May 27, 1954

To the Graduate Council:

I am submitting herewith a thesis written by Wilburn Curtis Brummitt entitled "Effect of Potassium Fertilization on Yield, Lodging, and Mineral Composition of Corn Inbreds and Single Crosses". 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
Major Professor

We have read this thesis
and recommend its acceptance:

L V Skold

Accepted for the Council:

E. A. Waters
Dean of the Graduate School

48
33

EFFECT OF POTASSIUM FERTILIZATION ON YIELD, LODGING, AND MINERAL COMPOSITION OF CORN INBREDS AND SINGLE CROSSES

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

Wilburn Curtis Brummitt

June 1954

ACKNOWLEDGEMENTS

The writer wishes to express his gratitude to:

Doctor Eric Winters and Doctor L. F. Seatz for directing this study.

Other members of the Agronomy Department for their cooperation and helpful suggestions.

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

Wilburn Curtis Brummitt

326225

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
II.	REVIEW OF LITERATURE	2
III.	METHODS AND PROCEDURES	6
	1952 Work	6
	1953 Work	8
IV.	RESULTS	11
	1952 Experiment	11
	Yield	11
	Root Lodging and Stalk Breakage	11
	Mineral Composition	15
	Influence of Inbred lines	18
	1953 Experiment	28
V.	DISCUSSIONS AND CONCLUSIONS	31
VI.	SUMMARY	34
VII.	BIBLIOGRAPHY	37

LIST OF TABLES

TABLE PAGE

I. Yield of Grain in Bushels per Acre of six single Crosses at Four Rates of Potassium Fertilization at Knoxville, Tennessee in 1952 12

II. Analysis of Variance of Yield 13

III. Percent Stalk Breakage and Root Lodging of Six Single Crosses at Four Rates of Potassium Fertilization at Knoxville, Tennessee in 1952 14

IV. Analysis of Variance of Root Lodging 16

V. Mineral Composition of Leaf Tissue From Six Single Crosses at Four Rates of Potassium Fertilization at Four Sampling Dates 17

VI. Total Cations (K, Ca, MG) Found in Corn Leaf Tissue Under Four Rates of Potassium Fertilization at Four Sampling Dates 19

VII. Influence of Four Inbred Lines Upon Yield of Grain in Bushels Per Acre of Six Single Crosses at Four Rates of Potassium Fertilization at Knoxville, Tenn. 1952. 20

VIII. Influence of Inbred Parent on Percent Root Lodging of the Six Single Crosses 21

LIST OF FIGURES

FIGURE PAGE

1. Planting Plan for 1952 Experiment 7
2. Percent Potassium, Calcium, and Magnesium in leaf Tissue of Six Corn Single Crosses at Four Rates of Potassium Fertilization at Four Sampling Dates . . . 22
3. Effect of 160 Pounds Potash Per Acre Upon Yield of Six Single Crosses (Base line represents yield of plots receiving no potash). 23
4. Effect of 160 Pounds Potash Per Acre Upon Root Lodging of Six Single Crosses (Base line represents root lodging in plots receiving no potash) 24
5. Effect of 160 Pounds Potash Per Acre Upon Leaf Content of Potassium 58 Days After Planting (Base Line represents leaf content of potassium 58 days after planting in plots receiving no potash) 25
6. Percent Potassium, Calcium, and Magnesium in Leaf Tissue of Six Corn Inbreds at Four Rates of Potassium Fertilization at Five Sampling Dates 27
7. Percent Potassium, Calcium, and Magnesium found 22 Days After Planting in Aerial Portion of Six Corn Inbreds which Received Four Rates of Potassium . . . Fertilization 28

INTRODUCTION

This study was designed to determine if different single crosses and inbreds of corn, Zea mays, reacted differently to potassium fertilization as related to yield, degree of lodging, and cation content of their leaf tissue.

One plant function of potassium has been related to carbohydrate synthesis, another to translocation. Both processes contribute to yield and to resistance to lodging.

Plants differ in total potassium requirements and in ability to obtain this potassium from the soil. Some of these differences between plants seem to be related to total potassium requirements of the species, feeding power of the plant roots, and the type of growth made by the plant.

REVIEW OF LITERATURE

The literature pertaining to potassium as a plant nutrient is extensive. However, definite conclusions as to the relationships of potassium in plant metabolism have been difficult to establish since potassium has been found in the plant only in the ionic form or as a soluble salt. The literature reviewed below and the results of this study should be considered with this in mind.

Jones and Huston (7) studied the relationship between the plant content of potassium and the synthesis of starch. They found that the sharpest rise in the percentage of potassium in plant tissue was closely correlated with the period of greatest starch development within the corn plant. Jansen and Bartholomew (6) found the starch content of plants which had been fertilized with potassium to be higher than that of plants which did not receive potassium fertilization. The unfertilized plants did, however, contain a higher content of reducing sugars. They suggested that potassium might be essential for the formation of complex carbohydrates from these sugars. Wall (17), (18) and Nightingale et al (12) support these conclusions concerning the relationship between high carbohydrate content and high rates of potassium fertilization. They believe that this might be caused by a direct need for potassium for carbon dioxide assimilation or by indirect effects on protoplasm brought on by interference with nitrogen metabolism in potassium deficient plants. Each of these investigations (17), (18), (12), found an accumulation of ammonia and a decreased protein content in potassium deficient plants.

The results of the preceding studies suggest that potassium is important for the formation of strong stems in plants since the plant is

supported primarily by cell walls, which, in a great part are composed of complex carbohydrates. Jensen and Bartholomew (6) reported that the stems of potassium deficient plants had smaller and fewer cortex cells than those of plants which had received potassium fertilization. Nightingale, et al (12) believed that cell wall thickness was intimately associated with the carbohydrate content of the plant and only indirectly with the plant's potassium content. The work of Reed (13) indicates that other elements also are important for cell wall formation. He demonstrated that a deficiency of calcium could prevent adequate cell wall formation even though carbohydrates were present in abundance. He attributed this to the essentiality of calcium for the formation of the middle lamella portion of the cell wall. The middle lamella is composed primarily of calcium pectate.

Lodging and stalk breakage of corn has been related to deficiencies of potassium by Williams et al (19) and Krantz and Chandler (9). Krantz and Chandler found that applications of potassium up to eighty pounds of K_2O per acre were effective in reducing stalk breakage and root lodging. Higher potassium applications did not affect stalk breakage or lodging. Other conclusions were that varieties differed in lodging tendencies and that heavy nitrate fertilization and thick spacing increased lodging. Varietal differences in lodging were also reported by Brady (2). Koehler, et al (8) at the Illinois Experiment Station fouhd that applications of four tons of limestone per acre decreased the amount of lodging in corn. They further concluded that three factors were responsible for broken stalks: (1) a weak morphological structure of the stalks (2) susceptibility to disease and (3) susceptibility to frost. They also found lodging to

vary according to variety, time of planting and thickness of stand.

Luxury consumption of potassium has been reported by Bartholomew and Jansen (1), Nightingale, et al (12), Tyner (15), and Krantz and Chandler (9). It is believe (1) that this luxury consumption during the early stages of growth is quite an important process. They state that this surplus potassium is probably translocated and reutilized at a later period of growth. Translocation of potassium is also reported by Nightingale, et al (12).

Heavy potassium fertilization has been shown to decrease plant uptake of calcium and magnesium, (3), (11), (16), (19). Stanford, et al (16) present data which indicate that the interaction among these three nutrients is important. A plant deficiency of any one of these nutrients may result if the soil ratio of the three elements is unbalanced.

Plant content of potassium has been shown to vary at different periods of plant growth (1), (7), (9), (14). Sayre (14) concluded that potassium accumulation reached a maximum within the corn plant about three weeks after silking. The leaves and stems contained a lower percentage of potassium after that time with the grain having a small increase in the percentage of potassium. He suggests that this decrease in percentage of potassium in the leaves and stems may either be caused by translocation to the grain, leaching, or by an increase in dry matter. Leaching of potassium from the mature corn plant has been reported by Jones and Huston (7).

