THE EFFECTS OF FERTILIZER TREATMENT ON YIELD AND UPTAKE OF NUTRIENTS BY KAFIR 44-14 SORGHUM

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INTRODUCTION

It has been shown many times that the chemical composition and other characteristics of plants may be changed by environmental factors such as climate and soil conditions. However, within limits, genetic factors chiefly determine the composition of the species.

Various rates and ratios of fertilizers have been used in fertility studies to determine nutrient uptake and the optimum level for maximum yields. These experiments do not answer the basic questions as to what happens in the metabolism of the plant. The possibility of increasing crop yields and improving quality has been studied in many areas of the United States as well as other countries. The consensus of opinion has been that the use of commercial fertilizers plus good management will be important factors in a permanent agriculture.

Grain Sorghum is one of the primary crops for Oklahoma. This plant is adapted to most soil types and climatic conditions in Oklahoma. Recommended varieties are available for all sections of the state. An increase in the acreage of grain sorghum in Oklahoma may be expected because of: low cost in production, short maturity period, drought tolerance, high yields of quality grain, and ease of harvest.

The purpose of the investigation was to determine the effects of variable rates of nitrogen and phosphorus with fixed levels of potassium and magnesium on the grain and forage yield of Kafir 44-14 and its elemental composition.

It is hoped that this investigation will be a significant contribution toward better understanding of the problem of fertilization of grain sorghums.

REVIEW OF LITERATURE

The cultivation of crops was begun several thousand years ago as shown by archeological research, and the use of fertilizers soon followed. Collings (8) states that as far back as five hundred B. C., the Celts and other European people used fish, chalk, guano, wood ashes, animal waste, and marl. The oldest continuous experiments on the response of crops and soils to fertilizers and manures were started at Rothamsted, England, in 1843 by John B. Lawes and J. H. Gilbert. For one hundred years, continuous, wheat fertilized with inorganic fertilizers have maintained yields equal to those obtained with animal manures and other treatments.

McVicker (16) states that one-fifth of the agricultural production in this country can be credited to fertilizers. He further stated that without fertilizers, it would take fifty million additional acres to produce the present quantities of farm products. Bear (2) reported that the fertilizer industry represents the most important advance ever made toward providing food for the people of the earth.

The selection of a fertilizer, according to Harper (12), depends upon the elements that are needed by plants and upon elements that have been leached or removed from the soil. Dumenil and Lloyd (10) reported that efficient fertilizer use could only result when each element was used to its fullest extent and advantage by the plants. If one fertilizer element was applied in quantities too small to benefit the crop, it could prevent effective utilization of other elements. The importance of a balanced nutrient supply for efficient growth cannot be overemphasized.

Nelson (19) presented a review on the effects of spacing and nitrogen fertilization on the yield of grain sorghums under irrigation. Three varieties were grown at four nitrogen levels and with several plant spacings. The amount of nitrogen applied was the only variable which significantly affected yields. Painter and Leamer (21) reported significant interactions between fertility X moisture and fertility X spacing. A proper balance of nutrient elements was emphasized for high yields.

At the present time, there are many methods by which the nutrient elements in the soil and plant tissue may be measured, and there are as many ideas on the proper procedure that should be followed. Lundegardh (15) reported that his technique of leaf analyses, if properly applied, would give a comprehensive picture of the effects of fertilization in the course of a crop year.

Thomas, et al. (25) reported that foliar analysis was the best comparative measure available, but he emphasized that the method was significant only in a relative sense. Chubb and Atkinson (6), investigated the foliar analysis method and arrived at the conclusion that a simple relationship between the composition of leaves and the addition of elements to the soil did not exist. They further stated that yields and inorganic composition of plants failed to be correlated with fertilizer. treatments.

Beeson, et al. (3) presented a review on the absorption of nutrient elements by forage plants with particular reference to the soil in which they were grown. They reported wide variations between plants and conflicting analytical results. Weideman, (32) reported on the effect of available phosphorus in the soil on the phosphorus content of grain. He believed it would be more desirable to add the needed fertilizer elements to the feed rations rather than to apply them to the soil. Murphy (18) reported that an application of three hundred pounds of 16 percent super phosphate increased the phosphorus content of wheat grain from 0.320 percent to 0.397 percent.

Reports by Murphy (18), Vandecaveye et al. (27), and Weeks et al. (31) showed that applications of phosphorus to the soil increased the phosphorus content of wheat grain and forage. Painter et al. (21), Weeks et al. (31), Beeson et al. (3), Cartter (4), and Chapman (5) indicated that phosphorus treatments had little or no effect on the uptake of phosphorus. Dunton (11) reported that phosphorus has more influence on plant characteristics than either nitrogen or potassium and that phosphorus was the key element from germination to maturity.

Studies by Murphy (18), Chapman (5), Nelson (19), Painter et al. (21), and Prince (22) indicated that additions of nitrogen to the soil resulted in an increase of nitrogen in the grain. Weideman (32), Weeks et al. (31), Vandecaveye et al. (28), Van Itallie (26), Kohnke et al. (14), and Chapman (5) reported that the effects of added nitrogen on the nitrogen content of the grain was variable and dependent on soil types, climatic conditions, time of application and many other factors.

Results of investigations dealing with the effects of potassium have been very irregular and inconsistent. Bartholomew and Janssen (1) presented a review on the luxury consumption of potassium and plant nutrition. It was suggested that translocation and reutilization was an important process in the assimilation of nutrient elements by plants. Dumenil and Lloyd (10), Prince (22), and Weeks et al. (31) showed that potassium depressed the uptake of other elements.

Cartter (4) found that the oil and protein content of soybean seed were significantly affected by environment. Coleman and Belcher (7) reported on the response of sorgo to short and long light photoperiods and variations in temperature. They found that the thermal requirements must be met before the plant would respond to critical photoperiods. Differences in varietal response to these two factors were also noted.

Veits and Dumingo (29) reported significant differences between corn hybrids at three nitrogen levels. Yields between hybrids and between nitrogen levels were positively correlated. Nichols (20) reported that the nitrogen content of alfalfa was more closely correlated with lime than phosphorus. He also emphasized the importance of light intensity, light quality, temperature, and humidity as factors which might affect plant metabolism.

Smith (23) found significant difference between fertilizer treatments on the nitrogen and phosphorus content of sorghum seed. Smith (23) and Jackson (13) reported on the effects of fertilizer treatment on sorghum seed germination. They found an interaction between fertilizers and varieties and reported that Kafir 44-14 was a variety susceptible to germination damage from high rates of fertilizers.

Results of investigations dealing with the effects of fertilizer on nutrient element uptake have been inconsistent and oftentimes conflicting.

This literature review indicates that basic research on this problem is needed.

METHODS AND MATERIALS

The experiment was conducted on the Oklahoma State University Agronomy Farm, located near Perkins, Payne County, Oklahoma. The plants studied were grown on plot series 2900, located in the south ¼, southwest ¼, of Section 36, Township 18 north, Range 2 east.

