102, 86, and 77 from Coastal Bermudagrass when fertilized with nitrate of soda, ammonium nitrate, cyanamide, and uramon, respectively. They stated that sodium nitrate and ammonium nitrate produced hay that contained significantly more protein than uramon and cyanamide.

Time and Number of Nitrogen Applications

Dodd, (9) who worked with Kentucky bluegrass, concluded that nitrogen fertilizer applied early in the spring increased the production not only in the early spring but throughout the growing season. The increased production late in the season was very small and inadequate to meet the mid-summer pasture shortage. Brown and Munsell (3) found that the most uniform seasonal distribution of pasturage was obtained by adding nitrogen only in the summer, but the returns per unit of nitrogen were about one-half of those from the spring treatments. Robinson and Pierre (28) reported that summer applications of nitrogen did not produce satisfactory increases in yield unless soil moisture was adequate. Burton and Devane (6) found that splitting the applications of nitrogen in wet seasons significantly increased yields from Bermudagrass but had no effect in a season of average rainfall.

Munsell and Brown (23) reported that the greatest recovery of nitrogen from bluegrass and bentgrass was obtained on plots receiving nitrogen in April. Nitrogen applied in August was the least efficient. Burton and Devane (6) found that the recovery of sodium nitrate nitrogen applied in four split applications was 42.4, 60.2, 65.7, and 64.4 percent for rates of 50, 100, 200, and 400 pounds of nitrogen, respectively.

Varietal Response

Elder (13) found that Greenfield produced more forage on the low-fertility, medium to fine-textured soils than Midland Bermudagrass. Langford and Evans (20) concluded that Coastal Bermudagrass was more responsive to high rates of nitrogen and more productive at all levels of nitrogen than common Bermudagrass and Pensacola Bahiagrass. Woodhouse, Chamblee, and Dobson (37) reported that Coastal Bermudagrass produced 9,258 pounds of dry forage per acre and common Bermudagrass produced 3,444 pounds. Workers in Texas (18) found that yields of dry forage were greater with Coastal than that of common Bermudagrass. Harlan, Burton, and Elder

(17) concluded that Midland is two to four times as productive as unselected common Bermudagrasses on medium to high fertility soils. They noted that Midland was no more productive than common Bermudagrass on low fertility soils. In tests conducted at Stillwater, Oklahoma, Midland produced higher yields of forage than Coastal and common Bermudagrass. They found the percent protein to be lower in Midland than in Oklahoma common Bermudagrass.

Nitrogen recovery was calculated by Enlow and Coleman (14) on Bahia, centipede, and carpetgrass. These grasses received four applications of ammonium sulfate at the rate of 16.16 pounds per acre. Nitrogen recovery for Bahia, centipede and carpetgrass was 32.1, 22.3, and 48.3 percent, respectively.

Devane, Stelly, and Burton (8) concluded that the effect of Bermudagrass strains in altering the soil organic matter was not significant although one of the strains tended to produce a higher organic matter content between the different nitrogen treatments. Organic matter tended to be higher under Bermudagrass and Bahiagrass than in adjacent cultivated fields.

Burton (4) noted that Coastal Bermudagrass tended to produce a sod containing fewer weeds than from sods of common Bermudagrass.

Prophet (27) reported that the application of high rates of nitrogen did not greatly influence the need for additional soil moisture. Burton (5) concluded from studies that an acre of plants used about the same amount of water regardless of the amount of fertilizer applied. Kimbrough, Wise, and McGuire (19) found that irrigation did not produce economical increases in yields from Coastal Bermudagrass. Fisher and Caldwell (16) suggested that 800 pounds of nitrogen per acre were not enough to produce maximum yields from irrigated Coastal Bermudagrass.

SOILS USED IN GREENHOUSE AND FIELD STUDIES

Stephenville Loamy Fine Sand

The Stephenville series (35) occurs principally in the West Cross Timber section of the state and is developed from weathered residue of sandstone. Topography is rolling hills (2 to 10% slopes) with occasional flat areas. Surface and internal drainage is moderate. Native vegetation is chiefly post oak, with hickory and other trees. This soil is low in inherent fertility but is productive with good soil management practices.

A soil sample of this series was taken from a field, NW 1/4, section 14, township 4S, range 1W located on the Noble Foundation Lone Grove Farm in Carter County, Oklahoma.

Kirkland Fine Sandy Loam

The Kirkland series (35) are Reddish Prairie soils developed from beds of red calcareous clay. Topography is relatively smooth, flat lands with slopes mostly less than 2%. Surface drainage is slow to moderate and internal drainage is very slow. The native vegetation is chiefly tall prairie grasses.

A soil sample of this series was taken from a field, NW 1/4, section 27, township 4S, range 2E located on the Noble Foundation Headquarters Farm in Carter County, Oklahoma.

EXPERIMENTAL PROCEDURES

Greenhouse Studies

The objectives of this study were to obtain information on the effect of different rates of nitrogen fertilization on the forage production, chemical composition, and efficiency of nitrogen utilization on four strains of Bermudagrass.

The physical and chemical properties of the Stephenville soil are presented in Table I.

A uniform application of monocalcium phosphate, potassium chloride, and ES-MIN-EL (a trace element mixture marketed by the Tennessee Corporation), was used that enabled the potted soils to be fertilized at the rates equivalent to 690 pounds of P_2O_5, 360 pounds of K_2O, and 50 pounds of ES-MIN-EL calculated on an acre basis. Ammonium nitrate was applied at rates equivalent to 0, 50, 100, 200, and 400 pounds of elemental nitrogen per acre. The nitrogen was applied in increments supplying 1/4 of the total rate used on each of the following dates: August 2, September 14, November 2, 1955 and April 2, 1956.

Nitrogen fertilizer treatments on the four strains of Bermudagrass were as follows:

NH_4NO_3 applied, lbs. of nitrogen/acre

(1) Check (no treatment)
(2) 50-0-0
(3) 100-0-0
(4) 200-0-0
(5) 400-0-0

TABLE I.

SOME PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOIL MATERIALS USED IN THE GREENHOUSE AND FIELD EXPERIMENTS.

	Stephenville Loamy Fine Sand	Kirkland Fine Sandy Loam
Sand	86.50%	62.25%
Silt	8.75%	28.25%
Clay	4.75%	9.50%
pH	6.4	6.7
Organic Matter	.83%	.98%
Total Exchange Capacity	2.89 meq./100 grams	5.96 meq./100 grams
Total nitrogen	.038%	.045%
Available phosphorus	4 lbs./acre	23 lbs./acre
Exchangeable potassium	60 lbs./acre	246 lbs./acre

Nine thousand five hundred grams of air-dry soil were placed in each of a sufficient number of two-gallon glazed, earthenware pots to enable all treatments to be made in quadruplicate.

On April 21, 1955, rhizomes from Midland, Coastal, Greenfield, and a local common Bermudagrass were sprigged in their respective pots. The sprigs in each pot were selected so as to contain forty nodes.

The design of the experiment was a split plot, randomized block design with four replications. Four strains of Bermudagrass were used as main plots and five rates of nitrogen as sub-plots.

The soil in each pot was watered with demineralized water and the soil moisture was kept at a high level and as uniform as possible between all pots.

On August 1, 1955, the above ground portion of the plants was harvested. This harvest of Bermudagrass was discarded and the first increment of nitrogen was applied August 2, 1955. The nitrogen fertilization was delayed until this date so that the Bermudagrass strains would become established and absorb available soil nitrogen that was present at the time of sprigging. Five additional harvests were made and the relative growth is indicated by oven-dry weight as presented in Tables II and XIX.

The results of the nitrogen, phosphorus, potassium analyses on the Bermudagrass harvested forage are presented in Tables V, XX, XXI, and XXII.

The efficiency of nitrogen utilization was calculated and is presented in Table VI.

Composite soil samples were taken from each of the four replications at the termination of the experiment. The results of the analyses for pH, organic matter, available phosphorus, and exchangeable potassium are presented in Table VII.

After the soil samples had been taken, the Bermudagrass roots were washed free of soil and dried in an oven. Oven-dry weights were taken and the roots were analyzed for nitrogen, phosphorus, and potassium. These results are presented in Table VIII.

Field Studies

An experiment was set up on the Noble Foundation Headquarters farm to study the effects of rate of nitrogen fertilization on the forage production, chemical composition, and efficiency of nitrogen utilization on four strains of Bermudagrass under field conditions.