Drake and Scarseth (3) have demonstrated that plant species differ in response to potassium fertilization. They concluded that these plant responses to potassium fertilization were inversely proportional to the

plant's ability to utilize native potassium from the soil. Work by Winer (19) at the Illinois Experiment Station showed varieties of corn to differ in mineral composition. He could not, however, correlate these differences with yield or length of season required for the maturity of these varieties.

Several selfed lines of corn and crosses between these lines were studied by Hoffer (5) under varying levels of soil fertility. His experiment showed that the vigorous hybrid absorbed smaller amounts of iron and aluminum than either of the parents which showed less vigorous growth. These differences among varieties were more pronounced in soils of low fertility and were associated with different rates of growth by the plants and with their relative resistance to root rot.

METHODS AND PROCEDURES

An outline of field and laboratory work in 1952 and 1953 is presented in this chapter.

1952 Work

Six corn single crosses, representing four inbreds in all combinations, were used in the 1952 experiment. These single crosses were:

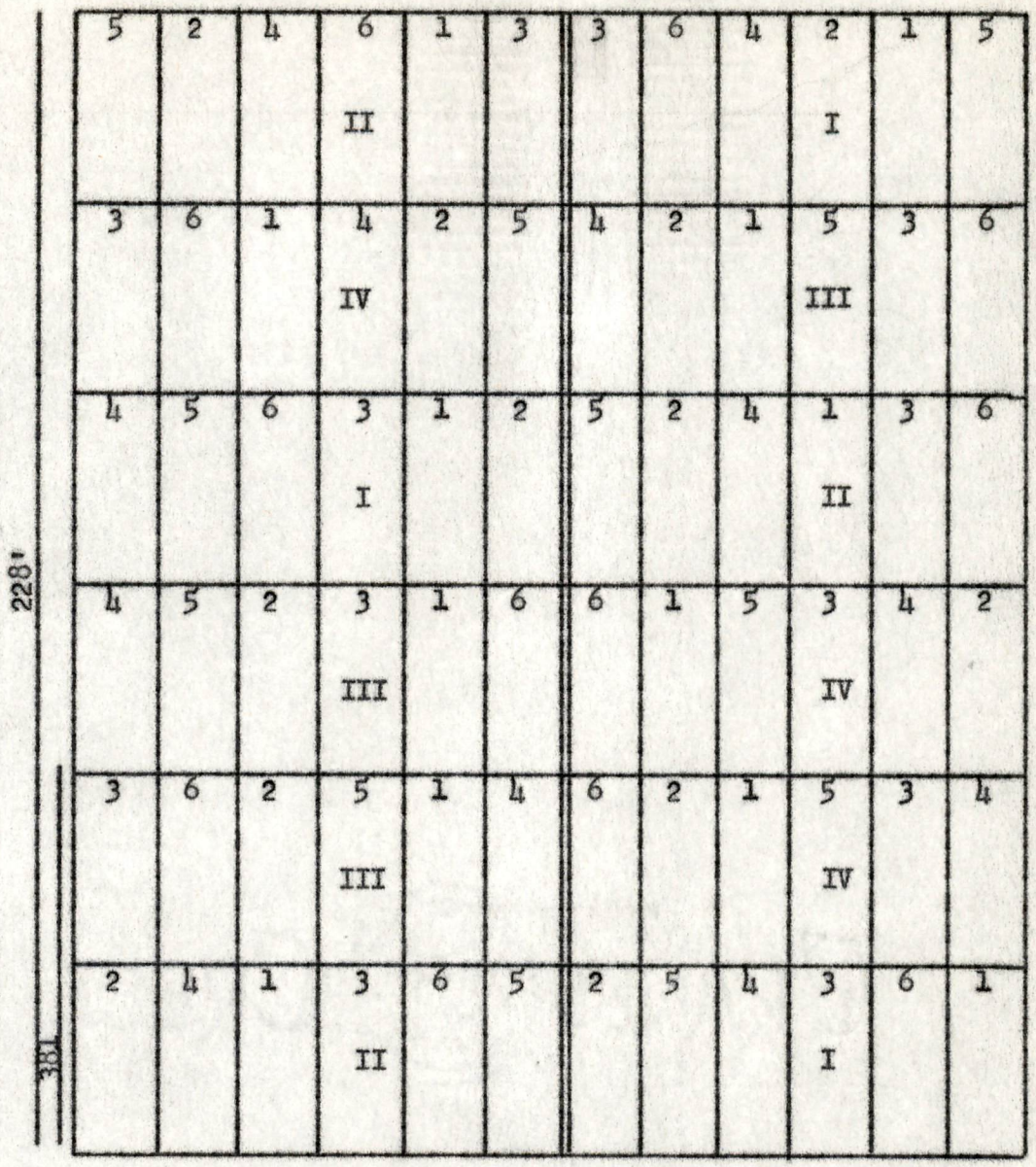
(1) T61 x T101
(2) T61 x T113
(3) T61 x T115
(4) T101 x T113
(5) T101 x T115
(6) T113 x T115

Four fertilizer rates were used:

	N	P_2O_5	K_2O
I	90	60	0
II	90	60	40
III	90	60	80
IV	90	60	160

The experiment was laid out in a randomized block design with three replications. The six single crosses and four rates of potassium fertilization made a total of twenty-four treatments in each block. Figure 1 illustrates this plot layout.

The border rows and buffer strip through the center of the experimental area were planted with Dixie 33 hybrid and received nitrogen and phosphorus fertilization only. The individual plots were 36 x 10½ feet or 0.00868 acre. Three rows were planted in each plot. The center row of each plot was thinned to twenty-four plants 28 days after planting with the border rows being thinned to twenty-four plants two weeks later.



Each plot 36' x 10½ = 378A 2 = 0.00868 Acre
Three row plots
Two row buffer between each fert. treat.
Each row = 48 plants before thinning.

1. T61xT101
2. T61xT113
3. T61x T115
4. T101xT113
5. T101xT115
6. T113xT115

The two border rows were used for sampling purposes, whereas yield data were collected from the middle row.

The first leaf samples were taken June 19 when the plants were four to five feet tall. Three other samples were taken at intervals of two weeks. The sampling procedure consisted of taking the first full leaf below the lowest ear from five plants in each row. Therefore, each sample consisted of ten leaves from each plot.

Soil tests showed the soil, a Huntington loam, to have a pH of 5.9 and to be low in phosphorus and potassium.

Ammonium nitrate at the rate of two hundred pounds per acre was applied to all plots June 17 when the corn was approximately fifteen inches tall.

Data pertaining to stalk breakage and root lodging were obtained by counting all stalks which were broken below the highest ear and all stalks which were leaning at more than a forty-five degree angle. These data were collected approximately a week before harvest. Yield data were taken and corrected for moisture.

1953 Work

Six corn inbreds were used in the 1953 work. They were:

(1) T61
(2) T105
(3) T113
(4) T202
(5) T204
(6) T210

This experiment was again located on a Huntington loam soil. Soil tests for this plot showed the pH to 5.5 with phosphorus and potassium

each being low. A randomized block design was used with three replications. The plot sizes were again 36' x 10½'. The border rows and center buffer strip were planted with Bolden Bantam sweet corn. This was done to minimize the competitive effect by border rows upon adjacent rows of inbred lines.

Fertilization rates and cultural methods were the same as for the previous year. The sampling procedure differed slightly from that used in 1952. Sampling was begun when the plants were four to six inches tall and continued at bi-weekly intervals until the corn reached the dough stage. The first sample consisted of the entire above-ground portion of six plants. The other samples were composed of the third and fourth leaves from six plants from the border rows of each plot. A total of six samples was taken.

The 1952 and 1953 plant tissue samples were handled similarly. They were oven dried, ground in a Wiley mill, and bottled for future analysis.