Soil Description

The soil in this study has been classified as a Vanoss Loam[1]. Vanoss is of the reddish prairie great soils group developed under prairie grasses. It is a very productive soil and is responsive to good management practices. It is farmed without terraces and has a surface gradient of less than one percent. Wind erosion on this soil has been a hazard especially during the late winter and early spring months. A complete description of the Vanoss Loam is given in the Appendix, page 35.

Fertilizer Treatments and Plot Design

Three levels of nitrogen and three levels of phosphorus with a constant level of potassium and magnesium were used in a completely randomized block design with four replications. The fertilizer treatments and plot design are illustrated in Table 1.

The nitrogen was supplied as 33 percent ammonium nitrate, the phosphorus as 45 percent triple superphosphate, the potassium as 60 percent

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[1]Unpublished data furnished by H. M. Galloway, Soil Survey Party Chief, (Coop. USDA, and S.C.S.)

TABLE I

FERTILIZER TREATMENTS AND PLOT DESIGN

Fertilizer Treatments

Treatment	Pounds per Acre				Treatment	Pounds per Acre			
	N	P_2O_5	K_2O	Mg		N	P_2O_5	K_2O	Mg
1	0	0	0	0	6	40	40	40	20
2	0	0	40	20	7	40	80	40	20
3	0	40	40	20	8	80	0	40	20
4	0	80	40	20	9	80	40	40	20
5	40	0	40	20	10	80	80	40	20

Plot Design

Row No.	Treatment	Row No.	Treatment	Row No.	Treatment
4 East	Check	8 East	4	21 West	7
17 East	Check	11 East	4	25 West	7
4 West	Check	24 West	4	3 West	8
34 West	Check	20 East	5	12 West	8
5 West	2	29 East	5	21 East	8
6 West	2	22 West	5	26 East	8
20 West	2	26 West	5	19 East	9
24 East	2	3 East	6	25 East	9
14 West	3	8 West	6	31 East	9
29 West	3	30 West	6	15 West	9
22 East	3	6 East	6	12 East	10
30 East	3	11 East	7	14 East	10
5 East	4	19 West	7	15 East	10
				31 West	10

potassium chloride and the magnesium as 20 percent magnesium sulfate. The forty pounds of potassium and twenty pounds of magnesium were assumed sufficient to prevent any deficiencies and yet small enough not to cause unbalance of the nutritive ratio. Each fertilizer treatment was carefully measured and mixed, then put into individual paper bags and labeled with the plot number. A belt type fertilizer distributor was used to assure even distribution of the fertilizer.

It was assumed that heavy applications of fertilizer salts would be detrimental to sorghum seed germination; therefore, the fertilizers were applied two weeks after planting. This assumption was later verified by Jackson (13) and Smith (23). The fertilizer band was placed four inches below and four inches to the side of the sorghum seedlings.

Planting and Cultivation

Kafir 44-14 was selected for this investigation because of its adaptation to Oklahoma conditions. Kafir 44-14 was developed by J. B. Seiglinger,[1] from the cross Sharon kafir X Dwarf hybrid feterita. This variety has good exertion, is white seeded, and exhibits more chinch bug resistance than the milos.

The plots were planted May 20, 1953, which is within the recommended planting date range at this location. The seeds were hand dropped through a funnel-type planter. A rotary hoe was used May 25 to break the soil crust and to eliminate the first weed crop. The second, third, and final cultivations were performed June 8, June 21, and July 3. The

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[1]Unpublished material furnished by Frank Davies, Associate Professor of Agronomy, Oklahoma Agricultural and Mechanical College.

plots were kept weed free throughout the growing season by hand hoeing.

The plot rows were 250 feet long running east and west, and numbered from south to north. A plant count indicated that there were 750 plants per row, or an average of three plants per foot, which was considered an excellent stand.

Harvesting

Leaves at three stages of growth; immature forage and grain, and mature forage and grain were harvested for chemical analyses. Yield data were taken on mature forage and grain.

The first leaf harvest was made June 17 when the plants were fourteen inches high. The first mature leaf, or flag leaf, was selected for chemical analyses throughout the study. Seventy-five leaves were selected at random in 220 feet of each row. Fifteen feet were left on each end to eliminate border effects. A second-leaf harvest was made July 7 when the plants were twenty-four inches high. The only dry period encountered throughout the growing season was at the time of the second-leaf harvest. During this period, the plants would tend to roll their leaves in the afternoon and later showed some evidence of firing. A third-leaf harvest was made August 8 at booting stage of growth. Immature forage and grain samples were made September 3 when the plants were in the early dough stage of maturity. Forage weights were taken in the field from twenty-five feet of row; the heads were removed and random samples taken for chemical analyses. The mature forage and grain samples were harvested September 20. A twenty-five foot row sample was taken from each plot for yield. Sub-samples were taken for chemical analyses.

Leaf samples were placed in paper bags, labeled, and autoclaved as soon as possible after harvest for five minutes at fifteen pounds pressure per square inch. This procedure was used in an attempt to stop all metabolic action. The leaves were then placed in a forced-air drying oven for forty-eight hours at seventy degrees Centigrade, and then they were ground in a Wiley mill and stored in metal containers. The immature stalks and heads and the mature stalks and heads were chopped with an ensilage cutter and then dried to constant weight at seventy degrees Centigrade. The mature heads were threshed in a nursery thresher to obtain grain yield data.

Chemical Analyses of Plant Material

Samples of forage and grain were ground to pass a twenty-mesh screen, then stored in small paper coin envelopes for analyses. Total nitrogen in forage and grain samples was determined by the standard Kjeldahl method, with a selenium catalyst. Phosphorus, calcium and magnesium determinations were made by the procedures outlined by Harper.[1] The potassium content was determined by the Beckman model DU Flame Spectrophotometer with a photomultiplier attachment.

All data collected were subjected to an analysis of variance (24). A multiple range test was used when five percent significance occurred.

[1] H. J. Harper, Methods for Analysis of Soil and Plant Material, Soils Laboratory, Oklahoma State University, 1948.

RESULTS AND DISCUSSION

The Effects of Treatments on Nitrogen Uptake

No significant differences were found between treatments and percent nitrogen in either the first, second, or third leaf harvest. The analysis of variance, Table II, indicates greater differences between blocks than treatments.

An increase in nitrogen uptake was observed when the nitrogen and phosphorus ratio was 1:1. This indicated that nitrogen uptake was dependent on the phosphorus content of the soil (Figure 1). The percent nitrogen in the leaves was approximately twice as great in the first and third harvests as in the second. This may have been due to the short drought that was recorded at the time of the second-leaf harvest.

The necessity of nutrient balance for growing plants has been demonstrated many times, (5, 10, and 27). A plant grown on a soil low in all available plant nutrients except one may show an antagonistic effect on the uptake of other elements or even a depression in growth. Economical use of fertilizers results when all elements are present in the proper amounts and ratios.