A site with uniform soil conditions and slope was selected from the field. The soil occupying this location is classified as Kirkland fine sandy loam. The physical and chemical properties are presented in Table I.

Previous to sprigging, the entire area received a uniform application of triple superphosphate and potassium chloride equivalent to 106 pounds of P_2O_5 and 60 pounds of K_2O per acre. These fertilizers were applied with a Gandy hand fertilizer spreader. Ammonium nitrate was applied by hand at rates equivalent to 0, 50, 100, 200, and 400 pounds of elemental nitrogen per acre.

The nitrogen fertilizer was applied in two equal applications, one-half May 18, and one-half July 2, 1956. The designation of the nitrogen fertilizer treatments is the same as described in the greenhouse experiment.

On April 11, 1956, Midland, Coastal, Greenfield, and a local common Bermudagrass were sprigged at random on 12.5 by 20-foot plots with four replications. The plots were marked off into one-foot squares and the sprigs were planted on one-foot centers.

After the Bermudagrass strains had become established, the 12.5 by

20-foot plots were subdivided into 5 by 12.5-foot plots. The first increments of nitrogen fertilizer were applied to these 5 by 12.5-foot plots May 18, 1956.

The design of the experiment was a latin square split plot including four strains of Bermudagrass, five levels of nitrogen with four replications.

The Bermudagrass forage was harvested with a rotary-type mower set to cut two inches above the ground. The first harvest was made July 2, 1956 and the second and last harvest was made August 16, 1956. A 3.5 by 11-foot strip was harvested from each plot. The oven dry forage converted to pounds per acre is reported in Tables IX and XXIII.

Analyses of the Bermudagrass forage for nitrogen, phosphorus, and potassium are presented in Tables XIII, XXIV, XXV, and XXVI.

The efficiency of nitrogen utilization was calculated and is presented in Tables XIV and XXVII.

The Bermudagrass plots received a total of 18.75 inches of water from April 10 to July 27, 1956. Rainfall contributed 8.60 inches and 10.15 inches of water were applied by sprinkler irrigation. The fifty-year average rainfall at Ardmore, Oklahoma during this period is 20.65 inches. The last irrigation was applied July 27, 1956.

Percent of weeds and foreign grasses was estimated on the plots June 29, 1956. The results of this estimation are reported in Table XVII.

Composite soil samples were taken August 20, 1956. Analyses of the soil samples for pH, organic matter, available phosphorus, and exchangeable potassium are presented in Table XVII.

Analysis of Soil

Samples from each of the soils used in the greenhouse and field studies were taken into the laboratory and prepared for analysis by crushing with a wooden roller and sieving through a twenty-mesh screen. The results of the physical and chemical properties are reported in Table I.

The soil texture was determined by the method of Bouyoucos (1). The pH determinations were made essentially by the method described by Peech and English (26). Soil organic matter was determined by the method of Schollenberger (31). The exchange capacity was determined by the method described by Russel (29).

The available phosphorus was determined by the method of Olsen, Cole, Watanabe, and Dean (24). Exchangeable potassium was determined by the method of Peech, Dean, and Reed (25) and readings were made on model 52C, Perkin Elmer flame photometer.

Analysis of Forage

Forage samples from the greenhouse and field studies were dried in an oven at 180° F. and ground to pass a twenty-mesh screen.

Total nitrogen was determined by the method described by Russel (29) and modified for semi micro analysis. Phosphorus was determined by the method of Shelton and Harper (32). Potassium was determined by digestion, as described by Shelton and Harper, and reading on the Model 52C, Perkin Elmer flame photometer.

Statistical Analysis

Forage yields were analyzed statistically. Analysis of variance for significant differences and coefficients of variations was determined by methods outlined by Snedecor (34). Duncan's (10) multiple range test was used as an aid in interpreting the data when significant values were obtained by the analysis of variance.

RESULTS AND DISCUSSION

Greenhouse Studies

The results reported from the greenhouse experiment are concerned primarily with the forage yields, chemical composition, efficiency of nitrogen utilization, chemical characteristics of the Stephenville soil, yields, and chemical composition of Bermudagrass roots as affected by various nitrogen fertilizer treatments.

Forage Yields

Forage yields and analyses of variance data are reported in Tables II and XIX. Multiple range test results are presented in Tables III and IV. Mean yields for Bermudagrass strains obtained by averaging the five nitrogen treatments are: Midland, 32.71; Coastal, 36.83; Greenfield, 31.51; and common Bermudagrass 33.40 grams, respectively. Forage yields were significantly different at the 5 percent level.

Forage yields increased with additional increments of nitrogen (Figure 1). Mean yields (grams) for nitrogen treatments obtained by averaging the four Bermudagrass strains are: check (no fertilizer)*, 18.00; 50-0-0, 28.50; 100-0-0, 37.52; 200-0-0, 41.81; and 400-0-0, 42.25 grams. Response to rates of nitrogen fertilization was significantly different at the one percent level.

The multiple range tests indicate that there was a significant difference between Coastal mean yield and the other three Bermudagrass strains.

*Check (no fertilizer)
50-0-0, 50 lbs. per acre of elemental nitrogen
100-0-0, 100 lbs. per acre of elemental nitrogen
200-0-0, 200 lbs. per acre of elemental nitrogen
400-0-0, 400 lbs. per acre of elemental nitrogen

TABLE II.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON FORAGE YIELDS OF MIDLAND, COASTAL, GREENFIELD AND COMMON BERMUDA-GRASS, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955.

Treatment (lbs./acre)	Oven-dry forage, grams per pot				
	Midland	Coastal	Greenfield	Common	$\bar{X}$
Check (no nitrogen)	16.04	19.25	17.22	19.49	18.00
50-0-0	28.80	31.94	25.74	27.52	28.50
100-0-0	38.11	40.97	34.50	36.49	37.52
200-0-0	41.46	45.85	38.94	41.00	41.81
400-0-0	39.16	46.16	41.17	42.50	42.25
$\bar{X}$	32.71	36.83	31.51	33.40	33.61

All pots received the equivalent of 690 lbs. P_2O_5, 360 lbs. K_2O, and 50 lbs. ES-MIN-EL per acre. Each yield figure represents the mean of accumulated total of five clippings and four replications.

Analysis of variance of yield data

Source	DF	SS	MS	F
Replications	3	56.51	18.84	1.10
Strains	3	316.31	105.44	6.14*
Reps. X Strains	9	154.63	17.18	
Nitrogen	4	6831.70	1707.92	214.29**
Strains X Nitrogen	12	93.85	7.82	.98
Error	48	382.37	7.97	
Total	79	7835.37		

C. V. 8.40%

* Denotes significance at the 5 percent probability level.

** Denotes significance at the 1 percent probability level.

TABLE III.

MULTIPLE RANGE TEST SHOWING AVERAGE FORAGE YIELDS (GRAMS) OF BERMUDAGRASS STRAINS GROWN WITH FIVE RATES OF NITROGEN FERTILIZER, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955. (SEE TABLE II FOR YIELD AND A.O.V. DATA.)

s_m = .630 (5% p. level)

Greenfield	Midland	Common	Coastal
31.51	32.71	33.40	36.83

TABLE IV.

MULTIPLE RANGE TEST SHOWING AVERAGE FORAGE YIELDS (GRAMS) FROM VARIOUS NITROGEN TREATMENTS ON FOUR STRAINS OF BERMUDAGRASS, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955. (SEE TABLE II FOR YIELD AND A.O.V. DATA.)

s_m = .707 (1% p. level)

Check	50-0-0	100-0-0	200-0-0	400-0-0
18.00	28.50	37.52	41.81	42.25

Note: Any two means not underscored by the same line are significantly different.

Any two means underscored by the same line are not significantly different.

Forage yield of common Bermudagrass was significantly different from Greenfield, but there was no significant difference between Midland and Greenfield. All levels of nitrogen treatments were significantly different from the check. There was no significant difference between the 200-0-0 and 400-0-0. Nitrogen levels of 200-0-0 and 400-0-0 were significantly different from the 50-0-0 and 100-0-0. There was a significant difference between the 50-0-0 and 100-0-0. There was no significant difference between the interaction of Bermudagrass strains times rates of nitrogen fertilizer. Coefficient of variation for these data was 8.40%.