A modification of the Gieseking, Snider, and Getz (4) wet oxidation procedure was used for ashing all samples. The method used was:

(1) A lone-gram sample was placed in a 150 milliliter beaker.
(2) Five milliliters of concentrated nitric acid was added.
(3) The beaker was covered with a watch glass and gently heated almost to dryness.
(4) The beaker was removed and five milliliters of dilute nitric acid (1 to 1) plus five milliliters of perchloric acid (70-72%) were added.
(5) The cover glass was replaced and the mixture was heated gently until dryness.
(6) The beaker was removed from the hot plate and cooled. Approximately ten milliliters of distilled water was then used to wash any adhering salts from the watch glass into the beaker. Five milliliters of dilute

hydrochloric acid (1 to 1) was added and the solution was gently warmed. The solution was then filtered into a one hundred milliliter volumetric flask and made up to volume with distilled water.

The potassium and calcium content of the samples was determined with a Perkin-Elmer Model 52 C flame photometer. The magnesium content was determined with a Beckman Model B spectrophotometer according to the thiazole yellow method of Young and Gill (21). Each of these instruments was calibrated with known concentrations of the element for which the analysis was being made. The sample reading was then compared with the calibration curve obtained from these standard concentrations.

RESULTS

1952 Experiment

Data pertaining to yield, root lodging, stalk breakage, and mineral composition were collected and are presented in this chapter.

Yield

Yield data are summarized in Table I. The analysis of variance of these data is presented in Table II. Treatment IV, 160 pounds of K_2O per acre, gave a highly significant response over treatments I, II, and III, which were 0, 40, and 80 pounds K_2O per acre treatments. There were no significant differences among treatments I, II, and III.

The "F" test showed no significant differences in yield among single crosses. The variation among replicates was significant at the .05 level.

Root Lodging and Stalk Breakage

The data presented in Table III indicate that potassium fertilization generally decreased root lodging but had little or no effect upon stalk breakage. There were approximately 40 percent root lodged plants in the check plots compared to approximately 24 per cent in the plots receiving 160 pounds of potash per acre.

Single crosses differed greatly in the percentage of broken and root-lodged plants. The combined totals of broken stalks and root-lodged plants ranged from a high of 74 percent for variety T61 x T115 to a low

TABLE I

YIELD OF GRAIN IN BUSHELS PER ACRE OF SIX SINGLE CROSSES AT FOUR RATES OF POTASSIUM FERTILIZATION AT KNOXVILLE, TENNESSEE IN 1952

Variety	0 lb.K_2O	40 lb.K_2O	80 lb.K_2O	160 lb.K_2O	Averages
T61 x T101	95.5 a/ b/	87.2	89.0	107.5	94.8
T61 x T113	99.2	97.4	85.9	131.0	104.4
T61 x T115	100.9	96.6	92.7	117.7	102.0
T101 x T113	78.0	83.1	75.3	105.7	85.5
T101 x T115	87.2	90.7	83.0	99.5	90.1
T113 x T115	104.0	94.2	95.4	99.9	98.4
Averages	94.1	91.5	86.9	110.2	

$LSD_{(05)}$ between rates of K = 11.7 bu.
$LSD_{(01)}$ between rates of K = 15.6 bu.
a/ Figures represent average of 3 replicates.
b/ Yields based on 15.5 percent moisture.

TABLE II

ANALYSIS OF VARIANCE OF YIELD

Source of variation	Degrees Freedom	Sum of squares	Variance	F Value
Total	71	27004.88	----	----
Treatments	23	10772.87	468.39	1.51
Replicates	2	2248.73	1124.31	3.70*
Varieties	5	3206.22	641.22	2.11
Potassium	3	5599.23	1866.41	6.14**
Varieties x Potassium	15	1967.42	131.16	0.43
Treatments x Replicates	46	13983.28	303.98	----

*Significant at .05 level
**Significant at .01 level

TABLE III

PERCENT STALK BREAKAGE AND ROOT LODGING OF SIX SINGLE CROSSES AT FOUR RATES OF POTASSIUM FERTILIZATION AT KNOXVILLE, TENNESSEE IN 1952

Variety	0 lb. K_2O acre			40 lb. K_2O acre			80 lb. K_2O acre			160 lb. K_2O acre			Averages		
	SB	RL	Total	SB	RL	Total	SB	RL	Total	SB	RL	Total	SB	RL	Total
T61 x T101	23.3	54.4	76.7	22.2	64.9	87.1	9.4	59.4	68.8	15.1	56.2	71.3	17.6	58.5	76.1
T61 x T113	12.4	48.6	61.0	23.3	47.5	65.8	19.4	52.8	72.2	13.9	25.0	38.9	17.3	42.2	59.6
T61 x T115	34.7	56.9	91.7	41.4	40.0	81.4	28.0	36.0	64.0	26.4	33.3	59.7	32.7	41.6	74.3
T101 x T113	5.8	40.6	46.4	15.3	47.2	62.5	2.7	15.1	17.8	5.5	6.8	12.3	7.4	27.5	34.8
T101 x T115	12.9	27.1	40.0	15.3	0.0	15.3	14.9	14.9	29.7	44.8	16.4	61.2	22.0	14.7	36.7
T113 x T115	9.9	12.7	22.6	16.7	6.9	23.6	0.0	18.1	18.1	7.0	5.6	12.6	8.4	10.9	19.3
Averages	16.5b/	40.0	56.5	22.4c/	33.6	56.0	15.5d/	32.8	48.3	19.3e/	24.0	43.3	17.6	32.6	50.2

a/Figures represent average of three replicates.
b/Least significant average difference in stalk breakage among single crosses = 7.5% and 10.1% at .05 and .01 levels respectively.
c/Least significant average differences in root lodging among single crosses = 13.0 and 15.6 at .05 and .01 levels respectively.
d/Least significant average differences in stalk breakage among K_2O applications = 6.1 and 8.2 at .05 and .01 levels respectively.
e/Least significant average differences in root lodging among K_2O applications = 10.7% and 14.3% at .05 and .01 levels respectively.

of 19 per cent for T113 x T115. Apparent varietal differences in response to potash fertilization in terms of root lodging are shown in Figure 4.

The analysis of variance of the root lodging data (Table IV) shows highly significant differences between single crosses. The differences between potassium treatments are significant at the .05 level.

Mineral Composition

Detailed data on mineral composition appear in Table V. Potassium fertilization resulted in an increased leaf content of potassium for all varieties. The leaf tissue in the check plots averaged 1.1 per cent potassium, whereas the plants in the plots receiving 160 pounds of K_2O per acre averaged 1.9 per cent potassium.

The percentage increase affected in each single cross by the addition of 160 pounds of K_2O per acre is presented in Figure 5. These varietal differences in increased potash content were generally small but seemed to be related to varietal responses in terms of yield increases and decreases in the percentage of root lodged stalks (Figures 3 and 4).

Figure 2 illustrates the time trend of the potassium content of the six single crosses. The maximum percentage of potassium in the leaf tissue of the plots receiving P, 40 and 80 pounds of K_2O per acre was found at the second sampling or 58 days after planting. The leaf tissue of the plots receiving 160 pounds of K_2O per acre reached their maximum potassium content at the first sampling or 44 days after planting. The

TABLE IV

ANALYSIS OF VARIANCE OF ROOT LODGING

Source of Variation	Degrees Freedom	Sum of Squares	Variance	"F" Value
Total	71	2293.11	-----	-----
Treatment	23	1561.11	67.87	4.56**
Replicates	2	46.86	23.43	N. S.
Varieties	5	1106.94	221.39	14.87**
Potassium	3	160.11	53.37	3.58*
Varieties x Potassium	15	293.06	19.54	N. S.
Treatments x Replicates	46	685.14	14.89	-----

*Significant at .05 level
**Significant at .01 level

TABLE V

MINERAL COMPOSITION OF LEAF TISSUE FROM SIX SINGLE CROSSES AT FOUR RATES OF POTASSIUM FERTILIZATION AT FOUR SAMPLING DATES