The uptake of nitrogen from the fertilizers as indicated by the analysis of the immature and mature stalks and heads was closely related to the total nitrogen contained in each (Figure 1). The nitrogen content of the grain was higher than that of the forage and followed a more consistent pattern. This trend was not expected, because as a

TABLE II

ANALYSIS OF VARIANCE OF THE PERCENT NITROGEN IN FIRST, SECOND, AND THIRD LEAF HARVEST

Analysis of Variance for %N First-Leaf Harvest				
Source	df	SS	MS	F
Total	39	1.116	.0286	
Block	3	.108	.0360	1.8848
Treatment	9	.107	.0191	.6181
Error	27	.136	.0309	
Analysis of Variance for %N Second-Leaf Harvest				
Source	df	SS	MS	F
Total	39	2.777	.0712	
Block	3	.345	.1150	3.2670
Treatment	9	.317	.0352	.4495
Error	27	2.115	.0783	
Analysis of Variance for %N Third-Leaf Harvest				
Source	df	SS	MS	F
Total	39	1.7147	.0439	
Block	3	.1034	.0344	1.0851
Treatment	9	.2857	.0317	.6469
Error	27	1.3256	.0490	

general rule, the nitrogen content of forage follows the fertilizer treatment more closely. Slight increases in nitrogen content were shown when the nitrogen-phosphorus (1:1) ratio was balanced. Analysis of variance and the multiple range test (Table III) indicated a significant difference due to treatment at the five percent probability level in percent nitrogen in the mature grain. A summary of the nitrogen content of the immature stalk, immature grain, and mature stalk is shown in the analysis of variance, Tables IV and V and Figure 1.

Phosphorus in the absence of nitrogen appears to exhibit a depressive interaction on nitrogen assimilation in the mature grain. Treatment 4, (0-80-40-20), with no nitrogen and high phosphorus, appears at the low end of the range (Table III), while the treatments that were assumed to be the balanced, that is No. 6 (40-40-40-20) and No. 10 (80-80-40-20), appear at the upper end of the range. This depressive effect on nitrogen uptake may also be attributed to the addition of potassium or some other unbalance. The check plot appears higher in the range than plots 2, 3, 4, or 5, which supports the contention that the use of unbalanced fertilizer ratios may depress the uptake of nitrogen and limit growth. Smith (23) reported a significant decrease in nitrogen uptake by Redlan grain sorghum due to high potassium fertilization.

The Effects of Treatments on Phosphorus Uptake

The percentage of phosphorus follows the same general pattern as nitrogen in the first, second, and third leaf harvests. Both the first and third leaf harvests yielded approximately twice the amount of phosphorus as did the second leaf harvest as shown in Figure 2. This might be caused by the extreme dry period that occurred prior to the second harvest. During the early growth stages, an abundance of nutrient

TABLE III

SUMMARY OF ANALYSIS OF VARIANCE, STANDARD ERROR OF TREATMENT MEAN AND MULTIPLE RANGE FOR PERCENT NITROGEN CONTENT OF KAFIR 44-14 MATURE GRAIN

Analysis of Variance

Source	df	SS	MS	F
Total	39	.6180	.0158	
Block	3	.1518	.0506	1.9312
Treatment	9	.2365	.0262	3.0823*
Error	27	.2297	.0085	

*Significant at 5 percent level

$$\text{Standard Error of Mean} = \sqrt{\frac{\text{Mean Square Error}}{\text{No. Items in Treatment}}} = .0460$$

Multiple Range Test

Treatment ranked in order of magnitude

4	2	3	5	1	7	8	9	10	6
0-80	0-0	0-40	40-0	Check	40-80	80-0	80-40	80-80	40-40
40-20	40-20	40-20	40-20		40-20	40-20	40-20	40-20	40-20
1.320	1.337	1.347	1.392	1.425	1.430	1.472	1.502	1.525	1.550

Any two means not underlined by the same line are significantly different at the 5 percent probability level.
Any two means underlined by the same line are not significantly different at the 5 percent probability level.

TABLE IV

ANALYSIS OF VARIANCE PERCENT NITROGEN IN IMMATURE STALK, MATURE STALK, AND POUNDS OF DRY FORAGE

Analysis of Variance for Percent Nitrogen in Immature Stalk

Source	df	SS	MS	F
Total	39	.6342	.0162	
Block	3	.0146	.0048	1.8848
Treatment	9	.1791	.0199	.6181
Error	27	.3505	.0129	

Analysis of Variance for Percent Nitrogen in Mature Stalk

Source	df	SS	MS	F
Total	39	.837	.0214	
Block	3	.072	.0240	3.2670
Treatment	9	.279	.0310	.4495
Error	27	.468	.0173	

Analysis of Variance for Pounds Dry Forage

Source	df	SS	MS	F
Total	39	338.99	8.6920	
Block	3	14.64	4.8800	1.0851
Treatment	9	175.85	19.5388	.6469
Error	27	248.50	9.2037	

TABLE V

SUMMARY OF ANALYSIS OF VARIANCE, STANDARD ERROR OF TREATMENT MEAN AND MULTIPLE RANGE TEST FOR PERCENT NITROGEN OF 44-14 SORGHUM IMMATURE GRAIN

Analysis of Variance

Source	df	SS	MS	F
Total	39	.875	.0224	
Block	3	.034	.0113	.2242
Treatment	9	.454	.0504	3.5744*

*Significant at 1 percent level

$$\text{Standard Error of Mean} = \sqrt{\frac{\text{Mean Square Error}}{\text{No. Items in Treatment}}} = .0578$$

Multiple Range Test

Treatment ranked in order of magnitude

1	3	4	2	5	7	8	6	9	10
Check	0-40	0-80	0-0	40-0	40-80	80-0	40-40	80-40	80-80
	40-20	40-20	40-20	40-20	40-20	40-20	40-20	40-20	40-20
1.3127	1.3975	1.4052	1.4547	1.4960	1.5325	1.5465	1.5855	1.6325	1.6700

Any two means not underlined by the same line are significantly different at the 1 percent probability level.
Any two means underlined by the same line are not significantly different at the 1 percent probability level.

elements were available and were probably taken up in excess amounts. Later, as the moisture stress became greater, this excess phosphorus supply was utilized in plant growth. Plants that have the ability to absorb large amounts of nutrient elements early in the growth cycle can make use of them later by translocation to other areas in the plant where they can be used in the metabolic processes, of growth and differentiation. The analysis of variance, Tables VI and VII, indicates that there were highly significant differences in percent phosphorus due to treatment in both the second and third leaf harvest.

An examination of the data in the multiple range test, Table VI, of the second leaf harvest shows that the four highest values were balanced ratios (1:1) in regard to the nitrogen and phosphorus levels. The lowest ranges might be considered to be unbalanced ratios. Since the plants from the check plot seem to agree in phosphorus content with the assumed balanced ratios, it appears that the soil had a balanced level of nutrient elements at the beginning of the study. The multiple range test, Table VII, shows that at the one percent probability level that treatments 7 (40-80-40-20) and 10 (80-80-40-20) were different from all other treatments except treatment 6 (40-40-40-20) at the third leaf harvest.

A comparison of phosphorus composition of the first and third leaf harvest to the second leaf harvest shows the same effect on the percent of phosphorus as observed for nitrogen, (Table VII). That is, the percent phosphorus decreased in the second harvest. Daniel and Harper (9) found that a similar condition probably accounted for the variable composition of prairie and alfalfa hays.