Chemical Composition

Nitrogen composition:

Chemical composition data are presented in Tables V, XX, XXI, and XXII. Increased rates of nitrogen fertilizer increased the percent nitrogen in the forage of Bermudagrass strains, with the exception of 50-0-0, applied to Midland and Coastal. Percent nitrogen means for Bermudagrass strains obtained by averaging the five nitrogen treatments are: Midland, 1.63%; Coastal, 1.72%; Greenfield, 1.76%; and common Bermudagrass, 1.61%. Percent nitrogen means in the forage were highest early in the growing season and then declined with each successive clipping, Table XX.

Phosphorus composition:

Percent phosphorus increased with higher rates of nitrogen fertilizer, Tables V and XXI. Percent phosphorus mean for Greenfield was the highest of the four Bermudagrass strains. Percent phosphorus means for the nitrogen treatments are: check, .32%; 50-0-0, .30%; 100-0-0, .33%; 200-0-0, .39%; and 400-0-0, .42%.

TABLE V.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT NITROGEN, PHOSPHORUS, AND POTASSIUM IN MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS FORAGE, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
			Nitrogen		
Check (no nitrogen)	1.12	1.27	1.18	1.08	1.16
50-0-0	1.11	1.11	1.32	1.09	1.16
100-0-0	1.27	1.66	1.74	1.35	1.50
200-0-0	1.88	2.05	2.15	1.97	2.01
400-0-0	2.77	2.52	2.44	2.56	2.57
$\bar{X}$	1.63	1.72	1.76	1.61	1.68
			Phosphorus		
Check (no nitrogen)	.35	.27	.33	.33	.32
50-0-0	.31	.27	.32	.32	.30
100-0-0	.33	.31	.36	.34	.33
200-0-0	.40	.33	.44	.41	.39
400-0-0	.45	.36	.44	.42	.42
$\bar{X}$	.37	.31	.38	.36	.36
			Potassium		
Check (no nitrogen)	1.25	1.25	1.41	1.29	1.30
50-0-0	1.40	1.13	1.48	1.32	1.33
100-0-0	1.49	1.43	1.76	1.48	1.54
200-0-0	1.83	1.68	1.89	1.78	1.79
400-0-0	1.99	1.67	1.89	1.69	1.81
$\bar{X}$	1.59	1.43	1.69	1.51	1.55

Each figure represents the mean of duplicate analysis on composite samples obtained by combining five clippings and four replications.

Potassium composition:

The potassium trend in the Bermudagrass forage was somewhat like the nitrogen and phosphorus in that it tended to be higher with increased rates of nitrogen fertilizer. Potassium content of the forage was progressively lower with each harvest, with the exception of the fifth harvest, as shown in Table XXII.

Nitrogen Utilization

Percent nitrogen utilization is presented in Table VI. The percent nitrogen utilization was calculated by this method: (Plots that received nitrogen) first clipping yields times percent nitrogen plus second clipping yields times percent nitrogen minus (Check plots) first clipping yields times percent nitrogen plus second clipping yields times percent nitrogen divided by nitrogen applied times 100 equals percent nitrogen utilization. Greenfield fertilized with 100-0-0 had the highest percent of nitrogen utilization. Percent nitrogen utilization means for Bermudagrass strains obtained by averaging the five nitrogen treatments are: 55.33%, 51.42%, 51.50%, and 47.39% for Midland, Coastal, Greenfield, and common Bermudagrass respectively. Percent nitrogen utilization means for nitrogen treatments obtained by averaging the four Bermudagrass strains are: 50-0-0, 43.48%; 100-0-0, 60.58%; 200-0-0, 58.57%, and 400-0-0, 43.00%. The highest percent of nitrogen utilization for Midland, Coastal, and Greenfield was with the 100-0-0, while 200-0-0 was the highest with common Bermudagrass.

Soil Chemical Composition

The greenhouse experiment soil chemical characteristics are shown in Table VII.

Soil acidity apparently increased with increased rates of nitrogen fertilizer for all Bermudagrass strains. Available phosphorus did not change appreciably with varying rates of nitrogen fertilizer. Exchangeable potassium decreased with increased rates of nitrogen fertilizer. Soil organic matter increased when fertilized with successive higher rates of nitrogen fertilizer.

Percent organic matter mean for the soil taken from pots containing Greenfield fertilized with all levels of nitrogen was .88% and was the highest of the four Bermudagrass strains.

TABLE VI.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT OF NITROGEN UTILIZATION OF MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
Check (no nitrogen)	--	--	--	--	--
50-0-0	56.88	36.12	45.98	34.95	43.48
100-0-0	60.02	64.14	65.39	52.78	60.58
200-0-0	58.90	61.71	55.48	58.19	58.57
400-0-0	45.51	43.72	39.14	43.64	43.00
$\bar{X}$	55.33	51.42	51.50	47.39	51.41

Each figure represents the mean of five clippings and four replications.

TABLE VII.

SOIL pH, AVAILABLE PHOSPHORUS, EXCHANGEABLE POTASSIUM, AND PERCENT ORGANIC MATTER, STEPHENVILLE SOIL FOLLOWING MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS, GREENHOUSE EXPERIMENT, ARDMORE, 1955.

Treatment (lbs./acre)	pH	Avail. P lbs./acre	Exc. K lbs./acre	% O.M.
		Midland		
Check (no nitrogen)	6.2	83	200	.65
50-0-0	6.2	67	150	.73
100-0-0	6.0	77	120	.75
200-0-0	5.9	68	120	.90
400-0-0	5.7	67	100	.90
$\bar{X}$		72	138	.79
		Coastal		
Check (no nitrogen)	6.1	84	200	.78
50-0-0	6.1	76	170	.73
100-0-0	6.0	68	140	.80
200-0-0	5.8	68	110	.85
400-0-0	5.5	73	130	.88
$\bar{X}$		73	150	.80
		Greenfield		
Check (no nitrogen)	6.2	87	210	.83
50-0-0	6.1	76	170	.90
100-0-0	5.9	68	140	.88
200-0-0	5.7	68	120	.93
400-0-0	5.5	67	120	.88
$\bar{X}$		73	154	.88
		Common		
Check (no nitrogen)	6.2	80	180	.83
50-0-0	6.1	76	150	.90
100-0-0	6.1	81	140	.83
200-0-0	6.0	90	120	.90
400-0-0	5.7	72	100	.90
$\bar{X}$		80	138	.87

Each figure represents the mean of duplicate chemical analysis on composite samples obtained by combining four replications.

Root Yields

Yield of roots and chemical composition data is presented in Table VIII. Mean yields in grams per pot for Bermudagrass roots obtained by averaging the five nitrogen treatments are Midland, 28.41; Coastal, 36.60; Greenfield, 26.58; and common Bermudagrass, 30.24 grams. Coastal produced the highest yield of roots and Greenfield had the lowest yield.

Chemical Composition

Nitrogen composition:

In general, increasing rates of nitrogen fertilizer increased the percent nitrogen in the roots of Bermudagrass strains. Percent nitrogen means for Bermudagrass strains obtained by averaging the five nitrogen treatments are: Midland, .91%; Coastal, .72%; Greenfield, .88%; and common Bermudagrass, .97%.

Phosphorus composition:

Percent phosphorus in the roots of the Bermudagrass strains was not affected appreciably by various rates of nitrogen fertilizer. Percent phosphorus means for Bermudagrass strains obtained by averaging the five nitrogen treatments are Midland, .27%; Coastal, .25%; Greenfield, .33%; and common Bermudagrass, .29%.

Potassium composition:

In general, increasing rates of nitrogen fertilizer decreased the percent potassium in the roots of the four Bermudagrass strains.

Percent potassium means for Bermudagrass strains are: Midland, .47%; Coastal, .44%; Greenfield, .69%; and common Bermudagrass, .49%.

TABLE VIII.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON OVEN-DRY WEIGHT, PERCENT NITROGEN, PHOSPHORUS, AND POTASSIUM IN MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS ROOTS, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955.