Variety	lb.K/ acre	44 days after planting			58 days			72 days			86 days		
		K	Ca	Mg	K	Ca	Mg	K	Ca	Mg	K	Ca	Mg
T61 x T101	0	1.33a/	.54	.13	1.70	.57	.20	.95	.87	.29	1.07	.61	.12
"	40	1.65b/	.58	.13	1.82	.50	.13	1.00	.58	.22	1.22	.62	.13
"	80	2.13	.49	.09	1.99	.50	.13	1.19	.71	.22	1.46	.66	.18
"	160	2.68	.43	.08	1.95	.40	.12	1.41	.69	.17	1.58	.49	.14
T61 x T113	0	.90	.51	.18	1.39	.52	.27	1.05	.74	.32	.90	.53	.17
"	40	1.55	.70	.14	1.63	.44	.23	1.15	.70	.28	1.24	.55	.13
"	80	2.22	.47	.10	1.73	.41	.22	1.34	.65	.26	1.43	.54	.13
"	160	2.52	.47	.08	1.92	.42	.20	1.40	.63	.17	1.40	.46	.12
T61 x T115	0	1.10	.52	.16	1.52	.40	.22	.95	.59	.31	.97	.62	.11
"	40	1.68	.51	.12	1.73	.46	.13	.98	.69	.21	1.24	.62	.17
"	80	1.77	.46	.12	1.93	.42	.17	1.27	.83	.21	1.36	.58	.13
"	160	2.65	.50	.10	2.10	.42	.10	1.41	.54	.14	1.58	.54	.13
T101 x T113	0	1.03	.51	.17	1.38	.43	.23	.97	.87	.31	.93	.62	.18
"	40	1.65	.52	.15	1.61	.54	.20	1.11	.76	.24	1.27	.61	.17
"	80	1.83	.45	.12	1.83	.52	.17	1.23	.70	.20	1.35	.69	.12
"	160	2.60	.45	.07	2.07	.38	.13	1.57	.65	.18	1.73	.61	.13
T101 x T115	0	1.13	.58	.14	1.33	.52	.17	1.00	.86	.17	.93	.61	.16
"	40	1.47	.55	.13	1.72	.55	.13	1.00	.68	.22	1.21	.59	.13
"	80	1.97	.45	.09	1.91	.44	.13	1.24	.72	.18	1.38	.69	.14
"	160	2.42	.48	.07	1.95	.37	.10	1.58	.72	.18	1.70	.53	.09
T113 x T115	0	1.10	.57	.14	1.42	.42	.22	1.07	.68	.20	.92	.52	.11
"	40	1.37	.52	.13	1.47	.44	.20	1.09	.70	.25	1.20	.52	.17
"	80	1.65	.45	.10	1.87	.50	.17	1.25	.83	.17	1.43	.58	.14
"	160	2.38	.48	.10	2.00	.42	.17	1.53	.64	.18	1.62	.49	.13

a/All figures represent % of element in air-dry weight of sample.
b/All figures represent average of 3 replicates.

potassium content for all plots declined sharply between the second and third samplings.

Potassium fertilization generally decreased the leaf content of calcium and magnesium of all single crosses. The ratio of potassium to calcium plus magnesium decreased from approximately 3 to 1 at 44 days after planting to a minimum of 1.3 to 1 at 72 days. The ratio widened slightly at 86 days due to a slight increase in potassium content during this period.

Table VI shows the total Milliequivalents of potassium, calcium, and magnesium per 100 grams to progressively increase at the higher levels of potassium fertilization at 44 days after planting. Analysis of leaf tissue samples taken later in the growing season shows little effect upon the total milliequivalents of these cations found in the leaf tissue.

Influence of Inbred Lines

Each inbred line was used in combination with all other lines; therefore the influence of each inbred could be compared with the others. Table VII shows no significance between inbred lines in affecting the yield of the single crosses. There was, however, a highly significant difference between inbred lines in affecting the root lodging of the single crosses as shown in Table VIII.

TABLE VI

TOTAL CATIONS (K, CA, MG) FOUND IN CORN LEAF TISSUE UNDER FOUR RATES OF POTASSIUM FERTILIZATION AT FOUR SAMPLING DATES

lbs. K_2O per acre	Days after planting				Averages
	44	58	72	86	
0	675.40a/	795.27	863.44	653.71	746.96
40	786.90	810.44	805.93	733.73	784.25
80	807.10	856.85	858.20	784.10	826.56
160	952.06	827.95	844.28	768.93	848.31
Average	805.37	822.63	842.96	735.12	801.52

a/Figures expressed as Me/100 gm. air dry tissue

TABLE VII

INFLUENCE OF FOUR INBRED LINES UPON YIELD OF GRAIN IN BUSHELS PER ACRE OF SIX SINGLE CROSSES AT FOUR RATES OF POTASSIUM FERTILIZATION AT KNOXVILLE, TENNESSEE IN 1952

Inbred	0 lb. K_2O	40 lb. K_2O	80 lb. K_2O	160 lb. K_2O	Averages
T61	97.8a/b/	95.0	89.3	118.7	100.2
T101	85.5	86.6	82.4	104.2	90.2
T113	93.7	90.3	85.6	112.3	92.3
T115	96.6	93.8	90.4	105.7	95.5
Averages	93.4	91.4	86.9	110.2	

a/The six single crosses studied represent four inbred lines in all possible combinations. Data presented for each incred line represent the mean of the three single crosses involving that inbred line.

b/Value represents 3 replication average of 3 single cross yields which contained the inbred.

ANALYSIS OF VARIANCE

Source of variation	Degrees Freedom	Sum of Squares	Variance	"F" Value
Total	47	206.37	------	------
Treatments	15	46.54	3.10	N. S.
Replicates	2	15.07	7.54	N. S.
Varieties	3	6.84	2.28	N. S.
Potassium	3	38.06	12.69	N. S.
Varieties x Potassium	9	1.64	.18	N. S.
Treatments x Replicates	30	144.76	4.83	------

TABLE VIII

INFLUENCE OF INBRED PARENT ON PERCENT ROOT LODGING OF THE SIX SINGLE CROSSES

Inbred	0 lb.K_2O/A	40 lb.K_2O/A	80 lb.K_2O/A	160 lb.K_2O/A	Averages
T61 a/	50.8 b/	47.7	49.0	36.0	45.9
T101	37.3	30.3	26.0	24.7	29.6
T113	34.2	36.8	26.9	11.7	27.4
T115	32.9	14.3	22.1	16.9	21.6
Averages	38.8	32.3	31.0	22.3	31.1

a/The six single crosses studied represent four inbred lines in all possible combinations. Data presented for each inbred line represent the mean of the three single crosses involving that inbred line.

b/Value reported in the mean of three replications.

ANALYSIS OF VARIANCE

Source of Variation	Degrees Freedom	Sum of Squares	Variance	"F" Value
Total	47	610.60	----	----
Treatments	15	382.21	25.48	4.11**
Replications	2	33.40	16.70	2.69 N.S.
Inbred lines	3	233.60	77.87	12.56**
Potassium	3	107.84	35.95	5.80**
Varieties x Potassium	9	40.77	4.53	N.S.
Treatments x Replicates	30	185.99	6.20	----

* Significant at .05 level.
** Significant at .01 level.

