February 27, 1956

To the Graduate Council:

I am submitting herewith a thesis written by Fred C. Boswell entitled "The Effect of Soil Potassium Levels on Yield, Lodging and Mineral Composition of Corn." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

E. Winters

We have read this thesis and recommend its acceptance:

Laurence N Skold

W. L. Parks

Accepted for the Council:

E. G. Waters
Dean of the Graduate School

THE EFFECT OF SOIL POTASSIUM LEVELS ON YIELD, LODGING AND MINERAL COMPOSITION OF CORN

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by

Fred C. Boswell

March 1956

ACKNOWLEDGEMENTS

The writer wishes to express his gratitude and appreciation to:

Dr. W. L. Parks not only for advice during the planning and performance of this study, but for his continued interest and encouragement throughout the period of graduate study,

Dr. Eric Winters, Professor L. N. Skold and other members of the Agronomy Department for their cooperation and helpful suggestions, and

The American Potash Institute for their financial support which made this study possible.

Fred C. Boswell

TABLE OF CONTENTS

CHAPTER PAGE

APPENDIX (continued)

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

This study was designed to determine the influence of rates of potassium fertilization on yield, chemical composition and amount of root lodging and stalk breakage in corn. The effects of potassium application on the potassium, calcium, magnesium and phosphorus composition of corn at several stages of growth were also determined.

CHAPTER II

REVIEW OF LITERATURE

The literature relating potassium functions to vital processes in plant metabolism and growth is extensive. However, definite conclusions as to the exact functions of this element are difficult to establish since it occurs in plants principally as soluble inorganic salts and in the ionic form. Meyer and Anderson (18)[1] state that the fundamental role of this element in plant metabolism is undoubtedly regulatory or catalytic.

Lawson and Cook (16) state that evidence is now available which shows that potassium affects the following processes: (a) synthesis of simple sugars and starches, (b) translocation of carbohydrates, (c) reduction of nitrates and synthesis of protein, particularly in meristematic tissues, and (d) normal cell division. In addition, it has been suggested by others (11) (21) that potassium may play a part in the maintenance of turgor in plant cells as well as in the formation of oils and in the enhancement of disease resitance.

Bartholomew and Janssen (1), Nightingale (20), and Hoffer (11) report that the potassium ion is generally absorbed in larger quantities than any other mineral element. Bartholomew and Janssen (2) stated the absorption of potassium takes place at a high rate throughout the life of the plant, and consequently a deficiency at any time should be

---

[1]Numbers in parentheses refer to references in the literature cited, pages 51-53.

very important.

Hoffer and Krantz (12) state that the initial symptom of potassium deficiency in young corn plants is a decrease in rate of growth. Very soon the leaf tips of lower leaves become yellow, and this chlorosis proceeds in a streak along each leaf margin and between veins which later turns brown. In severe cases leaves become damaged and growth of the plant is dwarfed because the tissue between nodes does not develop fully. Other characteristics of potassium-deficient corn plants are weak stalks, ears poorly filled at the tips, and susceptibility to ear rot organisms.

Experiments by Gregory (8), Hoffer (11), Wall (26), Nightingale (19), and others have clearly shown that plants well supplied with potassium contained significantly more carbohydrates than did plants deficient in this element.

Although a decrease in carbohydrates is associated with severe potassium deficiency, Nightingale, et al (21), Hartt (9), and Wall (25) have reported an initial accumulation of carbohydrates in potassium-deficient plants. Wall (26) indicated that nitrogen metabolism is affected prior to carbohydrate metabolism. If this is true, the initial accumulation of carbohydrates is probably the result of a lack of utilization of soluble organic nitrogen. Janssen and Bartholomew (14), however, found that there is not always a correlation between the percentages of sugars and starches in the plant and uptake of potassium. In some cases it appears that the highest percentages of sugars and starches were produced at a potassium concentration which was conducive to maximum growth; while in other cases high percentages of sugars and starches were found with a small uptake of potassium and with decreased plant growth. Steinberg (24) reported that potassium deficiency causes a greater increase in reducing sugars than in total carbohydrates. In most plant species, it has been shown that the per cent of potassium is inversely related to the per cent nitrogen content, both total and water-soluble. These results suggested that potassium might be directly or indirectly concerned in the synthesis of proteins, that the lack of condensation of amino acids to protein prevented growth, and this in turn caused the high water-soluble nitrogen fraction.

Levels of potassium, directly or indirectly, influence the structure of stems and cell walls. Observations and experiments indicate that stiffness of straw or stalk is related to an adequate supply of potassium within the plant. Nightingale (20) noted that when carbohydrates are abundant, stem structures are likely to be strongest. Certainly the development of lignin and cellulose will be limited in cases of low carbohydrate accumulation. However, Lawton and Cook (16) state that if carbohydrates are utilized in protein synthesis as fast as they are produced, as when nitrate supplies are high, cell walls may be thin and stems weak even though plant tissues contain adequate levels of potassium. Janssen and Bartholomew (14) found in a study of cowpeas and soybeans that thick cell walls are associated with low potassium in the plants. In general, there seems to be a greater development of the schlerenchyma cells and mechanical tissue of the vascular system and a smaller development of the cortex cells, both in number and size, in low potassium plants than in high potassium plants of the same variety. Cortex cells are important in reducing the amount of stalk breakage.

Krantz and Chandler (15), Wittels and Seatz (27), and Fisher (6) found a relationship between stalk breakage, lodging and the level of potassium. Krantz and Chandler obtained an increase in yield and a decrease in lodging from applications of up to eighty pounds of K_2O per acre but no further lodging reduction with applications up to three hundred and twenty pounds of K_2O per acre. Wittels and Seatz, using rates of nitrogen of sixty and one hundred and twenty pounds per acre, observed no further consistent decrease in the amount of stalk breakage on yield increase over the check plot at potassium applications greater than forty pounds per acre. At the lower potassium level, stalk breakage was less severe in the low nitrogen treatments than in the high.

It has been pointed out by Hoffer (10) that iron compounds accumulate in the joints of corn plants when the supply of available soil potassium is deficient. These iron accumulations disrupt translocation of foods from the leaves to the roots, and the latter are starved and weakened. They then become predisposed to injuries by fungi. When the roots become sufficiently rotted the weakened plants may lodge.

Krantz and Chandler (15) and Brady (3) also related lodging to varietal and plant population differences.

Stanford, et al (23) emphasize that potassium/calcium and potassium/magnesium antagonism becomes pronounced with increasing concentrations of potassium and causes a reduction in the absorption of divalent cations. Drake and Scareth (5), Janssen and Bartholomew (14), and Lundegardh (17) support the contention that as potassium levels decline, calcium and magnesium uptake by the plant tends to increase. Thus, it is important that these three elements be kept in balance.

Luxury consumption of potassium is reported by Nightingale, et al (21), Bartholomew and Janssen (1), Krantz and Chandler (15), and Stanford, et al (23).

James and Penston (13), Bartholomew and Janssen (1), and Nightingale, et al (21) show that potassium present in potassium deficient plants apparently is transferred from the older regions to the meristematic tissue as needed. The older leaves may then exhibit deficiency symptoms and die as a result.

Sayre (22) found that the greatest potassium accumulation in corn took place just before and after tasseling. He found the greatest accumulation in the stem about three weeks after silking. There was an actual loss of potassium after that time, largely from the leaves and stems of the plants. He states, "A probable explanation is that potassium was partly washed from the leaves and stems back into the soil or simply moved back into the soil through the root system."

CHAPTER III

METHODS AND PROCEDURES

Five varieties of corn, three single crosses and two double crosses, were grown on a soil low in "available" potassium. Potassium, calcium, magnesium, and phosphorus contents of plant samples were determined periodically throughout the growing season. Stalk breakage was determined periodically and grain yields were obtained.

The soil on which the experiment was conducted is classified as Holston loam. The Holston series is developed from moderately coarse-textured old alluvium on stream terraces under conditions of adequate drainage. The surface horizon is a brown (10 YR 5/3), very friable loam with weakly developed fine to medium granular structure. The "B" horizon ranges from yellowish brown to brownish yellow clay loam that is slightly firm and which has weakly developed fine and medium subangular blocky structure.

Where a similar experiment had been located the previous year, soil samples were obtained from between the old corn rows (and thus would not reflect row fertilization in the experimental plots) and analyzed. The results of these analyses are shown in Table I.

	Block	N	P_2O_5	K_2O
Rates of fertilizer used in 1954 were:	I	100	40	0
	II	100	40	50
	III	100	40	150
	IV	100	40	250
Rates of fertilizer used in 1955 were:	I	100	50	0
	II	100	50	25
	III	100	50	25
	IV	100	50	25

TABLE I

EXCHANGEABLE POTASSIUM, CALCIUM, MAGNESIUM, AVAILABLE PHOSPHORUS, AND pH OF SOIL SAMPLES OBTAINED FROM EXPERIMENTAL AREA

Block Number	1955 Soil Test Spring Sampled					1955 Soil Test Fall Sampled									
	Randomized					Row					Middle				
	Pounds per acre				pH	Pounds per acre				pH	Pounds per acre				pH
	K	Ca	P	Mg		K	Ca	P	Mg		K	Ca	P	Mg	
I	80	1110	22.1	136	5.3	48	905	88.7	98	5.0	55	905	20.7	120	5.4
II	82	1045	19.3	98	5.4	58	940	73.9	89	5.2	55	895	19.3	105	5.5
III	122	1060	19.6	110	5.4	95	975	77.5	77	5.2	78	880	19.6	100	5.5
IV	178	1070	19.3	156	5.3	105	1010	82.2	82	5.2	98	845	20.8	95	5.5

In 1954, nitrogen was applied at the rate of thirty pounds of N per acre in the row at planting and seventy pounds per acre as side-dressing. Phosphorus was applied in the row at the rate of forty pounds of P_2O_5 per acre at planting. Following plowing and preceding disking, one hundred and two hundred pounds of K_2O per acre was applied broadcast to blocks III and IV respectively. Blocks II, III, and IV received fifty pounds of K_2O per acre in the row at time of planting.

In 1955, nitrogen was applied at the rate of thirty pounds of N per acre in the row at planting and seventy pounds per acre as side-dressing twenty-six days after planting or when corn was about eighteen inches high. Phosphorus was applied in the row at the rate of fifty pounds of P_2O per acre at planting. Blocks II, III, and IV received twenty-five pounds of K_2O per acre in the row at time of planting.

The experiment was laid out in a modified randomized block design with four replications. The five varieties and four rates of potash fertilization made a total of twenty treatments. Plot size was ten and one-half by thirty feet or 1/138.29 acre, each plot consisting of three rows forty-two inches apart.