Treatment (lbs./acre)	Oven-dry weight Yield in grams /pot	N	P	K
		Midland		
Check (no fertilizer)	17.93	.55	.29	.66
50-0-0	27.18	.55	.26	.50
100-0-0	33.25	.59	.26	.46
200-0-0	36.70	.98	.26	.40
400-0-0	26.97	1.86	.28	.34
$\bar{X}$	28.41	.91	.27	.47
		Coastal		
Check (no fertilizer)	23.31	.51	.24	.52
50-0-0	28.62	.57	.26	.48
100-0-0	35.97	.57	.26	.52
200-0-0	44.79	.64	.27	.40
400-0-0	50.31	1.32	.24	.30
$\bar{X}$	36.60	.72	.25	.44
		Greenfield		
Check (no fertilizer)	20.25	.56	.34	.80
50-0-0	24.00	.50	.30	.72
100-0-0	30.62	.52	.32	.82
200-0-0	28.43	1.01	.37	.70
400-0-0	29.60	1.79	.34	.42
$\bar{X}$	26.58	.88	.33	.69
		Common		
Check (no fertiliber)	20.48	.62	.32	.70
50-0-0	32.87	.62	.26	.52
100-0-0	31.72	.61	.28	.50
200-0-0	33.80	1.05	.28	.40
400-0-0	32.34	1.97	.31	.34
$\bar{X}$	30.24	.97	.29	.49

Each yield figure represents the mean of four replications. The nitrogen, phosphorus, and potassium figures represent the mean of duplicate analysis on composite samples obtained by combining four replications.

Field Studies

The results reported in the field studies are concerned primarily with the forage yields, chemical composition, and efficiency of nitrogen utilization. Chemical characteristics of Kirkland soil and an estimation of weeds and foreign grasses of Bermudagrass strains as affected by various nitrogen fertilizer treatments are also reported.

Forage Yields

Forage yields and analysis of variance data are reported in Tables IX and XXIII. Multiple range test results are presented in Tables X, XI, and XII. Mean yields, oven-dry forage pounds per acre, for Bermudagrass strains obtained by averaging the five nitrogen treatments are: Midland, 5314; Coastal, 5704; Greenfield, 2641; and common Bermudagrass, 2293 pounds per acre, respectively, and were significantly different at the one percent level. Midland and Coastal with all levels of nitrogen fertilizer produced more than twice as much forage as did Greenfield and common. The mean yields of Midland and Coastal indicate that these two strains were similar in yield response to nitrogen fertilization.

Mean yields for nitrogen treatments obtained by averaging the four Bermudagrass strains are: check (no fertilizer), 2138; 50-0-0, 3312; 100-0-0, 4102; 200-0-0, 5264; and 400-0-0, 5079 pounds of forage per acre. Yield differences were significantly different at the one percent level. Mean yields for nitrogen treatments increased markedly with higher rates of nitrogen fertilizer, (Figure 2), with the exception of the 400-0-0 when compared with the 200-0-0. The 400-0-0 rate of nitrogen affected growth adversely (7). Mean yields for the check (no fertilizer) plots produced about one-half as much forage as the 100-0-0 with all Bermudagrass strains.

TABLE IX.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON FORAGE YIELDS OF MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDA-GRASS, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956.

Treatment (lbs./acre)	Oven-dry forage, pounds per acre				
	Midland	Coastal	Greenfield	Common	$\bar{X}$
Check (no nitrogen)	2908	3445	1310	1069	2183
50-0-0	4797	5154	1533	1762	3312
100-0-0	5683	5635	2769	2322	4102
200-0-0	6172	7476	3731	3680	5265
400-0-0	7012	6808	3861	2633	5079
$\bar{X}$	5314	5704	2641	2293	3988

All plots received the equivalent of 106 lbs. P_2O_5 and 60 lbs. K_2O per acre. Each yield figure represents the mean of accumulated total of two clippings and four replications.

Analysis of variance of yield data

Source	DF	SS	MS	F
Columns	3	27823814.00	9274604.66	6.90
Rows	3	7760278.00	2586759.33	1.92
Strains	3	187781845.00	62593948.30	46.54**
Reps. X Strains	6	8068848.00	1344808.00	
Nitrogen	4	104775763.00	26193940.70	59.03**
Strains X Nitrogen	12	11602109.00	966842.42	2.18*
Error	48	21300154.00	443753.21	
Total	79	369112811.00		

C. V. 16.81%

* Denotes significance at the 5 percent probability level

** Denotes significance at the 1 percent probability level

TABLE X.

MULTIPLE RANGE TEST SHOWING AVERAGE OVEN-DRY FORAGE YIELDS OF BERMUDAGRASS STRAINS GROWN WITH FIVE RATES OF NITROGEN FERTILIZER, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956. (SEE TABLE IX FOR YIELD AND A.O.V. DATA).

$S_m = 148.95$ (1% p. level)

Common	Greenfield	Midland	Coastal
2293	2641	5314	5704

TABLE XI.

MULTIPLE RANGE TEST SHOWING AVERAGE FORAGE YIELDS FROM VARIOUS NITROGEN TREATMENTS ON FOUR STRAINS OF BERMUDAGRASS, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956. (SEE TABLE IX FOR YIELD AND A.O.V. DATA).

$S_m = 166.54$ (1% p. level)

Check	50-0-0	100-0-0	400-0-0	200-0-0
2183	3312	4102	5079	5265

Note: Any two means not underscored by the same line are significantly different.
Any two means underscored by the same line are not significantly different.

TABLE XII.

MULTIPLE RANGE TEST SHOWING INTERACTION OF BERMUDAGRASS STRAINS WITH VARIOUS RATES OF NITROGEN FERTILIZER ON FORAGE YIELDS, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956. (SEE TABLE IX FOR YIELD AND A.O.V. DATA).

(5% p. level)

Coastal 200-0-0, 7476	—															
Midland 400-0-0, 7012	—	—														
Coastal 400-0-0, 6808	—	—	—													
Midland 200-0-0, 6172		—	—	—												
Midland 100-0-0, 5683				—	—											
Coastal 100-0-0, 5635				—	—	—										
Coastal 50-0-0, 5154				—	—	—	—									
Midland 50-0-0, 4797					—	—	—	—								
Greenfield 400-0-0, 3861						—		—	—							
Greenfield 200-0-0, 3731									—	—						
Common 200-0-0, 3680									—	—	—					
Coastal check, 3445									—	—	—	—				
Midland check, 2908									—	—	—	—	—			
Greenfield 100-0-0, 2769										—	—	—	—	—		
Common 400-0-0, 2633											—	—	—	—		
Common 100-0-0, 2322												—	—	—	—	
Common 50-0-0, 1762														—	—	—
Greenfield 50-0-0, 1533															—	—
Greenfield check, 1310															—	—
Common check, 1069																—

Note: Any two means not underscored by the same line are significantly different.
Any two means underscored by the same line are not significantly different.

Mean yields for Bermudagrass strains X rates of nitrogen fertilizer interaction were significantly different at the 5 percent level. Greenfield and common fertilized with 200-0-0 produced slightly higher yields than did Coastal with no nitrogen fertilizer. Coastal produced the highest forage yield and this yield was obtained with the 200-0-0 rates of nitrogen. Coefficient of variation for these data was 16.81%.

The multiple range test indicates that significant difference between mean yields existed when comparing Midland and Coastal with Greenfield and common at the various rates of nitrogen. There was no significant difference between Greenfield and common. This was also true with Midland and Coastal. All rates of nitrogen fertilizer were significantly different from the check. Rate of 400-0-0 was significantly lower than the 200-0-0.

There was a significant interaction between Bermudagrass strains and rates of nitrogen fertilizer, Table XII. Coastal fertilized with 200-0-0, Midland fertilized with 400-0-0, and Coastal fertilized with 400-0-0, all were significantly different from all other rates of nitrogen fertilizer applied to those respective strains. Midland and Coastal fertilized with 50-0-0 gave significantly higher yields of forage than Greenfield and common Bermudagrass fertilized with 400-0-0.

Chemical Composition

Nitrogen composition:

Increased rates of nitrogen fertilizer increased the percent nitrogen in the forage of Bermudagrass strains, Tables XIII and XXIV. Percent nitrogen means for Bermudagrass strains with all nitrogen fertility levels are: Midland, 1.80%; Coastal, 1.82%; Greenfield, 2.03%; and common Bermudagrass, 2.06%, respectively. Nitrogen percent, in general, was lower in the second harvest up to and including the 100-0-0 than in the first harvest.