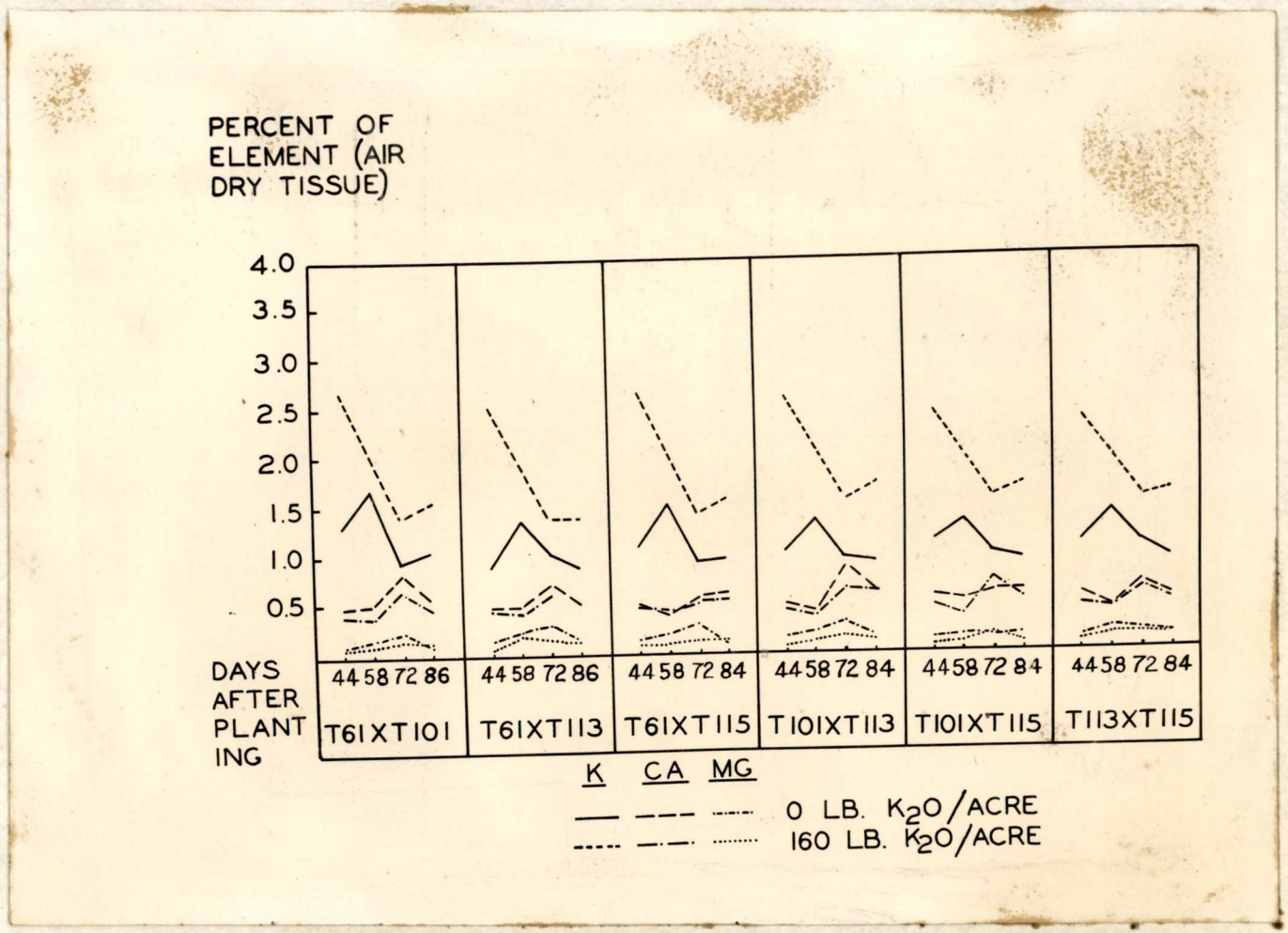


Figure 2. Percent potassium, calcium, and magnesium in leaf tissue of six corn single crosses at four rates of potassium fertilization at four sampling dates.

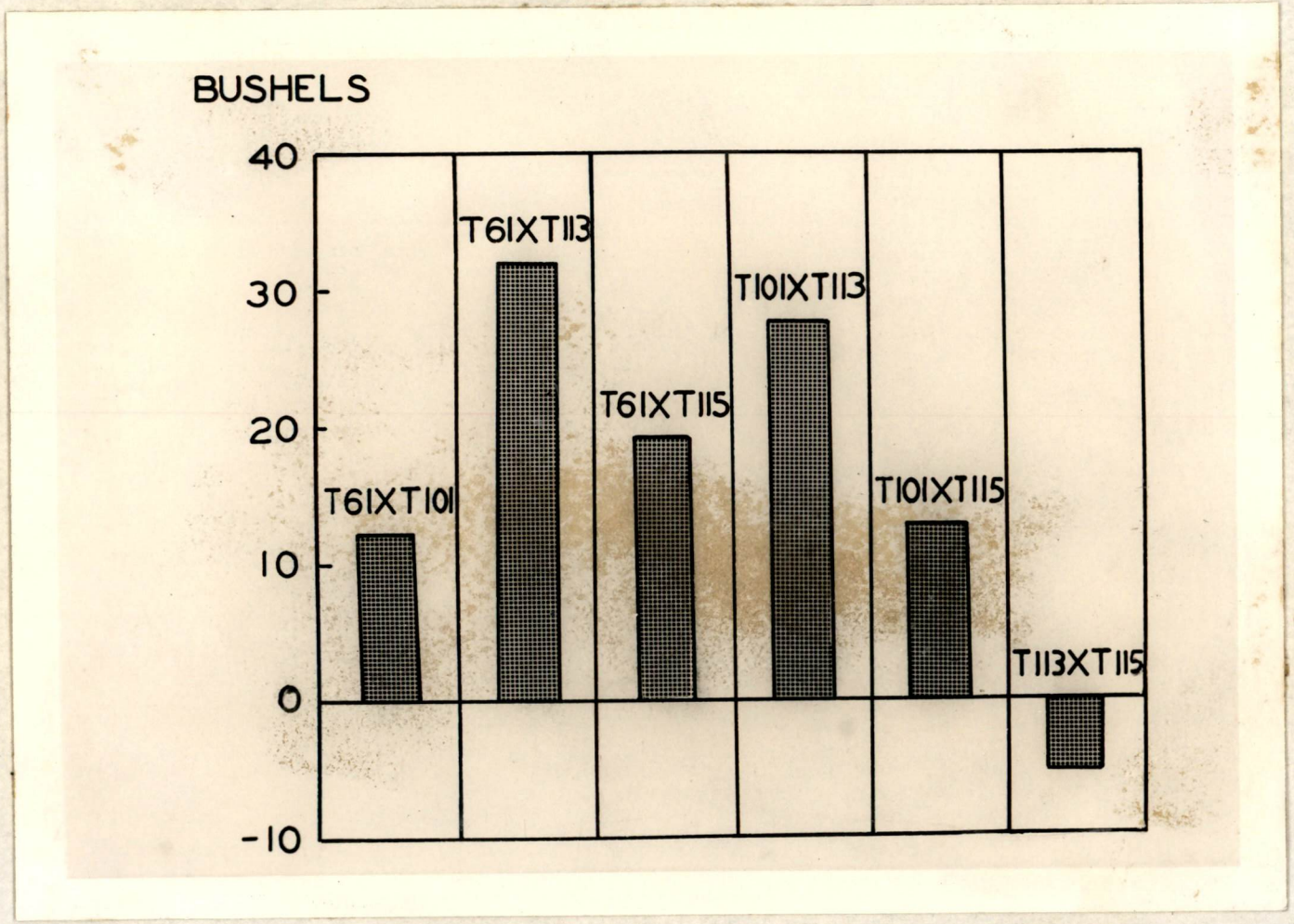


Figure 3. Effect of 160 pounds potash per acre upon yield of six single crosses (Base line represents yield of plots receiving no potash).