As might be expected, a wide difference was found in the amount

TABLE VI

SUMMARY OF ANALYSIS OF VARIANCE, STANDARD ERROR OF TREATMENT MEAN AND MULTIPLE RANGE TEST FOR PERCENT PHOSPHORUS IN SECOND LEAF HARVEST

Analysis of Variance

Source	df	SS	MS	F
Total	39	.5754	.0147	
Block	3	.0735	.0245	.8221
Treatment	9	.2690	.0298	3.4651
Error	27	.2329	.0086	

*Significant at 1 percent level

$$\text{Standard Error of Mean} = \sqrt{\frac{\text{Mean Square Error}}{\text{No. Items in Treatment}}} = .0463$$

Multiple Range Test

Treatments ranked in order of magnitude

9	7	3	5	8	4	6	1	10	2
80-40	40-80	0-40	40-0	80-0	0-80	40-40		80-80	0-0
40-20	40-20	40-20	40-20	40-20	40-20	40-20	check	40-20	40-20
.1392	.1812	.2080	.2375	.2400	.2550	.2880	.3097	.3262	.4387

Any two means not underlined by the same line are significantly different at the 1 percent probability level.
Any two means underlined by the same line are not significantly different at the 1 percent probability level.

TABLE VII

SUMMARY OF ANALYSIS OF VARIANCE, STANDARD ERROR OF TREATMENT MEAN AND MULTIPLE RANGE TEST FOR PERCENT PHOSPHORUS IN THIRD LEAF HARVEST

Analysis of Variance

Source	df	SS	MS	F
Total	39	.6307	.0161	
Block	3	.0133	.0044	.1232
Treatment	9	.3220	.0353	3.2752*
Error	27	.2954	.0109	

*Significant at 1 percent probability level

Standard Error of Mean = $\sqrt{\dfrac{\text{Mean Square Error}}{\text{No. Items in Treatment}}}$ = .0522

Multiple Range Test

Treatments ranked in order of magnitude

4	5	8	1	2	9	3	6	7	10
0-80	40-0	80-0	check	0-0	80-40	0-40	40-40	40-80	80-80
40-20	40-20	40-20		40-20	40-20	40-20	40-20	40-20	40-20
.6220	.6310	.6545	.6675	.6680	.6960	.7370	.7510	.7940	.9380

Any two means not underlined by the same line are significantly different at 1 percent probability level.
Any two means underlined by the same line are not significantly different at 1 percent probability level.

of phosphorus in the grain and the amount in mature stalk and is shown in Figure 2. The grain grown on the check plots contained an average of 0.38 percent phosphorus while the check plots for forage averaged 0.067 percent or approximately six times less than that of grain.

The low phosphorus content of the forage appears to be the result of low soil phosphorus and the ability of the plant to vegetate and reproduce on these soils. Weathers (30) found wide variations in the percent phosphorus in lespedeza grown on several soil types.

No significant differences were found in the percent phosphorus due to treatment in the first leaf cutting, mature stalk, or mature grain, as shown in analysis of variance, Table VIII.

The Effects of Treatment on Forage and Grain Yields

The effect of treatments on yield was noteworthy. The fifty-nine bushel yield that was secured on the check plot substantiated the statement that this was a fertile soil. An increase of 12.25 bushels for the highest fertilizer increment, or treatment 10, (80-80-40-20), shows that even this very fertile soil responded to added fertility in this favorable rainfall year. Treatment 10, produced 70.18 bushels per acre while treatment 4, (0-80-40-20), produced 52.86 bushels per acre, or a 17.32 bushel increase. A summary of all plot yields are found in Table IX.

An analysis of variance of yield, Table X, shows significant difference at the 5 percent probability level. The multiple range test, Table X, shows that there was a significant difference in yield between treatment 10 and treatments 1, 2, 3, 4, and 5, and treatment 4 gave yields significantly lower than treatments 6, 7, 8, 9, and 10.

The grain yield for treatment 4, (0-80-40-20), was not as high as the

TABLE VIII

ANALYSIS OF VARIANCE PERCENT PHOSPHORUS IN FIRST LEAF HARVEST, MATURE STALK, AND MATURE GRAIN

Analysis of Variance for Percent Phosphorus in First Leaf Harvest

Source	df	SS	MS	F
Total	39	.153	.0039	
Block	3	.035	.0116	2.9000
Treatment	9	.036	.0040	1.333
Error	27	.082	.0030	

Analysis of Variance for Percent Phosphorus in Mature Stalk

Source	df	SS	MS	F
Total	39	.0108	.00027	
Block	3	.0006	.00020	.4761
Treatment	9	.0038	.00040	1.8260
Error	27	.0064	.00023	

Analysis of Variance for Percent Phosphorus in Mature Grain

Source	df	SS	MS	F
Total	39	.0843	.00216	
Block	3	.0056	.00186	.5923
Treatment	9	.0283	.00314	1.6681
Error	27	.0504	.00186	

TABLE IX

THE EFFECTS OF FERTILIZER TREATMENTS

ON KAFIR 44-14 GRAIN YIELDS

	Treatments	Total for Plot 1/500 acre	Average for Plot 1/500 acre	Pounds per acre	Bushel
1.	0-0-0-0	26.63	6.66	3,300	58.93
2.	0-0-40-20	26.75	6.69	3,345	59.73
3.	0-40-40-20	24.94	6.24	3,120	55.71
4.	0-80-40-20	17.76	5.92	2,960	52.86
5.	40-0-40-20	28.12	7.03	3,515	62.77
6.	40-40-40-20	29.51	7.38	3,690	65.89
7.	40-80-40-20	28.84	7.21	3,605	64.38
8.	80-0-40-20	29.44	7.36	3,680	65.71
9.	80-40-40-20	29.95	7.49	3,745	66.86
10.	80-80-40-20	31.44	7.86	3,930	70.18

TABLE X

SUMMARY OF ANALYSIS OF VARIANCE, STANDARD ERROR OF TREATMENT MEAN AND MULTIPLE RANGE TEST FOR POUNDS THRESHED GRAIN

Analysis of Variance

Source	df	SS	MS	F
Total	39	34.3744	.8813	
Block	3	2.2480	.7493	.4412
Treatment	9	15.2803	1.6978	2.7212*
Error	27	16.8461	.6239	

*Significant at 5 percent level

$$\text{Standard Error of Mean} = \sqrt{\frac{\text{Mean Square Error}}{\text{No. Items in Treatment}}} = .3949$$

Multiple Range Test

Treatment means ranked in order of magnitude

4	3	1	2	5	7	8	6	9	10
0-80	0-40	Check	0-0	40-0	40-80	80-0	40-40	80-40	80-80
40-20	40-20		40-20	40-20	40-20	40-20	40-20	40-20	40-20
5.800	6.235	6.657	6.687	7.030	7.110	7.360	7.377	7.487	8.360

Any two means not underlined by the same line are significantly different at the 5 percent probability level.
Any two means underlined by the same line are not significantly different at the 5 percent probability level.

check plot for treatment 3, (0-40-40-20). Treatment 4 and treatment 3 are at the low end of the range. This would indicate that the presence of excess phosphorus in the absence of nitrogen possibly inhibits grain production on this soil. Dunton (11) reported that nitrogen alone could decrease yields, which is similar to the effects reported in this study for phosphorus. He concluded that an unbalanced nutrient condition due to excessive nitrogen had a detrimental effect on seed yield.

