PLANT NUTRIENT EQUILIBRIUM EVALUATIONS FOR CYNODON DACTYLON (L.) PERS. (VAR. MIDLAND) WITH AN ABRUPTIC PALEUSTOLL (KIRKLAND FINE SANDY LOAM)

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CHAPTER I

INTRODUCTION

Soil testing is a useful and widely accepted method for estimating soil fertility. The farmer who applies the recommended fertilizer based on a soil test, then obtains another soil test shortly thereafter, often wonders why the results of the second test are not drastically higher than the first. Literature reporting previous research on this subject indicates many contributing factors. Objectives of this study were to determine changes in soil test values resulting from plant nutrient additions and to correlate these changes with the forage production and composition of Midland bermudagrass (Cynodon dactylon L. Pers.).

CHAPTER II

LITERATURE REVIEW

According to Melsted (22)[1], soil testing can be defined as any chemical or physical measurement made on soil. Most any chemist can analyze a soil or an extract of a soil, but a principal problem is the interpretation of results (28). Tisdale (27) proposes that one of the most important problems in soil testing is calibration of data on which recommendations are based.

Various methods have been devised to obtain better correlation between soil test results and field response (4, 7, 8). Bray (7) developed a factor to use in conjunction with the soil test value for potassium to predict the yield increase from fertilization. In another study Bray (8) used the Mitscherlich equation to calculate fertilizer requirements for each soil test value using certain soil testing methods (5, 6).

The development and results of a soil testing procedure for phosphorus depends on the form of phosphorus being extracted (9, 10, 11, 15, 21, 24). Measuring the different forms of phosphorus

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[1]Figures in parentheses refer to Literature Cited.

in the soil, using methods similar to those developed by Chang and Jackson (13), may be helpful for understanding the functions of soil phosphorus availability (10).

Early procedures were not effective in extracting adsorbed forms of phosphate (11), but the use of ammonium fluoride as an extractant seemed to offer promise (15). Other workers have also obtained satisfactory results by using a fluoride extractant (5, 6, 19, 21).

Many factors other than form of nutrient being extracted may influence the soil test values for phosphorus. Soil texture and pH have been found to influence results of soil tests for phosphorus (3, 10, 14, 19, 23, 24). John, et al. (19) compared eight testing methods on soils from 192 fields by comparing plant and soil analyses. Multiple correlation studies indicated that soil texture and pH were required to explain the contribution of available soil phosphorus to phosphorus in plants. Work by Pratt and Garber (24) indicates that as clay content increases the Bray reagent[2] becomes exhausted while Baldovinos (3) and Cole and Olsen (14) proposed this effect to be caused directly by such factors as adsorption of phosphates by clay. However, Olsen and Watanabe (23) found only a slight increase of phosphorus with increasing clay content on calcareous soils.

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[2]Bray reagent is 0.03N NH_4F in 0.025 N HCl.

Hipp and Thomas (17) have found the type of clay to be responsible for different crop responses and soil test values when potassium is added to the soil. The solution potassium and exchangeable potassium decreased quickly after potassium applications to kaolinitic soils, but they found little reduction on montmorillonitic soils. Albrecht (2) proposed soil potassium relationships as very complex and suggested that the adsorbed form may become fixed even during short periods of growth.

Several recent studies have attempted to correlate the response of Coastal bermudagrass (Cynodon dactylon L. Pers.) to added phosphorus and/or potassium and the soil test values (1, 12, 20, 25, 29, 30). Most of these studies have been on sandy soils in the southern and southeastern part of the United States. At moderate rates of phosphorus and/or potassium fertilization, 50 or 60 pounds per acre, soil levels increased in the absence of nitrogen, but decreased when nitrogen was applied, and the forage production increased (16). Woodhouse (30) also found that rates above 46.5 Kg/ha were needed to prevent rapid declines in soil potassium levels. Jordan, et al. (20) obtained yield responses when soil phosphorus levels were less than 25 ppm and soil potassium levels less than 40 ppm. They also found the surface two inches of soil to be representative of the soil fertility level.

CHAPTER III

MATERIALS AND METHODS

This study was initiated in 1967 on an existing two-year old stand of Midland bermudagrass. This area of Kirkland fine sandy loam had been fertilized with 200 pounds of 10-20-10 per acre in 1965, and 200 pounds of 33.5-0-0 per acre in 1965 and 1966. The five feet by twenty feet plots were all located at this site with a completely randomized design having three replications per treatment.

Fertilizer levels were 0, 50, 100, 200 and 400 pounds of nitrogen per acre; 0, 40 and 80 pounds of phosphorus (P_2O_5) per acre; 0, 40 and 80 pounds of potassium (K_2O) per acre and various combinations. In 1968, all plots that had received phosphorus and/or potassium were split, and one half continued to receive phosphorus and/or potassium annually, while the other half received none after 1967. Phosphorus and potassium were applied in March, and nitrogen in May, with the second half of split applications applied in August. Plots receiving 400 pounds of nitrogen had 100 pounds applied the first of May, June, July and August. A complete list of treatments is shown in Table LX of the appendix.

Fertilizer materials used in this study were ammonium nitrate

(33.5-0-0), superphosphate (0-20-0), muriate of potash (0-0-60) and a commercial mixed fertilizer, 0-20-20.

Plots were harvested with a nineteen-inch rotary lawn mower equipped with a grass catcher and set to cut approximately three inches above the soil surface. The forage was harvested when approximately 20 per cent of the plants produced seedheads. The frequency of harvest was greatly influenced by rainfall (Tables LXI, LXII and LXIII of the appendix).

The forage was analyzed for nitrogen, phosphorus and potassium, using the methods given by Jackson (18). This information was used to assist with interpretations of differences in nutrient additions and soil test values.

Soil samples were collected from each plot March 21, 1969, and again October 22, 1969, at a depth of 0-6 inches. Composite samples from the three plots treated with 400-80-80 were collected October 22, 1969, at depths of 0-2 inches, 2-4 inches and 4-6 inches. Soil pH was determined on a saturated paste. Phosphorus was extracted with Bray solution as described by Jackson (18), using a 1:10 dilution and shaking 40 seconds. Color was developed on the extract with ammonium molybdate and 1, 2, 4-aminonaphtholsulfonic acid as described by Sherman (26). Potassium was extracted with ammonium acetate and determined by flame photometry according to the procedures given by Jackson (18). All determinations were done at the Samuel Roberts Noble Foundation Soil Testing Laboratory.

CHAPTER IV

RESULTS AND DISCUSSION

Since rainfall during July and August of 1967 was limited, Table LXI, the plots were only harvested two times. The results of the first harvest, Table I, show that the nitrogen rates had more influence on forage yields than the phosphorus and potassium treatments. Increases in phosphorus and potassium rates did increase forage production at the 100 and 200 pounds per acre nitrogen rates. At the 50 pounds per acre nitrogen rate, the addition of 40 pounds per acre potassium reduced forage yields. When the 40 pounds of potassium were applied with the 50 pounds per acre nitrogen rate, 80 pounds per acre of phosphorus were needed to make the forage yields equal to the yields at 50 pounds of nitrogen with no phosphorus or potassium.

The forage yields of the second harvest in 1967 were influenced by nitrogen only. The phosphorus and potassium rates had little influence on forage yields. At the 100 pounds per acre nitrogen rate, the split application produced more than twice as much forage as the single application.