TABLE XIII.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT NITROGEN, PHOSPHORUS, AND POTASSIUM IN MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS FORAGE, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
			Nitrogen		
Check (no nitrogen)	1.35	1.46	1.55	1.52	1.47
50-0-0	1.53	1.66	1.62	1.81	1.65
100-0-0	1.67	1.73	1.90	2.05	1.84
200-0-0	2.10	1.95	2.38	2.27	2.17
400-0-0	2.37	2.28	2.70	2.65	2.50
$\bar{X}$	1.80	1.82	2.03	2.06	1.93
			Phosphorus		
Check (no nitrogen)	.18	.17	.18	.18	.18
50-0-0	.18	.16	.18	.18	.17
100-0-0	.18	.17	.18	.18	.18
200-0-0	.18	.16	.18	.18	.17
400-0-0	.20	.17	.19	.19	.19
$\bar{X}$	.18	.17	.18	.18	.18
			Potassium		
Check (no nitrogen)	1.23	1.31	1.21	1.35	1.27
50-0-0	1.44	1.41	1.31	1.53	1.42
100-0-0	1.52	1.52	1.54	1.77	1.59
200-0-0	1.56	1.63	1.66	1.82	1.67
400-0-0	1.74	1.72	1.67	1.90	1.76
$\bar{X}$	1.50	1.52	1.48	1.68	1.54

Each figure represents the mean of duplicate analysis on composite samples obtained by combining two clippings and four replications.

Midland and Coastal were comparable in nitrogen percent as were Greenfield and common. Greenfield and common were higher in percent nitrogen than Midland and Coastal.

Phosphorus composition:

Phosphorus composition data are presented in Tables XIII and XXV. Nitrogen fertility rates did not affect the phosphorus content appreciably in the Bermudagrass strains. All Bermudagrass strains contained approximately the same percent phosphorus.

Potassium composition:

Percent potassium increased in all Bermudagrass strains with increased rates of nitrogen fertilization. Percent potassium means were: Midland, 1.50%; Coastal, 1.52%; Greenfield, 1.48%; and common Bermudagrass, 1.68%. Percent potassium was higher in the second harvest than the first, Table XXVI.

Nitrogen Utilization

Percent nitrogen utilized by the plants is presented in Tables XIV and XXVII. Multiple range test results are shown in Tables XV and XVI. Percent nitrogen utilization means for Bermudagrass strains obtained by averaging the four nitrogen treatments are: Midland, 49.10%; Coastal, 47.78%; Greenfield, 23.78%; and common Bermudagrass, 25.80%, and were significantly different at the 5 percent level. Percent nitrogen utilization means for nitrogen treatments obtained by averaging the four Bermudagrass strains are: 50-0-0, 44.55%; 100-0-0, 41.09%; 200-0-0, 38.77%; and 400-0-0, 22.05%, and were significantly different at the 1 percent level. There was no significant difference between the interaction of Bermudagrass strains X rates of nitrogen. Coastal had the highest percent of

TABLE XIV.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT OF NITROGEN UTILIZATION OF MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
Check (no nitrogen)	--	--	--	--	--
50-0-0	68.00	72.45	8.75	29.00	44.55
100-0-0	55.55	47.58	32.80	28.43	41.09
200-0-0	42.36	46.03	33.16	33.54	38.77
400-0-0	30.50	25.06	20.42	12.23	22.05
$\bar{X}$	49.10	47.78	23.78	25.80	36.61

Each figure represents the mean for two clippings and four replications.

Source	DF	SS	MS	F
Columns	3	4320.92	1440.31	
Rows	3	1465.31	488.44	
Strains	3	8994.76	2998.25	4.87*
Reps. X Strains	6	3697.64	616.27	
Nitrogen	3	4795.85	1598.62	5.23**
Strains X Nitrogen	9	5548.72	616.52	2.02
Error	36	11012.70	305.91	
Total	63	29835.90		

C.V. 47.76%

* Denotes significance at the 5 percent probability level.

** Denotes significance at the 1 percent probability level.

TABLE XV.

MULTIPLE RANGE TEST SHOWING AVERAGE PERCENT OF NITROGEN UTILIZATION OF BERMUDAGRASS STRAINS WITH FIVE RATES OF NITROGEN FERTILIZER, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956. (SEE TABLE XIV FOR PERCENT NITROGEN UTILIZATION AND A.O.V. DATA).

$S_m = 4.372$ (5% p. level)

Greenfield	Common	Coastal	Midland
23.78	25.80	47.78	49.10

TABLE XVI.

MULTIPLE RANGE TEST SHOWING AVERAGE PERCENT OF NITROGEN UTILIZATION FROM VARIOUS NITROGEN TREATMENTS ON FOUR STRAINS OF BERMUDAGRASS, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956. (SEE TABLE XIV FOR PERCENT NITROGEN UTILIZATION AND A.O.V. DATA).

$S_m = 4.372$ (1% p. level)

400-0-0	200-0-0	100-0-0	50-0-0
22.05	38.77	41.09	44.55

Note: Any two means not underscored by the same line are significantly different.

Any two means underscored by the same line are not significantly different.

nitrogen utilization with the 50-0-0 rate and Greenfield had the lowest percent with 50-0-0 rate.

The highest percent of nitrogen utilization was obtained with 50-0-0 for Midland and Coastal, while the 200-0-0 was the highest for Greenfield and common Bermudagrass. Coefficient of variation for these data was 47.76%.

The multiple range test indicates that the only significant difference between percent nitrogen utilization mean for Bermudagrass strains existed in comparing only Midland and Coastal means with Greenfield and common. The multiple range test for rates of nitrogen effects on nitrogen utilization indicates that the only significant difference existed in comparing only the 400-0-0 treatment mean with the means from the other three nitrogen fertility levels.

Soil Chemical Composition

The field experiment soil chemical characteristics are shown in Table XVII. Soil acidity increased with increased rates of nitrogen fertilizer for all Bermudagrass strains. Available phosphorus was variable with no apparent relation to Bermudagrass strain or nitrogen treatment. Exchangeable potassium increased with higher rates of nitrogen fertilizer but was lower in all plots than the original untreated soil. Nitrogen rates did not affect the organic matter content of the Kirkland soil appreciably. Soil samples taken from the Midland plots tended to be higher in organic matter percent than the other three strains.

Weeds and Foreign Grasses

Percent weeds and foreign grass means for Bermudagrass strains with all levels of nitrogen were: Midland, 10.0%; Coastal, 7.2%; Greenfield, 15.0%; and common, 13.0%, Table XVIII.

TABLE XVII.

SOIL pH, AVAILABLE PHOSPHORUS, EXCHANGEABLE POTASSIUM, AND PERCENT ORGANIC MATTER ON KIRKLAND FINE SANDY LOAM GROWING MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS, FIELD EXPERIMENT, ARDMORE, 1956.

Treatment (lbs./acre)	pH	Avail. P lbs./acre	Exc. K lbs./acre	% O.M.
		Midland		
Check (no nitrogen)	7.3	14.3	155	.94
50-0-0	7.2	22.6	150	1.12
100-0-0	7.0	23.0	140	1.12
200-0-0	7.0	20.0	125	.94
400-0-0	6.4	15.2	138	.88
$\bar{X}$		19.0	142	1.00
		Coastal		
Check (no nitrogen)	7.3	13.5	125	.83
50-0-0	7.3	11.3	125	.88
100-0-0	7.0	11.3	125	.94
200-0-0	6.6	13.5	145	.88
400-0-0	6.3	10.9	135	.86
$\bar{X}$		12.1	131	.88
		Greenfield		
Check (no nitrogen)	7.4	20.9	165	.91
50-0-0	7.3	17.4	140	.94
100-0-0	7.2	15.2	155	1.01
200-0-0	6.9	12.2	150	.94
400-0-0	6.4	10.4	140	.86
$\bar{X}$		15.2	150	.93
		Common		
Check (no nitrogen)	7.3	15.7	210	.86
50-0-0	7.2	15.2	170	1.04
100-0-0	7.1	11.3	200	.91
200-0-0	6.6	13.0	175	.91
400-0-0	6.4	11.3	180	.91
$\bar{X}$		13.3	187	.93

Each figure represents the mean of duplicate analysis on composite samples obtained by combining four replications.