The five corn varieties used were:

(1) T115 x T111
(2) T105 x T101
(3) T61 x T13
(4) Tenn. 29 (T115 x T111)(T105 x T101)
(5) Dixie 33 (T61 x T13) (T105 x T101)

The corn was planted on May 7 at the rate of two kernels every nine to twelve inches. Twenty-six days after planting, the plots were thinned to one plant every fifteen inches or twenty-four plants per thirty feet row, making a stand equivalent to 10,000 plants per acre. The experimental plots were cultivated two times during the growing season. The crop was harvested October 5, which was 151 days after planting.

The first leaf tissue samples were taken June 4 when the plants were eighteen to twenty-four inches tall. Two more samples were obtained at intervals of about three weeks. The sampling procedure consisted of taking the youngest mature leaf on the first two sampling dates and the first full leaf below the lowest ear on the third sampling date. Six plants, selected at random, were sampled in each plot.

All tissue samples were dried in an oven at 70° C. The dried samples were ground in a Wiley mill, mixed thoroughly, and stored in bottles until analyzed.

A modification of the wet oxidation procedure of Gieseking, Snider, and Getz (7) was used for ashing all samples.

The potassium, calcium, and magnesium contents of the samples were determined with a Beckman DU flame spectrophotometer equipped with a photomultiplier attachment. The Beckman B spectrophotometer was used to measure blue color intensities in the phosphorus determinations. Each instrument was calibrated with known concentrations of the element for which the analysis was being made. Sample readings were then compared with the calibration curve obtained from these standard solutions.

Per cent stalk breakage was obtained by counting all stalks which were broken below the highest ear. Stalks which were leaning more than forty-five degrees were considered to be root lodged.

Yield data were determined by harvesting all plots and recording field weights which were then converted to bushels of shelled corn per acre on a 15.5 per cent moisture basis.

CHAPTER IV

RESULTS

Yield

Yield data are summarized in Table II. These data were subjected to analysis by statistical procedures as outlined by Cochran and Cox (4).

A comparison of the 0-pound K_2O treated plots with an average of those plots receiving K_2O showed a significant yield difference. The least significant difference in yield at the .05 level was 6.7 bushels.

In comparison of variety means, Tenn. 29 showed a significant yield increase over Dixie 33 and T61 x T13. Single cross T115 x T111 gave a significant yield increase over Dixie 33.

At the same level of K_2O fertilization, Tenn. 29 showed a significant yield increase over T115 x T111, T61 x T13, and Dixie 33 at the 0-pound K_2O level. At the 75-pound level of K_2O, T115 x T111 gave a significant yield increase over T105 x T101, T61 x T13 and Dixie 33. Tenn. 29 showed a significant yield increase over Dixie 33 at the 75-pound level of K_2O. There were no significant yield differences among varieties at the 175- and 275-pound levels of K_2O.

When comparing the same variety at different K_2O levels, 75- and 275-pound levels of K_2O gave a significant yield increase over the 0-pound K_2O level for T115 x T111. For the single cross T61 x T13, 175 pounds of K_2O gave a significant yield increase over the 0-pound K_2O level. Dixie 33 showed a significant yield increase at the 175-pound

TABLE II

YIELD OF GRAIN[a] IN BUSHELS PER ACRE FOR FIVE VARIETIES OF CORN AT FOUR LEVELS OF POTASSIUM FERTILIZATION

Variety	Pounds K_2O per acre				Average
	0	75	175	275	
T115 x T111	52.6[b]	70.6	60.3	63.4	61.7
T105 x T101	57.0	60.0	61.9	63.4	60.6
T61 x T13	52.1	56.9	65.7	57.5	58.1
Tenn. 29	63.3	65.0	64.2	63.7	64.1
Dixie 33	50.5	55.2	61.2	59.8	56.7
Average	55.1	61.5	62.7	61.6	
Av. no K_2O vs. K_2O	55.1		61.9		

LSD (.05)* between variety means - - - - - - - - - - - 4.6 bu.
LSD (.05)* between no K_2O vs. K_2O - - - - - - - - - - 6.7 bu.
LSD (.05)* between varieties at same level of K_2O - 9.1 bu.
LSD (.05)* between K_2O levels of the same variety - 10.6 bu.

C. V. For varieties - - - - - - - - - - - - - - - - - - 10.7%
C. V. For no K_2O vs. K_2O - - - - - - - - - - - - - - 15.5%

[a]Grain yields are based on 15.5 per cent moisture.

[b]Figures represent an average of four replications.

* No significant difference at .01 level.

level of K_2O over the 0-pound K_2O level. There was no significant yield difference between K_2O levels for Tenn. 29 and T105 x T101. The variation among replicates was significant at the .05 and .01 levels as indicated by the F test. The yield results are shown graphically in Figure 1.

Root Lodging and Stalk Breakage

The data on root lodging and stalk breakage are summarized in Tables III through XI. Root lodging and stalk breakage were most prevalent in the 0-pound K_2O treated plots. Figure 2 shows that as the season progressed the amount of combined root lodging and stalk breakage increased.

At all three root lodging count dates, the 0-pound K_2O treated plots showed a higher per cent lodging than did the 75-, 175-, and 275-pound levels of K_2O. This difference was significant at the .01 level. Single cross T61 x T13 showed a higher per cent root lodging, significant at .01 level, when compared with the other four varieties at all three dates. Dixie 33 showed a higher per cent root lodging than did T115 x T111, T105 x T101 and Tenn. 29. This difference was significant at .05 level.

The per cent stalk breakage at all three dates showed a highly significant increase in lodging for 0-pound K_2O treated plots over the 75-, 175- and 275-pound levels of K_2O. At all three dates, T61 x T13 gave a greater difference for per cent stalk breakage than T115 x T111, T105 x T101 and Tenn. 29. This difference was significant at .01 level.

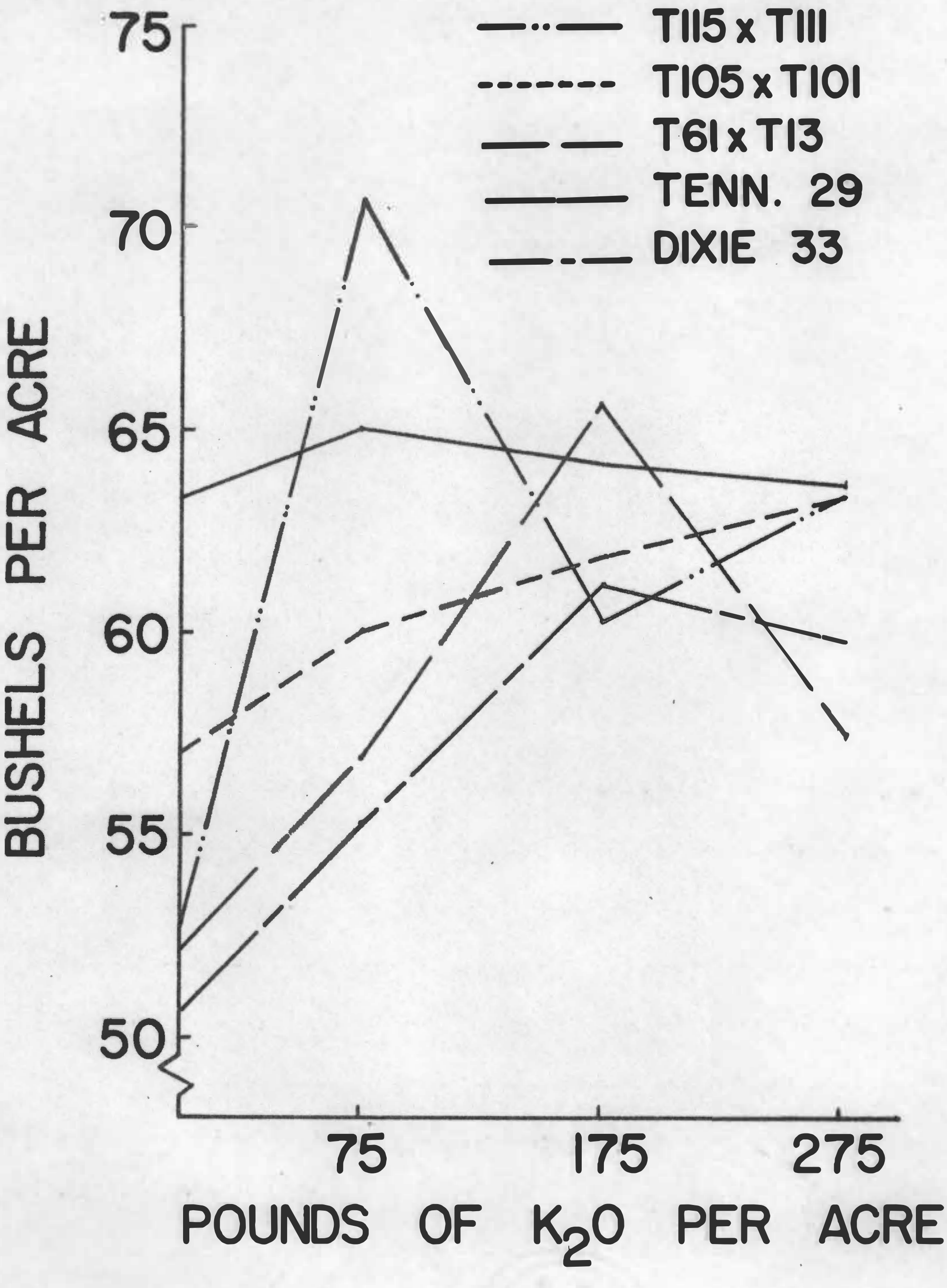

FIG. 1. — YIELD OF GRAIN (15.5% MOISTURE) FOR 5 VARIETIES OF CORN AT 4 LEVELS OF K_2O.

TABLE III

PER CENT ROOT LODGING 108 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre				Average
	0	75	175	275	
T115 x T111	3.5[a]	0.7	1.0	0.4	1.4
T105 x T101	0.4	0.0	0.0	0.7	0.3
T61 x T13	9.7	2.1	1.0	1.7	3.6
Tenn. 29	3.5	0.0	0.7	0.7	1.2
Dixie 33	5.6	2.1	1.0	0.7	2.3
Average	4.5	1.0	0.8	0.8	

LSD (.05) between rates of K_2O - - - - - - - - - - - - - 0.76%
LSD (.01) between rates of K_2O - - - - - - - - - - - - - 0.83%

C. V. For rates of K O - - - - - - - - - - - - - - - - - - - 27.4%

LSD (.05) between varieties - - - - - - - - - - - - - - - - 0.92%
LSD (.01) between varieties - - - - - - - - - - - - - - - - 1.10%

C. V. For varieties - 48.7%

[a] Figures represent an average of four replications.

