THE EFFECT OF LEVELS OF PHOSPHATE AND POTASH FERTILIZATION ON YIELD, QUALITY, AND COMPOSITION OF SEBAGO POTATOES GROWN ON HOUGHTON MUCK

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by

Leo Klameth

AN ABSTRACT

Submitted to the College of Agriculture of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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LEO KLAMETH ABSTRACT

In this study several combinations of phosphate and potash fertilizer were evaluated regarding their influence upon soil test and yield, quality, and composition of potatoes grown on organic soil during the growing seasons of 1956 and 1957. The yield, size, specific gravity, and composition of the tubers were determined. From top samples the yield, per cent dry matter and composition were determined. Regression analysis, analysis of variance, and simple correlations were used in evaluating the relationships that existed.

The yield of tubers was significantly influenced by fertilization. A curvilinear type equation apparently fitted the yield data with a much greater degree of accuracy than did a straight line function used. Also restricting the analysis to data in the response range gave a much better fit than when all the data were used.

Specific gravity of the tubers was related inversely to application rates of P_2O_5 and K_2O.

The maturity of tops as indicated by the per cent dry matter was affected inversely as additional amounts of P_2O_5 and K_2O were applied.

The tubers and tops were analyzed for nitrogen, calcium, phosphorus, potassium, magnesium, and sodium. In general, there was a marked seasonal variation in the effect of the applied P_2O_5 and K_2O on the per cent composition of several of the elements. A straight line equation explained more of the variance than did the curvilinear equation when applied fertilizer was used as the variable to predict their composition.

The phosphorus percentages of tops and tuber increased with increased application of P_2O_5. The potassium percentages of tops and tubers increased with increased application of K_2O.

The K soil test reflected the amount of applied K_2O to a greater degree than did the P soil test in predicting the amount of applied P_2O_5.

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

High yields of potatoes (Solanum tuberosum) are produced on organic soils. Approximately 17,000,000 acres of organic soils are located in the north central region of the United States. These land resources under proper management represent potential areas suitable for future food production.

Proper management includes an understanding of the effect of applied nutrients upon the yield, quality, and chemical composition of the crop, as well as its residual effect upon the soil.

In this experiment several combinations of phosphate and potash fertilizer were evaluated regarding their influence upon yield, quality, and composition of Sebago potatoes, and soil tests during the growing seasons of 1956 and 1957.

REVIEW OF LITERATURE

Work on the fertilization of potatoes grown continuously on the same land was done by Lawes and Gilbert. Burton (2) reported results for the first twelve years in the following table:

EFFECT OF MANURIAL TREATMENT AVERAGE RESULTS FOR THE YEARS 1876-87 (from Gilbert, 1888)

Treatment	Tons/A	% Diseased Tubers	% Dry Matter	Specific Gravity
Unmanured	2.0	3.15	28.1	1.118
Dung (average of years 1876-81)	5.2	5.54	25.8	1.106
Superphosphate	3.7	3.66	26.8	1.115
Mixed mineral manure	3.8	3.45	26.5	1.114
Ammonium salts alone	2.3	4.06	26.2	1.110
Nitrate of soda alone	2.6	4.93	26.5	1.112
Ammonium salts and mixed mineral manure	6.7	6.26	25.6	1.104
Nitrate of soda and mixed mineral manure	6.7	7.00	25.8	1.108

The data show a maximum reduction in the percentage dry matter from 28.1 to 25.6. This was accompanied by a 235 per cent increase in yield, so that the net result was an increase of 0.56 to 1.72 tons of dry matter per acre.

Bigger, _et al_. (1) and Lucas, _et al_. (18) found that the highest average yield of potatoes was produced where 100 pounds per acre of phosphate and 300 pounds per acre of potash was applied. Davis (6) found that potatoes growing in soil to which 600 pounds of 0-9.5-27.5 per acre had been applied produced the highest yield of No. 1 Irish Cobbler per acre. Fitch (13) on 10 Iowa soils obtained highest yields from potatoes growing in soil to which 500 pounds of 0-9-27 fertilizer per acre had been added. Hardenburg (15) stated that old muck is usually deficient in available nitrogen and contains some residual potash while newly developed organic soils seldom need much commercial nitrogen and are likely to be deficient in both potash and phosphate.

Cobb (5) reported that good cooking quality is closely associated with high dry matter and low nitrogen content of the tuber, with temperature and variety as the more important factors influencing these.

Potatoes at the extremes of the density range are unsuited for commercial usage. Low density potatoes are watery and waxy and produce a translucent product of poor reconstitution properties, while potatoes of very high density often result in products which slough badly on cooking or have low cohesive properties (31).

Clark, et al. (4) found specific gravity to be a practical method for making a preliminary selection for mealiness. Shoemaker (24) used specific gravity to express different degrees of mealiness. Potatoes with a specific gravity of greater than 1.080 are bakers, from 1.080 to

1.070 are boilers, and those less than 1.070 are fryers.

Terman, et al. (28), (29), (30); Chucka, et al. (3); Fineman (11); Dunn and Nylund (9); and Smith and Kelly (25) reported that soils fertilized with muriate of potash as compared to the non-chloride forms produced tubers that had a lower specific gravity and a lower starch percentage. Eastwood and Watts (10) found that specific gravity was affected by a complex of factors including potato variety, potash level, and potash source.

Hawkins (16) reported that the proportion of the nutrients absorbed by the plant from the soil that were translocated into the tubers was as follows: 80 per cent of P, 67 per cent of N, 60 per cent of S, 40 per cent of Mg, and 5 per cent of Ca.

Terman, et al. (27) noted a decrease in the concentration of NO_3 and Mg in the plant with an increase in potash fertilization. The nutritional unbalance in plants grown on soils fertilized with excessive amounts of potash may be the reason for the decrease in yield frequently obtained. Gausman and Awn (14) concluded from an experiment showing the effects of Cl^- from $CaCl_2$ on P^{32} accumulation in potatoes that the amount of P^{32} increased as increments of Cl^- from $CaCl_2$ were increased to 400 ppm. Above 400 ppm. there was an apparent and progressive decrease in the amount of P^{32} accumulating in the potatoes. Hence, the inhibitory effect of the higher amounts of Cl^- on the uptake of P^{32} is implied.