TABLE XVIII.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT OF WEEDS AND FOREIGN GRASSES IN MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS PLOTS, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
Check (no nitrogen)	11.4	8.7	11.4	11.4	10.7
50-0-0	11.4	7.5	16.3	11.4	11.6
100-0-0	8.7	8.7	17.5	13.7	12.1
200-0-0	11.4	5.0	15.0	15.0	11.6
400-0-0	7.5	6.3	15.0	13.7	10.6
$\bar{X}$	10.0	7.2	15.0	13.0	11.3

Each figure represents the mean of four replications.
Weeds and foreign grass count was made on June 29, 1956.

SUMMARY AND CONCLUSIONS

The objectives of this study were to obtain information on the effect of different rates of nitrogen fertilization on the forage production, chemical composition, and efficiency of nitrogen utilization on four Bermudagrass strains.

Midland, Coastal, Greenfield, and common Bermudagrass were grown in the greenhouse and field experiments. Stephenville loamy fine sand was used in the greenhouse study and the field study was conducted on Kirkland fine sandy loam. A uniform application of phosphorus and potassium was applied to pots and plots in the greenhouse and field experiments. Ammonium nitrate was applied at rates equivalent to 0, 50, 100, 200, and 400 pounds of elemental nitrogen per acre.

The following conclusions were based on results and statistical analyses on the data obtained from these experiments.

Greenhouse Studies

1. Coastal Bermudagrass gave significantly higher yields than Midland, Greenfield, and common Bermudagrass.
2. All rates of nitrogen fertilizer gave significantly higher yields than the check treatment.
3. Increasing rates of nitrogen fertilizer increased the percent nitrogen in the forage of all the Bermudagrass strains.

4. In general, percent phosphorus and potassium increased with increasing rates of nitrogen fertilization in all strains of Bermudagrass.
5. Nitrogen, phosphorus, and potassium content of Greenfield Bermudagrass was higher than the other three Bermudagrass strains.
6. Midland apparently had the highest percent of nitrogen utilization.

Field Studies

1. Coastal and Midland produced significantly higher yields than Greenfield and common.
2. All rates of nitrogen fertilizer were significantly different in forage production from the check treatment.
3. Coastal fertilized with 200-0-0, Midland fertilized with 400-0-0, and Coastal fertilized with 400-0-0, were significantly different from all other rates of nitrogen fertilizer.
4. Increasing rates of nitrogen fertilizer increased the percent nitrogen in the forage of all the Bermudagrass strains.
5. Nitrogen fertility rates did not affect the phosphorus content appreciably in the Bermudagrass strains.
6. Increasing rates of nitrogen fertilizer increased the potassium percent in the forage of all the Bermudagrass strains.
7. Percent nitrogen utilization for Midland and Coastal was significantly different from Greenfield and common Bermudagrass.
8. All levels of nitrogen treatments were significantly different from the 400-0-0 in percent nitrogen utilization.

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A P P E N D I X

TABLE XIX.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON FORAGE YIELDS OF MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955.

Treatment (lbs./acre)	Reps.	Oven-dry weight in grams				
		Midland	Coastal	Greenfield	Common	$\bar{X}$
Check (no nitrogen)	1	16.03	20.64	16.56	21.09	
	2	17.54	18.28	17.05	20.73	
	3	13.92	18.49	15.69	18.42	
	4	16.66	19.58	19.58	17.71	18.00
50-0-0	1	29.54	33.11	25.14	31.17	
	2	27.32	34.25	28.46	26.01	
	3	29.27	33.05	22.04	27.19	
	4	29.05	27.33	27.33	25.72	28.50
100-0-0	1	43.67	39.34	35.14	39.34	
	2	38.69	45.36	34.16	36.68	
	3	35.05	40.65	34.20	34.14	
	4	35.01	38.52	34.53	35.81	37.52
200-0-0	1	50.09	42.15	37.84	42.34	
	2	38.36	44.16	37.60	44.92	
	3	34.37	48.96	41.97	38.67	
	4	43.02	48.14	38.35	38.06	41.81
400-0-0	1	39.82	43.13	36.29	47.71	
	2	37.53	43.96	46.36	42.39	
	3	36.69	45.51	37.61	38.99	
	4	42.58	52.03	44.43	40.92	42.25
$\bar{X}$		32.71	36.83	31.51	33.40	33.61

All pots received the equivalent of 690 lbs. P_2O_5, 360 lbs. K_2O, and 50 lbs. ES-MIN-EL per acre. Each yield figure represents the accumulated total from five clippings.

TABLE XX.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT NITROGEN IN MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS FORAGE, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
			First Harvest		
Check (no nitrogen)	1.18	2.25	1.86	1.48	1.69
50-0-0	1.45	1.73	2.26	1.53	1.74
100-0-0	1.69	2.66	2.46	1.91	2.17
200-0-0	2.35	2.55	2.62	2.55	2.52
400-0-0	2.90	2.63	2.56	2.51	2.65
$\bar{X}$	1.91	2.36	2.34	2.00	2.15
			Second Harvest		
Check (no nitrogen)	1.41	1.37	1.47	1.12	1.34
50-0-0	1.56	1.56	1.80	1.48	1.60
100-0-0	1.85	2.36	2.71	1.75	2.17
200-0-0	2.60	3.03	3.00	2.82	2.86
400-0-0	3.12	2.16	2.85	3.04	3.04
$\bar{X}$	2.11	2.30	2.37	2.04	2.20
			Third Harvest		
Check (no nitrogen)	1.45	1.45	1.35	1.43	1.42
50-0-0	1.39	1.22	1.51	1.35	1.37
100-0-0	1.52	2.16	2.37	1.69	1.93
200-0-0	2.19	2.58	2.66	2.37	2.45
400-0-0	3.14	3.13	3.04	3.09	3.10
$\bar{X}$	1.94	2.11	2.19	1.99	2.05
			Fourth Harvest		
Check (no nitrogen)	.90	.71	.68	.75	.76
50-0-0	.56	.53	.54	.56	.55
100-0-0	.76	.63	.70	.86	.74
200-0-0	1.58	1.43	1.74	1.50	1.56
400-0-0	2.87	2.00	2.11	2.54	2.38
$\bar{X}$	1.33	1.06	1.15	1.24	1.20
			Fifth Harvest		
Check (no nitrogen)	.66	.56	.53	.60	.59
50-0-0	.58	.49	.49	.54	.53
100-0-0	.52	.48	.48	.52	.50
200-0-0	.68	.65	.73	.62	.67
400-0-0	1.83	1.70	1.64	1.65	1.71
$\bar{X}$	.85	.78	.77	.79	.80

Each figure represents the mean of duplicate analysis on composite samples obtained by combining four replications.

TABLE XXI.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT PHOSPHORUS IN MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS FORAGE, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
			First Harvest		
Check (no nitrogen)	.24	.28	.33	.25	.27
50-0-0	.27	.27	.33	.27	.28
100-0-0	.29	.32	.35	.28	.31
200-0-0	.34	.31	.36	.33	.33
400-0-0	.36	.31	.34	.33	.33
$\bar{X}$	.30	.30	.34	.29	.31
			Second Harvest		
Check (no nitrogen)	.32	.28	.36	.26	.30
50-0-0	.34	.28	.37	.33	.33
100-0-0	.38	.34	.41	.34	.37
200-0-0	.45	.37	.41	.41	.41
400-0-0	.47	.39	.41	.43	.42
$\bar{X}$	.39	.33	.39	.35	.36
			Third Harvest		
Check (no nitrogen)	.32	.27	.33	.31	.31
50-0-0	.26	.26	.32	.29	.28
100-0-0	.30	.33	.42	.31	.34
200-0-0	.37	.37	.44	.38	.39
400-0-0	.37	.40	.44	.40	.40
$\bar{X}$	.32	.33	.39	.34	.34
			Fourth Harvest		
Check (no nitrogen)	.43	.28	.36	.46	.38
50-0-0	.31	.26	.30	.36	.31
100-0-0	.34	.27	.33	.43	.34
200-0-0	.44	.33	.49	.53	.45
400-0-0	.52	.30	.44	.46	.43
$\bar{X}$	.41	.29	.38	.45	.38
			Fifth Harvest		
Check (no nitrogen)	.39	.26	.29	.37	.32
50-0-0	.36	.28	.28	.37	.30
100-0-0	.33	.29	.27	.36	.31
200-0-0	.42	.29	.49	.42	.38
400-0-0	.53	.39	.54	.50	.49
$\bar{X}$	.41	.30	.37	.40	.36

Each figure represents the mean of duplicate analysis on composite samples obtained by combining four replications.