TABLE IV

PER CENT STALK BREAKAGE 108 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre				Average
	0	75	175	275	
T115 x T111	3.5[a]	0.7	1.7	2.1	2.0
T105 x T101	1.0	1.4	1.0	1.4	1.2
T61 x T13	11.5	4.5	2.8	2.1	5.2
Tenn. 29	3.5	0.4	3.5	0.7	2.0
Dixie 33	3.1	4.2	5.2	3.5	4.0
Average	4.5	2.2	2.8	1.9	

LSD (.05) between rates of K_2O - - - - - - - - - - - - - 0.78%
LSD (.01) between rates of K_2O - - - - - - - - - - - - - 0.88%

C. V. For rates of K_2O - - - - - - - - - - - - - - - - - 23.8%

LSD (.05) between varieties - - - - - - - - - - - - - - - 0.89%
LSD (.01) between varieties - - - - - - - - - - - - - - - 1.06%

C. V. For varieties - 37.4%

[a]Figures represent an average of four replications.

TABLE V

PER CENT COMBINED ROOT LODGING AND STALK BREAKAGE
108 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre: 0	75	175	275	Average
T115 x T111	6.9[a]	1.4	2.8	2.4	3.4
T105 x T101	1.4	1.4	1.0	2.1	1.5
T61 x T13	21.2	6.6	3.8	3.8	8.9
Tenn. 29	6.9	0.4	4.2	1.4	3.2
Dixie 33	8.7	6.2	6.2	4.2	6.3
Average	9.0	3.2	3.6	2.8	

LSD (.05) between rates of K_2O - - - - - - - - - - - - 0.83%
LSD (.01) between rates of K_2O - - - - - - - - - - - - 0.99%

C. V. For rates of K_2O - - - - - - - - - - - - - - - - 25.0%

LSD (.05) between varieties - - - - - - - - - - - - - - - 1.04%
LSD (.01) between varieties - - - - - - - - - - - - - - - 1.32%

C. V. For varieties - - - - - - - - - - - - - - - - - - 40.3%

[a]Figures represent an average of four replications.

TABLE VI

PER CENT ROOT LODGING 131 DAYS AFTER PLANTING

Variety	Pounds K20 per acre				Average
	0	75	175	275	
T115 x T111	9.4[a]	1.4	2.4	0.7	3.5
T105 x T101	2.8	0.0	0.4	0.4	0.9
T61 x T13	17.7	2.1	1.0	2.1	5.7
Tenn. 29	4.2	0.4	0.7	0.7	1.5
Dixie 33	10.8	2.1	1.0	1.4	3.8
Average	9.0	1.2	1.1	1.0	

LSD (.05) between rates of K_2O - - - - - - - - - - - - 0.88%
LSD (.01) between rates of K_2O - - - - - - - - - - - - 1.07%

C. V. For rates of K_2O - - - - - - - - - - - - - - - - 35.7%

LSD (.05) between varieties - - - - - - - - - - - - - - - 0.94%
LSD (.01) between varieties - - - - - - - - - - - - - - - 1.12%

C. V. For varieties - - - - - - - - - - - - - - - - - - 42.1%

[a] Figures represent an average of four replications.

TABLE VII

PER CENT STALK BREAKAGE 131 DAYS AFTER PLANTING

Variety	Pounds K20 per acre				Average
	0	75	175	275	
T115 x T111	5.6[a]	1.7	3.8	2.8	3.5
T105 x T101	1.0	1.4	1.0	2.8	1.6
T61 x T13	20.8	8.3	3.5	6.2	9.7
Tenn. 29	7.6	1.7	3.8	3.1	4.1
Dixie 33	10.1	7.3	7.3	5.6	7.6
Average	9.0	4.1	3.9	4.1	

LSD (.05) between rates of K_2O - - - - - - - - - - - - 0.75%
LSD (.01) between rates of K_2O - - - - - - - - - - - - 0.81%

C. V. For rates of K_2O - - - - - - - - - - - - - - - - 15.7%

LSD (.05) between varieties - - - - - - - - - - - - - 0.92%
LSD (.01) between varieties - - - - - - - - - - - - - 1.10%

C. V. For varieties - - - - - - - - - - - - - - - - - 29.8%

[a]Figures represent an average of four replications.

TABLE VIII

PER CENT COMBINED ROOT LODGING AND STALK BREAKAGE
131 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre				Average
	0	75	175	275	
T115 x T111	14.9[a]	3.1	6.2	3.5	6.9
T105 x T101	3.8	1.4	1.4	3.1	2.4
T61 x T13	38.5	10.4	4.5	8.3	15.4
Tenn. 29	11.8	2.1	4.5	3.8	5.6
Dixie 33	20.8	2.4	8.3	6.9	11.4
Average	18.0	5.3	5.0	5.1	

LSD (.05) between rates of K_2O - - - - - - - - - - - - 0.86%
LSD (.01) between rates of K_2O - - - - - - - - - - - - 1.03%

C. V. For rates of K_2O - - - - - - - - - - - - - - - - 20.5%

LSD (.05) between varieties - - - - - - - - - - - - - - 1.04%
LSD (.01) between varieties - - - - - - - - - - - - - - 1.32%

C. V. For varieties - - - - - - - - - - - - - - - - - - 30.6%

[a]Figures represent an average of four replications.

TABLE IX

PER CENT ROOT LODGING 149 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre 0	75	175	275	Average
T115 x T111	9.4[a]	1.4	2.4	1.4	3.6
T105 x T101	2.8	0.0	0.4	0.4	0.9
T61 x T13	17.7	2.1	1.4	2.1	5.8
Tenn. 29	3.5	0.4	1.0	0.7	1.4
Dixie 33	10.8	2.1	1.0	1.7	3.9
Average	8.8	1.2	1.2	1.2	

LSD (.05) between rates of K O - - - - - - - - - - - - - 1.03%
LSD (.01) between rates of K O - - - - - - - - - - - - - 1.11%

C. V. For rates of K_2O - - - - - - - - - - - - - - - - - 38.0%

LSD (.05) between varieties - - - - - - - - - - - - - - - 0.94%
LSD (.01) between varieties - - - - - - - - - - - - - - - 1.12%

C. V. For varieties - - - - - - - - - - - - - - - - - - 40.8%

[a] Figures represent an average of four replications.

TABLE X

PER CENT STALK BREAKAGE 149 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre 0	75	175	275	Average
T115 x T111	7.3[a]	1.7	4.5	4.5	4.5
T105 x T101	1.4	2.8	1.4	2.8	2.1
T61 x T13	21.2	9.0	3.8	6.9	10.2
Tenn. 29	8.3	3.1	4.9	5.2	5.4
Dixie 33	10.1	8.0	8.3	6.6	8.2
Average	9.6	4.9	4.6	5.2	

LSD (.05) between rates of K_2O - - - - - - - - - - - - - 0.74%
LSD (.01) between rates of K_2O - - - - - - - - - - - - - 0.79%

C. V. For rates of K_2O - - - - - - - - - - - - - - - - - 11.6%

LSD (.05) between varieties - - - - - - - - - - - - - - 0.92%
LSD (.01) between varieties - - - - - - - - - - - - - - 1.10%

C. V. For varieties - - - - - - - - - - - - - - - - - - 27.7%

[a] Figures represent an average of four replications.

TABLE XI

PER CENT COMBINED ROOT LODGING AND STALK BREAKAGE
149 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre				Average
	0	75	175	275	
T115 x T111	16.7[a]	3.1	6.9	5.9	8.2
T105 x T101	4.2	2.8	1.7	3.1	3.0
T61 x T13	38.9	11.1	5.2	9.0	16.1
Tenn. 29	11.8	3.5	5.9	5.9	6.8
Dixie 33	20.8	10.1	9.4	8.3	12.2
Average	18.5	6.1	5.8	6.5	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.81%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.94%

C. V. For rates of K_2O - - - - - - - - - - - - - - - - - 16.8%

LSD (.05) between varieties - - - - - - - - - - - - - 1.04%
LSD (.01) between varieties - - - - - - - - - - - - - 1.32%

C. V. For varieties - - - - - - - - - - - - - - - - - - - 29.1%

[a] Figures represent an average of four replications.

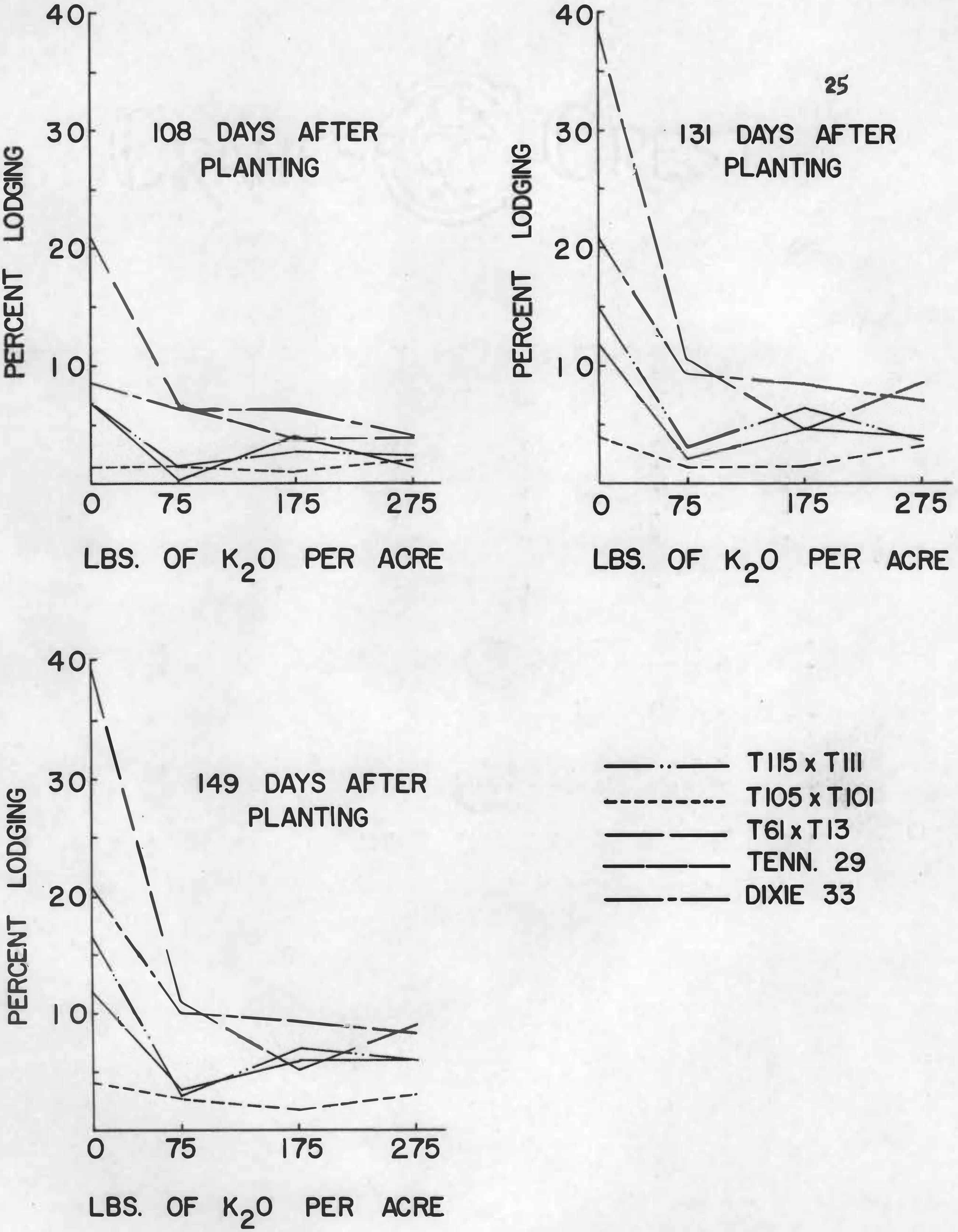

FIG. 2. — PERCENT LODGING OF 5 VARIETIES OF CORN AT 4 LEVELS OF K_2O AT 3 DATES FOLLOWING PLANTING.