Metzger (19) found that phosphate fertilized plots produced vines slightly heavier than the check and that they reached their maximum weight and declined in weight one week earlier than the check. Plots fertilized with potash reached maximum weight three weeks later than did those grown on the unfertilized plots.

Penston (21) stated in a study of the potato plant that the regions of meristematic division, photosynthesis, and translocation and storage of food materials contain K in considerable quantity. The association of K with protein in nearly all tissues also suggests that it may be necessary for protein metabolism.

METHODS AND MATERIALS

The potatoes were grown on a Houghton muck (pH 6.0-6.3) at the Michigan State University Muck Experimental Farm, in Clinton county. An incomplete factorial design was used having four no fertilizer plots and using ten levels of P_2O_5 and 18 levels of K_2O. Included within this incomplete factorial was a 4 x 4 x 3 factorial having 100, 200, 300, and 400 pound per acre rates of P_2O_5 and 200, 400, 600, and 800 pounds per acre rates of K_2O. The plot outline (Table 1) was the same for the years of 1956 and 1957, with 1956 being the first year of crop production on this land.

Fertilizers used the first year were muriate of potash (60%-K_2O) and treblesuperphosphate (45%-P_2O_5). The second year sulfate of potash (48%-K_2O) and treblesuperphosphate (45%-P_2O_5) were used. The fertilizer was broadcast on the plots and mixed into the soil with a tandem disk harrow in the spring just previous to planting. The 30 foot plots were planted by machine in four rows 32 inches apart. Potatoes from the two inside rows for a length of twenty feet were used for the harvest area. At the time of harvest the tubers were graded as to size, those being considered as grade A to be larger than 1-7/8 inch in diameter and those less as grade B (20). The weights of A's and B's were recorded for each plot.

A sample of approximately 10 pounds of tubers was saved from each plot. The specific gravity was determined on these tubers by comparing their weight in water to their weight in air. The tubers were then sliced, dried, ground, and stored in glass jars for chemical analysis. On forty selected plots in 1957 top samples were taken late in the growing season and yields of tops and per cent dry matter determined. The samples were dried, ground, and saved for chemical analysis.

The samples receiving the same treatment in each year were bulked together, with the check plots being the only exceptions. Thus, as can be seen from Tables 10 and 16 determinations were made for N, Ca, K, P, Mg, and Na on 123 different samples.

Nitrogen was determined by the Kjeldahl process (22). A two-gram sample of the tubers and a one-gram sample of the tops was used.

The perchloric acid method of Piper (23) was used in wet ashing the plant samples. A one-gram sample was placed in a 125 ml beaker and 15 mls of concentrated nitric acid was added to it. The sample was digested on an electric hot plate until almost all the organic matter was destroyed and a clear solution was obtained. Six mls of 70 per cent perchloric acid was then added to the solution and the digestion continued until the oxidation was complete and a clear, colorless solution was obtained. The solution was then evaporated almost to dryness, cooled and the volume was made up to 100 mls with 0.1N HCl. The solution was filtered through Whatman No. 42 filter paper and put in bottles as stock solution.

The P content was determined by the ammonium molybdate method. One ml of the stock solution was diluted to ten mls and six drops of ammonium molybdate-sulfuric acid reagent was added, followed by the same amount of Fiske-Subbarrow reagent (12). The solution was then shaken thoroughly and allowed to stand for fifteen minutes. Then it was placed in a colorimeter tube and the transmittancy of the solutions was measured using a Lumetron Colorimeter with a red filter (650 mu). These readings were compared to those recorded on a previously developed standard curve.

Potassium in the stock solution was determined on the Perkin-Elmer Model 52C flame emission spectrophotometer as described by Jackson (17).

Calcium and sodium contents of the stock solutions were determined by using the Beckman spectrophotometer Model DU equipped with flame emission source. Adjustment of the Beckman for specific cations are given in Table 2.

Magnesium was determined colorimetrically using the thiazole yellow method of Drosdoff and Nearpass (8). One ml of the stock solution was placed in a 50 ml volumetric flask. Approximately 25 mls of 0.1N HCl was added followed by: 1 ml of 5 per cent hydroxylamine hydrochloride, 5 mls of an equal mixture of 2 per cent starch solution and compensating solution, 1 ml of thiazole yellow, and 5 mls of 3N sodium hydroxide solution. It was brought to volume, mixed and allowed to stand for ten minutes. The intensity of the color of the solution was then measured by a Coleman Universal Spectrophotometer Model 14, set at a wavelength of 540 mu.

The soil samples were taken in the spring of 1957 previous to the application of fertilizer. The samples were extracted with 0.018 N acetic acid, the extractant proposed by Spurway and Lawton (26). The soil extract ratio was 1:4 and the mixture, with one-fourth teaspoon of activated carbon, was shaken for one minute. The extractable P was determined by a colorimetric method using the ammonium-molybdate-hydrochloric acid solution proposed by Dickman and Bray (7) and Fiske and Subbarrow reducing reagent.

The extractable K was determined with a photolometer using a red filter (wave length of 650 mu) and employing a sodium cobaltinitrite procedure involving the use of 95 per cent ethyl alcohol.

RESULTS AND DISCUSSION

Yield Relationships

The average yields of tubers from all plots were 218.8 and 366.5 cwt. per acre for 1956 and 1957, respectively. This increase of 67.1 per cent could possibly be attributed to a more favorable growing season in 1957.

Analysis of variance of yield of the 4 x 4 x 3 factorial is given in Table 5.

The average yield from plots of replication 1 of this factorial was consistently lower than from replication 2 or 3. Replication 1 had an average yield per plot of 216.0 cwt. per acre with replication 2 and 3 at 230.0 and 227.7 cwt. per acre in 1956. For 1957, replication 1 had an average yield per plot of 329.4 cwt. per acre with replication 2 and 3 at 384.4 and 404.1 cwt. per acre.

Highly significant yield differences (1% level) were obtained in 1956 between 100 versus 200, 300, and 400 pounds per acre rates of P_2O_5 fertilizer. The highest yields were obtained where the lower rate of P_2O_5 was used. The levels of K_2O application had a significant influence upon the yield. Plots where 400 pounds of K_2O per acre were applied in 1956 had a significantly higher yield than plots that received either 600 or 800 pounds per acre. The interaction of fertilizers had a highly significant influence upon the yield in 1956. This is indicated by the difference in yields of the plots receiving the different K_2O levels where P_2O_5 levels of fertilization were different.