Apparently the addition of potassium and magnesium did not cause an unbalance of the nutrient supply. Treatment 2, (0-2-40-20), produced approximately one bushel more grain than treatment 1, (check).

A study of the grain yields obtained indicates: (1) the necessity of a balanced nutrient supply in the soil (2) decreased grain yield from the use of phosphorus alone (3) an uneconomical return from high fertilizer applications (under the conditions of this experiment). An increase of twelve bushels of sorghum grain per acre (80-80-40-20 vs check) would only pay for the fertilizer cost. Yield data for all treatments are given in Figure 5 and Tables IX and XI.

According to the analysis of variance, Table IV, there was no significant difference in forage yields. Forage yields are of lesser importance in grain sorghum production than grain; however, it was thought that grain yields and forage yields might be related.

A summary of yields of forage on all treatments are given in Figure 5 and Table XI.

<u>The Effects of Treatment on Potassium and Calcium Uptake</u>

The uptake of calcium and potassium was not a major consideration in this study; however, as these data were available, it seemed advisable to include them in the discussion. No analysis of variance or multiple

TABLE XI

THE EFFECTS OF FERTILIZER TREATMENTS ON KAFIR 44-14

YIELDS OF GREEN FORAGE AND DRY HEAD

	Treatments	Pounds of Green Forage per acre	Percent Dry Matter	Pounds of Dry Heads per acre	Percent Threshed Grain
1.	Check	10,440	38.14	4,655	71.88
2.	0-0-40-20	11,405	30.29	4,850	69.04
3.	0-40-40-20	11,940	32.73	4,465	69.19
4.	0-80-40-20	11,690	30.88	4,120	70.74
5.	40-0-40-20	12,310	35.55	4,950	70.77
6.	40-40-40-20	12,685	31.78	5,210	70.74
7.	40-80-40-20	12,935	31.34	5,265	67.49
8.	80-0-40-20	14,465	32.35	5,175	70.97
9.	80-40-40-20	13,905	31.88	5,180	72.32
10.	80-80-40-20	15,030	31.21	5,645	69.56

range was made on these analyses because of missing data from the check plot.

The comparison of percent potassium in first, second and third leaf harvest and the potassium composition of the mature forage and grain is given in Figure 3.

The first leaf harvest showed that leaves from treatment 2 contained 6 percent potassium, while leaves from treatment 7 contained almost 7.5 percent potassium. The second and third leaf harvests, however, decreased in percent potassium to .15 to .25 percent, respectively. Again, as was reported for phosphorus and nitrogen in the second leaf harvest, the potassium was lower than either the first or third leaf harvest. The potassium content of the grain was lower than that of the mature forage as shown in Figure 3.

No visible symptoms of potassium deficiency occurred throughout the growing season. The data from this investigation did not indicate any favorable response from the forty pound application of potassium.

The percent calcium found in the first, second, and third leaf harvest is reported in Figure 4. Calcium varied less than the other elements studied. However, the calcium content of the leaves in the second harvest was higher than harvests one and three. The pattern of calcium uptake was opposite to that of the other elements. It was also of interest to compare the calcium content of leaves from the low fertilizer treatments with those of the high. As the fertilizer applications were increased, the percent calcium did not continue to increase, with low fertilizer treatments, however, much greater differences in calcium content were found between treatments with the exception of the mature grain. The percent of all elements reported in the mature grain was found to be much less a function of treatment than the other plant tissue sampled. Since the soil pH was considered ideal for plant growth, nutrient deficiency symptoms were not expected. The calcium content of 44-14 Kafir, both grain and forage, reported in this study exceed the tabulated averages of similar feeds as reported by Morrison (17).

SUMMARY AND CONCLUSIONS

A uniform soil area on the Oklahoma Experiment Station farm near Perkins was selected to study the effects of various fertilizer treatments on yield and nutrient element uptake by 44-14 Kafir. A randomized block design was used with four replications. The fertilizer treatments were nitrogen and phosphorus at three levels of 0-40-80 pounds per acre of each element. Forty pounds of muriate of potash and twenty pounds of magnesium (magnesium sulfate) were added to insure adequate levels of these two elements.

The results of this investigation are summarized as follows:

1. Yields and nutrient uptake by 44-14 Kafir were highest when the nitrogen and phosphorus were in a 1:1 ratio.
2. The soil on which the experiment was conducted contained a balanced nutrient supply as indicated by the yield data.
3. The lack of response to potassium and magnesium was indicative of an adequate supply of these elements in the soil.
4. Grain yields were significantly increased by some of the fertilizer treatments; however, the increases were probably not economically justified.
5. Phosphorus had less influence than nitrogen on grain yields.
6. Under the conditions of this experiment, the fertilizer treatments did not visibly affect the plants in regard to such factors as: plant color, plant height, date of maturity, disease

resistance or booting date.

7. The elemental content of the grain was higher than the stalk in nitrogen and phosphorus, and the reverse was true for potassium and calcium.

8. The elemental content of the grain was much more constant than the composition of the forage.

9. The second leaf harvest was lower in elemental content than the first and third harvest. Extreme moisture stress apparently prevented nutrient uptake at the second leaf harvest.

10. No significant difference was found between treatments on the percent nitrogen of the three leaf harvests; percent nitrogen in the immature stalk and mature stalk; pounds of dry forage; and percent phosphorus in the first leaf cutting, mature stalk, and mature grain.

11. A significant difference was found between the treatments and pounds of threshed grain; percent phosphorus in both the second and third leaf harvest; and percent nitrogen in both the mature and immature grain.

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PROFILE DESCRIPTION OF VANOSS LOAN

The plots referred to in this thesis were grown on block 2900. The soil has been classified as Vanoss Loam. This soil occurs in one large area 550 feet north and 1,250 feet east of the southwest corner of section 36. The surface is plane to convex and surface gradient is less than one percent.

The Soil Profile is described as follows:

A_{1_p} 0-8" Brown (7.5 yr. 5/3; 3.5, m) loam or coarse silt loam; weak medium granular; friable; soft and crumbly; permeable; pH 6.0; many pores and pin holes; rests with a shear face on the layer below.

A_1 8-16 Brown (7.5 yr. 4.5/3 when moist) loam or silt loam; moderately medium granular; friable; porous and permeable; pH 6.2; the upper 3 inches has a tendency to weak coarse platiness and the upper surface has a thin glazed plow sole; grades to the layer below.

A_3 16-32 Brown (7.5 yr. 4/3; 3/2, m) heavy loam or light clay loam; moderate medium granular friable; permeable; pH 6.0; many pin holes; grades to layer below.

B_{2-1} 22-32" Brown (7.5 yr. 5/3; 4/3 m) clay loam; compound moderate medium granular and weak fine subangular blocky; firm; hard when dry; porous and permeable; pH 6.0; grades to the layer below.

B_2-2 32-40" Brown (7.5 yr. 5/4; 4/4, m) Sandy Clay loam same as above layer; pH 6.5; becomes increasingly more coarse with depth and grades to layer below.