At the three different dates, the 0-pound K_2O treated plots showed a higher per cent combined root lodging and stalk breakage, significant at .01 level, when compared with the 75-, 175-, and 275-pound levels of K_2O. There was no significant difference among the 75-, 175- and 275-pound levels of K_2O. Variety T61 x T13 showed a higher per cent combined root lodging and stalk breakage when compared with the other four varieties. This difference was significant at the .01 level. With the exception of T115 x T111 over Tenn. 29 at the first combined count date (108 days after planting), there was a highly significant increase in per cent combined root lodging and stalk breakage for T61 x T13 over Dixie 33, Dixie 33 over T115 x T111, T115 x T111 over T105 x T101 and Tenn. 29 over T105 x T101. Therefore, from Figure 2, the standing ability for the five varieties could be ranked as:

1. T105 x T101
2. Tenn. 29
3. T115 x T111
4. Dixie 33
5. T61 x T13

Mineral Composition

The summary of potassium, calcium, magnesium and phosphorus contents of the corn plants are given in Tables XII through XXIII. The data from these summary tables are plotted in Figure 3. Varieties were not considered in Figure 3 since there were no significant differences among varieties.

The per cent potassium for the three sampling dates averaged 0.78 for the 0-pound K_2O treated plots, 1.80 per cent for the 75-pound level,

TABLE XII

PER CENT POTASSIUM IN CORN LEAF TISSUE
28 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre: 0	75	175	275	Average
T115 x T111	1.20[a/b/]	3.10	3.02	3.28	2.65
T105 x T101	1.06	3.16	3.61	3.85	2.92
T61 x T13	1.25	2.72	3.21	3.34	2.63
Tenn. 29	1.16	2.76	3.42	3.59	2.73
Dixie 33	1.26	3.28	3.36	3.60	2.88
Average	1.19	3.00	3.32	3.53	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.20%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.29%

C. V. for rates of K_2O - - - - - - - - - - - - - - - 5.3%

LSD (.05) between varieties - - - - - - - - - - - - N.S.

[a/]Figures represent an average of four replications.

[b/]Figures represent per cent of element in air-dry weight of sample.

TABLE XIII

PER CENT POTASSIUM IN CORN LEAF TISSUE
53 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre 0	75	175	275	Average
T115 x T111	0.55 a/ b/	1.59	1.76	2.08	1.50
T105 x T101	0.56	1.39	1.80	2.50	1.56
T61 x T13	0.75	1.29	1.81	1.96	1.45
Tenn. 29	0.84	1.55	1.78	2.25	1.60
Dixie 33	0.62	1.30	1.99	2.15	1.52
Average	0.66	1.42	1.83	2.19	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.29%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.41%

C. V. for rates of K_2O - - - - - - - - - - - - - - - - 13.7%

LSD (.05) between varieties - - - - - - - - - - - - N.S.

a/ Figures represent an average of four replications.

b/ Figures represent per cent of element in air-dry weight of sample.

TABLE XIV

PER CENT OF POTASSIUM IN CORN LEAF TISSUE
76 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre 0	75	175	275	Average
T115 x T111	0.50 a/ b/	1.11	1.28	1.86	1.19
T105 x T101	0.38	0.89	1.34	1.85	1.12
T61 x T13	0.60	0.84	1.40	1.60	1.11
Tenn. 29	0.41	0.98	1.52	2.04	1.24
Dixie 33	0.51	1.04	1.39	1.90	1.21
Average	0.48	0.97	1.39	1.85	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.15%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.21%

C. V. for rates of K_2O - - - - - - - - - - - - - - - - - 9.3%

LSD (.05) between varieties - - - - - - - - - - - - - N.S.

a/ Figures represent an average of four replications.

b/ Figures represent per cent of element in air-dry weight of sample.

TABLE XV

PER CENT CALCIUM IN CORN LEAF TISSUE
28 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre				Average
	0	75	175	275	
T115 x T111	0.58[a/b]	0.40	0.46	0.36	0.45
T105 x T101	0.97	0.63	0.56	0.50	0.66
T61 x T13	0.96	0.64	0.68	0.64	0.73
Tenn. 29	0.71	0.45	0.56	0.44	0.54
Dixie 33	0.88	0.65	0.52	0.58	0.66
Average	0.82	0.55	0.56	0.50	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.10%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.14

C. V. for rates of K_2O - - - - - - - - - - - - - - - - 11.3%

LSD (.05) between varieties - - - - - - - - - - - - - - 0.08%
LSD (.01) between varieties - - - - - - - - - - - - - - 0.10%

C. V. for varieties - - - - - - - - - - - - - - - - 8.8%

[a]Figures represent an average of four replications.

[b]Figures represent per cent of element in air-dry weight of sample.

TABLE XVI

PER CENT CALCIUM IN CORN LEAF TISSUE
53 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre				Average
	0	75	175	275	
T115 x T111	0.94[a/b/]	0.66	0.52	0.52	0.66
T105 x T101	1.33	1.12	1.01	0.96	1.10
T61 x T13	1.25	1.03	0.88	0.89	1.01
Tenn. 29	1.16	0.87	0.81	0.73	0.89
Dixie 33	1.25	1.07	0.90	0.94	1.04
Average	1.19	0.95	0.82	0.81	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.12%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.17%

C. V. for rates of K_2O - - - - - - - - - - - - - - - - - 8.3%

LSD (.05) between varieties - - - - - - - - - - - - 0.10%
LSD (.01) between varieties - - - - - - - - - - - - 0.13%

C. V. for varieties - - - - - - - - - - - - - - - - - 7.4%

[a/]Figures represent an average of four replications.

[b/]Figures represent per cent of element in air-dry weight of sample.

TABLE XVII

PER CENT CALCIUM IN CORN LEAF TISSUE
76 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre: 0	75	175	275	Average
T115 x T111	0.84[a/][b/]	0.63	0.56	0.54	0.64
T105 x T101	1.15	1.28	1.10	0.77	1.08
T61 x T13	1.34	1.02	0.99	0.92	1.07
Tenn. 29	1.14	0.76	0.92	0.70	0.88
Dixie 33	1.29	1.28	0.92	0.93	1.10
Average	1.15	0.99	0.90	0.77	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.12%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.18%

C. V. for rates of K_2O - - - - - - - - - - - - - - - - - 9.4%

LSD (.05) between varieties - - - - - - - - - - - - - 0.15%
LSD (.01) between varieties - - - - - - - - - - - - - 0.20%

C. V. for varieties - - - - - - - - - - - - - - - - - 11.3%

[a/]Figures represent an average of four replications.

[b/]Figures represent per cent of element in air-dry weight of sample.

TABLE XVIII

PER CENT MAGNESIUM IN CORN LEAF TISSUE
28 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre: 0	75	175	275	Average
T115 x T111	0.68[a/][b/]	0.26	0.28	0.20	0.36
T105 x T101	1.09	0.31	0.30	0.18	0.47
T61 x T13	1.08	0.43	0.34	0.28	0.53
Tenn. 29	0.85	0.28	0.33	0.19	0.41
Dixie 33	0.93	0.37	0.23	0.24	0.44
Average	0.93	0.33	0.29	0.22	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.11%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.17%

C. V. for rates of K_2O - - - - - - - - - - - - - - - - 20.2%

LSD (.05) between varieties - - - - - - - - - - - - 0.09%
LSD (.01) between varieties - - - - - - - - - - - - N.S.

C. V. for varieties - - - - - - - - - - - - - - - - 15.2%

[a/]Figures represent an average of four replications.

[b/]Figures represent per cent of element in air-dry weight of sample.

TABLE XIX

PER CENT MAGNESIUM IN CORN LEAF TISSUE
53 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre				Average
	0	75	175	275	
T115 x T111	1.37[a/][b/]	0.49	0.44	0.24	0.64
T105 x T101	1.90	0.95	0.84	0.46	1.04
T61 x T13	1.73	0.94	0.61	0.64	0.98
Tenn. 29	1.35	0.59	0.60	0.34	0.72
Dixie 33	1.91	0.90	0.69	0.53	1.01
Average	1.65	0.77	0.64	0.44	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.20%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.29%

C. V. for rate of K_2O - - - - - - - - - - - - - - - - 17.3%

LSD (.05) between varieties - - - - - - - - - - - - - 0.16%
LSD (.01) between varieties - - - - - - - - - - - - - 0.20%

C. V. for varieties - - - - - - - - - - - - - - - - 13.3%

[a/]Figures represent an average of four replications.

[b/]Figures represent per cent of element in air-dry weight of sample.

TABLE XX

PER CENT MAGNESIUM IN CORN LEAF TISSUE
76 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre: 0	75	175	275	Average
T115 x T111	1.62[a/b/]	0.68	0.43	0.34	0.77
T105 x T101	1.89	1.42	1.07	0.38	1.19
T61 x T13	2.04	1.50	0.96	0.91	1.35
Tenn. 29	1.76	0.82	0.70	0.46	0.94
Dixie 33	2.17	1.36	0.75	0.70	1.24
Average	1.90	1.16	0.78	0.56	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.24%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.35%

C. V. for rates of K_2O - - - - - - - - - - - - - - - - - 16.7%

LSD (.05) between varieties - - - - - - - - - - - - 0.21%
LSD (.01) between varieties - - - - - - - - - - - - 0.28%

C. V. for varieties - - - - - - - - - - - - - - - - - - 14.6%

a/Figures represent an average of four replications.

b/Figures represent per cent of element in air-dry weight of sample.