Multiple correlation analyses were conducted using three types of equations: (a) $\hat{y} = a + b_1x_1 + b_2x_2 + b_3(x_1x_2)$; (b) $\log \hat{y} = a + b_1 \log x_1 + b_2 \log x_2$; and (c) $\log \hat{y} = a + b_1 \log x_1 + b_2x_1 + b_3 \log x_2 + b_4x_2$; x_1 and x_2 refer to the pounds of P_2O_5 and K_2O, respectively.

Where type c equation was used applied P_2O_5 and K_2O produced a significant influence upon the yield (Table 6). The interaction of P_2O_5 and K_2O had a significant negative influence upon the yield but was not of sufficient magnitude to cause a negative slope to the curve. The adjusted coefficient of multiple determination ($\bar{R}^2$) showed that the equation used explained 10 per cent of the variation in yield in 1956, and 20 per cent in 1957 as due to fertilizer. The standard errors of estimate indicate a high degree of variation in the data.

A curvilinear equation which allows for decreasing yields as well as increasing yields as more fertilizer is applied was fitted to the 1956 and 1957 yield data. The results indicate that 34 per cent of the variance in yield in 1956, and 61 per cent in 1957 was explained by the equation that was used. This type of equation apparently fitted the data to a much greater degree of accuracy than the straight line function used.

Thirty-six plots receiving 150 pounds per acre and less of P_2O_5 and those receiving 400 pounds per acre and less of K_2O were selected to make a further analysis because they were in the "response range" as indicated by Table 3. The response range is defined as the range of fertilizer application over which an additional increment causes an increase in yield. With this group of observations two analyses were made; one using a straight line type equation: $\hat{y} = a + b_1x_1 + b_2x_2 + b_3 (x_1x_2)$; and the second using a curvilinear type equation: $\log \hat{y} = a + b_1 \log x_1 + b_2 \log x_2$.

Comparison of the four analyses of yield and applied fertilizer are given in Table 7. Restricting the analysis to data in the response range gave a higher $\bar{R}^2$ when the straight line and curvilinear type equations were used then when all data were used. This would be expected because there were fewer observations and the data appear to be less heterogenous within this range. It is evident that the curvilinear type equation used with 36 observations explained more variance as indicated by larger $\bar{R}^2$ values. This might imply that data from plots where fertilizer applications are made beyond where an increase in yield results, is largely of academic interest. Insofar as possible fertilizer treatments should be for the most part within the response range.

Specific Gravity

Highest average specific gravity tubers were produced on plots which received 25 pounds per acre of P_2O_5 fertilizer in 1956 and zero pounds per acre in 1957. The plots receiving 25 and 50 pounds per acre of K_2O produced the tubers with the highest specific gravity in 1956. In 1957 those receiving zero and 50 pounds per acre of K_2O produced the highest specific gravity tubers. Inverse relationships were indicated between specific gravity and applied P_2O_5 and specific gravity and K_2O (Tables 6, 8, and 9).

These observations were substantiated by linear regression analysis which gave a negative significant relationship between applied P_2O_5 and specific gravity, and applied K_2O and specific gravity. The interaction factor had an appreciable influence only at the high rates of fertilization. The adjusted coefficient of multiple determination showed that the equation explains 64 and 38 per cent of the variance for 1956 and 1957, respectively.

Size

The percentage of grade B tubers tended to be highest on the unfertilized plots (Tables 8 and 9). A small, but significant, correlation was found between the interaction of P_2O_5 and K_2O applied and the percentage of grade B tubers (Table 6). A significant negative correlation also existed between K_2O applied in 1956 and the per cent of grade B tubers. The regression equations explained a limited amount of the variance (16 and 1 per cent) in the per cent of grade B tubers for 1956 and 1957, respectively. This indicates a minor effect of fertilizer combinations on the number of tubers smaller than 1-7/8 inch in diameter.

Chemical Composition of Tubers

The tubers were analyzed for nitrogen, calcium, phosphorus, potassium, magnesium, and sodium. These data are reported in Tables 10, 11, 12, and 15. The relationships between the composition of tubers and the levels of P_2O_5 and K_2O fertilizers as expressed by the equation $\hat{y} = a + b_1x_1 + b_2x_2 + b_3(x_1x_2)$ are reported in Table 15. This type of equation was used because higher $\overline{R}^2$ values and lower S values were obtained than where the curvilinear type equation ($\log y = a + b_1\log x_1 + b_2\log x_2$) was calculated to express these relationships for Ca, P, and K.

In general, there was a marked seasonal variation in the effect of the applied P_2O_5 and K_2O on the per cent composition of several of the elements.

In 1957 as applied P_2O_5 and K_2O were increased the per cent N in the tubers decreased. The coefficients of both terms were negative and significantly different from zero. The results in 1956 were so heterogenous that no coefficient of any variable was significantly different from zero.

There was a tendency for the per cent of Ca to be reduced as P_2O_5 applications increased in 1956. In 1957 an increase in Ca percentage was associated with the amount of K_2O applied. This is indicated by the significant coefficients of the respective terms. The amount of variance explained in the per cent Ca was much higher in 1957 than in 1956, as indicated by the respective higher values of 60 and 22 per cents.

As the amount of P_2O_5 applied increased, the percentage of P in the tubers increased. This relationship was highly significant both years as indicated by the significance of the coefficients for the applied P_2O_5 term (x_1) and also by the amount of variance accounted for. In 1956, 65 per cent of the variance was accounted for, and in 1957 approximately 77 per cent.

Similarly, as the amount of K_2O applied increased, the per cent of K in the tubers increased. There appears to be a significant effect on percentage of K in the tuber with increasing rates of applied P_2O_5 in 1957 (Table 15). Simple correlation coefficients of the per cent K were calculated according to the amount of applied phosphate fertilizer, where the K_2O level is held constant (Table 20). In two cases out of four where the amount of applied K_2O fertilizer was held constant the applied P_2O_5 fertilizer appeared to have a significant effect on the percentage of K in the tubers in 1957. In 1956 the K in the tuber did not appear to be significantly affected by the amounts of P_2O_5 fertilizer applied (Table 15). This was also found to be true where simple correlation coefficients were determined to evaluate this relationship (Table 20).