Forage yields from the first 1968 harvest of the plots receiving

TABLE I

Summary of the Effects of Soil Fertility Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, First Crop, July, 1967. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	693	918	580	859			762
50	1704	1866	1375	1559	1743	1844	1682
100	2644			3455			3049
100 (Split)*	1456			1983	1919	2218	1894
200 (Split)*				3398		3807	3602
400 (Split)*						5026	5026
$\bar{\bar{X}}$	1624	1392	977	2251	1831	3224	

Treatment F = 28.54($P < .05$) Coefficient of Variation = 18.3%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE II

Summary of the Effects of Soil Fertility Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, Second Crop, November, 1967. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	495	482	474	479			482
50	608	692	675	549	614	685	637
100	620			728			674
100 (Split)*	1418			1592	1592	1671	1568
200 (Split)*				2563		2795	2679
400 (Split)*						2988	2988
$\bar{\bar{X}}$	785	587	574	1182	1103	2035	

Treatment F = 10.20($P < .05$) Coefficient of Variation = 33.7%

(*) The nitrogen applications were split as described in the materials and methods section.

only nitrogen are shown in Table III. The 50-80-40 treatment had a much lower yield than the other 50 pounds per acre nitrogen treatments. The combination of 80 pounds phosphorus and 80 pounds potassium at the 100 and 200 pounds per acre nitrogen rate continued to yield more than the combination of 40 pounds phosphorus and 40 pounds potassium per acre. Nitrogen rate made more difference in yield than phosphorus and potassium rate.

Table IV gives forage yields for the first 1968 harvest on the plots that continued to receive nitrogen, phosphorus and potassium. At 0 nitrogen, the 40 pounds per acre potassium rate reduced forage yields. The yields of the 100-40-40 treatment were higher than those of the 100-0-0 treatment. Where the 100 pounds of nitrogen per acre were applied as a split application, the 100-40-40 treatment produced more forage than the 100-0-0 treatment, and the 100-80-80 treatment produced the highest yield. Apparently, the 100-80-40 treatment did not have enough potassium for that rate of nitrogen and phosphorus. The 200-40-40 and 200-80-80 treatments produced almost the same amount of forage. The 400-80-80 treatment was showing the influence of residual nitrogen since this treatment and the 200 pounds per acre nitrogen treatments had only received 100 pounds of nitrogen in 1968.

The residual effect of phosphorus and potassium, applied in 1967, can be seen by comparing the forage yields in Tables III and IV. The residual phosphorus and potassium levels were sufficient to maintain the yields at all the 50 pounds per acre nitrogen treat-

TABLE III

Summary of the Effects of Nitrogen Fertilization Levels With Residual Phosphorus and Potassium Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, First Crop, June, 1968. Reported as Average Pounds of Oven-dry Forage Per Acre From Triplicate Plots.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	1163	768	608	993			883
50		1871	1719	1746	1476	1662	1695
100				2217			2217
100 (Split)*				1761	2063	2186	2003
200 (Split)*				2456		2856	2656
400 (Split)*						3647	3647
$\bar{\bar{X}}$	1163	1319	1163	1835	1769	2588	

Treatment F = 10.07($P < .05$) Coefficient of Variation = 23.9%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE IV

Summary of the Effects of Soil Fertility Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, First Crop, June, 1968. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	1163	1145	647	1278			1058
50	1745	1867	1703	1700	1732	1772	1753
100	1905			2742			2323
100 (Split)*	1927			2297	2060	2653	2234
200 (Split)*				2835		2880	2857
400 (Split)*						3831	3831
$\bar{\bar{X}}$	1685	1506	1175	2170	1896	2784	

Treatment F = 6.84($P < .05$) Coefficient of Variation = 24.9%

(*) The nitrogen applications were split as described in the materials and methods section.

ments, except the 50-80-40 treatment. At 100 and 200 pounds of nitrogen per acre the continued application of phosphorus and potassium increased the yields of all treatments except 200-80-80. The 400-80-80 treatment had a slight increase in forage production when phosphorus and potassium were added again in 1968.

Rainfall in 1968 was excessive in May and very limited during June and July, Table LXII. Therefore, the forage yields of the August harvest, Tables V and VI were relatively low. The low yields make it difficult to detect differences in treatments.

Table V gives the forage yields of the August harvest where phosphorus and potassium were not added after 1967. At all phosphorus and potassium treatment levels, increases in nitrogen increased forage production. Variations in phosphorus and potassium levels made little difference in forage yields at any given nitrogen level.

Forage yields of the August, 1968, harvest from plots receiving annual applications of phosphorus and potassium are shown in Table VI. Again, the 0-0-40 treatment had the lowest yield, where no nitrogen had been applied, while the 0-40-40 treatment produced more forage than the check plot. Forage yields were increased as the nitrogen rate increased, but phosphorus and potassium levels had little influence on forage yields. At 50 pounds of nitrogen per acre, 80 pounds per acre phosphorus and potassium reduced the forage yield.

TABLE V

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, Second Crop, August, 1968. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	478	456	394	451			445
50		666	574	551	535	661	597
100				680			680
100 (Split)*				741	685	741	722
200 (Split)*				835		814	824
400 (Split)*						1482	1482
$\bar{\bar{X}}$	478	561	484	652	610	924	

Treatment F = 8.69($P < .05$) Coefficient of Variation = 22.2%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE VI

Summary of the Effects of Soil Fertility Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, Second Crop, August, 1968. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	478	496	402	536			478
50	629	618	530	597	530	479	564
100	629			635			632
100 (Split)*	742			654	640	626	665
200 (Split)*				780		830	805
400 (Split)*						1856	1856
$\bar{\bar{X}}$	619	557	466	640	585	948	

Treatment F = 16.2($P < .05$) Coefficient of Variation = 19.8%

(*) The nitrogen applications were split as described in the materials and methods section.

When Tables V and VI are compared, the August harvest shows little or no difference in forage yields caused by the annual application of phosphorus and potassium, except at the 400-80-80 treatment. At the 400-80-80 treatment the annual application of phosphorus and potassium increased the forage yields well above the yields produced by applying phosphorus and potassium every two or three years.

The forage yields of the November, 1968, harvest were very low, Tables VII and VIII. Increases in nitrogen rates increased forage production, but phosphorus and potassium treatments had little influence on yields. The continued application of phosphorus and potassium made little difference in forage yields at this harvest.

The forage yields of the June, 1969, harvest on the plots that had not received phosphorus and potassium since 1967 are shown in Table IX. Increasing nitrogen rates resulted in increased forage production. Where no nitrogen was applied, the check plot had a higher yield than the plots that received phosphorus and potassium in 1967. At 50 pounds of nitrogen, the 50-40-0 treatment had the highest yield and the 50-80-80 treatment had the lowest yield. The 200-80-80 treatment produced slightly more forage than the 200-40-40 treatment.

Forage yields of the June, 1969, harvest from plots that had received annual applications of phosphorus and potassium are shown in Table X. The 0-40-40 treatment produced more forage than the check, and the 0-0-40 treatment had the lowest yield. At 50 pounds

TABLE VII

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, Third Crop, November, 1968. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	157	153	80	123			128
50		144	131	154	125	108	132
100				108			108
100 (Split)*				323	378	305	335
200 (Split)*				551		538	544
400 (Split)*						541	541
$\bar{\bar{X}}$	157	148	105	252	251	373	

Treatment F = 35.83($P < .05$) Coefficient of Variation = 20.1%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE VIII

Summary of the Effects of Soil Fertility Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, Third Crop, November, 1968. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	157	109	123	125			128
50	148	146	146	146	119	135	140
100	146			142			144
100 (Split)*	292			315	394	311	328
200 (Split)*				538		580	559
400 (Split)*						467	467
$\bar{\bar{X}}$	186	127	134	253	256	373	

Treatment F = 13.11($P < .05$) Coefficient of Variation = 30.6%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE IX

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, First Crop, June, 1969. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	388	271	242	234			284
50		670	731	631	667	514	643
100				1354			1354
100 (Split)*				970	806	867	881
200 (Split)*				1541		1690	1615
400 (Split)*						1990	1990
$\bar{\bar{X}}$	388	470	486	946	736	1265	

Treatment F = 15.00 ($P < .05$) Coefficient of Variation = 28.7%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE X

Summary of the Effects of Soil Fertility Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, First Crop, June, 1969. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	388	298	225	405			329
50	604	825	827	930	1186	1117	915
100	1066			1553			1309
100 (Split)*	796			1340	1429	1414	1245
200 (Split)*				2281		2509	2395
400 (Split)*						2452	2452
$\bar{\bar{X}}$	713	561	526	1302	1307	1873	

Treatment F = 18.82($P < .05$) Coefficient of Variation = 24.2%

(*) The nitrogen applications were split as described in the materials and methods section.

of nitrogen per acre phosphorus and potassium increased the forage yields, but the 50-80-80 treatment did not produce as much forage as the 50-80-40 treatment. At 100 pounds of nitrogen per acre the 100-80-40 treatment produced the highest yield. The 200-80-80 treatment produced the highest yield, however, the plots scheduled to receive 200 and 400 pounds of nitrogen per acre had only received 100 pounds per acre during this part of 1969.