TABLE XXI

PER CENT PHOSPHORUS IN CORN LEAF TISSUE
28 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre 0	75	175	275	Average
T115 x T111	0.33[a/][b/]	0.32	0.31	0.32	0.32
T105 x T101	0.36	0.32	0.31	0.32	0.33
T61 x T13	0.34	0.30	0.36	0.36	0.34
Tenn. 29	0.35	0.36	0.34	0.30	0.34
Dixie 33	0.38	0.31	0.31	0.32	0.33
Average	0.35	0.32	0.33	0.32	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.02%

C. V. for rates of K_2O - - - - - - - - - - - - - - - 4.3%

LSD (.05) between varieties - - - - - - - - - - - - - N.S.

[a/]Figures represent an average of four replications.

[b/]Figures represent per cent of element in air-dry weight of sample.

TABLE XXII

PER CENT PHOSPHORUS IN CORN LEAF TISSUE
53 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre: 0	75	175	275	Average
T115 x T111	0.20[a/][b/]	0.21	0.21	0.22	0.21
T105 x T101	0.21	0.22	0.21	0.23	0.22
T61 x T13	0.20	0.25	0.21	0.26	0.23
Tenn. 29	0.21	0.22	0.24	0.25	0.23
Dixie 33	0.24	0.23	0.22	0.23	0.23
Average	0.21	0.23	0.22	0.24	

LSD (.05) between rates of K_2O - - - - - - - - - - - N.S.

C. V. for rates of K_2O - - - - - - - - - - - - - - - - - 7.2%

LSD (.05) between varieties - - - - - - - - - - - - - N.S.

[a/]Figures represent an average of four replications.

[b/]Figures represent per cent of element in air-dry weight of sample.

TABLE XXIII

PER CENT PHOSPHORUS IN CORN LEAF TISSUE
76 DAYS AFTER PLANTING

Variety	Pounds K_2O per acre				Average
	0	75	175	275	
T115 x T111	0.20[a/b/]	0.19	0.15	0.18	0.18
T105 x T101	0.21	0.14	0.18	0.18	0.18
T61 x T13	0.18	0.17	0.17	0.18	0.18
Tenn. 29	0.19	0.16	0.20	0.18	0.18
Dixie 33	0.21	0.16	0.14	0.17	0.17
Average	0.20	0.16	0.17	0.18	

LSD (.05) between rates of K_2O - - - - - - - - - - - 0.01%
LSD (.01) between rates of K_2O - - - - - - - - - - - 0.02%

C. V. for rates of K_2O - - - - - - - - - - - - - - - - 5.4%

LSD (.05) between varieties - - - - - - - - - - - - N.S.

a/Figures represent an average of four replications.

b/Figures represent per cent of element in air-dry weight of sample.

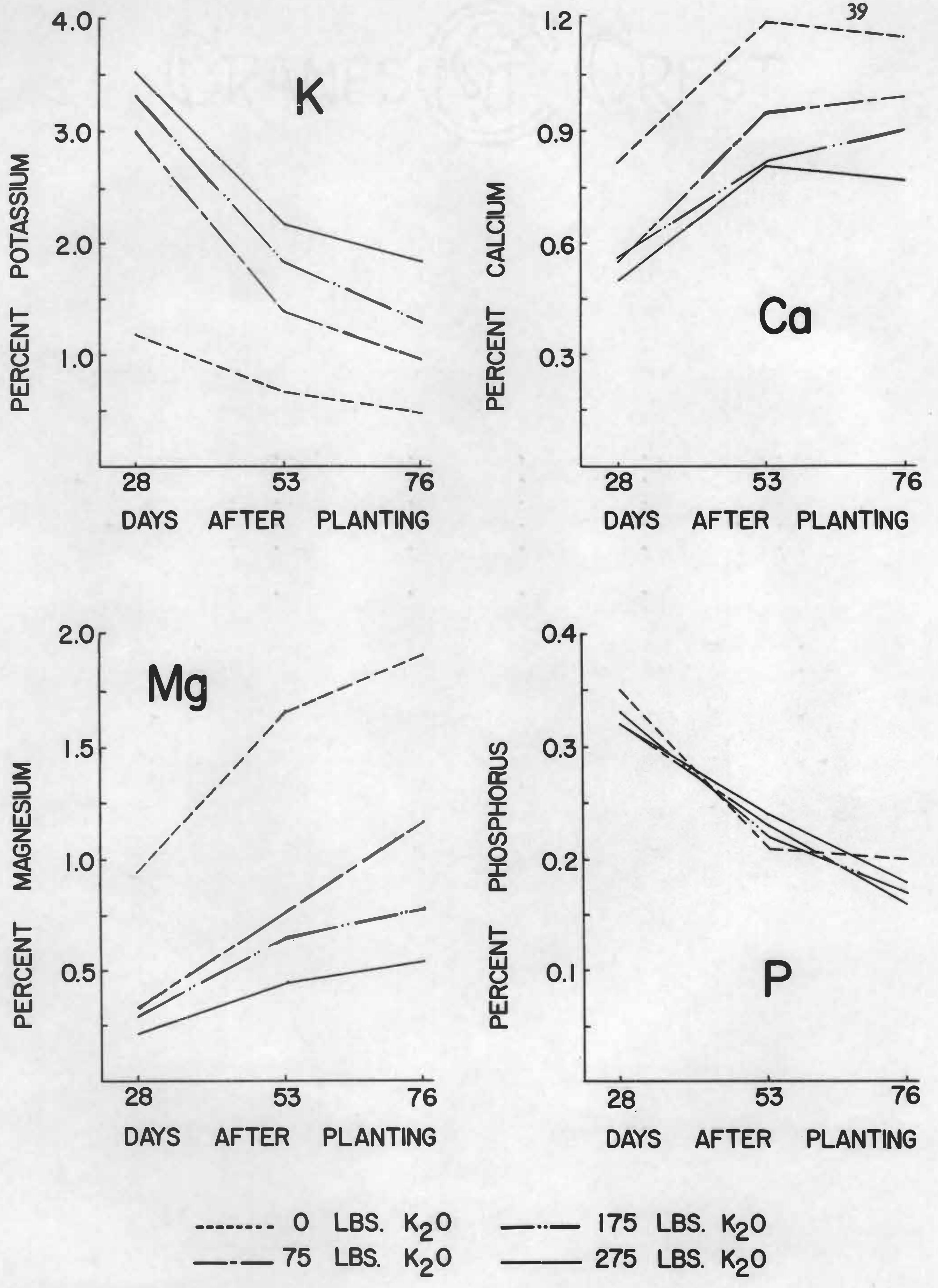

FIG. 3 — PERCENT K, Ca, Mg, AND P IN CORN LEAF TISSUE AT 4 LEVELS OF K_2O AT 3 DATES FOLLOWING PLANTING.

2.18 for the 175-pound level and 2.52 per cent for the 275-pound level of K_2O.

As indicated by Figure 3, the potassium content of the leaves was greatest at the first sampling date (twenty-eight days after planting). The potassium content decreased as the season progressed and tended to level off from the second to third sampling dates, fifty-three and seventy-six days after planting, respectively.

Potash fertilization generally decreased the leaf content of calcium and magnesium of all varieties, but did not appreciably affect the phosphorus content. The ratio of potassium to calcium plus magnesium was 5 to 1 at the first sampling date (twenty-eight days after planting) at the 275-pound level of K_2O. The ratio was approximately 2 to 1 at the second sampling date (fifty-three days after planting) and approximately 1.5 to 1 at the third sampling date (seventy-six days after planting) at the 275-pound level of K_2O.

Table XXIV presents the milliequivalents of total cations (potassium, calcium and magnesium) per one hundred grams of oven-dry tissue throughout the season. The milliequivalents of total cations decreased as the rate of potash fertilization increased (Figure 4). However, the milliequivalents of total cations increased the greatest with age of plant at the 0-pound K_2O level of fertilization. The magnitude of this effect decreased with each increment of K_2O and there was little change in the milliequivalents of total cations with age of plants at the 275-pound level of K_2O.

TABLE XXIV

MILLIEQUIVALENTS OF TOTAL CATIONS (K, Ca, Mg) PER 100 GRAMS OF OVEN-DRY TISSUE IN CORN LEAVES AT FOUR LEVELS OF K_2O AT THREE DATES FOLLOWING PLANTING

Rates of K_2O	Days after planting: 28	53	76	Average
0	149.0	213.9	228.1	197.0
75	131.9	148.1	171.0	150.4
175	137.3	141.2	145.6	141.4
275	133.8	133.3	132.6	133.2
Average	138.0	159.1	169.3	