In 1957 the per cent of Mg increased as the amount of P_2O_5 and K_2O applied increased. This is indicated by the large amount of variance (77 per cent) accounted for. This relationship was not apparent in 1956.

Under conditions of the experiment, the application of P_2O_5 and K_2O apparently had little effect on the per cent of Na contained in the tuber.

Data in Table 13 and 14 show considerable variation occurred in 1957 and 1956 based on the per cent change of values. It is interesting to note the changes of 67.1 per cent in yield, 0.2 per cent in specific gravity, 8.9 per cent in grade B, 1.2 per cent in per cent N, 21.6 per cent Ca, 7.8 per cent P, 7.4 per cent K, 13.8 per cent in per cent Mg, and 18.0 per cent Na.

Yield and Chemical Composition of Tops

The effect of P_2O_5 and K_2O applications on the yield, per cent dry matter and composition of tops are reported in Tables 16, 17, 18, and 19.

There was a very small effect from applied P_2O_5 and K_2O on the yield of tops. None of the coefficients of the equation are significant. As the amount of P_2O_5 and K_2O applied increased, the per cent dry matter decreased. Seventy-six per cent of the variance was explained as indicated by the value of $\bar{R}^2$.

There was a tendency for the per cent of N to decrease with additional applications of P_2O_5 and K_2O, and a tendency for the per cent of Ca to decrease as the amount of P_2O_5 applied increased. The per cent of Ca decreased as the K_2O applied increased. The percentage of P in the tissue increased as the amount of P_2O_5 applied was increased.

There appears to be a significant effect on the percentage of K in the tissue with increasing rates of applied P_2O_5. This was also true with tubers in 1957 (Table 15). However, if simple correlation coefficients of the per cent K in the tops are calculated according to the amount of applied P_2O_5 fertilizer where the K_2O level is held constant, this over-all relationship apparently fails to hold (Table 20). A negative or positive correlation can be noted depending on the level of K_2O used. This might suggest that the interpretation of data on an over-all basis may be different than what might be the case if the relationships are considered where the levels of one of the factors is held constant. The per cent K was higher in tissue that was grown on plots where the highest amounts of K_2O were applied.

The per cent of Mg decreased as the amount of P_2O_5 and K_2O used were increased. There appeared to be a tendency for the per cent of Na to decrease as P_2O_5 and K_2O applied to the soil increased. However, no significant coefficients were observed in these relationships.

Soil Tests

The data in Table 21 show that the K soil test reflected the amount of applied K_2O to a greater degree than did the P test in predicting a similar P_2O_5 relationship.

The small range of the determinations of the P soil test were found not to have a significant relationship with the P_2O_5 applied. The determinations of the K soil test were found to be significantly influenced by K_2O applied.

SUMMARY

Studies were carried out to determine the effects of levels of phosphate and potash fertilization on yield, quality, and composition of potatoes grown on Houghton Muck. The yield, size, specific gravity, and composition of the tubers were determined. From top samples the yield, per cent dry matter, and composition were determined. Regression analysis, analysis of variance and simple correlations were used in evaluating the relationships that existed. The results are summarized as follows:

1. The average yields of tubers were 218.8 and 366.5 cwt. per acre for 1956 and 1957, respectively. This difference of 67.1 per cent could be attributed possibly to a more favorable growing season for the production of tubers.

2. Multiple correlation analysis and analysis of variance showed that fertilization had a significant influence upon the yield.

3. The prediction of yield based on applied fertilizer with a curvilinear type equation using a selected group of plots gave higher $\overline{R}^2$ values and lower S values than a straight line type equation.

4. Specific gravity of the tubers was related inversely to application rates of P_2O_5 and K_2O.

5. Check plots had a higher percentage of size grade B tubers than those receiving fertilizer.

6. The maturity of tops as indicated by the per cent dry matter was affected inversely as additional amounts of P_2O_5 and K_2O were applied. The interaction of P_2O_5 and and K_2O, however, had a significantly positive effect on the per cent dry matter.

7. In 1957 N percentages of the tubers and the tops decreased as additional amounts of P_2O_5 and K_2O were applied.

8. Phosphorus percentages of tops and tubers increased with increased application of P_2O_5.

9. Potassium percentages of tops and tubers increased with increased application of K_2O.

10. The straight line equation explained more of the variance than did the curvilinear equation when applied fertilizer was used as the variable to predict composition of tubers.

11. The K of the soil test was significantly influenced by K_2O fertilization.

12. The P of the soil test was not significantly influenced by P_2O_5 fertilization.

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APPENDIX

TABLE 1

PLOT DIAGRAM--SECTION F-2

MUCK EXPERIMENTAL FARM
Plot size 30 ft. by 10-2/3 ft.

Plot #	Treatments		Treatments		Plot #
114	*P150	**K450	P200	K700	95
113	P300	K300	P300	K800	94
112	P400	K400	P400	K800	93
111	P300	K900	P50	K400	92
110	P250	K600	P200	K200	91
109	P25	K25	P200	K800	90
108	P300	K600	P400	K200	89
107	P300	K200	P150	K150	88
106	P200	K400	P250	K250	87
105	P300	K700	P300	K400	86
104	P50	K50	P250	K500	85
103	P0	K200	P200	K100	84
102	P25	K75	P100	K800	83
101	P150	K300	P50	K100	82
100	P100	K400	P100	K300	81
99	P100	K200	P250	K750	80
98	P0	K0	P100	K600	79
97	P400	K600	P350	K700	78
96	P100	K0	P200	K600	77

*P as P_2O_5.