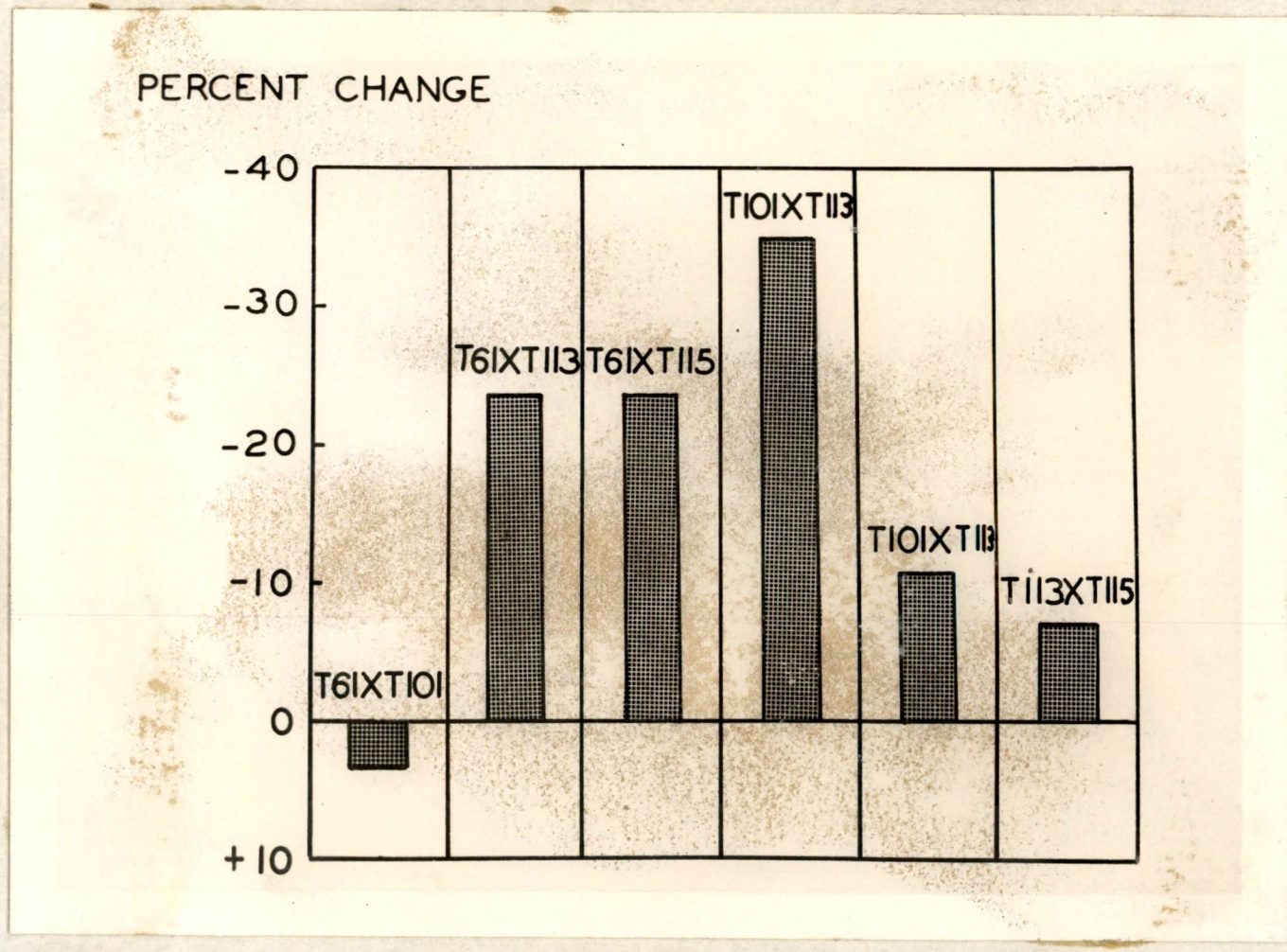


Figure 4. Effect of 160 pounds potash per acre upon root lodging of six single crosses (Base line represents root lodging in plots receiving no potash).

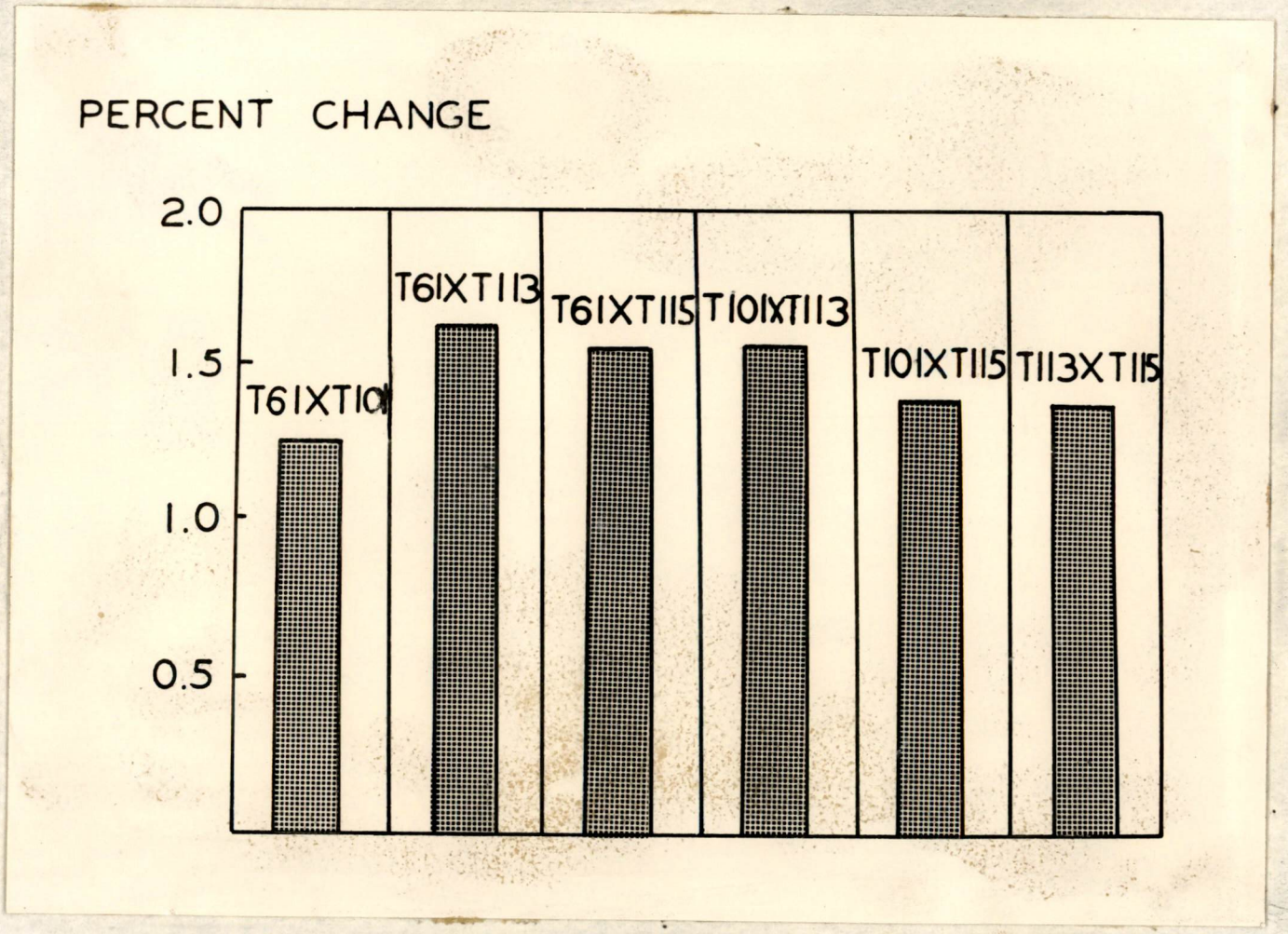


Figure 5. Effect of 160 pounds potash per acre upon leaf content of potassium 58 days after planting (Base line represents leaf content of potassium 58 days after planting in plots receiving no potash).

1953 Experiment

Poor surface drainage prevented getting an adequate stand of plants in approximately one-third of the experimental area. For that reason, yield data and data pertaining to strength of stalk could not be obtained from all replicates. However, plant material was collected for mineral analysis. The results of that mineral analysis are presented in this chapter.

Data on mineral composition of the inbreds are summarized in Figures 7 and 8. The leaf tissue from the check plots averaged 1.4 per cent K while the leaf tissue from the plots receiving 160 pounds K_2O per acre averaged 2.3 per cent K. Differences in percentage K in tissue from plants receiving the 0 and 160 pounds K_2O per acre treatments were most pronounced during the early stages of growth; however, they were evident throughout the sampling period. The maximum percentage of K was found at 34 to 47 days after planting. The percentage K declined during later periods of growth.

The percentages of calcium and magnesium found in the plant tissue was inversely related to the rate of potassium fertilization. Both the calcium and magnesium percentages tended to increase during the growing season.