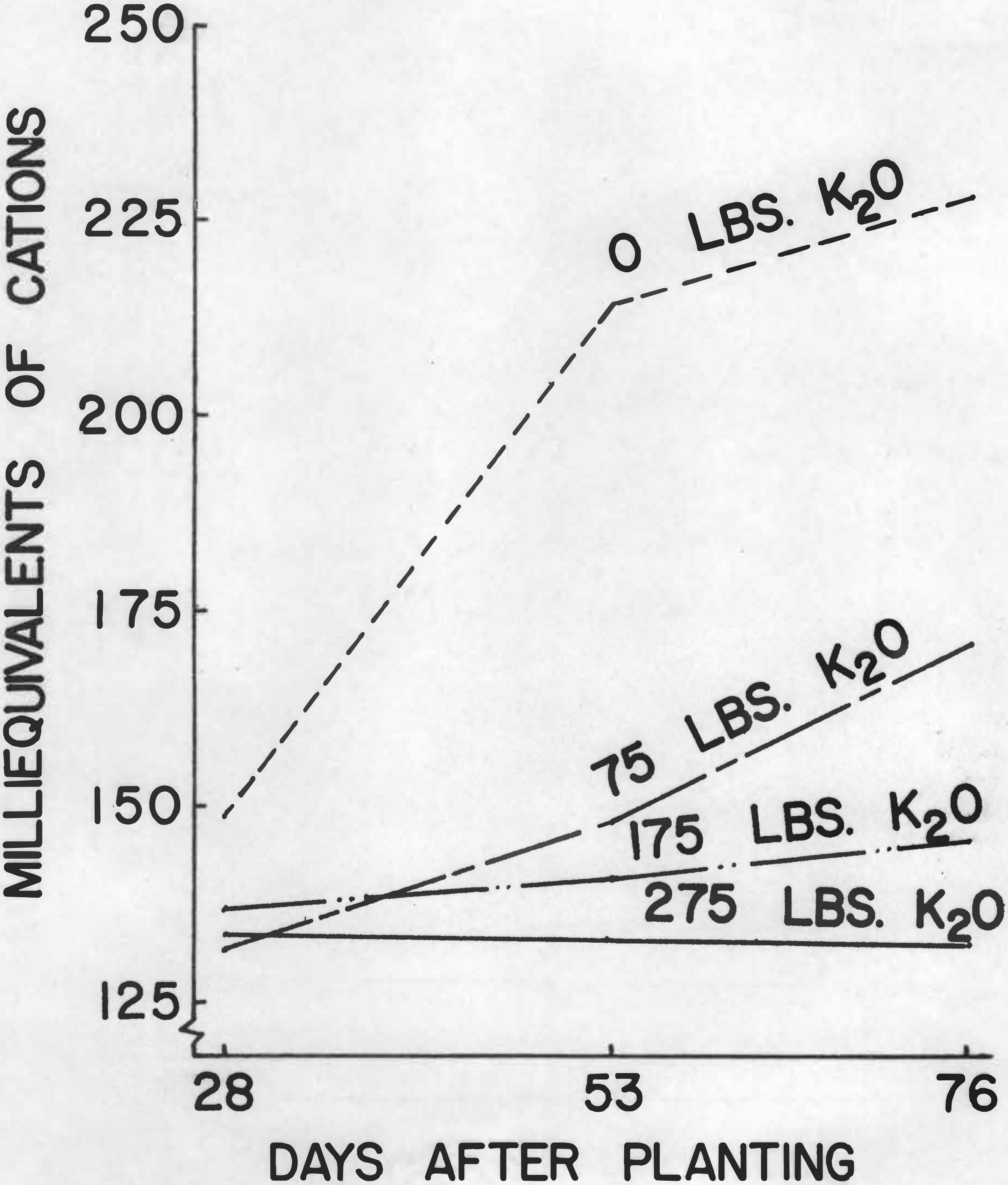

FIG. 4. — TOTAL CATIONS (K, Ca, Mg) PER 100 GRAMS OF OVEN-DRY TISSUE IN CORN LEAVES AT 4 LEVELS OF K_2O AT 3 DATES FOLLOWING PLANTING.

CHAPTER V

DISCUSSION AND CONCLUSIONS

Yield

A significant yield difference was obtained between the 0-pound K_2O treated plots and the average for the plots receiving the 75-, 175-, and 275-pound levels of K_2O (Table II). There was no significant difference among the three levels of K_2O. These results are in agreement with data on root lodging and stalk breakage (Tables III-XI), which decreased progressively with increased levels of potash fertilization, but was only significantly different between the 0-pound K_2O treated plots and the three levels of K_2O. There was no significant difference among levels of K_2O. These results also agree with the mineral content data (Tables XII-XXIII) which shows the potassium content increased as increments of K_2O increased.

An explanation for the significant increase of the average of the 75-, 175-, and 275-pound levels of K_2O over the 0-pound K_2O treated plots only, and the lack of significance among levels, might be that the major yield response was obtained by the first increment of K_2O and no subsequent yield response was obtained from additional increments of K_2O. The 75-, 175-, and 275-pound increments of applied K_2O would contribute to error of variance and yet be essentially equal as far as yield is concerned. Due to this increased error, a larger difference would be required for significance.

Root Lodging and Stalk Breakage

Root lodging and stalk breakage tended to decrease as potash fertilization increased as shown by Tables III-XI. This is in agreement with the work of Janssen and Bartholomew (14), who found that under low potassium conditions, there was a smaller development of the cortex cells which are important in reducing stalk breakage. The nitrogen-potassium-carbohydrate relationship (20) in the plant seems to be a major factor in determining the strength of the stalk and this could be an explanation for the lack of significant differences in the 75-, 175-, and 275-pound levels of K_2O.

Single cross T61 x T13 and Dixie 33 showed the greatest per cent root lodging and stalk breakage at all levels of K_2O and at all dates of sampling (Figure 2). T61 is the seed parent of the single cross T61 x T13 which in turn is the seed parent of Dixie 33. They apparently have a genotype which conditions in a weak stalk in their progeny. Single cross T115 x T111 held an intermediate position as to root lodging and stalk breakage while single cross T105 x T101 had the least per cent of lodging and breakage, followed by Tenn. 29, which is the progeny of these two single crosses. During the growing season, T61 x T13 and Dixie 33 began lodging before any of the other varieties. Lodging on these two varieties was first noticed ninety-five days after planting.

Mineral Composition

The highest percentage of potassium found in the leaf tissue of the plants was at the first sampling date (twenty-eight days after planting) for all four levels of potash fertilization. This was probably because the root system was in the zone where the twenty-five pounds of K_2O was applied in 1955 and also being able to utilize a portion of the exchangeable K_2O remaining in the soil from the previous year and utilizing other exchangeable K_2O present before any applications.

It has been suggested (1) that potassium can accumulate in large quantities, be translocated and re-utilized. These results are in agreement with this suggestion as is evident from Figure 3 in that at mid-season and later the potassium content decreased rapidly. A portion of this decrease can be attributed to a "dilution effect" but the smaller decline in the 0-pound K_2O treated plots, compared to the 75-, 175-, and 275-pound level treated plots, tends to indicate translocation. The corn ears were being formed between the second and third sampling dates (fifty-three and seventy-six days after planting, respectively), therefore, an explanation for the potassium decrease would be the translocation of this element from the lower leaves to the meristematic region where it was re-utilized in carbohydrate synthesis.

Other reasons for a decrease in potassium content as the season progressed are a leaching of the applied potash and a fixation of a portion of the applied potassium in a less available form by the soil colloidal system.

In all varieties, increased potash fertilization generally decreased the leaf content of calcium and magnesium, but did not affect the phosphorus content appreciably. The potassium content of the plants in the 0-pound K_2O treated plots was approximately 1.2 per cent, calcium 0.8 per cent, magnesium 0.9 per cent and phosphorus 0.3 per cent, whereas, in plots with high K_2O fertilization, the potassium content was about 3.5 per cent, calcium 0.5 per cent, magnesium 0.2 per cent and phosphorus 0.3 per cent. These results are in agreement with the work of Stanford, et al (23), which showed a calcium plus magnesium/potassium ratio of 3.5 to 1 to be most favorable.

Nutrient deficiency symptoms observed in the field were correlated with mineral content as found by laboratory analysis. Deficiency symptoms were first observed about fifty-three days after planting on the 0-pound K_2O treated plots and were most noticeable on the older leaves (which were approximately the first five leaves from the ground). Moderate to severe deficiencies and reduced growth were observed on the 0-pound K_2O treated plots at sixty-five to seventy-five days after planting. There was no noticeable difference in corn growing at the 75-, 175-, and 275-pound levels of K_2O. These observations are in agreement with yield data, root lodging and stalk breakage data, and mineral content data.

Figure 4 shows that the greatest difference in cation content is between the 0-pound K_2O treated plots and the three levels of K_2O treated plots and there is not as great a difference in cation content among the three levels of K_2O. Since the potassium in the leaf is inversely related to the calcium and magnesium content (23), the greatest difference would be between the 0-pound K_2O level treatment and the three treatments receiving K_2O.

At the 0-pound level of K_2O fertilization, there was a lower content of potassium in the plant and a higher content of calcium and magnesium than at 75-, 175-, and 275-pound levels. This difference, along with the extreme differences in equivalent weights, thirty-nine for potassium, twenty for calcium and twelve for magnesium, resulted in the milliequivalents of total cations in the plants being very high for the 0-pound K_2O treatments. It is evident from these results that the equivalent weight of the cation present has a great effect in determining the milliequivalents of total cations present in a plant. At the 275-pound K_2O level, the milliequivalents of total cations were almost a constant for all sampling dates even though the per cent potassium decreased from 3.53 per cent to 2.19 to 1.85 per cent at twenty-eight, fifty-three and seventy-six days after planting, respectively; the per cent calcium increased from 0.50 per cent at twenty-eight days to 0.8 per cent at fifty-three days and dropped to 0.77 per cent at seventy-six days after planting; and the magnesium increased from 0.22 to 0.44 to 0.56 per cent at twenty-eight, fifty-three and seventy-six days after planting, respectively.

Since the 75-, 175-, and 275-pound levels of K_2O yielded essentially the same, resulted in approximately the same amount of root lodging and stalk breakage, and field observations indicated no appreciable difference in plant growth, it is suggested that, under the conditions of this experiment, applications above 75 pounds of K_2O do not materially benefit the crop.

CHAPTER VI

SUMMARY

Five varieties of corn, three single crosses and two double crosses, were grown on a soil low in "available" potassium. Root lodging and stalk breakage were determined periodically throughout the growing season. Potassium, calcium, magnesium, and phosphorus contents of leaf samples also were determined periodically throughout the growing season. Finally, grain yields were obtained.

The major results were as follows:

1. There was a significant increase in yield between the 0-pound K20 treated plots and the average of the 75, 175 and 275 pounds of K_2O treated plots.

2. There was no significant difference among the 75-, 175-, and 275-pound levels of K_2O.

3. Variety Tenn. 29 showed a significant yield increase over Dixie 33 and T61 x T13. Single cross T115 x T111 gave a significant yield increase over Dixie 33.

4. Potash fertilization significantly decreased both root lodging and stalk breakage.

5. Single cross T61 x T13 showed a highly significant increase in root lodging and stalk breakage over all other varieties at three dates.

6. The maximum potassium content of the plant was observed twenty-eight days after planting. The potassium decreased percentage-

wise during the latter stages of growth.

7. The calcium and magnesium contents of the leaf tissue were generally inversely related to potash fertilization; the phosphorus content was relatively unaffected.

8. The milliequivalents of total cations decreased as the rate of potash fertilization increased.

LITERATURE CITED

LITERATURE CITED

1. Bartholomew, R. P. and Janssen, George. Luxury consumption of of potassium by plants and its significance. Jour. Amer. Soc. of Agron. 21:751-765. 1929.

2. Bartholomew, R. P. and Janssen, George. Ark. Agri. Sta. Bul. 265. 1931.

3. Brady, J. Some factors influencing lodging in grain. Jour. Agr. Sci. 24:209-231. 1934.

4. Cochran, W. G. and Cox G. M. Experimental designs. New York. John Wiley and Sons, Inc. 218-240. 1950.

5. Drake, Mack and Scareth, G. D. Relative abilities of different plants to absorb potassium and the effect of different levels of potassium on the absorption of calcium and magnesium. Soil Sci. Soc. of Amer. Proc. 4:201-204. 1939.