**K as K_2O.

TABLE 1 (Continued)

Plot #	Treatments		Treatments		Plot #
76	P150	K600	P0	K0	57
75	P400	K800	P0	K200	56
74	P75	K225	P200	K800	55
73	P50	K150	P200	K200	54
72	P250	K400	P350	K350	53
71	P350	K500	P100	K800	52
70	P0	K0	P100	K600	51
69	P300	K200	P25	K75	50
68	P350	K350	P150	K150	49
67	P200	K400	P200	K500	48
66	P400	K200	P100	K200	47
65	P300	K400	P250	K250	46
64	P200	K500	P350	K400	45
63	P400	K600	P300	K700	44
62	P200	K600	P25	K25	43
61	P300	K600	P300	K800	42
60	P400	K900	P400	K400	41
59	P350	K400	P100	K0	40
58	P100	K100	P100	K400	39

TABLE 1 (Continued)

Plot #	Treatments		Treatments		Plot #
38	P300	K800	P200	K100	19
37	P200	K600	P400	K800	18
36	P100	K400	P300	K400	17
35	P150	K600	P300	K300	16
34	P400	K400	P400	K900	15
33	P250	K500	P200	K800	14
32	P50	K100	P50	K50	13
31	P300	K900	P350	K700	12
30	P100	K600	P250	K600	11
29	P200	K700	P75	K225	10
28	P150	K300	P50	K150	9
27	P400	K200	P100	K100	8
26	P250	K750	P100	K200	7
25	P200	K400	P350	K500	6
24	P250	K400	P300	K600	5
23	P100	K800	P100	K300	4
22	P150	K450	P50	K400	3
21	p400	K600	P200	K200	2
20	P300	K200	P0	K0	1

TABLE 2

ADJUSTMENT OF THE BECKMAN SPECTROPHOTOMETER FOR THE DETERMINATION OF CALCIUM AND SODIUM

Wave length	422.7	589.3
Photo tube resistor	"2	"2
Photo tube filter	blue	blue
Selector	0.1	0.1
Photo-multiplier sensitivity	full	2
Zero suppression	1.0	1.0
Oxygen pressure		
(a) tank	40	40
(b) instrument panel	11	11
Hydrogen pressure		
(a) tank	10	10
(b) instrument panel	5.75	5.75
Slit width	.07	.05

TABLE 3

SOIL TEST AND YIELD, SPECIFIC GRAVITY AND PER CENT OF GRADE B TUBERS
AS AFFECTED BY LEVELS OF PHOSPHATE AND POTASH FERTILIZATION

Plot	Pounds per Acre				Cwt/A		Specific Gravity		% Grade B	
No.	P_2O_5	K_2O	P*	K*	1956	1957	1956	1957	1956	1957
98	0	0	6.	55.	206.8	226.3	1.063	1.071	9.4	7.7
70	0	0	6.	34.	130.6	175.8	1.071	1.068	13.4	17.2
57	0	0	6.	27.	123.7	157.9	1.063	1.066	10.2	12.9
1	0	0	5.	48.	123.7	168.1	1.074	1.082	6.6	14.3
96	100	0	5.	27.	114.4	133.9	1.069	1.071	14.6	15.0
40	100	0	5.	34.	88.3	264.6	1.059	1.067	6.0	7.7
109	25	25	5.	89.	148.6	286.9	1.075	1.066	7.9	7.5
43	25	25	2.	27.	170.9	332.1	1.071	1.065	5.2	3.7
104	50	50	5.	41.	151.0	243.8	1.070	1.070	8.3	7.8
13	50	50	5.	48.	181.5	352.0	1.076	1.073	8.1	3.9
102	25	75	2.	27.	254.8	284.5	1.071	1.066	5.1	9.0
50	25	75	6.	48.	190.1	319.9	1.071	1.071	5.8	5.3
82	50	100	--	--	158.3	359.0	1.065	1.064	6.4	4.4
32	50	100	5.	55.	251.5	358.2	1.073	1.070	6.1	2.6
58	100	100	6.	62.	178.3	368.7	1.068	1.072	4.7	4.0
8	100	100	7.	55.	208.4	328.8	1.076	1.079	6.2	7.6
84	200	100	9.	55.	162.8	296.7	1.063	1.063	6.5	8.1
19	200	100	10.	89.	122.1	338.6	1.064	1.066	13.3	4.6
73	50	150	--	--	287.3	349.2	1.069	1.069	2.8	5.3
9	50	150	10.	82.	273.1	319.9	1.074	1.073	2.4	7.4
88	150	150	8.	185.	163.2	288.6	1.067	1.062	6.7	5.2
49	150	150	6.	48.	229.1	356.5	1.066	1.066	4.1	4.0
103	0	200	4.	41.	216.5	304.4	1.061	1.068	2.8	12.1
56	0	200	3.	76.	210.8	333.3	1.059	1.061	4.6	6.2
99	100	200	6.	89.	264.6	355.7	1.069	1.070	5.5	3.9

*Extracted with .018N acetic acid.

TABLE 3 (Continued)

Plot No.	Pounds per Acre P_2O_5	K_2O	P*	K*	Cwt/A 1956	1957	Specific Gravity 1956	1957	% Grade B 1956	1957
47	100	200	3.	48.	247.0	387.9	1.064	1.064	5.4	5.4
7	100	200	8.	76.	264.1	411.1	1.073	1.069	1.8	4.8
91	200	200	6.	151.	235.2	324.8	1.066	1.061	7.6	10.6
54	200	200	14.	82.	226.3	263.7	1.064	1.063	5.0	8.5
2	200	200	7.	82.	293.9	415.1	1.074	1.069	2.8	5.3
107	300	200	--	--	209.6	324.8	1.065	1.059	9.7	8.6
69	300	200	--	--	204.7	444.4	1.064	1.068	2.6	3.5
20	300	200	10.	76.	184.8	365.5	1.063	1.066	8.8	3.6
89	400	200	9.	55.	178.7	282.4	1.063	1.056	8.2	9.2
66	400	200	7.	158.	211.6	387.0	1.060	1.064	6.5	4.9
27	400	200	27.	82.	266.6	408.2	1.073	1.069	5.0	9.3
74	75	225	5.	96.	170.1	401.7	1.066	1.062	8.8	6.4
10	75	225	4.	76.	260.9	371.6	1.069	---	5.1	8.9
87	250	250	7.	82.	153.4	248.3	1.061	1.054	14.6	11.5
46	250	250	10.	172.	210.0	426.5	1.056	1.062	6.2	5.4
81	100	300	4.	110.	266.2	412.7	1.061	1.058	4.9	4.5
4	100	300	7.	76.	395.4	498.6	1.064	1.072	2.3	4.4
101	150	300	3.	34.	245.8	374.0	1.064	1.068	5.6	4.0
28	150	300	7.	62.	294.3	458.7	1.071	1.065	4.0	4.9
113	300	300	7.	220.	203.9	350.0	1.064	1.061	9.0	6.7
16	300	300	16.	124.	262.5	459.1	1.064	1.065	5.4	4.9
68	350	350	10.	82.	117.2	468.0	1.065	1.067	5.6	4.7
53	350	350	8.	82.	219.4	381.4	1.059	1.062	7.2	6.1
92	50	400	7.	199.	317.9	313.0	1.066	1.057	4.5	6.1
3	50	400	5.	117.	317.5	370.0	1.065	1.071	2.3	5.6
100	100	400	6.	48.	237.7	465.6	1.065	1.062	3.9	5.6
39	100	400	7.	89.	252.7	422.1	1.056	1.063	4.3	3.3
36	100	400	8.	158.	219.4	356.1	1.058	1.056	3.9	6.5
106	200	400	6.	124.	172.6	331.3	1.056	1.058	9.0	9.1