TABLE XXII.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT POTASSIUM IN MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS FORAGE, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
			First Harvest		
Check (no nitrogen)	1.70	2.15	2.25	2.15	2.06
50-0-0	2.25	1.80	2.25	2.33	2.15
100-0-0	2.30	2.30	2.30	2.60	2.37
200-0-0	2.75	2.25	2.25	2.80	2.51
400-0-0	2.90	2.30	2.30	2.90	2.60
$\bar{X}$	2.38	2.16	2.29	2.55	2.34
			Second Harvest		
Check (no nitrogen)	1.30	1.27	1.40	1.25	1.30
50-0-0	1.75	1.10	1.75	1.37	1.49
100-0-0	1.95	2.00	2.30	1.70	1.99
200-0-0	2.20	2.42	2.32	2.45	2.35
400-0-0	2.45	2.00	2.25	2.40	2.29
$\bar{X}$	1.93	1.76	2.00	1.83	1.88
			Third Harvest		
Check (no nitrogen)	1.10	1.06	1.30	1.10	1.14
50-0-0	1.10	1.05	1.30	1.15	1.15
100-0-0	1.30	1.33	2.14	1.25	1.50
200-0-0	1.93	1.85	2.40	1.64	1.93
400-0-0	1.84	2.20	2.23	1.20	1.87
$\bar{X}$	1.45	1.50	1.87	1.27	1.52
			Fourth Harvest		
Check (no nitrogen)	.90	.78	.90	.80	.84
50-0-0	.79	.72	.90	.65	.76
100-0-0	.90	.60	.90	.85	.81
200-0-0	1.10	.83	1.00	.85	.94
400-0-0	1.40	.75	1.10	.80	1.01
$\bar{X}$	1.02	.73	.96	.79	.87
			Fifth Harvest		
Check (no nitrogen)	1.26	1.00	1.20	1.15	1.15
50-0-0	1.09	.98	1.18	1.09	1.08
100-0-0	1.00	.93	1.14	1.00	1.02
200-0-0	1.16	1.05	1.49	1.16	1.21
400-0-0	1.36	1.10	1.55	1.17	1.29
$\bar{X}$	1.17	1.01	1.31	1.11	1.15

Each figure represents the mean of duplicate analysis on composite samples obtained by combining four replications.

TABLE XXIII.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON FORAGE YIELDS OF MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDA-GRASS, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956.

Treatment (lbs./acre)	Reps.	Oven-dry weight yield in pounds per acre				
		Midland	Coastal	Greenfield	Common	$\bar{X}$
Check (no nitrogen	1	4163	5261	1867	928	
	2	2489	3168	984	860	
	3	3688	2523	1437	1425	
	4	1290	2829	950	1063	2183
50-0-0	1	6178	6902	1822	962	
	2	3723	5872	1290	1652	
	3	4628	3281	1686	1788	
	4	4662	4560	1335	2648	3312
100-0-0	1	7784	7196	3689	1064	
	2	4311	7208	1924	3191	
	3	6166	3870	2817	2331	
	4	4469	4265	2647	2704	4102
200-0-0	1	8067	8259	4300	2422	
	2	4605	7716	2874	4107	
	3	6744	5861	4096	3937	
	4	5273	8068	3655	4254	5265
400-0-0	1	6619	7037	3745	2104	
	2	6370	7264	2557	2229	
	3	7264	5853	4277	2203	
	4	7795	7083	4865	2998	5079
$\bar{X}$		5314	5704	2641	2293	3988

All plots received the equivalent of 106 lbs. P_2O_5 and 60 lbs. K_2O per acre.
Each yield figure represents the accumulated total of two clippings..

TABLE XXIV.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT NITROGEN IN MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS FORAGE, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
			First Harvest		
Check (no nitrogen)	1.43	1.48	1.65	1.70	1.56
50-0-0	1.69	1.69	1.73	1.92	1.76
100-0-0	1.74	1.74	1.96	2.01	1.86
200-0-0	2.00	1.92	2.28	2.16	2.09
400-0-0	2.26	2.13	2.72	2.40	2.38
$\bar{X}$	1.82	1.79	2.07	2.04	1.93
			Second Harvest		
Check (no nitrogen)	1.26	1.43	1.44	1.34	1.37
50-0-0	1.37	1.63	1.51	1.70	1.55
100-0-0	1.59	1.71	1.84	2.08	1.80
200-0-0	2.20	1.98	2.48	2.37	2.25
400-0-0	2.48	2.42	2.67	2.90	2.62
$\bar{X}$	1.78	1.83	1.99	2.08	1.92

Each figure represents the mean of duplicate analysis on composite samples obtained by combining four replications.

TABLE XXV.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT PHOSPHORUS IN MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
			First Harvest		
Check (no nitrogen)	.18	.17	.19	.19	.18
50-0-0	.18	.16	.19	.19	.18
100-0-0	.17	.17	.19	.18	.18
200-0-0	.17	.16	.18	.18	.17
400-0-0	.18	.16	.19	.18	.18
$\bar{X}$	.18	.16	.19	.18	.18
			Second Harvest		
Check (no nitrogen)	.18	.16	.16	.17	.17
50-0-0	.18	.16	.16	.16	.16
100-0-0	.18	.16	.16	.18	.17
200-0-0	.19	.16	.18	.18	.18
400-0-0	.21	.17	.18	.20	.19
$\bar{X}$	.19	.16	.17	.18	.17

Each figure represents the mean of duplicate analysis on composite samples obtained by combining four replications.

TABLE XXVI.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT POTASSIUM IN MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS, KIRKLAND FINE SANDY LOAM FIELD EXPERIMENT, ARDMORE, 1956.

Treatment (lbs./acre)	Midland	Coastal	Greenfield	Common	$\bar{X}$
			First Harvest		
Check (no nitrogen)	1.20	1.32	1.20	1.40	1.28
50-0-0	1.44	1.40	1.28	1.52	1.41
100-0-0	1.44	1.48	1.48	1.64	1.51
200-0-0	1.48	1.56	1.56	1.64	1.56
400-0-0	1.68	1.72	1.64	1.64	1.67
$\bar{X}$	1.45	1.50	1.43	1.57	1.49
			Second Harvest		
Check (no nitrogen)	1.26	1.30	1.22	1.30	1.27
50-0-0	1.44	1.42	1.34	1.54	1.43
100-0-0	1.60	1.56	1.60	1.90	1.66
200-0-0	1.64	1.70	1.76	2.00	1.77
400-0-0	1.80	1.72	1.70	2.16	1.87
$\bar{X}$	1.55	1.54	1.52	1.78	1.60

Each figure represents the mean of duplicate analysis on composite samples obtained by combining four replications.

TABLE XXVII.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON THE PERCENT OF NITROGEN UTILIZATION OF MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956.

Treatment (lbs./acre)	Reps.	Midland	Coastal	Greenfield	Common	$\bar{X}$
50-0-0	1	87.60	79.20	00.00	8.60	
	2	42.60	136.20	13.80	30.60	
	3	28.40	26.80	10.00	16.20	
	4	113.40	47.60	11.20	60.60	44.55
100-0-0	1	93.80	46.70	51.60	7.70	
	2	37.50	89.50	18.80	50.10	
	3	43.20	30.60	31.10	24.60	
	4	47.70	23.50	29.70	31.30	41.09
200-0-0	1	51.35	32.70	36.85	21.00	
	2	33.20	55.90	25.65	45.60	
	3	41.10	44.80	37.30	32.25	
	4	43.80	50.70	32.85	35.30	38.77
400-0-0	1	23.03	16.83	17.18	9.58	
	2	29.52	28.15	13.23	10.58	
	3	31.10	25.57	23.90	15.43	
	4	38.34	29.67	27.37	13.33	22.05
$\bar{X}$		49.10	47.78	23.78	25.80	36.61

Each figure represents the mean of two clippings.

Figure 1.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON GROWTH OF MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS, STEPHENVILLE LOAMY FINE SAND, GREENHOUSE EXPERIMENT, ARDMORE, 1955. (SEE PAGE 8 FOR TREATMENT DETAILS AND TABLES II AND XIX FOR YIELD DATA.)