6. Fisher, F. L. Nutrient balance affects corn yield and stalk strength. Better Crops. 38:15-17. (4) 1954.

7. Gieseking, J. E., Snider, H. J., and Getz, C. A. Destruction of organic matter in plant material by the use of nitric and perchloric acids. Ind. and Eng. Chem. Anal. Ed. 7:185-186. 1935.

8. Gregory, F. G. Mineral nutrition of plants. Ann. Rev. Bio-chem. 6:557-578. 1937.

9. Hartt, C. E. Some effects of potassium upon the amount of protein and amino forms of nitrogen, sugars and enzyme activity of sugar cane. Plant Physiol. 9:452-490. 1934.

10. Hoffer, G. N. Testing corn stalks chemically to aid in determining their plant food needs. Purdue Univ. Agr. Exp. Sta. Bul. 298 (Rev.) 1-31. 1930.

11. Hoffer, G. N. Potash in plant metabolism. Ind. and Eng. Chem. 30:885-889. 1938.

12. Hoffer, G. N. and Krantz, B. A. In "Hunger Signs in Crops", 2nd ed. 59-84. The American Society of Agronomy and the National Fertilizer Association, Washington, D. C. 1949.

13. James, W. O. and Penston, N. L. Studies of the physiological importance of the mineral elements in plants. Ann. Bot. 47:279-293. 1933.

14. Janssen, George and Bartholomew, R. P. The effect of potassium on the production of protein, sugars and starches in cowpeas and in sugar beet plants and the relation of potassium to plant growth. Jour. Amer. Soc. Agron. 24:667-680. 1932.

15. Krantz, B. A. and Chandler, W. V. Lodging, leaf composition and yield of corn as influenced by heavy applications of nitrogen and potash. Agron. Jour. 43:547-552. (11) 1951.

16. Lawton, Kirk and Cook, R. L. Potassium in plant nutrition. Advances in Agronomy. 6:253-298. 1954.

17. Lundegardh, Henrik. The influence of the soil upon the growth of the plant. Soil Sci. 40:89-101. 1935.

18. Myer, B. S. and Anderson, D. B. Plant Physiology. 2nd ed. New York. D. Van Nostrand Co. 481-483. 1952.

19. Nightingale, G. T. Nitrate and carbohydrate reserves in relation to nitrogen nutrition of pineapple. Botan. Gaz. 103:409-456. 1942.

20. Nightingale, G. T. Physiological-chemical functions of potassium in crop growth. Soil Sci. 55:73-78. 1943.

21. Nightingale, G. T., Schemerhorn, L. M. and Robbins, W. M. Some effects of potassium deficiency on the histological structure and nitrogenous and carbohydrate constituents of plants. N. J. Agri. Exp. Sta. Bul. 499. 1930.

22. Sayre, J. D. Mineral accumulation in corn. Plant Physiology. 73:267-281. 1948.

23. Stanford, G., Kelly, S. B. and Pierre, W. H. Cation balance in corn grown on high-lime soils in relation to potassium deficiency. Soil Sci. Soc. of Amer. Proc. 6:335-341. 1941.

24. Steinberg, R. A. In "Mineral Nutrition of Plants". E. Truog Ed. Univ. of Wisconsin Press. 359-388. 1951.

25. Wall, M. E. The role of potassium in plants. Soil Sci. 47:143-161. 1939.

26. Wall, M. E. The role of potassium in plants. Soil Sci. 49:393-409. 1940.

27. Wittels, H. and Seatz, L. F. Effect of potash fertilization on yield, stalk breakage and mineral composition of corn. Soil Sci. Soc. of Amer. Proc. 17:369-371. 1953.

APPENDIX

APPENDIX

APPENDIX A

PROCEDURE FOR DETERMINATION OF EXCHANGEABLE POTASSIUM, CALCIUM AND MAGNESIUM OF SOILS

1. Place 10 grams of air-dry soil (ground to a fineness that will pass a 2 mm. sieve) in a 125 ml. erlenmeyer flask.

2. Add 50 ml. of neutral normal ammonium acetate.

3. Shake for 30 minutes and let set overnight.

4. Shake for 30 minutes the following morning.

5. Filter, using Whatman No. 42 filter paper, with suction flask and wash with an additional 50 ml. of neutral ammonium acetate, collecting entire filtrate.

6. Procure a small portion of the filtrate (about 5 ml.) and determine exchangeable potassium and calcium content with a Beckman DU flame spectrophotometer equipped with a photomultiplier attachment. A wavelength of 766.5 is used for potassium and 422.7 is used for calcium.

7. Sample readings are compared with the calibration curve obtained from standard solutions and the potassium and calcium content of the soil is calculated.

8. Samples for determining magnesium are obtained by procuring a 50 ml. aliquot of the original filtrate and taking to dryness on the hot plate.

9. Destroy organic matter with 30% hydrogen peroxide.

10. Add 20 ml. of 0.1N hydrochloric acid.

11. Procure a small portion of this solution (about 5 ml.) to determine exchangeable magnesium with a Beckman DU flame spectrophotometer equipped with a photomultiplier attachment. A wavelength of 285.2 is used.

12. The sample readings are compared with the calibration curve obtained from standard solutions and magnesium content of the soil calculated.

APPENDIX B

PROCEDURE FOR DETERMINATION OF AVAILABLE PHOSPHORUS IN SOILS

1. Transfer 6.25 grams of air-dry soil (ground to a fineness that will pass a 2 mm. sieve) into a 125 ml. erlenmeyer flask.

2. Add small amount of activated carbon and mix.

3. Add 25 ml. of extracting solution (0.05N sulfuric acid containing 1% ammonium sulfate).

4. Shake for five minutes.

5. Filter, using Whatman No. 1 filter paper, collecting entire filtrate.

6. Pippette 10 ml. of filtrate into 25 ml. erlenmeyer flask.

7. Add 0.5 ml. of molybdic acid solution and mix.

8. Add 8 drops of reducing agent (amino-naphthol-sulfonic acid) and mix immediately.

9. Read in spectrophotometer at 650 wavelength 15 minutes after adding reducing agent.

10. Convert readings to ppm. phosphorus from standard curve plotted from readings obtained from phosphorus standards run in a similar manner.

APPENDIX C

PROCEDURE FOR DETERMINATION OF pH OF SOILS

1. Place about 25 grams of air-dry soil (ground to a fineness that will pass a 2 mm. sieve) in a 50 ml. beaker.

2. Add distilled water until thin pasty mixture is obtained.

3. Allow to set until soil becomes well saturated.

4. Re-mix and place electrodes of pH meter into the soil mixture and read pH directly.

APPENDIX D

PROCEDURE FOR DETERMINATION OF POTASSIUM, CALCIUM, MAGNESIUM AND PHOSPHORUS CONTENT OF PLANT TISSUE

1. Plant samples are oven dried at 70° C., stored in air-tight bottles until analyzed.

2. Weigh a 0.5 gram plant sample into a 150 ml. beaker.

3. Add 5 ml. of concentrated nitric acid and take to dryness on hot plate.

4. Add 5 ml. of diluted nitric acid (1 to 1) and 5 ml. of concentrated perchloric acid (70-72%) and take to dryness on hot plate.

5. Add 5 ml. of diluted hydrochloric acid (1 to 1) and enough distilled water to wash off watch glass and gently warm.

6. Filter, using Whatman No. 42 filter paper, into 250 volumetric flasks.

7. Make up to volume with distilled water.

8. Mix well and procure a small portion of the solution (about 5 ml.) to determine potassium, calcium and magnesium with a Beckman DU flame spectrophotometer equipped with a photomultiplier attachment. Wavelength required for potassium is 766.5, for calcium is 422.7 and 285.2 for magnesium.

9. The sample readings are compared with the calibration curve obtained from standard solutions and calculated.

10. A 2 ml. aliquot of the 250 volumetric flask sample is transferred to a 25 ml. erlenmeyer flask for phosphorus determination.

11. Add 8 ml. of 0.05N hydrochloric acid.

12. Add 0.5 ml. of molybdic acid solution and mix.

13. Add 5 drops of reducing agent (ameno-naphthol-sulfonic acid) and mix immediately.

14. Read in spectrophotometer at 650 wavelength 15 minutes after adding reducing agent.

APPENDIX E

YIELD OF GRAIN[a] IN BUSHELS PER ACRE FOR FIVE VARIETIES OF CORN AT FOUR LEVELS OF POTASSIUM FERTILIZATION

Rates of K_2O	Variety	Replications 1	2	3	4	Average	Rate Average
0	T115 x T111	52.2	58.1	53.2	46.9	52.6	
	T105 x T101	66.0	50.6	58.6	52.9	57.0	
	T61 x T13	51.9	50.5	50.7	55.3	52.1	55.1
	Tenn. 29	72.8	72.4	52.3	55.7	63.3	
	Dixie 33	39.4	64.7	50.2	47.8	50.5	
75	T115 x T111	92.1	76.2	57.8	56.4	70.6	
	T105 x T101	72.9	63.4	48.5	55.0	60.0	
	T61 x T13	77.4	59.2	50.5	40.6	56.9	61.5
	Tenn. 29	74.7	55.4	65.0	65.0	65.0	
	Dixie 33	64.8	55.6	57.2	43.4	55.2	
175	T115 x T111	65.9	66.9	55.4	53.0	60.3	
	T105 x T101	71.1	61.6	61.0	53.9	61.9	
	T61 x T13	72.1	78.0	60.8	52.0	65.7	62.7
	Tenn. 29	74.1	72.7	51.4	58.6	64.2	
	Dixie 33	74.7	69.9	53.5	46.7	61.2	
275	T115 x T111	79.4	66.7	54.7	52.7	63.4	
	T105 x T101	66.1	69.5	58.4	59.4	63.4	
	T61 x T13	60.7	56.5	62.0	50.8	57.5	61.5
	Tenn. 29	75.6	60.1	59.5	59.7	63.7	
	Dixie 33	67.9	64.3	59.7	47.2	59.8	

[a] Yield based on 15.5 per cent moisture.

Analysis of Variance

Source of Variation	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	79	7879.08		
Main Plots:				
Rates of K_2O	3	712.56	237.52	2.73
Replications	3	3130.55	1043.52	11.99
No K_2O vs. K_2O	1	696.00	696.00	8.00*
Error (a)	9	783.27	87.03	
Sub Plots:				
Varieties	4	548.42	137.10	3.31*
Varieties x K_2O	12	715.96	59.66	1.44
Error (b)	48	1988.32	41.42	

*Significant at .05 per cent level.