TABLE 3 (Continued)

Plot No.	Pounds per Acre P_2O_5	K_2O	P*	K*	Cwt/A 1956	1957	Specific Gravity 1956	1957	% Grade B 1956	1957
67	200	400	--	--	374.0	440.8	1.058	1.061	3.2	5.3
25	200	400	7.	62.	258.0	418.4	1.068	1.067	1.6	4.7
72	250	400	10.	110.	230.4	435.9	1.048	1.058	13.0	6.4
24	250	400	7.	76.	293.8	467.6	1.064	1.062	2.8	6.5
86	300	400	--	--	160.8	279.2	1.051	1.059	7.8	8.2
65	300	400	7.	130.	266.6	378.9	1.058	1.061	6.3	10.8
17	300	400	--	--	177.8	354.9	1.060	1.061	8.9	5.3
59	350	400	12.	144.	339.0	462.8	1.054	1.065	7.1	4.0
45	350	400	9.	130.	196.6	354.1	1.053	1.057	4.3	7.5
112	400	400	10.	117.	274.7	329.7	1.056	1.060	7.0	11.6
41	400	400	6.	144.	166.4	344.3	1.048	1.060	11.2	7.0
34	400	400	16.	137.	295.5	458.3	1.061	1.077	3.9	5.0
114	150	450	10.	103.	223.8	282.4	1.053	1.056	4.7	6.2
22	150	450	5.	110.	204.7	393.6	1.053	1.059	7.4	5.8
64	200	500	6.	117.	243.0	435.5	1.052	1.070	6.2	5.2
48	200	500	9.	110.	282.9	354.9	1.056	1.062	7.1	5.8
85	250	500	9.	96.	184.8	304.0	1.052	1.056	4.8	9.5
33	250	500	10.	144.	291.8	447.7	1.060	1.063	3.5	4.7
71	350	500	8.	130.	225.5	428.6	1.059	1.062	4.9	4.8
6	350	500	10.	158.	274.3	433.4	1.061	1.070	3.4	9.7
79	100	600	3.	165.	233.2	388.7	1.059	1.056	4.0	7.0
51	100	600	6.	151.	323.2	407.8	1.057	1.060	3.3	5.6
30	100	600	6.	144.	233.6	418.0	1.055	1.054	4.5	5.3
76	150	600	6.	130.	160.4	313.0	1.047	1.056	5.6	7.4
35	150	600	16.	172.	230.0	399.7	1.051	1.060	3.9	6.3
77	200	600	8.	165.	203.5	398.0	1.053	1.063	8.4	6.3
62	200	600	--	--	199.0	405.0	1.052	1.060	5.1	6.4
37	200	600	10.	371.	173.4	328.0	1.047	1.056	9.9	6.8
110	250	600	7.	144.	211.6	374.0	1.049	1.062	7.1	12.3

TABLE 3 (Continued)

Plot No.	Pounds per Acre				Cwt/A		Specific Gravity		% Grade B	
	P_2O_5	K_2O	P*	K*	1956	1957	1956	1957	1956	1957
11	250	600	7.	48.	279.6	481.1	1.054	1.073	6.6	8.2
108	300	600	6.	137.	220.2	326.0	1.054	1.055	5.4	6.5
61	300	600	8.	165.	212.0	413.5	1.051	1.057	2.9	7.5
5	300	600	7.	103.	274.7	466.4	1.059	1.067	6.1	7.2
97	400	600	11.	165.	216.1	381.0	1.055	1.059	3.6	4.5
63	400	600	11.	82.	179.9	440.8	1.047	1.058	9.0	6.9
21	400	600	9.	103.	226.7	441.6	1.059	1.055	8.1	3.4
95	200	700	6.	103.	146.1	256.0	1.060	1.052	7.0	10.3
29	200	700	10.	96.	296.3	499.8	1.061	---	3.0	4.5
105	300	700	10.	158.	208.4	297.1	1.051	1.056	7.4	12.5
44	300	700	8.	178.	217.3	435.9	1.054	1.060	5.8	4.6
78	350	700	12.	220.	127.4	421.6	1.042	1.058	14.4	6.2
12	350	700	10.	199.	217.3	434.3	1.055	1.062	7.8	5.9
80	250	750	3.	117.	234.8	343.9	1.043	1.054	7.8	7.1
26	250	750	6.	158.	237.7	411.9	1.057	1.070	3.8	5.9
83	100	800	3.	185.	187.2	156.7	1.050	1.053	82.	11.7
52	100	800	5.	124.	232.0	408.6	1.046	1.055	5.6	5.4
23	100	800	12.	233.	264.1	461.9	1.054	1.059	2.9	5.7
90	200	800	--	--	257.2	286.9	1.056	1.057	1.6	10.4
55	200	800	5.	69.	136.8	341.9	1.045	1.056	6.6	8.7
14	200	800	10.	240.	208.4	515.3	1.048	1.065	8.6	4.2
94	300	800	5.	151.	198.2	291.4	1.055	1.052	9.2	14.4
42	300	800	5.	55.	234.0	381.4	1.054	1.056	6.4	7.7
38	300	800	8.	158.	158.7	330.5	1.050	1.055	9.2	5.7
93	400	800	6.	41.	205.9	347.6	1.055	1.059	8.7	8.9
75	400	800	13.	268.	214.1	281.6	1.051	1.052	6.3	12.1
18	400	800	14.	240.	144.1	317.9	1.049	1.060	14.1	4.4
111	300	900	10.	295.	238.9	357.3	1.051	1.057	4.9	13.2