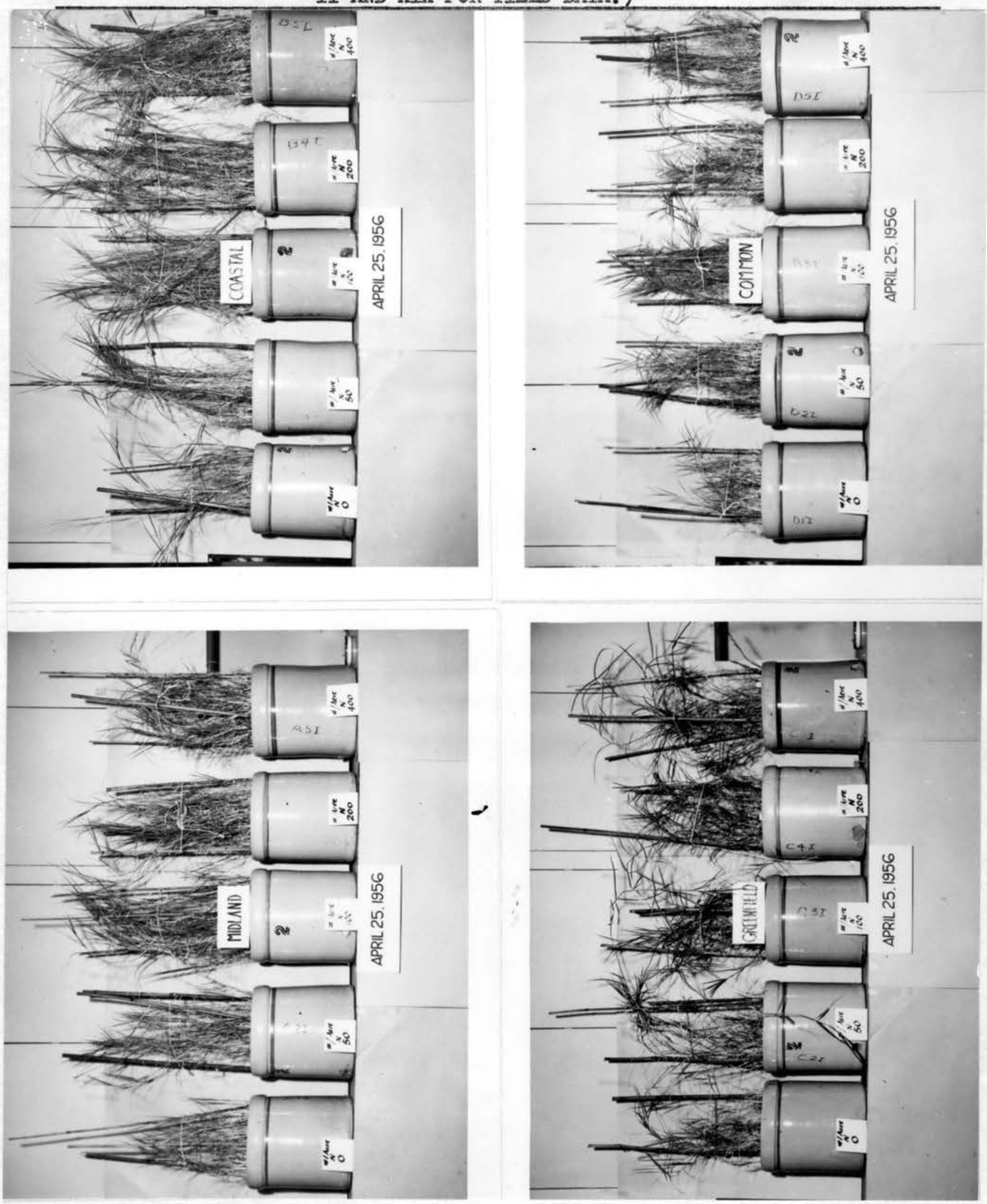
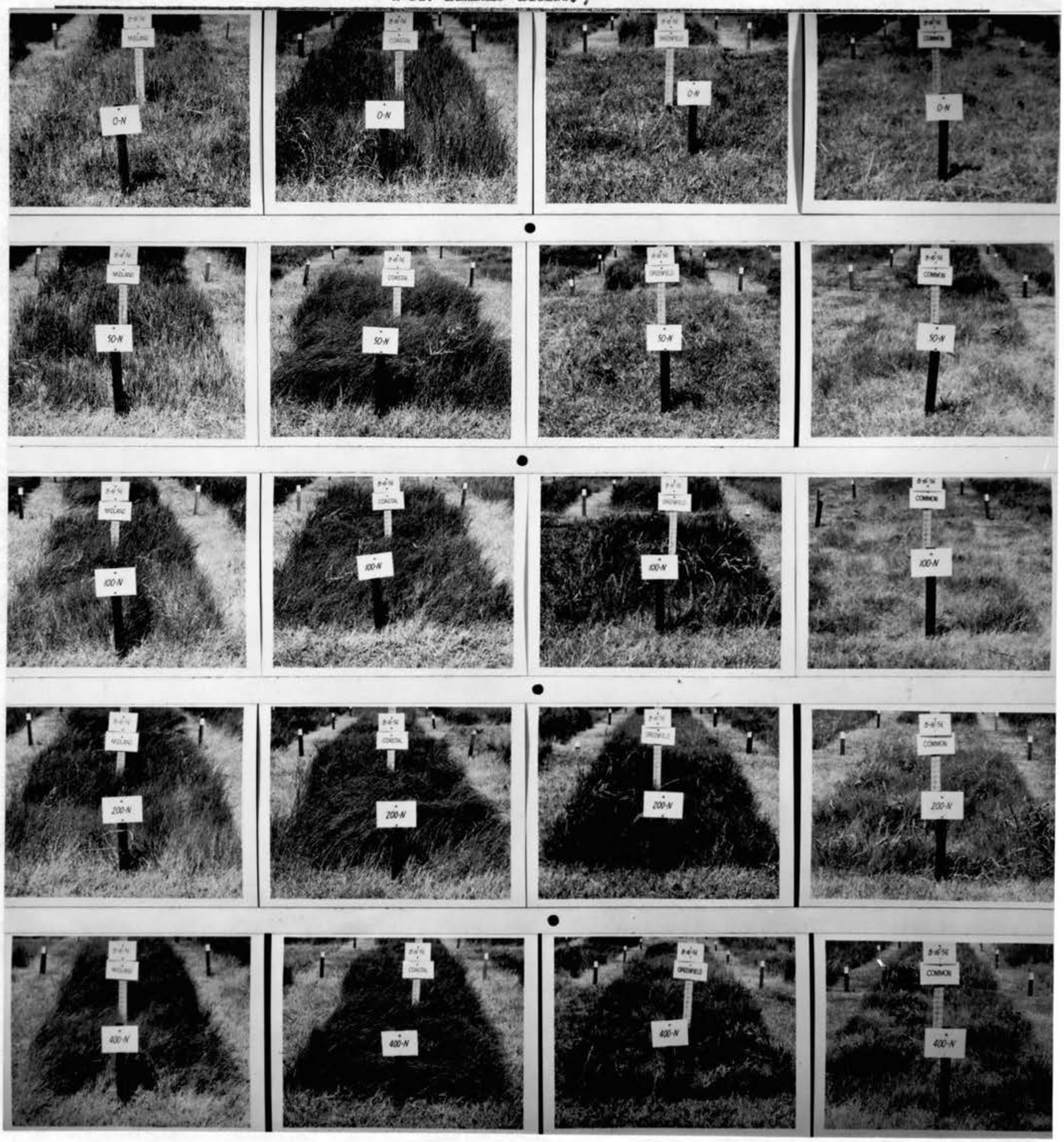


FIGURE 2.

EFFECT OF VARIOUS NITROGEN TREATMENTS ON GROWTH OF MIDLAND, COASTAL, GREENFIELD, AND COMMON BERMUDAGRASS, KIRKLAND FINE SANDY LOAM, FIELD EXPERIMENT, ARDMORE, 1956. (SEE PAGE 11 FOR TREATMENT DETAILS AND TABLES IX AND XXIII FOR YIELD DATA.)



VITA

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Master of Science

Thesis: THE EFFECTS OF DIFFERENT RATES OF NITROGEN FERTILIZER ON FOUR STRAINS OF BERMUDAGRASS

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