B_3 40-50" Strong Brown (7.5 yr. 5.5/6; 5/6, m) Sandy Clay loam; weak medium subangular blocky; friable to firm; purous and permeable; pH 6.5; grades to layer below.

C_1 50-60" Same as layer above but contains a few, medium, distinct yellowish red (5 yr. 5/6) mottles; pH 6.5; grades to layer below.

C_2 74-90" Red (2.5 yr. 5/6; 4/6, m) sandy clay loam with seams of pink (7.5 yr. 5/4) fine sandy loam; permeable; pH 7.0; breaks out in thin plates on the stratification planes; grades to the layer below.

C_3 74-90" Red (2.5 yr. 5/6; 4/6, m) sandy clay loam with seams of pink (7.5 yr. 7/4) fine sandy loam; permeable; pH 7.0; breaks out in thin plates on the stratification planes; grades to the layer below.

C_4 90-100" Much like the layer above but lacks the pink seam; firm when dry; pH 7.0.

The lower three horizons are visible stratified old alluvium while the upper four horizons seem to be developed in less sandy materials which may be a loess cap which overlies the older alluvium.

Figure 1
The Percent of Nitrogen in the First, Second, and Third Leaf Harvest, Immature Stalk, Immature Grain, Mature Stalk, and Mature Grain

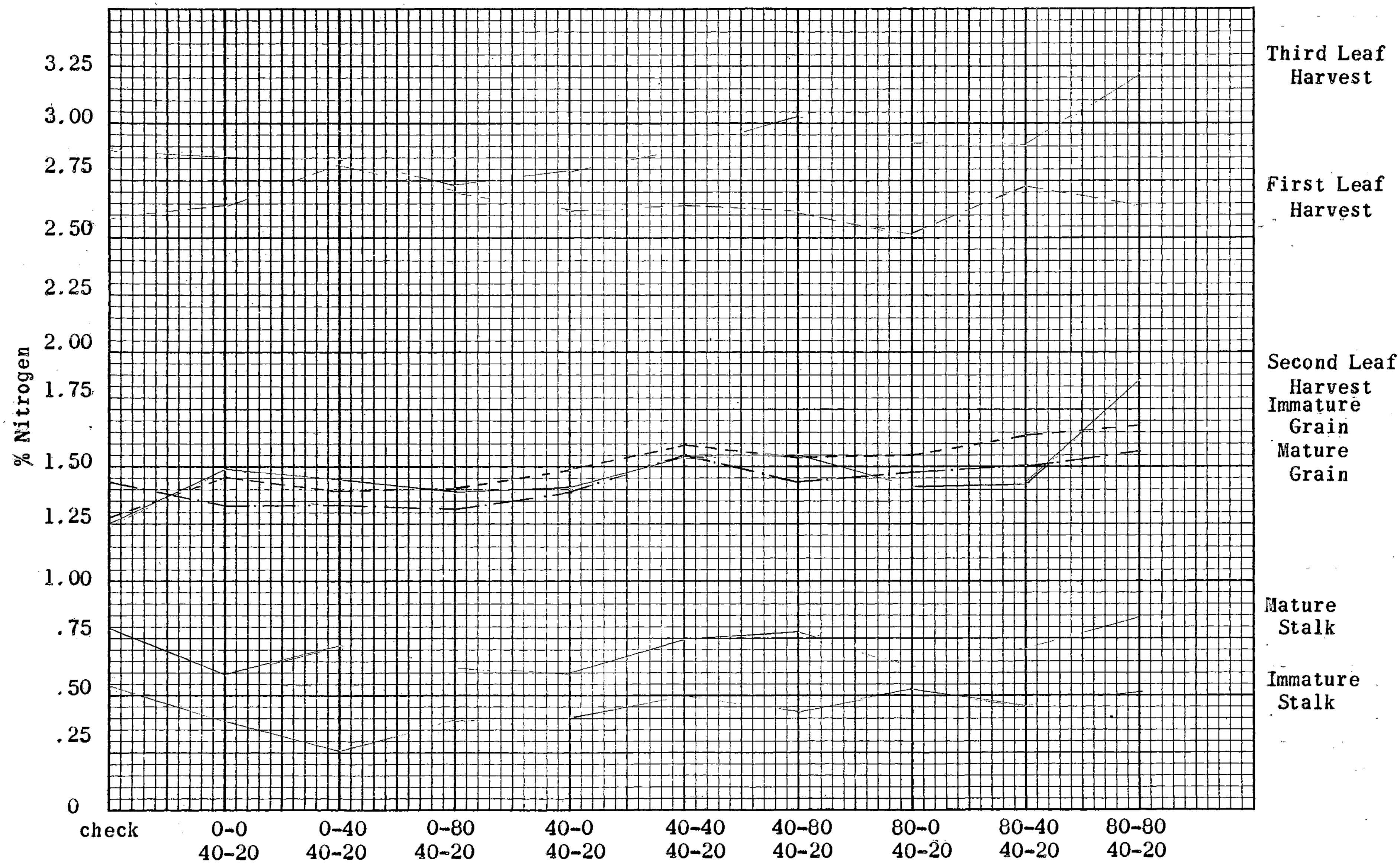


Figure 2

The Percent of Phosphorus in the First, Second, and Third Leaf Harvest, Mature Stalk and Mature Grain