TABLE 3 (Continued)

Plot No.	Pounds per Acre P_2O_5	Pounds per Acre K_2O	Pounds per Acre P*	Pounds per Acre K*	Cwt/A 1956	Cwt/A 1957	Specific Gravity 1956	Specific Gravity 1957	% Grade B 1956	% Grade B 1957
31	300	900	6.	76.	230.8	454.6	1.050	1.065	4.8	6.3
60	400	900	13.	281.	108.7	428.6	1.051	1.056	16.1	6.6
15	400	900	11.	268.	238.9	452.2	1.053	1.063	9.0	5.0

TABLE 4

YIELD AS INFLUENCED BY LEVELS OF PHOSPHATE AND POTASH FERTILIZATION

Lbs/A P_2O_5	Cwt/A 1956	Cwt/A 1957	Lbs/A K_2O	Cwt/A 1956	Cwt/A 1957
No fert.	146.2	182.0	No fert.	146.2	182.0
100	246.6	386.5	200	232.3	364.2
200	228.2	372.4	400	238.0	381.6
300	208.5	363.1	600	224.6	401.1
400	215.0	368.4	800	203.4	343.5

TABLE 5

ANALYSIS OF VARIANCE OF YIELD OF 4 x 4 x 3 FACTORIAL AS INFLUENCED BY LEVELS OF PHOSPHATE AND POTASH FERTILIZATION

Source	DF	Sum of Squares		Mean Squares		F		SD	
		1956	1957	1956	1957	1956	1957	1956	1957
Total	47	103,367.81	208,008.93	--	--	--	--	--	--
Reps.	2	1,822.07	47,973.86	911.04	23,986.93	1.72	16.84**	--	--
Treat.	15	33,621.06	45,970.52	2,241.40	3,064.70	4.23**	2.15*	--	--
P level	3	10,150.74	3,628.18	3,383.58	1,209.39	6.39**	.849	--	--
P_1 vs P_2, P_3, P_4	1	7,738.13	3,099.71	7,738.13	3,099.71	14.61**	2.18	--	--
P_2 vs P_3, P_4	1	2,157.15	360.46	2,157.15	360.46	4.07	.253	--	--
P_3 vs P_4	1	255.45	168.01	255.45	168.01	.482	.118	--	--
K Level	3	8,264.07	21,725.98	2,754.69	7,241.99	5.20*	5.08*	--	--
K_2 vs K_4, K_6, K_8	1	944.54	1,123.93	944.54	1,123.93	1.78	.789	--	--
K_4 vs K_6, K_8	1	4,614.40	701.25	4,614.40	701.25	8.71**	.492	--	--
K_6 vs K_8	1	2,705.13	19,900.80	2,705.13	19,900.80	5.11*	13.97**	--	--
P x K	9	15,206.25	20,619.70	1,689.58	2,291.08	3.19**	1.61	--	--
Error	30	15,888.82	42,735.95	529.63	1,424.53	--	--	23.01	37.74

LSD 30/3 : 1.667 x 23.01 = 38.36

LSD 30/3 : 1.667 x 37.74 = 62.91

*--Significant at 5 per cent level.

**--Significant at 1 per cent level.

TABLE 6

REGRESSION RELATIONSHIPS BETWEEN YIELD, PER CENT OF GRADE B, AND SPECIFIC GRAVITY OF TUBERS AND THE LEVELS OF PHOSPHATE AND POTASH FERTILIZATION USING 114 OBSERVATIONS AND DETERMINED BY THE EQUATION $\hat{y} = a + b_1x_1 + b_2x_2 + b_3 x_1 x_2$

						$\bar{R}^2$	S
Cwt/A 1956	$\hat{y}$ =	178.752 +	.166448x_1 *(.075653)	+ .152888x_2 *(.039490)	- .000571(x_1x_2) *(.000162)	.098490	52.7676
Cwt/A 1957	$\hat{y}$ =	271.172 +	.357316x_1 *(.099351)	+ .193248x_2 *(.051860)	- .000598(x_1x_2) *(.000212)	.197693	69.2967
Per cent grade B 1956	$\hat{y}$ =	7.50918 +	.004846x_1 (.003986)	- .008281x_2 *.002081)	+ .000033(x_1x_2) *(.000008)	.155396	2.78050
Per cent grade B 1957	$\hat{y}$ =	8.09567 -	.007735x_1 (.004066)	- .003240x_2 (.002123)	+ .000018(x_1x_2) *(.000009)	.013840	2.83628
Specific gravity 1956	$\hat{y}$ =	1.07172 -	.000015x_1 *(.000007)	- .000028x_2 *(.000004)	+ .00000002(x_1x_2) (.000000015)	.636539	.004914
Specific gravity 1957	$\hat{y}$ =	1.07094 -	.000016x_1 *(.000007)	- .000021x_2 *(.000004)	+ .00000004(x_1x_2) *(.000000015)	.375501	.004868

x_1 -- Pounds per acre of applied P_2O_5 fertilizer   * Significantly different from zero

x_2 -- Pounds per acre of applied K_2O fertilizer

(x_1x_2) -- Interaction of x_1 and x_2

$\bar{R}^2$ -- Adjusted coefficient of multiple determination

S -- Standard error of estimate

TABLE 7

COMPARISON OF REGRESSION RELATIONSHIPS OF THE YIELD OF TUBERS AND THE LEVELS OF PHOSPHATE AND POTASH FERTILIZATION USING VARIATION IN OBSERVATIONS AND TYPE OF EQUATIONS