When Tables IX and X are compared, the influence of phosphorus and potassium on forage yields becomes apparent. All treatments, except 0-0-40, produced more forage where phosphorus and potassium had been applied annually than where phosphorus and potassium had not been applied since 1967. The influence of annual phosphorus and potassium applications is greater in the June, 1969, harvest than in the June, 1968, harvest.

The October, 1969, forage yields, Tables XI and XII, were low since summer rainfall was again limited, Table LXIII. Where phosphorus and potassium had not been applied since 1967, Table XI, increased nitrogen rates caused the forage production to be increased. At 50 pounds of nitrogen per acre, 50-40-0 produced the highest forage yield. The 100-80-40 treatment produced the highest forage yield where 100 pounds of nitrogen per acre were used. The 200-80-80 treatment produced more forage than the 200-40-40 treatment.

October, 1969, forage yields, where phosphorus and potassium

TABLE XI

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, Second Crop, October, 1969. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	230	238	175	232			219
50		307	348	282	255	303	299
100				382			382
100 (Split)*				348	537	449	445
200 (Split)*				511		574	542
400 (Split)*						756	756
$\bar{\bar{X}}$	230	272	261	351	396	520	

Treatment F = 9.16($P < .05$) Coefficient of Variation = 24.3%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XII

Summary of the Effects of Soil Fertility Treatments on Midland Bermudagrass Forage Yields, Kirkland Fine Sandy Loam, Second Crop, October, 1969. Reported as Average Pounds of Oven-dry Forage per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	230	223	171	236			215
50	351	405	342	317	336	338	348
100	399			401			400
100 (Split)*	436			382	463	455	434
200 (Split)*				702		845	773
400 (Split)*						983	983
$\bar{\bar{X}}$	354	314	256	408	399	655	

Treatment F = 10.5($P < .05$) Coefficient of Variation = 26.5%

(*) The nitrogen applications were split as described in the materials and methods section.

had been applied annually, Table XII, followed the same trends as the yields in Table XI. The annual application of phosphorus and potassium increased forage yields over those of the plots that had not received phosphorus and potassium since 1967, in all treatments except 0-40-0, 0-0-40, 50-40-0 and 100-80-40, Tables XI and XII.

The total forage yields, from the plots receiving phosphorus and potassium in 1967, for the three-year period (1967-1969) are given in Table XIII. When nitrogen was excluded none of the plots made as much total forage as the check. At 50 pounds of nitrogen per acre, the 50-40-0 treatment made the highest yield with 50-80-80 making a slightly lower yield. The 100-80-80 treatment had the highest yield when 100 pounds of nitrogen per acre was applied as a split application. At the 100-40-40 treatment level, the most forage was produced by applying all of the nitrogen in May. The 200-80-80 treatment produced more forage than the 200-40-40 treatment. The highest total yield was produced by the 400-80-80 treatment.

Total forage production where phosphorus and potassium had been applied annually for three years is shown in Table XIV. The 0-40-40 treatment produced slightly more forage than the check while the 0-0-40 treatment decreased the total forage yield. At 50 pounds of nitrogen per acre the 50-40-0 treatment had the highest yield and the 50-0-40 treatment produced less forage than the 50-0-0 treatment. When 100 pounds of nitrogen per acre were applied as

TABLE XIII

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium Treatments on Total Midland Bermudagrass Forage Yields, 1967 - 1969. Reported as Pounds of Oven-dry Forage per Acre from Triplicate Plot Averages.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	3604	3286	2553	3371			3203
50		6216	5379	5472	5415	5777	5652
100				8924			8924
100 (Split)*				7718	7980	8437	8045
200 (Split)*				11855		13074	12464
400 (Split)*						16430	16430
$\bar{\bar{X}}$	3604	4751	3966	7468	6697	10929	

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XIV

Summary of the Effects of Soil Fertility Treatments on Total Midland Bermudagrass Forage Yields, 1967 - 1969. Reported as Pounds of Oven-dry Forage per Acre from Triplicate Plot Averages.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	3604	3671	2645	3918			3459
50	5789	6420	5598	5798	6260	6370	6039
100	7409			9656			8532
100 (Split)*	7067			8563	8494	9348	8368
200 (Split)*				13097		14246	11768
400 (Split)*						17603	17603
$\bar{\bar{X}}$	5967	5045	4121	8206	7377	10940	

(*) The nitrogen applications were split as described in the materials and methods section.

a split application, the 100-80-80 treatment had the highest yield. The highest yield produced by 100 pounds of nitrogen per acre was from the 100-40-40 treatment when all the nitrogen was applied in May. The 200-80-80 treatment produced more forage than the 200-40-40 treatment. The highest total forage yield was produced by the 400-80-80 treatment.

All of the plots that received annual applications of phosphorus and potassium produced more forage than the plots that had not received phosphorus and potassium since 1967, Tables XIII and XIV. Since the largest difference occurred during the third year, it is possible that another year would produce even greater differences in forage yields. Forage from the first harvest in 1967 was not analyzed, but forage from the November harvest was analyzed for nitrogen. The results in Table XV show that the highest fertility level, 400-80-80, produced forage with the highest nitrogen content. Many of the low nitrogen treatments produced forage with less nitrogen than the forage from the check plots.

During 1968 all harvested forage was analyzed for nitrogen, phosphorus and potassium content. For the first two harvests a composite sample was prepared for each treatment by mixing subsamples of forage from each replication of the treatment. Analysis was then made on these composite samples.

The nitrogen content of the forage from the June, 1968, harvest is given in Tables XVI and XVII. When the forage was harvested,

TABLE XV

Summary of the Effects of Soil Fertility Treatments on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, November, 1967.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.93	.83	.79	.87			.85
50	.91	.85	.81	.81	.90	.95	.87
100	.77			.94			.85
100 (Split)*	1.07			1.04	.99	1.00	1.02
200 (Split)*				1.20		1.09	1.14
400 (Split)*						1.64	1.64
$\bar{\bar{X}}$	.92	.84	.80	.97	.94	1.17	

Treatment F = 12.71($P < .05$) Coefficient of Variation = 9.8%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XVI

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1968.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	1.13	1.37	1.10	1.10			1.17
50		1.10	1.40	1.27	1.45	1.13	1.27
100				1.62			1.62
100 (Split)*				1.31	1.43	1.23	1.32
200 (Split)*				1.45		1.50	1.47
400 (Split)*						1.27	1.27
$\bar{\bar{X}}$	1.13	1.23	1.25	1.35	1.44	1.28	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XVII

Summary of the Effects of Soil Fertility Treatments on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1968.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	1.13	1.40	1.03	1.17			1.18
50	1.42	1.25	1.30	1.40	1.08	1.34	1.30
100	1.61			1.61			1.61
100 (Split)*	1.43			1.24	1.34	1.35	1.34
200 (Split)*				1.61		1.49	1.55
400 (Split)*						1.37	1.37
$\bar{\bar{X}}$	1.40	1.32	1.16	1.41	1.21	1.39	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

only 50 pounds of nitrogen had been applied on the 100 (Split) treatment and 100 pounds had been applied to the 100, 200 (Split) and 400 (Split) treatments. The highest nitrogen content was produced by the 100-40-40 treatment where phosphorus and potassium had not been applied since 1967. However, the 100-0-0 treatment had almost the same nitrogen content. The annual application of phosphorus increased the nitrogen content of the forage in all of the 80P-80K treatments, except 200-80-80. The 200-40-40 treatment also had an increase in nitrogen content due to annual phosphorus and potassium applications.