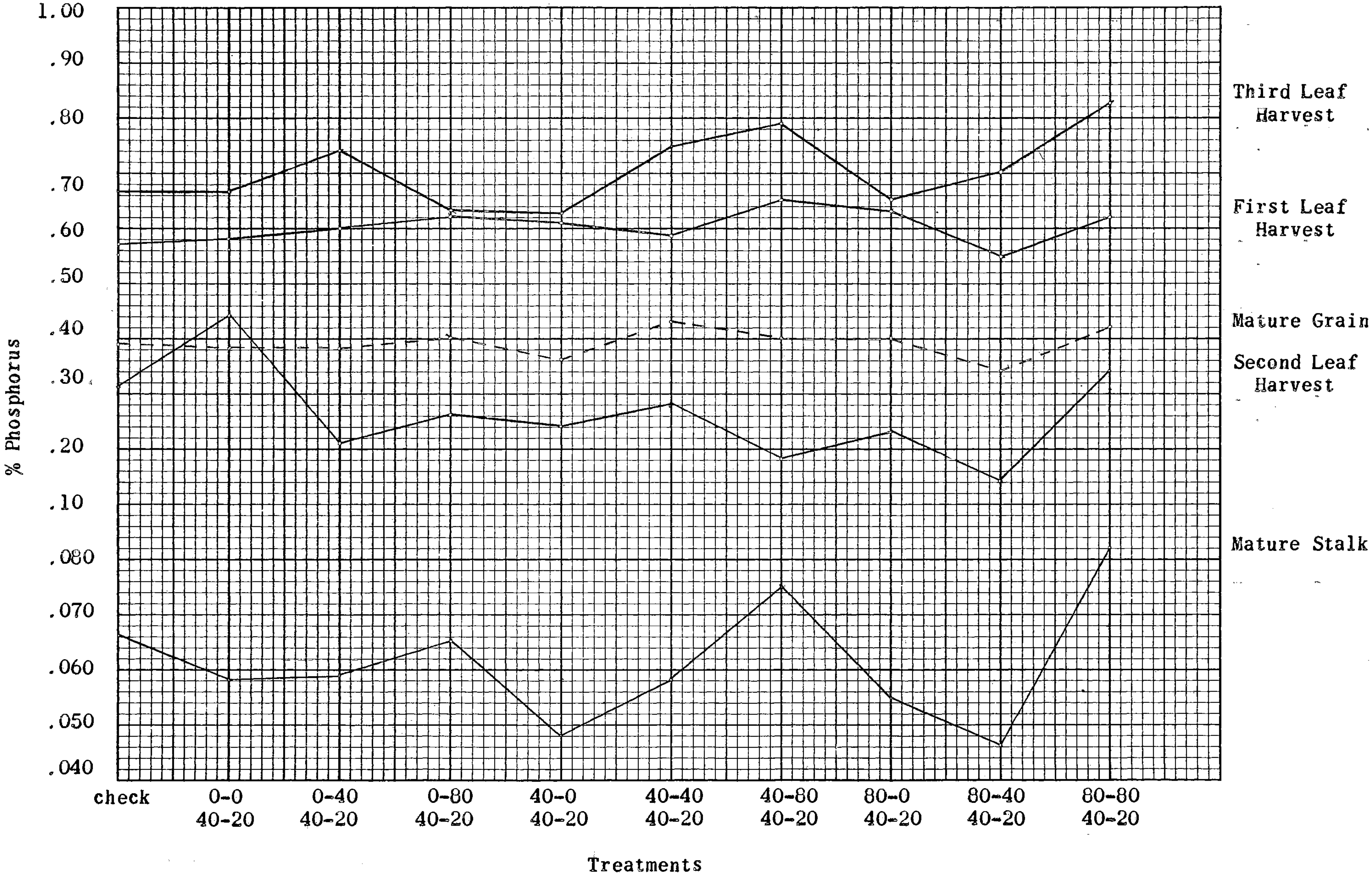


Figure 3

The Percent of Potassium in the First, Second and Third Leaf Harvest, Mature Stalk, and Mature Grain

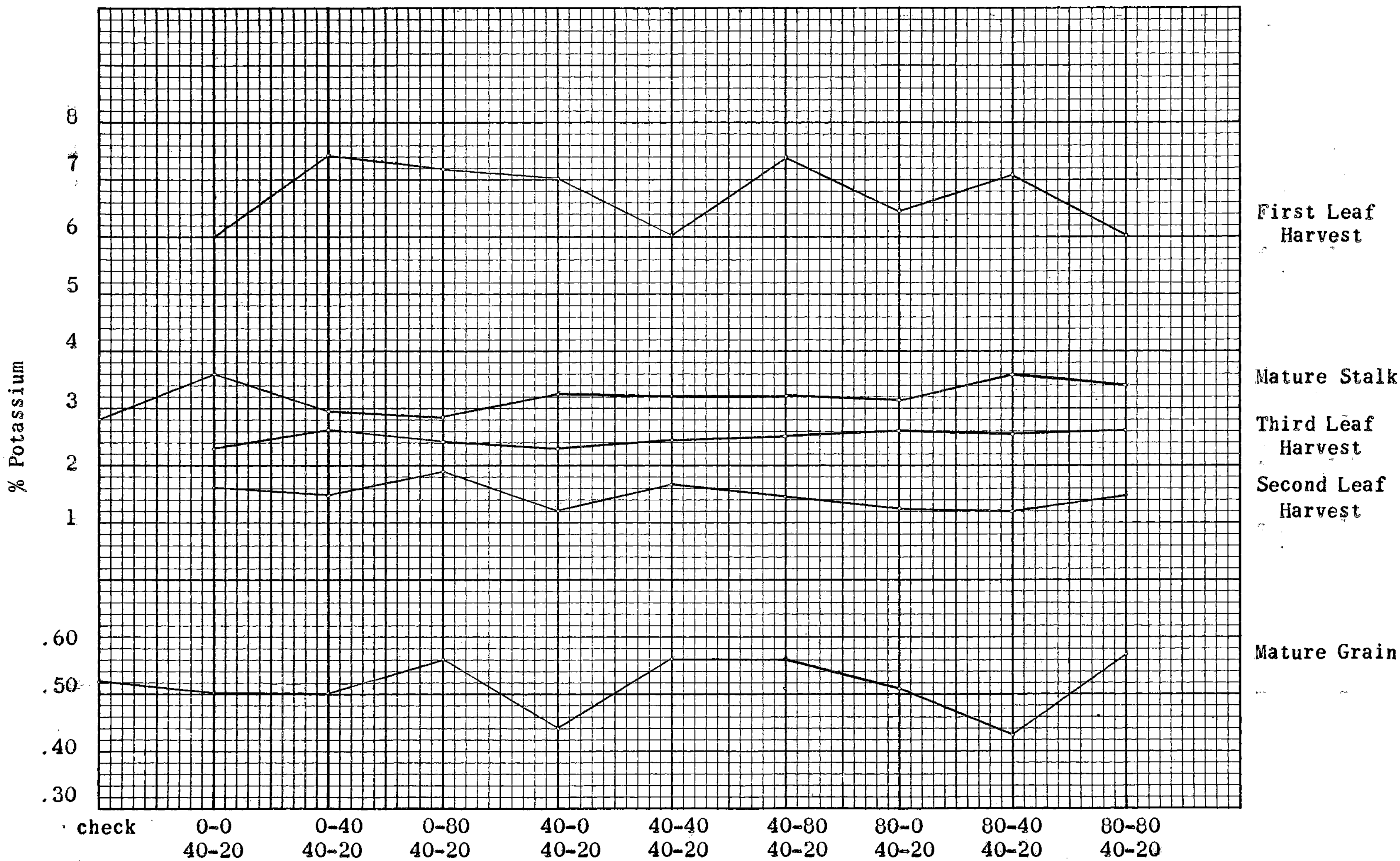


Figure 4

The Percent of Calcium in the First, Second, and Third Leaf Harvest, Mature Stalk and Mature Grain