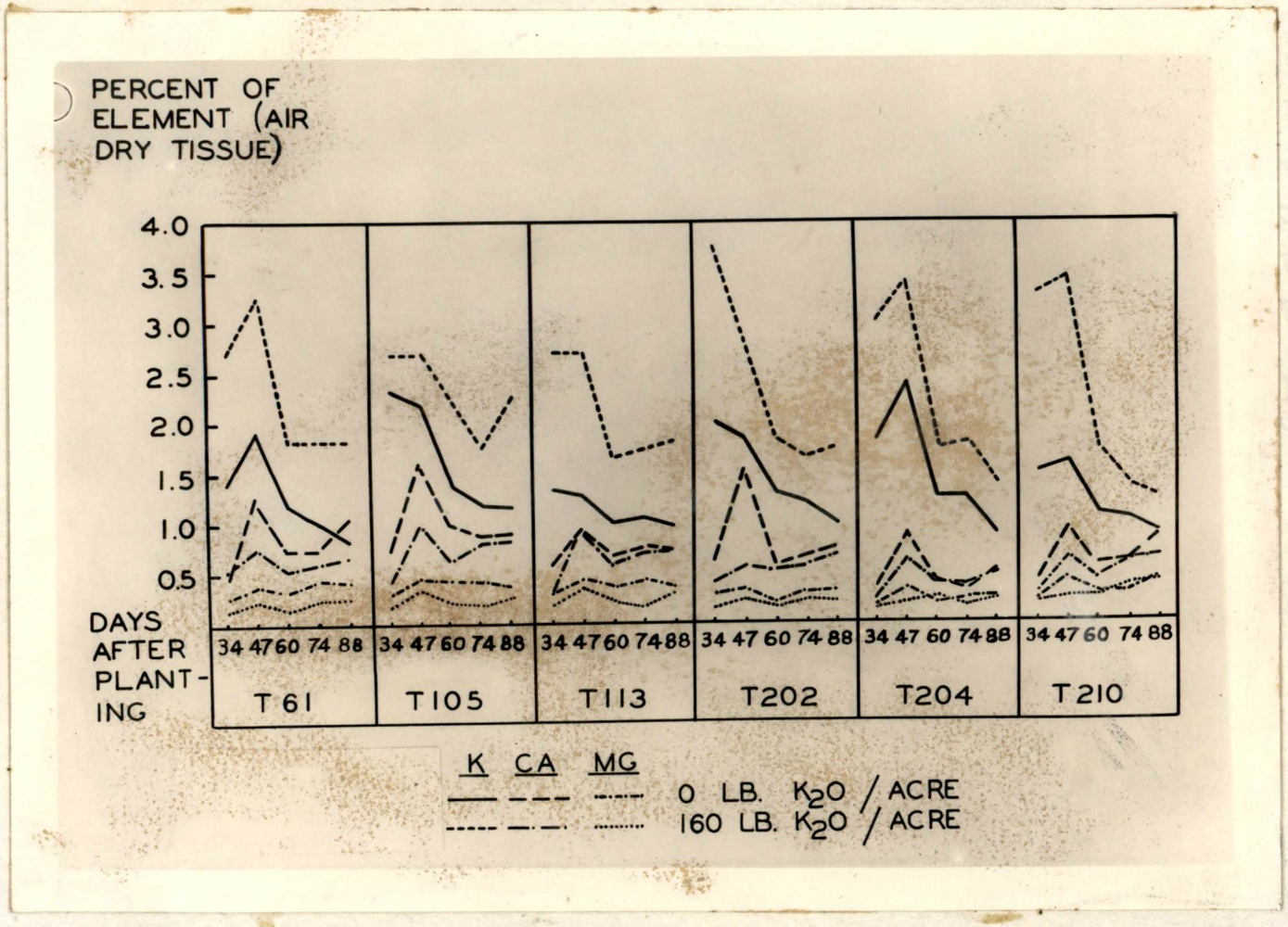


Figure 6. Percent potassium, calcium, and magnesium in leaf tissue of six corn inbreds at four rates of potassium fertilization at five sampling dates.

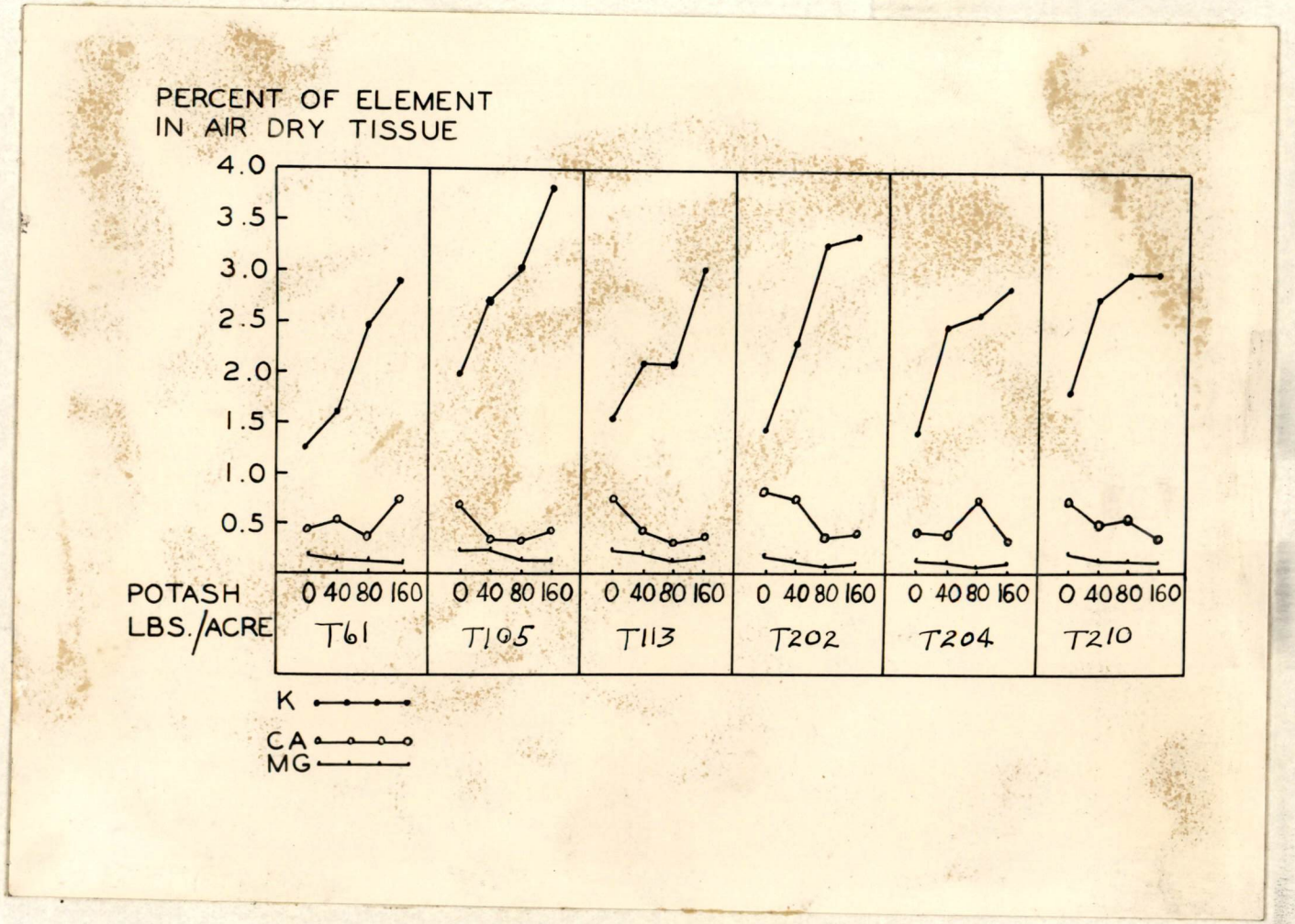


Figure 7. Percent potassium, calcium, and magnesium found 22 days after planting in aerial portion of six corn inbreds which received four rates of potassium fertilization.