The phosphorus content of the forage from the June, 1968, harvest is shown in Tables XVIII and XIX. When these tables are compared with the corresponding forage yields, Tables III and IV, the influence of fertilizer treatments and forage yields is shown. At the 80P-80K treatment, the highest nitrogen treatment level produced the most forage, but the forage had the lowest phosphorus content. At the 50 and 100 pounds per acre nitrogen treatment levels, phosphorus additions increased phosphorus content in the forage.

Potassium content of the forage from the June, 1968, harvest is shown in Tables XX and XXI. The annual application of potassium did not increase the potassium content of the forage. Nitrogen alone, at the 50 and 100 pounds per acre rates, produced forage with as much potassium as the treatments receiving phosphorus

TABLE XVIII

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Phosphorus in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1968.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.16	.18	.17	.17			.17
50		.18	.15	.16	.19	.18	.17
100				.17			.17
100 (Split)*				.15	.19	.17	.17
200 (Split)*				.16		.17	.16
400 (Split)*						.16	.16
$\bar{\bar{X}}$	.16	.18	.16	.16	.19	.17	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XIX

Summary of the Effects of Soil Fertility Treatments on Per Cent Phosphorus in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1968.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.16	.20	.17	.20			.18
50	.16	.20	.15	.19	.22	.23	.19
100	.16			.20			.18
100 (Split)*	.14			.18	.22	.20	.18
200 (Split)*				.17		.20	.18
400 (Split)*						.19	.19
$\bar{\bar{X}}$	.16	.20	.16	.19	.22	.20	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XX

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Potassium in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1968.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.74	.70	.76	.72			.73
50		.79	.81	.84	.86	.80	.82
100				.89			.89
100 (Split)*				.79	.82	.80	.80
200 (Split)*				.79		.84	.81
400 (Split)*						.86	.86
$\bar{\bar{X}}$	.74	.74	.78	.81	.84	.82	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXI

Summary of the Effects of Soil Fertility Treatments on Per Cent Potassium in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1968.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.74	.75	.69	.75			.73
50	.84	.82	.76	.83	.80	.80	.81
100	.89			.85			.87
100 (Split)*	.82			.77	.80	.80	.80
200 (Split)*				.82		.84	.83
400 (Split)*						.83	.83
$\bar{\bar{X}}$	.82	.78	.72	.80	.80	.82	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

and potassium with the nitrogen.

Nitrogen content of the forage from the August, 1968, harvest is shown in Tables XXII and XXIII. The 400-80-80 treatment produced forage with the highest nitrogen content. The greatest increase in nitrogen content of the forage due to the application of phosphorus and potassium was 0.04 per cent at the 100 (Split)-40-40 treatment where phosphorus and potassium had not been applied since 1967 (the 100-0-0 results are in Table XIII). The annual application of phosphorus and potassium did not increase the nitrogen content of the forage.

At the August, 1968, harvest only slight increases in phosphorus content of the forage were produced by the addition of phosphorus and potassium, Tables XXIV and XXV. At the higher treatment levels the annual application of phosphorus and potassium increased the phosphorus content of the forage no more than 0.04 per cent.

The addition of phosphorus and potassium had little influence on the per cent potassium in the forage at the August, 1968, harvest, Tables XXVI and XXVII. The 40 pounds per acre phosphorus treatment produced forage with a slightly higher potassium content than the 40 pounds per acre potassium treatment. At 400 pounds of nitrogen per acre, the annual application of phosphorus and potassium increased the potassium content of the forage, but this was the only instance where a significant difference was observed.

TABLE XXII

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, August, 1968.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	1.04	.93	.87	.97			.95
50		.90	.98	.88	.89	.82	.89
100				.94			.94
100 (Split)*				.90	.95	1.00	.95
200 (Split)*				.94		.98	.96
400 (Split)*						1.45	1.45
$\bar{\bar{X}}$	1.04	.91	.92	.93	.92	1.06	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXIII

Summary of the Effects of Soil Fertility Treatments on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, August, 1968.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	1.04	.93	1.03	1.07			1.02
50	.98	.83	1.01	.84	.83	.80	.88
100	.97			.93			.95
100 (Split)*	.94			.90	.95	.91	.92
200 (Split)*				.92		.96	.94
400 (Split)*						1.29	1.29
$\bar{\bar{X}}$	.98	.88	1.02	.93	.89	.99	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXIV

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Phosphorus in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, August, 1968.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.11	.13	.10	.12			.11
50		.12	.09	.11	.12	.10	.11
100				.10	.11	.12	.11
100 (Split)*				.10			.10
200 (Split)*				.09		.10	.09
400 (Split)*						.08	.08
$\bar{\bar{X}}$	.11	.12	.09	.10	.11	.10	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXV

Summary of the Effects of Soil Fertility Treatments on Per Cent Phosphorus in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, August, 1968.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.11	.12	.11	.12			.11
50	.10	.12	.10	.12	.13	.14	.12
100	.09			.12			.10
100 (Split)*	.09			.11	.13	.13	.11
200 (Split)*				.11		.12	.11
400 (Split)*						.12	.12
$\bar{\bar{X}}$	.10	.12	.10	.12	.13	.13	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXVI

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Potassium in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, August, 1968.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.50	.56	.49	.47			.50
50		.50	.47	.48	.48	.46	.48
100				.51			.51
100 (Split)*				.47	.45	.52	.48
200 (Split)*				.53		.51	.52
400 (Split)*						.59	.59
$\bar{\bar{X}}$	.50	.53	.48	.49	.46	.52	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXVII

Summary of the Effects of Soil Fertility Treatments on Per Cent Potassium in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, August, 1968.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.50	.51	.49	.49			.50
50	.54	.48	.44	.50	.49	.55	.50
100	.47			.55			.51
100 (Split)*	.50			.50	.48	.49	.49
200 (Split)*				.50		.47	.48
400 (Split)*						.65	.65
$\bar{\bar{X}}$	.50	.50	.46	.51	.48	.54	

No F value since data was taken from composite samples.

(*) The nitrogen applications were split as described in the materials and methods section.

The nitrogen content of the forage from the November, 1968, treatment is shown in Tables XXVIII and XXIX. At this harvest, the 50 pounds of nitrogen per acre that had been applied in May did not increase the nitrogen content of the forage. Increases in the nitrogen rate, above 50 pounds per acre, did increase the nitrogen content of the forage. The annual application of phosphorus and potassium increased the nitrogen content of the forage at the 100 (Split)-40-40, 200-40-40 and 400-80-80 treatment levels.

The application of phosphorus, with or without potassium, increased the phosphorus content of the forage from the November, 1968, harvest, Tables XXX and XXXI. The annual application of 80P and 80K produced forage with a higher phosphorus content than the plots that had not received phosphorus and potassium since 1967. However, differences in the phosphorus content of the forage were very small.

At 50 pounds of nitrogen per acre, none of the phosphorus and potassium treatments had a significant effect on the potassium content of the forage at the November, 1968, harvest, Tables XXXII and XXXIII. At the 40P-40K and 80P-80K treatment levels the potassium content of the forage increased as the nitrogen rate was increased. A slight increase in the potassium content of the forage was produced by the annual application of phosphorus and potassium at the 200-40-40 and 400-80-80 treatment levels.

The application of phosphorus and potassium did not signif-

TABLE XXVIII

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Third Crop, November, 1968.