C. V. for varieties - - - - - - - - - - - 10.7%

C. V. for no K_2O vs. K_2O - - - - - - - - 15.5%

APPENDIX F

COMBINED ROOT LODGING AND STALK BREAKAGE 149 DAYS AFTER PLANTING

Rates of K_2O	Variety	Replications 1	2	3	4	Average
0	T115 x T111	9	16	10	13	12.00
	T105 x T101	3	3	2	4	3.00
	T61 x T13	29	45	28	10	28.00
	Tenn. 29	2	8	14	10	8.50
	Dixie 33	22	12	6	20	15.00
75	T115 x T111	0	0	5	4	2.25
	T105 x T101	0	4	2	2	2.00
	T61 xT13	10	7	9	6	8.00
	Tenn. 29	2	4	1	3	2.50
	Dixie 33	6	7	7	9	7.25
175	T115 x T111	6	5	3	6	5.00
	T105 x T101	3	1	0	1	1.25
	T61 x T13	1	7	5	2	3.75
	Tenn. 29	4	2	6	5	4.25
	Dixie 33	6	10	1	10	6.75
275	T115 x T111	0	5	3	9	4.25
	T105 x T101	2	3	2	2	2.25
	T61 x T13	12	5	4	5	6.50
	Tenn. 29	2	6	4	5	4.25
	Dixie 33	6	6	4	8	6.00

Analysis of Variance

Source of Variation	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	79	94.15		
Main Plots:				
Rates of K_2O	3	27.79	9.26	54.47**
Replications	3	1.77	0.59	3.47
Error (a)	9	1.49	0.17	
Sub Plots:				
Varieties	4	25.35	6.34	12.43**
Varieties x K_2O	12	13.20	1.10	2.16
Error (b)	48	24.55	0.51	

**Significant at .01 per cent level.

C. V. for rates of K_2O - - - - - - - - - - - 16.8%

C. V. for varieties - - - - - - - - - - - - 29.1%

APPENDIX G

PER CENT POTASSIUM IN CORN LEAF TISSUE 76 DAYS AFTER PLANTING

Rates of K_2O	Variety	Replications 1	2	3	4	Average
0	T115 x T111	0.43[a]	0.35	0.70	0.50	0.50
	T105 x T101	0.43	0.30	0.35	0.45	0.38
	T61 x T13	0.45	0.43	0.58	0.95	0.60
	Tenn. 29	0.30	0.35	0.50	0.50	0.41
	Dixie 33	0.38	0.70	0.35	0.60	0.51
75	T115 x T111	0.85	1.15	1.13	1.30	1.11
	T105 x T101	0.75	0.90	0.95	0.95	0.89
	T61 x T13	0.60	0.90	0.90	0.96	0.84
	Tenn. 29	0.35	1.15	0.85	1.55	0.98
	Dixie 33	1.35	0.90	0.95	0.96	1.04
175	T115 x T111	0.45	1.65	1.85	1.15	1.28
	T105 x T101	1.35	1.50	1.35	1.15	1.34
	T61 x T13	1.15	0.85	1.55	2.05	1.40
	Tenn. 29	1.35	1.25	1.40	2.10	1.52
	Dixie 33	1.35	1.50	0.80	1.90	1.39
275	T115 x T111	2.05	1.78	1.95	1.65	1.86
	T105 x T101	2.15	1.60	1.15	2.50	1.85
	T61 x T13	1.55	1.25	1.75	1.85	1.60
	Tenn. 29	1.85	2.05	1.95	2.33	2.04
	Dixie 33	1.78	2.00	1.95	1.85	1.90

[a] Figures represent per cent of element in air-dry weight of sample.

Analysis of Variance

Source of Variation	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	79	213.76		
Main Plots:				
Rates of K_2O	3	162.62	54.21	174.87**
Replications	3	8.50	2.83	9.13
Error (a)	9	2.76	0.31	
Sub Plots:				
Varieties	4	1.08	0.27	0.39
Varieties x K_2O	12	5.55	0.46	0.66
Error (b)	48	33.25	0.69	

**Significant at .01 per cent level.

C. V. for rates of K_2O - - - - - - - - - - - 9.3%

APPENDIX H

PER CENT CALCIUM IN CORN LEAF TISSUE 76 DAYS AFTER PLANTING

Rates of K_2O	Variety	Replications 1	2	3	4	Average
0	T115 x T111	0.85[a]	0.83	0.73	0.95	0.84
	T105 x T101	0.93	1.08	1.25	1.33	1.15
	T61 x T13	1.38	1.15	1.30	1.55	1.34
	Tenn. 29	0.63	1.33	1.23	1.35	1.14
	Dixie 33	1.23	1.53	1.13	1.28	1.29
75	T115 x T111	0.55	0.68	0.50	0.78	0.63
	T105 x T101	1.10	1.28	1.40	1.35	1.28
	T61 x T13	0.75	1.03	1.15	1.13	1.02
	Tenn. 29	0.33	1.00	0.93	0.80	0.76
	Dixie 33	1.25	1.25	1.40	1.20	1.28
175	T115 x T111	0.30	0.55	0.65	0.73	0.56
	T105 x T101	1.13	0.85	1.30	1.10	1.10
	T61 x T13	1.35	0.63	0.88	1.10	0.99
	Tenn. 29	0.68	0.95	1.20	0.85	0.92
	Dixie 33	1.08	1.28	0.45	0.85	0.92
275	T115 x T111	0.50	0.50	0.58	0.60	0.54
	T105 x T101	0.90	0.60	0.63	0.95	0.77
	T61 x T13	1.00	0.68	1.08	0.90	0.92
	Tenn. 29	0.73	0.75	0.68	0.63	0.70
	Dixie 33	0.73	1.05	0.95	1.00	0.93

[a]Figures represent per cent of element in air-dry weight of sample.

Analysis of Variance

Source of Variation	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	79	66.79		
Main Plots:				
Rates of K_2O	3	13.49	4.50	16.67**
Replications	3	2.58	0.86	3.19
Error (a)	9	2.43	0.27	
Sub Plots:				
Varieties	4	23.46	5.86	15.03**
Varieties x K_2O	12	5.93	0.49	1.26
Error (b)	48	18.90	0.39	

**Significant at .01 per cent level.

C. V. for rates of K_2O - - - - - - - - - - 9.4%

C. V. for varieties - - - - - - - - - - - 11.3%

APPENDIX I

PER CENT MAGNESIUM IN CORN LEAF TISSUE 76 DAYS AFTER PLANTING

Rates of K_2O	Variety	Replications 1	2	3	4	Average
0	T115 x T111	2.15[a]	1.65	1.00	1.70	1.62
	T105 x T101	1.38	2.28	2.05	1.85	1.89
	T61 x T13	2.15	2.15	1.93	1.93	2.04
	Tenn. 29	1.13	2.05	1.85	2.00	1.76
	Dixie 33	2.28	2.20	2.28	1.93	2.17
75	T115 x T111	0.63	0.80	0.43	0.88	0.68
	T105 x T101	1.33	1.38	1.38	1.58	1.42
	T61 x T13	0.80	1.85	1.78	1.58	1.50
	Tenn. 29	0.38	1.33	0.68	0.88	0.82
	Dixie 33	0.80	1.50	1.70	1.45	1.36
175	T115 x T111	0.25	0.38	0.30	0.80	0.43
	T105 x T101	1.13	0.63	1.38	1.13	1.07
	T61 x T13	1.58	0.63	0.63	1.00	0.96
	Tenn. 29	0.63	0.80	0.95	0.43	0.70
	Dixie 33	0.95	1.00	0.43	0.63	0.75
275	T115 x T111	0.30	0.13	0.38	0.55	0.34
	T105 x T101	0.50	0.25	0.38	0.38	0.38
	T61 x T13	0.95	0.80	1.13	0.75	0.91
	Tenn. 29	0.38	0.63	0.43	0.38	0.46
	Dixie 33	0.50	0.88	0.63	0.80	0.70

a/Figures represent per cent of element in air-dry weight of sample.

Analysis of Variance

Source of Variation	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	79	247.86		
Main Plots:				
Rates of K_2O	3	156.01	52.00	55.91**
Replications	3	2.28	0.76	0.82
Error (a)	9	8.38	0.93	
Sub Plots:				
Varieties	4	34.46	8.62	12.14**
Varieties x K_2O	12	12.79	1.07	1.51
Error (b)	48	33.94	0.71	

**Significant at .01 per cent level.

C. V. for rates of K_2O - - - - - - - - - - - 16.7%

C. V. for varieties - - - - - - - - - - - 14.6%

APPENDIX J

PER CENT PHOSPHORUS IN CORN TISSUE 76 DAYS AFTER PLANTING

Rates of K_2O	Variety	Replications 1	2	3	4	Average
0	T115 x T111	0.28[a]	0.16	0.17	0.17	0.20
	T105 x T101	0.19	0.24	0.22	0.18	0.21
	T61 x T13	0.14	0.16	0.21	0.20	0.18
	Tenn. 29	0.20	0.19	0.16	0.20	0.19
	Dixie 33	0.23	0.17	0.28	0.17	0.21
75	T115 x T111	0.21	0.16	0.20	0.18	0.19
	T105 x T101	0.14	0.15	0.13	0.16	0.14
	T61 x T13	0.17	0.16	0.18	0.18	0.17
	Tenn. 29	0.16	0.14	0.15	0.19	0.16
	Dixie 33	0.16	0.12	0.18	0.16	0.16
175	T115 x T111	0.16	0.12	0.19	0.14	0.15
	T105 x T101	0.18	0.15	0.20	0.18	0.18
	T61 x T13	0.20	0.14	0.17	0.18	0.17
	Tenn. 29	0.24	0.18	0.20	0.20	0.20
	Dixie 33	0.15	0.12	0.16	0.14	0.14
275	T115 x T111	0.20	0.19	0.19	0.16	0.18
	T105 x T101	0.20	0.14	0.19	0.18	0.18
	T61 x T13	0.20	0.17	0.18	0.16	0.18
	Tenn. 29	0.19	0.12	0.19	0.20	0.18
	Dixie 33	0.20	0.16	0.18	0.14	0.17

[a] Figures represent per cent of element in air-dry weight of sample.

Analysis of Variance

Source of Variation	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	79	3.49		
Main Plots:				
Rates of K_2O	3	0.50	0.17	8.50**
Replications	3	0.62	0.21	10.50
Error (a)	9	0.15	0.02	
Sub Plots:				
Varieties	4	0.07	0.02	0.67
Varieties x K_2O	12	0.76	0.06	2.00
Error (b)	48	1.39	0.03	

**Significant at .01 per cent level.

C. V. for rates of K_2O - - - - - - - - - - 5.4%