DISCUSSION AND CONCLUSIONS

A highly significant average yield increase was obtained with the application of 160 pounds of K_2O per acre in the 1952 experiment (Table I). Applications of 0, 40, and 80 pounds of K_2O per acre gave no significant differences. These results are in apparent contrast with root lodging data (Table III) in which the 0, 40, 80, and 160 pounds of K_2O applications progressively decreased root lodging and with mineral composition data (Table IV) which show the leaf content of potassium to increase progressively with increasing increments of K_2O. The question might then logically be raised as to why the 40 and 80 pounds per acre applications of K_2O gave no yield increase. One might suspect that the competitive effect of the soil for potassium is a factor to partially account for this yield response only at the highest rate of potassium fertilization. However, the plant did respond in potassium uptake at these intermediate rates of potash fertilization which apparently disproves this hypothesis. A better explanation seems to be that the single crosses grown under the conditions of this experiment require a very high potassium content in order to increase the yield whereas a smaller increase in potassium content increases the strength of stalk.

The single crosses differed widely in the percentages of plants which were root lodged or broken as an average for all fertilizer treatments. T61 x T101, T61 x T113, and T61 x T115 ranked 1, 2, and 3 respectively, in the percentages of plants which were root lodged and 3, 4, and 1, respectively, in the percentages of broken stalks (Table III). T61, a common parent of these single crosses, apparently has a genotype

which results in a weak stalk in its progeny.

Single crosses T61 x T113, T61 x T115, and T101 x T113 had the greatest decreases in root lodging as affected by the application of 160 pounds of K_2O per acre (Figure 4). It will be noted that these were also the single crosses which gave the greatest yield response to 160 pounds of K_2O per acre (Figure 3). The single crosses showed similar increases in uptake of potassium with treatment IV compared with treatment I (Figure 5). There did, however, seem to be a tendency for single crosses which had a larger percentage increase to respond most in terms of increased yield and decreased root lodging. These observations indicate that single crosses T61 x T113, T61 x T115, and T101 x T113 were better able to increase their potassium content under the higher rates of potassium fertilization than the less responsive varieties. This potassium could have then been translocated and re-utilized by these varieties in the formation of more grain and stronger stalks as evidenced in Figures 3 and 4.

The highest percentages of potassium found in the leaf tissue of the plants receiving treatments I, II, and III (0, 40, and 80 pounds K_2O per acre) was found at the second sampling 58 days after planting; whereas the highest percentage of potassium in the tissue of the plants receiving treatment IV (160 pounds of K_2O per acre) was found at the first sampling 44 days after planting. This difference was probably due to the limited root development of the plants 44 days after planting which enhanced the importance of the potash present in the row. As the root systems expanded the plants were better able to utilize potash from other portions of the soil. A similar trend was evident in the 1953 data on

mineral composition (Figure 6).

A decrease in the percentage of potassium in the leaves was noted between 58 and 72 days after planting (Figure 2). The corn ears were being formed at this time; therefore, it is suggested that this decrease was due to translocation of potassium from these lower leaves to meristematic regions where it was re-utilized in the production of carbohydrates. Translocation of potassium has been reported by Bartholemew and Jansen (1) and Nightingale, et al (12).

As the season progressed (Figures 2 and 6) the differences in mineral composition due to rates of potassium fertilization were reduced. The increase in K content brought about by potassium fertilization became smaller and the ratio of potassium to magnesium became more narrow as the season progressed. One factor suggested as a partial explanation for these observations is that the available potassium in the fertilized zone decreased as the season progressed due to (a) leaching of applied K_2O (b) plant uptake of this potassium, and (c) fixation in a less available form of part of the applied potash by the soil colloidal system. The expanding root systems of the plants moved out of the zone of fertilizer application as the season progressed which also contributed to a decreased influence of applied potassium.

SUMMARY

Six corn single crosses were grown under four rates of potassium fertilization in 1952. Six corn inbreds were grown under the same four levels of potassium fertilization in 1953.

Data were taken pertaining to yield, stalk breakage, root lodging, and mineral composition from the 1952 experiment. A poor stand was obtained in 1953 so only mineral composition data are presented in this paper.

The results of the 1952 experiment were:

1. The application of 160 pounds of K_2O per acre gave a significant yield increase over 0, 40, and 80 pounds K_2O per acre. No other treatments gave significant yield differences.

2. Potassium fertilization generally decreased root lodging but had no apparent effect upon stalk breakage.

3. Single crosses which had inbred T61 as a parent had the highest percentages of broken or root-lodged plants. It was interpreted that T61 had a genotype which resulted in a weak stalk in its progeny.

4. The single crosses differed in response to the addition of 160 pounds of K_2O per acre. The varieties which had the greatest yield increases generally had the greatest reduction in root lodging and the largest increases in the percentages of potassium in the leaf tissue 58 days after planting.

5. The potash content of the leaf tissue of all varieties was increased by each additional increment of K_2O. The calcium and magnesium contents of the leaf tissue were generally inversely related to potassium fertilization.

6. The maximum percentage potassium within the leaf tissue receiving 0, 40, and 80 pounds K_2O per acre was found 58 days after planting whereas the leaf tissue of the plants receiving 160 pounds of K_2O per acre reached their maximum percentages of potassium 44 days after planting.

7. The percentage of potassium in the sampled tissue declined after 58 days. This was interpreted as being due to translocation during the process of ear formation.

The mineral composition of the inbreds used in the 1953 experiment followed a trend similar to that of the single crosses studied in 1952.

BIBLIOGRAPHY

BIBLIOGRAPHY

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

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

3. Drake, M., and Scarseth, G. D. Relative abilities of different plants to absorb potassium and the effect of potassium on the absorption of calcium and magnesium. Soil Sci. Soc. Proc. 4:201-204. 1939

4. 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

5. Hoffer, G. N. Some differences in the functioning of selfed lines of corn under varying nutritional conditions. Jour. Amer. Soc. Agron. 18:322-334. 1926

6. Jansen, G., and Bartholomew, R. P. The effect of potassium on the production of proteins, sugars and starch in cowpea and in sugar beet plants and the relation of potassium to plant growth. Jour. Amer. Soc. Agron. 24:667-680. 1932

7. Jones, W. J., and Huston, H. A. Composition of maize at various stages of its growth. Purdue Agr. Exp. Sta. Bul. 175. 1914

8. Koehler, B., Dungan, G. H. and Holbert, J. R. Factors influencing lodging in corn. Ill. Agr. Exp. Sta. Bul. 226. 1925

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

10. Lotshaw, W. L. and Miller, E. C. Elemental composition of the corn plant. Jour. Agr. Res. 27:845-859. 1924

11. Lochwing, W. F. Calcium, potassium, and iron balance in certain crop plants in relation to their metabolism. Plant Physiol. 3:261-275. 1928

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

13. Redd, H. S. The value of certain nutritive elements in the plant cell. Ann. Bot. 21:501-544. 1907

14. Sayre, J. D. Mineral accumulation in corn. Plant Physiol. 23: 267-281. 1948

15. Stanford, G., Kelley, J. B., and Pierre, W. H. Cation balance in corn grown on high lime soils in relation to potassium deficiencies. Soil Sci. Soc. Amer. Proc. 6:335-341. 1941

16. Tyner, E. H. The relation of corn yields to leaf nitrogen, phosphorus, and potassium. Soil Sci. Amer. Proc. 11: 317-323. 1946

17. Wall, M. E. The role of potassium in plants I: Effect of varying amounts of potassium on nitrogenous, carbohydrate, and mineral metabolism of the tomato plant. Soil Sci. 47:143-161. 1939

18. Wall, M. E. The role of potassium in Plants II: Effect of varying amounts of potassium on the growth status and metabolism of the tomato plant. Soil Sci. 49:315-331. 1940

19. Williams, C. B., Mann, H. B., and Rea, R. L. Crop response to lime and fertilizer on muck soil. N. C. Agr. Exp. Sta. Bul. 292. 1934

20. Wimer, D. C. Composition of mature corn stover as affected by variety, soil type, and fertilizer treatment. Ill. Agr. Exp. Sta. Bul. 437. 1937

21. Young, H. Y., and Gill, R. F. Determination of magnesium in plant tissue with thiazole yellow. Anal. Chem. 23:751-754. 1951