N levels (lbs./Ac.	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.98	.95	.94	.91			.94
50		.90	.90	.90	.91	.97	.92
100				1.01			1.01
100 (Split)*				1.06	1.15	1.05	1.09
200 (Split)*				1.16		1.32	1.24
400 (Split)*						1.48	1.48
$\bar{\bar{X}}$	.98	.92	.92	1.01	1.03	1.20	

Treatment F = 4.53($P < .05$) Coefficient of Variation = 12.9%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXIX

Summary of the Effects of Soil Fertility Treatments on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Third Crop, November, 1968.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.98	1.03	.98	.91			.97
50	.96	.88	.99	.97	1.04	.99	.97
100	.92			1.03			.97
100 (Split)*	1.12			1.32	1.00	1.13	1.14
200 (Split)*				1.33		1.28	1.30
400 (Split)*						1.56	1.56
$\bar{\bar{X}}$	.99	.95	.98	1.11	1.02	1.24	

Treatment F = 11.11($P < .05$) Coefficient of Variation = 8.9%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXX

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Phosphorus in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Third Crop, November, 1968.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.13	.15	.12	.15			.14
50		.13	.12	.14	.14	.15	.14
100				.15			.15
100 (Split)*				.12	.13	.13	.13
200 (Split)*				.12		.13	.12
400 (Split)*						.12	.12
$\bar{\bar{X}}$	.13	.14	.12	.14	.13	.13	

Treatment F = 2.39($P < .05$) Coefficient of Variation = 11.7%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXXI

Summary of the Effects of Soil Fertility Treatments on Per Cent Phosphorus in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Third Crop, November, 1968.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.13	.16	.14	.15			.14
50	.12	.15	.11	.15	.17	.18	.15
100	.11			.14			.12
100 (Split)*	.11			.14	.14	.17	.14
200 (Split)*				.13		.16	.14
400 (Split)*						.16	.16
$\bar{\bar{X}}$	.12	.15	.12	.14	.15	.17	

Treatment F = 6.16($P < .05$) Coefficient of Variation = 9.9%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXXII

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Potassium in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Third Crop, November, 1968.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.52	.52	.50	.54			.52
50		.49	.51	.54	.58	.54	.53
100				.59			.59
100 (Split)*				.65	.64	.67	.65
200 (Split)*				.68		.79	.73
400 (Split)*						.87	.87
$\bar{\bar{X}}$	.52	.50	.50	.60	.61	.72	

Treatment F = 10.53($P < .05$) Coefficient of Variation = 10.0%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXXIII

Summary of the Effects of Soil Fertility Treatments on Per Cent Potassium in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Third Crop, November, 1968.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.52	.44	.48	.43			.47
50	.51	.46	.51	.49	.54	.56	.51
100	.51			.51			.51
100 (Split)*	.63			.71	.65	.69	.67
200 (Split)*				.78		.81	.79
400 (Split)*						.94	.94
$\bar{\bar{X}}$	.54	.45	.49	.58	.59	.75	

Treatment F = 21.85($P < .05$) Coefficient of Variation = 8.8%

(*) The nitrogen applications were split as described in the materials and methods section.

icantly increase the nitrogen content of the forage from the June, 1969, harvest, Tables XXXIV and XXXV. Increases in nitrogen rate produced an increase in the nitrogen content of the forage. The only significant increase in nitrogen content of the forage produced by the annual application of phosphorus or potassium was at the 50-40-0 treatment level. The annual application of phosphorus and potassium reduced the nitrogen content of the forage at the 200-80-80 and 400-80-80 treatment levels. However, these treatments did produce more forage, Tables IX and X.

The phosphorus content of the forage from the June, 1969, harvest was almost the same for all treatments where phosphorus and potassium had not been applied since 1967, Table XXXVI. The annual application of phosphorus, with or without potassium, increased the phosphorus content of the forage, Table XXXVII. The forage from this harvest also had the highest phosphorus content of any forage harvested. When Tables XXXVI and XXXVII are compared it is obvious that the annual application of phosphorus increased the phosphorus content of the forage, particularly at the 80 pounds per acre rate.

The potassium content of the forage harvested in June, 1969, was much lower than that of the forage harvested in 1968. Where phosphorus and potassium had not been applied since 1967, the treatments had little effect on the potassium content of the forage, Table

TABLE XXXIV

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1969

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	1.27	1.12	1.20	1.24			1.21
50		1.42	1.66	1.51	1.48	1.47	1.51
100				1.79			1.79
100 (Split)*				1.61	1.53	1.44	1.53
200 (Split)*				1.81		1.93	1.87
400 (Split)*						2.02	2.02
$\bar{\bar{X}}$	1.27	1.27	1.43	1.59	1.50	1.71	

Treatment F = 10.89($P < .05$) Coefficient of Variation = 9.0%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXXV

Summary of the Effects of Soil Fertility Treatments on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1969.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	1.27	1.21	1.13	1.36			1.24
50	1.60	1.71	1.57	1.46	1.55	1.48	1.56
100	1.72			1.70			1.71
100 (Split)*	1.47			1.50	1.59	1.55	1.53
200 (Split)*				1.81		1.77	1.79
400 (Split)*						1.76	1.76
$\bar{\bar{X}}$	1.51	1.46	1.34	1.57	1.57	1.64	

Treatment F = 4.27($P < .05$) Coefficient of Variation = 10.4%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXXVI

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Phosphorus in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1969.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.19	.19	.19	.19			.19
50		.19	.18	.19	.20	.19	.19
100				.18			.18
100 (Split)*				.16	.18	.18	.17
200 (Split)*				.17		.19	.18
400 (Split)*						.16	.16
$\bar{\bar{X}}$	.19	.19	.18	.18	.19	.18	

Treatment F = 2.13($P < .05$) Coefficient of Variation = 7.0%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXXVII

Summary of the Effects of Soil Fertility Treatments on Per Cent Phosphorus in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1969.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.19	.24	.17	.23			.21
50	.17	.22	.18	.22	.27	.25	.22
100	.17			.23			.20
100 (Split)*	.16			.21	.25	.26	.22
200 (Split)*				.21		.25	.23
400 (Split)*						.23	.23
$\bar{\bar{X}}$	.17	.23	.17	.22	.26	.25	

Treatment F = 16.0($P < .05$) Coefficient of Variation = 6.4%

(*) The nitrogen applications were split as described in the materials and methods section.

XXXVIII. However, the higher nitrogen rates did produce forage with a slightly higher potassium content. The annual application of potassium did slightly increase the potassium content of the forage, Tables XXXVIII and XXXIX.

Nitrogen treatments had more influence on the nitrogen content of the forage from the October, 1969, harvest than phosphorus or potassium, Tables XL and XLI. The 200-80-80 and 400-80-80 treatments were the only treatments that showed an increase in nitrogen content due to the annual application of phosphorus and potassium.

The phosphorus content of the forage from the October, 1969, harvest is shown in Tables XLII and XLIII. Where phosphorus and potassium had not been applied since 1967, Table XLII, the phosphorus content of the forage was similar for most treatments. The annual application of phosphorus produced forage with a slightly higher phosphorus content that that produced on plots that had not received phosphorus since 1967 or had received only nitrogen. Increasing nitrogen fertilization had almost no effect on the phosphorus content of the forage.

The potassium content of the forage from the October, 1969, harvest was lower than that from any of the previous harvests, Tables XLIV and XLV. The treatments had little influence on the potassium content of the forage. The highest potassium content in the forage was produced by the 200-80-80 treatment. The annual

TABLE XXXVIII

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Potassium in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1969.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.32	.30	.31	.29			.30
50		.36	.35	.36	.33	.36	.35
100				.45			.45
100 (Split)*				.36	.36	.36	.36
200 (Split)*				.43		.43	.43
400 (Split)*						.40	.40
$\bar{\bar{X}}$	.32	.33	.33	.38	.34	.39	

Treatment F = 6.4($P < .05$) Coefficient of Variation = 8.8%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XXXIX

Summary of the Effects of Soil Fertility Treatments on Per Cent Potassium in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, First Crop, June, 1969.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.32	.32	.30	.33			.32
50	.36	.42	.40	.41	.43	.47	.41
100	.43			.46			.44
100 (Split)*	.37			.49	.46	.48	.45
200 (Split)*				.47		.52	.49
400 (Split)*						.50	.50
$\bar{\bar{X}}$	.37	.37	.35	.43	.44	.49	

Treatment F = 16.37($P < .05$) Coefficient of Variation = 6.7%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XL

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, October, 1969.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	1.08	1.07	1.04	1.03			1.05
50		1.11	.97	1.10	1.12	1.09	1.08
100				1.22			1.22
100 (Split)*				1.25	1.52	1.46	1.41
200 (Split)*				1.88		1.69	1.78
400 (Split)*						1.66	1.66
$\bar{\bar{X}}$	1.08	1.09	1.00	1.30	1.32	1.47	

Treatment F = 12.53($P < .05$) Coefficient of Variation = 10.9%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XLI