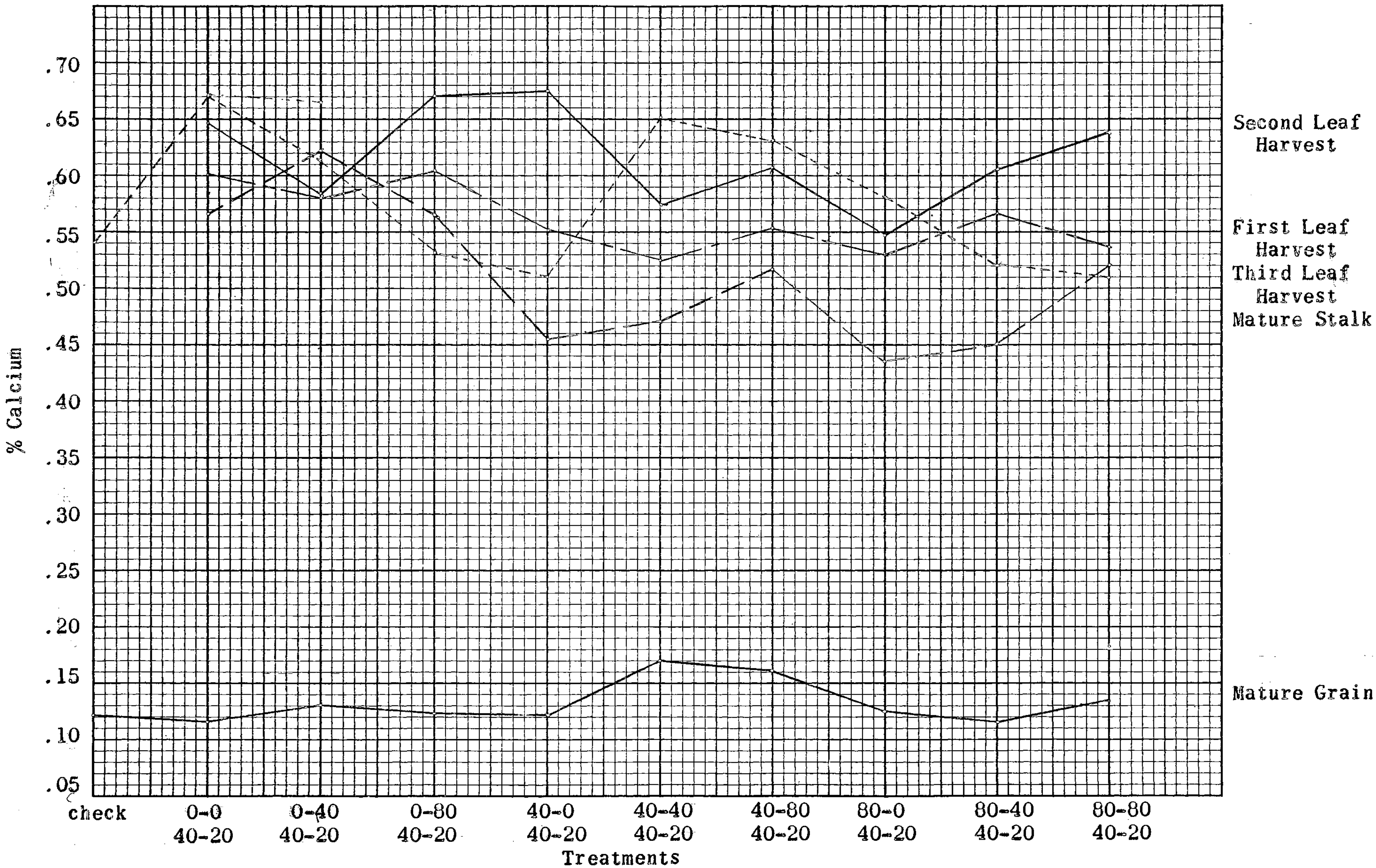
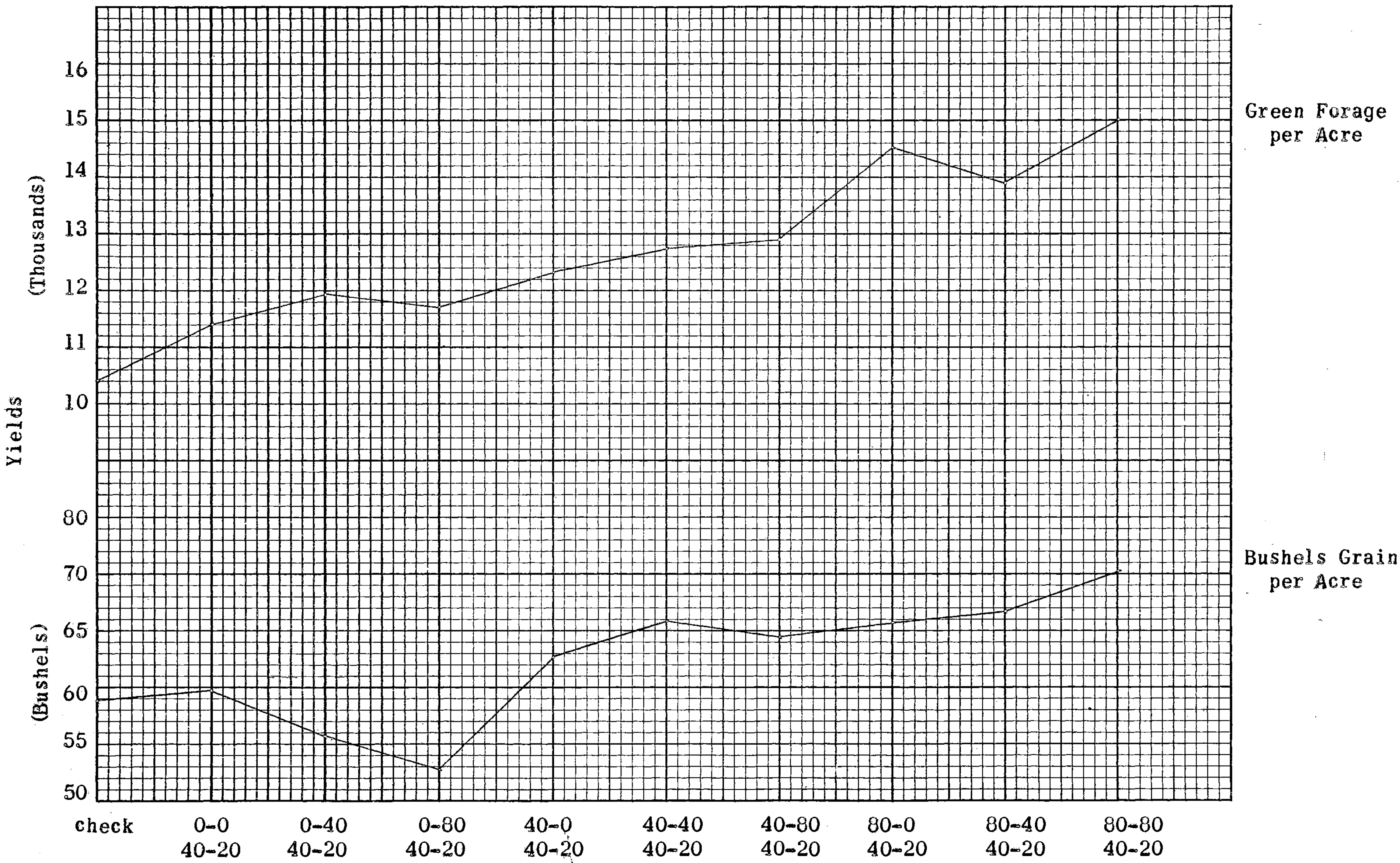


Figure 5

The Effects of Treatment on Yields on Grain and Green Forage



VITA

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Master of Science

Thesis: THE EFFECTS OF FERTILIZER TREATMENT ON YIELD AND UPTAKE OF NUTRIENTS BY KAFIR 44-14 SORGHUM

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