Summary of the Effects of Soil Fertility Treatments on Per Cent Nitrogen in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, October, 1969.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	1.08	1.03	.97	1.19			1.07
50	1.23	1.14	1.06	1.14	1.09	1.12	1.13
100	1.11			1.14			1.12
100 (Split)*	1.36			1.33	1.42	1.41	1.38
200 (Split)*				1.84		1.83	1.83
400 (Split)*						1.99	1.99
$\bar{\bar{X}}$	1.19	1.08	1.01	1.33	1.25	1.59	

Treatment F = 12.98($P < .05$) Coefficient of Variation = 11.0%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XLII

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Phosphorus in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, October, 1969.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.13	.15	.13	.13			.13
50		.14	.10	.14	.13	.14	.13
100				.13			.13
100 (Split)*				.12	.14	.14	.13
200 (Split)*				.15		.15	.15
400 (Split)*						.12	.12
$\bar{\bar{X}}$	.13	.14	.11	.13	.13	.14	

Treatment F = 4.0($P < .05$) Coefficient of Variation = 7.7%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XLIII

Summary of the Effects of Soil Fertility Treatments on Per Cent Phosphorus in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, October, 1969.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.13	.15	.13	.14			.14
50	.13	.16	.11	.16	.17	.16	.15
100	.12			.15			.13
100 (Split)*	.11			.15	.17	.18	.15
200 (Split)*				.16		.18	.17
400 (Split)*						.17	.17
$\bar{\bar{X}}$	.12	.15	.12	.15	.17	.17	

Treatment F = 7.0($P < .05$) Coefficient of Variation = 9.4%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XLIV

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Per Cent Potassium in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, October, 1969.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.18	.19	.19	.17			.18
50		.17	.19	.19	.21	.20	.19
100				.21			.21
100 (Split)*				.23	.25	.22	.23
200 (Split)*				.24		.26	.25
400 (Split)*						.22	.22
$\bar{\bar{X}}$	.18	.18	.19	.21	.23	.23	

Treatment F = 1.69(N.S.@.05) Coefficient of Variation = 17.2%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XLV

Summary of the Effects of Soil Fertility Treatments on Per Cent Potassium in Midland Bermudagrass Forage, Kirkland Fine Sandy Loam, Second Crop, October, 1969.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	.18	.18	.19	.20			.19
50	.21	.18	.17	.22	.23	.20	.20
100	.21			.22			.21
100 (Split)*	.21			.22	.25	.24	.23
200 (Split)*				.28		.30	.29
400 (Split)*						.27	.27
$\bar{\bar{X}}$	.20	.18	.18	.23	.24	.25	

Treatment F = 2.00($P < .05$) Coefficient of Variation = 19.8%

(*) The nitrogen applications were split as described in the materials and methods section.

application of phosphorus and potassium did increase the potassium content of the forage at the 200-40-40, 200-80-80 and 400-80-80 treatment levels.

Just before applying the phosphorus and potassium in March of 1969, soil samples were collected by taking cores at a depth of 0-6 inches from all plots. The pH of the plots that had not received phosphorus and potassium since 1967 ranged from 6.2 for the 0-40-0 treatment to 5.8 for the 400-80-80 treatment, Table XLVI. Where 100 pounds of nitrogen had been applied in May, the 100-40-40 treatment had a 5.9 pH. The check had a 6.1 pH, which was also slightly lower than the 6.4 reading in November, 1966, Table LIX. Where phosphorus and potassium were applied annually the pH was very similar to that where phosphorus and potassium had not been applied since 1967, Table XLVII.

Soil phosphorus levels from the March, 1969, sampling are shown in Tables XLVIII and XLIX. Where phosphorus and potassium had not been applied since 1967, Table XLVIII, only two treatments, 0-40-0 and 100-80-80, had phosphorus levels higher than the check. All of the other treatments had a phosphorus level slightly lower than the check and the 400-80-80 treatment had the lowest level. This suggests that an application of phosphorus every other year is not adequate to maintain or increase the soil levels, except at a fertilization level similar to the 0-40-0 or 100-80-80 treatments. Phosphorus readings lower than 46 pounds per acre are usually

TABLE XLVI

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Soil pH, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, First Sampling, March 21, 1969.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	6.1	6.2	6.1	6.0			6.1
50		6.1	6.0	6.1	6.1	6.1	6.1
100				5.9			5.9
100 (Split)*				6.1	6.1	6.0	6.1
200 (Split)*				6.0		6.0	6.0
400 (Split)*						5.8	5.8
$\bar{\bar{X}}$	6.1	6.1	6.0	6.0	6.1	6.0	

Treatment F = 2.48($P < .05$) Coefficient of Variation = 1.7%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XLVII

Summary of the Effects of Soil Fertility Treatments on Soil pH, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, First Sampling, March 21, 1969.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						$\bar{\bar{X}}$
	0	40P	40K	40-40	80-40	80-80	
0	6.1	6.1	6.1	5.9			6.0
50	6.0	6.0	6.0	6.0	5.9	6.1	6.0
100	6.0			6.0			6.0
100 (Split)*	6.0			6.0	6.0	6.0	6.0
200 (Split)*				6.0		6.0	6.0
400 (Split)*						5.8	5.8
$\bar{\bar{X}}$	6.0	6.0	6.0	6.0	5.9	6.0	

Treatment F = 1.18(N.S.@.05) Coefficient of Variation = 1.9%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XLVIII

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Available Soil Phosphorus Under Midland Bermudagrass, Kirkland Fine Sandy Loam, First Sampling, March 21, 1969. Reported as Average Pounds of P_2O_5 per Acre from Triplicate Plots.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	40	47	31	32			37
50		38	38	33	37	37	37
100				34			34
100 (Split)*				32	36	44	37
200 (Split)*				31		32	31
400 (Split)*						25	25
$\bar{\bar{X}}$	40	42	34	32	36	34	

Treatment F = .78 (N.S. @. 05) Coefficient of Variation = 31.5%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE XLIX

Summary of the Effects of Soil Fertility Treatments on Available Soil Phosphorus, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, First Sampling, March 21, 1969. Reported as Average Pounds of P_2O_5 per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	40	57	32	59			47
50	38	58	34	44	85	58	53
100	22			35			28
100 (Split)*	25			34	46	57	40
200 (Split)*				42		43	42
400 (Split)*						36	36
$\bar{\bar{X}}$	31	57	33	43	65	48	

Treatment F = 4.17($P < .05$) Coefficient of Variation = 28.4%

(*) The nitrogen applications were split as described in the materials and methods section.

considered low when the soil testing method described in the materials and methods section is used.

Soil phosphorus levels from the plots that had received annual applications of phosphorus and potassium are shown in Table XLIX. In all treatments except 100-40-40 the soil phosphorus levels were higher where phosphorus had been applied annually. At 0 nitrogen, 40 pounds of phosphorus with or without potassium increased the soil phosphorus level. At 50 pounds of nitrogen per acre, 40 pounds of phosphorus per acre increased the soil phosphorus level, but when 40 pounds of potassium were added (50-40-40) the soil level was almost equal to that of the 50-0-0 treatment while the total forage yield from the two plots showed little difference. The phosphorus content of the forage was about the same for both treatments so the soil difference cannot be explained by forage removal. The same trend, but with a greater difference, occurred between the 50-80-40 and 50-80-80 treatments. However, 80 pounds of phosphorus per acre did increase the soil level at the 50-80-40 treatment. The soil phosphorus level at 100-80-80 was higher than at the 100-80-40 treatment and the 100-80-80 treatment produced the most forage. A general trend was that an increase in nitrogen caused a reduction in the soil phosphorus level especially at the 80P-80K treatment level.

Soil potassium levels were about the same in March, 1969, as they were in November, 1966, Tables L, LI and LIX. Where

TABLE L

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Extractable Soil Potassium, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, First Sampling, March 21, 1969. Reported as Average Pounds of K_2O per Acre from Triplicate Plots.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	203	221	230	207			215
50		196	213	191	183	204	197
100				180			180
100 (Split)*				190	195	196	194
200 (Split)*				189		187	188
400 (Split)*						158	158
$\bar{\bar{X}}$	203	208	221	191	189	186	

Treatment F = 1.48(N.S.@.05) Coefficient of Variation = 12.4%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE LI

Summary of the Effects of Soil Fertility Treatments on Extractable Soil Potassium, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, First Sampling, March 21, 1969. Reported as Average Pounds of K_2O per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	203	221	217	238			220
50	202	219	237	216	237	239	225
100	193			226			209
100 (Split)*	198			212	185	209	201
200 (Split)*				193		210	201
400 (Split)*						174	174
$\bar{\bar{X}}$	199	220	227	217	211	208	

Treatment F = 1.65(N.S.@.05) Coefficient of Variation = 11.7%

(*) The nitrogen applications were split as described in the materials and methods section.

nitrogen was applied on the plots that had not received phosphorus and potassium since 1967 the soil potassium level was reduced at the 80P-80K treatment level, Table L. The 50-80-40, 100-40-40 and 400-80-80 treatments had a significant reduction in the soil potassium level. The annual application of potassium increased the potassium content of the soil in all plots except 400-80-80, 200-80-80, 200-40-40, 100-80-40 and 100-80-80. The reduced soil potassium level was not directly correlated to forage yield and potassium removal at the 100-40-40 and 100-80-40 treatments. In most treatments the soil potassium level was higher on plots that received annual potassium applications than on plots that had not received potassium since 1967, Tables L and LI. At the 80 pounds per acre phosphorus level, potassium additions had increased the soil potassium levels and resulted in increased forage yields. Soils testing below 180 pounds of K_2O, by the method used in this study, will usually respond to potassium additions.

Soil samples were again collected in October, 1969, just after the final forage harvest. The soil pH values were about the same as they were in March, 1969, Tables LII and LIII. Again, the pH values showed only a slight variation. Most pH values were about the same whether or not the plots had received annual applications of phosphorus and potassium. The annual applications of phosphorus and potassium caused the soil pH reduction to be less at the 400-80-80 treatment.

TABLE LII

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Soil pH, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, Second Sampling, October 22, 1969.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	6.1	6.2	6.1	6.2			6.1
50		6.1	6.2	6.2	6.1	6.1	6.1
100				6.2			6.2
100 (Split)*				6.1	6.0	6.2	6.1
200 (Split)*				6.1		6.2	6.1
400 (Split)*						5.8	5.8
$\bar{\bar{X}}$	6.1	6.1	6.1	6.2	6.0	6.1	

Treatment F = 1.44(N.S.@.05) Coefficient of Variation = 2.6%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE LIII

Summary of the Effects of Soil Fertility Treatments on Soil pH, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, Second Sampling, October 22, 1969.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	6.1	6.2	6.2	6.2			6.2
50	6.1	6.1	6.1	6.1	6.2	6.0	6.1
100	6.1			6.2			6.1
100 (Split)*	6.1			6.1	6.1	6.1	6.1
200 (Split)*				6.1		6.1	6.1
400 (Split)*						6.0	6.0
$\bar{\bar{X}}$	6.1	6.1	6.1	6.1	6.1	6.0	

Treatment F = 0.92(N.S.@.05) Coefficient of Variation = 1.9%

(*) The nitrogen applications were split as described in the materials and methods section.

Soil phosphorus values for the October, 1969, sampling are shown in Tables LIV and LV. The plots that had not received phosphorus since 1967 had phosphorus values higher than the check at the 50-40-0, 50-80-40 and 50-80-80 treatments, Table LIV. The 100-40-40 and 400-80-80 treatments had the lowest phosphorus values. The soil phosphorus values were generally lower at the October sampling than at the March sampling, Tables XLVIII and LIV.

The annual applications of phosphorus increased the soil phosphorus levels above those of the check at all treatments except the 100-40-40 treatment, Table LV. Phosphorus levels were higher in October than in March at the 0-40-0, 50-80-40, 50-80-80, 100-40-40, 100-80-40, 100-80-80, 200-80-80 and 400-80-80 treatments, Tables XLIX and LV. The phosphorus content of the forage from the October harvest did not always correlate with the soil levels, Tables XLIII and LV.

The annual application of phosphorus did increase the soil phosphorus levels as shown in the October sampling, Table LV. An increase in phosphorus application produced an increase in the soil level. Again, the 50-80-40 treatment had a much higher phosphorus level than the 50-80-80 treatment. The change did not occur at 100 and 200 pounds of nitrogen per acre. As the nitrogen rate increased, the forage yield increased and the soil phosphorus level decreased.

TABLE LIV

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Available Soil Phosphorus, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, Second Sampling, October 22, 1969. Reported as Average Pounds of P_2O_5 per Acre from Triplicate Plots.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	28	31	35	27			30
50		38	22	24	34	32	30
100				21			21
100 (Split)*				23	27	22	24
200 (Split)*				23		24	23
400 (Split)*						21	21
$\bar{\bar{X}}$	28	34	28	24	30	25	

Treatment F = 2.02($P < .05$) Coefficient of Variation = 24.9%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE LV

Summary of the Effects of Soil Fertility Treatments on Available Soil Phosphorus, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, Second Sampling, October 22, 1969. Reported as Average Pounds of P_2O_5 per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	28	80	25	56			47
50	23	47	27	45	122	71	56
100	22			28			25
100 (Split)*	23			47	78	75	56
200 (Split)*				39		68	53
400 (Split)*						45	45
$\bar{\bar{X}}$	24	63	26	43	100	65	

Treatment F = 10.68($P < .05$) Coefficient of Variation = 28.2%

(*) The nitrogen applications were split as described in the materials and methods section.

When soil analysis data and forage yields are compared, the data indicates that a yield response by Midland bermudagrass to phosphorus fertilization ceases at a soil test level somewhere between 30 and 40 pounds per acre.

Soil potassium levels at the October, 1969, sampling, Tables LVI and LVII, were about half as high as they were in March, Tables L and LI. This occurred on the check plots as well as all of the treated plots. Perhaps "fixation", as suggested by Albrecht (2), occurred during the growing season since the forage did not remove enough potassium to account for the difference. The annual application of potassium increased the soil potassium levels at the 0-0-40, 50-0-40, 50-80-80 and 100-80-80 treatments. Very few plots had potassium levels higher than the check and the 200-80-80 and 400-80-80 treatments had potassium levels considerably lower than the check. Generally, an increase in nitrogen application caused an increase in forage production and a decrease in soil potassium levels.

The addition of potassium to plots with soil test levels less than 200 pounds of potassium, at the March sampling, caused an increase in forage production if the phosphorus level was higher than 40 pounds per acre, Tables XLIX and LI. Therefore, the critical soil potassium level, at the site being studied, seems to be about 200 pounds per acre for bermudagrass.

Composite soil samples were collected from the 400-80-80

TABLE LVI

Summary of the Effects of Nitrogen Fertilization Levels with Residual Phosphorus and Potassium on Extractable Soil Potassium, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, Second Sampling, October 22, 1969. Reported as Average Pounds of K_2O per Acre from Triplicate Plots.

N levels (lbs./Ac.)	Residual 1967 P and K treatment levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	106	98	121	106			108
50		98	107	105	102	109	104
100				91			91
100 (Split)*				99	99	99	99
200 (Split)*				95		87	91
400 (Split)*						88	88
$\bar{\bar{X}}$	106	98	114	99	100	96	

Treatment F = 2.27($P < .05$) Coefficient of Variation = 9.6%

(*) The nitrogen applications were split as described in the materials and methods section.

TABLE LVII

Summary of the Effects of Soil Fertility Treatments on Extractable Soil Potassium, Under Midland Bermudagrass, Kirkland Fine Sandy Loam, Second Sampling, October 22, 1969. Reported as Average Pounds of K_2O per Acre from Triplicate Plots.

N levels (lbs./Ac.)	P and K levels (lbs./Ac. P_2O_5 and/or K_2O)						
	0	40P	40K	40-40	80-40	80-80	$\bar{\bar{X}}$
0	106	107	131	111			114
50	104	101	129	103	105	129	112
100	100			105			102
100 (Split)*	104			98	99	117	104
200 (Split)*				91		88	100
400 (Split)*						86	86
$\bar{\bar{X}}$	103	104	130	102	102	105	

Treatment F = 3.14($P < .05$) Coefficient of Variation = 11.9%

(*) The nitrogen applications were split as described in the materials and methods section.

treatments at three depths October 22, 1969. The results in Table LVIII indicate that the surface two inches were the most severely affected. The pH is lower than that at the other depths, and phosphorus and potassium levels are the highest. The pH increased and phosphorus and potassium levels decreased with depth. The values for the 0-6 inch depth are not an average of the other three samples.

TABLE LVIII

Soil Test Results of a Composite Sample Collected October 22, 1969, from all Three Replications of the 400-80-80 Treatment.

Depth	pH	P_2O_5 (lbs. /Ac.)	K_2O (lbs. /Ac.)
0-2"	5. 3	81	133
2-4"	6. 2	22	94
4-6"	6. 3	15	67
0-6"	6. 0	45	86

CHAPTER V

SUMMARY AND CONCLUSIONS

Changes in soil test values resulting from plant nutrient additions were studied. An attempt was also made to correlate fertilizer additions, forage production of Midland bermudagrass and composition of the forage with the soil test levels.

The annual application of phosphorus increased the soil phosphorus levels. However, at the 80P and 80K treatment levels an increase in nitrogen increased the forage production and lowered the soil phosphorus level. At the 50 pounds per acre nitrogen treatment, potassium fertilization influenced the soil phosphorus level. The 50-80-40 treatment had a higher soil phosphorus level than the 50-80-80 treatment, although forage production and composition were about the same.

Phosphorus content of the forage from the 1967 and 1968 harvests did not always correlate with fertilization. An increase in nitrogen usually increased forage production and reduced the phosphorus content of the forage. Forage from the June, 1969, harvest had a phosphorus content that correlated with the soil levels at the March sampling. Differences in phosphorus content

of the forage from the October, 1969, harvest were very small, but the general trend was for the phosphorus content of the forage to follow the soil levels at the October sampling. Midland bermudagrass responded to phosphorus applications when the soil level, just prior to the growing season, was below 40 pounds per acre.

The annual application of potassium increased the soil potassium levels at the 0-0-40, 50-0-40, 50-80-80 and 100-80-80 treatments. At the higher nitrogen levels the soil potassium levels were lower than the level of the check plot, although 80 pounds of potassium per acre were applied each year. Generally, an increase in nitrogen fertilization increased forage yields and reduced the soil potassium levels. During the 1969 growing season the soil potassium levels were reduced in all plots.

The potassium content of the forage did not always follow the fertilizer additions. Potassium content of the forage from the June, 1969, harvest tended to follow the March soil levels, but were not well correlated when fertilizer additions were considered. The October, 1969, harvest produced forage with a potassium content that seemed to correlate with total fertility additions rather than soil potassium levels. In all harvests an increase in nitrogen fertilization increased the potassium content of the forage.

Forage yields were increased by the addition of potassium when soil potassium levels were less than 200 pounds per acre and soil phosphorus levels were higher than 40 pounds per acre.

Soil fertility treatments had little effect on soil pH when a 0 to 6 inch sample was taken. However, soil pH was apparently affected at the 0 to 2 inch level by the 400-80-80 treatments.

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TABLE LIX

Soil Test Results of a Composite Sample Collected November, 1966, From the Entire Plot Area

Depth	pH	P_2O_5 (lbs./Ac.)	K_2O (lbs./Ac.)
0-6"	6.4	23	200

TABLE LX

Fertilizer Treatments Used on Midland Bermudagrass. Reported as Pounds Per Acre N-P_2O_5-K_2O.

1967 Treatment	1968-69 Treatment
0-0-0	0-0-0
0-40-0	0-0-0
0-40-0	0-40-0
0-0-40	0-0-0
0-0-40	0-0-40
0-40-40	0-0-0
0-40-40	0-40-40
50-0-0	50-0-0
50-40-0	50-0-0
50-40-0	50-40-0
50-0-40	50-0-0
50-0-40	50-0-40
50-40-40	50-0-0
50-40-40	50-40-40
50-80-40	50-0-0
50-80-40	50-80-40
50-80-80	50-0-0
50-80-80	50-80-80
100-0-0	100-0-0
100-0-0 (Split)*	100-0-0
100-40-40	100-0-0
100-40-40	100-40-40
100-40-40 (Split)*	100-0-0
100-40-40 (Split)*	100-40-40
100-80-40 (Split)*	100-0-0
100-80-40 (Split)*	100-80-40
100-80-80 (Split)*	100-0-0
100-80-80 (Split)*	100-80-80
200-40-40 (Split)*	200-0-0

TABLE LX (Continued)

1967 Treatment	1968-69 Treatment
200-40-40 (Split)*	200-40-40
200-80-80 (Split)*	200-0-0
200-80-80 (Split)*	200-80-80
400-80-80 (Split)*	400-0-0
400-80-80 (Split)*	400-80-80

(*) When the nitrogen was applied as a split application, one-half was applied in May and one-half in early August, except at the 400 pound level, 100 pounds of nitrogen were applied about the first of May, June, July and August.

TABLE LXI

Daily Rainfall Data Collected One-half Mile South of Bermudagrass Plots During 1967.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1		.20					T					
2							T				.17	
3					T		.86					
4					T		.11		.88			
5					.70		.62		1.50			.05
6									.66			
7				.15						.30		
8												
9											.32	
10				1.65				.46				.10
11		.11				.05						
12				7.25	.32	.50	T					
13												.56
14					.24				.10			.50
15									1.35	1.75		.07
16							.10		.35			.30
17						.11		.30	.13			
18				.28	.09		.10		.90			
19				.24			.05					
20			.50		1.80			.60				.19
21				1.45	T			T				
22			.10	.13	T							
23												
24												
25			.60			1.65						
26	.30					1.80		T	.54			
27											.14	.04
28												
29				.28	.34					2.55	.11	
30				.08	1.90					.19		.05
31										.13		.05
Tot.	.30	.31	1.20	11.51	5.39	4.11	1.84	1.36	6.41	4.92	.74	1.91

TABLE LXII

Daily Rainfall Data Collected One-half Mile South of Bermudagrass Plots During 1968.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1				.18		.07	.90					
2				.40							.58	.07
3					.66	T						
4									.49			
5										1.35		
6											T	
7					.06	.30						
8	.30	.08			T							
9			.05		.68					.85		
10			1.15		1.15			1.25			T	
11			.30		T							
12				.42	3.15							.05
13					.64							
14		.34						.34	.24			
15						1.10					.36	
16										.48		
17					2.30							
18	2.80	.15	.31	.16			.80					
19	.07		1.60	.16	T							
20	.19		.07									
21	.26	.20		.84	.66				.07	.12		.17
22	.03	.02	.06									
23												
24						.95			2.51			
25						1.05						
26											2.00	
27	.42	.22		T	.14						.56	1.90
28	.18			T			.30					
29	.48											
30	.05		.60		.62						.30	
31	.03				2.25							
Tot.	4.81	1.01	4.14	2.16	12.31	3.47	2.00	1.59	3.31	2.80	3.80	2.19

TABLE LXIII

Daily Rainfall Data Collected One-half Mile
South of Bermudagrass Plots
During 1969.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1						.15						
2			.70								.22	
3												
4					2.60					.05		
5			.19					.66				
6					1.60					1.20		
7			.70									
8						.13						
9												
10									.18			
11												
12				.60	.24	.05				3.00		
13		.56				1.05						
14		.92										
15	.24		.36		.24			.02				
16	T			.30					.34		T	
17	T				.49							
18	T											
19	T					.26						
20	T					.06	.06					
21	T	1.54										
22	T							.10	.90			
23		.08	1.15						.35	.09		
24												
25								.40				
26				1.40				.15			.50	
27							.18			.40		
28										.50		
29	.49									.08		
30					.76							
31	.24											
Tot.	.97	3.10	2.40	2.30	5.93	1.70	.24	1.33	1.77	5.32	.72	

VITA

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