Observations		$\bar{R}^2$	S
114(1956)	$\hat{y} = 178.752 + .166448x_1 + .152888x_2 - .000571(x_1x_2)$	.098490	52.7676
114(1957)	$\hat{y} = 271.172 + .357316x_1 + .193248x_2 - .000598(x_1x_2)$	.197693	69.2967
114(1956) log	$\hat{y} = 1.42131 - .055099\log x_1 - .000131x_1 + .205021\log x_2 - .000211x_2$	.342	
114(1957)	$\hat{y} = 43.8146 - 2.49736x_1 + 4.22147\sqrt{x_1} - 3.21284x_2 + 19.1151\sqrt{x_2} + 2.75367(\sqrt{x_1x_2})$	.61	
36(1956)	$\hat{y} = 156.881 + .001995x_1 + .414397x_2 - .000674(x_1x_2)$	.499012	45.5564
36(1957)	$\hat{y} = 236.814 + .438644x_1 + .377174x_2 + .000134(x_1x_2)$	.532734	58.0459
36(1956) log	$\hat{y} = 2.10385 - .030107\log x_1 + .140321\log x_2$	.620480	1.12222
36(1957) log	$\hat{y} = 2.24649 + .026249\log x_1 + .117892\log x_2$	.762655	1.11595

TABLE 8

SOIL TEST AND YIELD, SPECIFIC GRAVITY, AND PER CENT OF GRADE B TUBERS AS AFFECTED BY PHOSPHATE FERTILIZATION

Lbs/A		Cwt/A		Specific Gravity		% Grade B	
P_2O_5*	P	1956	1957	1956	1957	1956	1957
0	5	168.7	227.6	1.065	1.069	7.8	11.7
25	4	191.1	305.8	1.072	1.067	6.0	6.4
50	6	242.2	333.1	1.070	1.068	5.1	5.4
75	4	215.5	386.6	1.068	1.062	7.0	7.6
100	6	227.7	364.7	1.062	1.064	5.1	6.3
150	7	218.9	358.4	1.059	1.062	5.2	5.5
200	8	219.9	368.6	1.058	1.061	6.8	6.9
250	8	232.8	394.1	1.054	1.061	7.0	7.8
300	8	216.4	375.5	1.056	1.059	6.7	7.6
350	10	214.6	421.8	1.056	1.062	6.8	6.1
400	10	206.8	382.8	1.056	1.060	8.3	7.0

*Averages of all plots receiving listed amount of fertilizer as given in Table 3.

TABLE 9

SOIL TEST AND YIELD, SPECIFIC GRAVITY, AND PER CENT OF GRADE B TUBERS AS AFFECTED BY POTASH FERTILIZATION

Lbs/A		Cwt/A		Specific Gravity		% Grade B	
K_2O*	K	1956	1957	1956	1957	1956	1957
0	38.	131.2	187.8	1.066	1.071	10.0	12.5
25	58.	159.8	309.5	1.073	1.065	6.5	5.6
50	44.	166.2	297.9	1.073	1.071	8.2	5.8
75	38.	222.4	302.2	1.071	1.069	5.4	7.2
100	57.	180.2	341.7	1.068	1.069	7.2	5.2
150	98.	238.2	328.6	1.069	1.068	4.0	5.5
200	80.	228.5	355.1	1.065	1.065	5.4	6.8
225	86.	215.2	386.6	1.068	1.062	7.0	7.6
250	127.	181.7	337.4	1.058	1.058	10.4	8.4
300	104.	272.0	425.5	1.065	1.065	5.2	4.9
350	82.	168.3	419.7	1.062	1.064	6.4	5.4
400	120.	257.1	389.7	1.058	1.061	5.8	6.6
450	106.	214.2	338.0	1.053	1.058	6.0	6.0
500	126.	250.4	400.7	1.057	1.064	5.0	6.6
600	150.	223.2	398.0	1.053	1.060	5.8	6.7
700	159.	202.1	390.8	1.053	1.057	7.6	7.3
750	138.	236.2	377.9	1.050	1.062	5.8	6.5
800	169.	203.4	343.4	1.051	1.056	7.3	8.3
900	230.	204.3	423.2	1.051	1.060	8.7	7.8

*Averages of all plots receiving listed amount of fertilizer as given in Table 3.

TABLE 10

COMPOSITION OF TUBERS AS AFFECTED BY LEVELS OF PHOSPHATE AND POTASH FERTILIZATION

Plot	Lbs/A		N		Ca		P		K		Mg		Na	
Nos.	P_2O_5	K_2O	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
98	0	0	1.886	2.201	.040	.024	.55	.37	2.67	1.92	.144	.071	.120	.080
70	0	0	1.929	2.084	.026	.021	.40	.40	1.64	1.70	.104	.085	.064	.072
57	0	0	1.926	2.181	.043	.027	.45	.35	2.07	2.04	.096	.078	.100	.048
1	0	0	1.436	1.983	.037	.021	.45	.40	2.25	1.80	.108	.091	.064	.052
96,40	100	0	1.928	2.238	.032	.023	.55	.52	2.13	1.82	.111	.093	.064	.068
109,43	25	25	1.910	2.007	.037	.023	.42	.40	2.13	2.07	.100	.104	.080	.084
104,13	50	50	1.835	2.094	.035	.023	.45	.42	2.00	2.00	.098	.092	.075	.052
102,50	25	75	1.754	2.000	.032	.021	.40	.35	2.04	2.04	.100	.104	.092	.064
82,32	50	100	1.852	1.906	.040	.026	.42	.37	2.34	2.25	.109	.111	.070	.060
58,8	100	100	1.688	1.805	.038	.023	.47	.42	2.16	1.94	.108	.095	.064	.064
84,19	200	100	1.896	2.010	.044	.026	.47	.52	2.32	2.43	.108	.116	.064	.072
73,9	50	150	1.547	1.812	.038	.023	.35	.37	2.22	2.18	.106	.116	.090	.072
88,49	150	150	1.895	1.936	.034	.026	.47	.47	2.31	2.34	.116	.108	.064	.076
103,56	0	200	1.846	2,027	.043	.030	.35	.32	2.46	2.43	.102	.116	.072	.064
99,47,7	100	200	1.722	1.721	.043	.023	.42	.37	2.34	2.34	.096	.100	.075	.068
91,54,2	200	200	1.688	1.919	.040	.029	.47	.50	2.25	2.61	.112	.116	.070	.080
107,69,20	300	200	2.084	1.926	.029	.024	.60	.55	2.64	2.47	.120	.111	.064	.080
89,66,27	400	200	1.909	1.913	.023	.026	.57	.57	2.00	2.61	.121	.118	.085	.072
74,10	75	225	1.600	2.128	.027	.026	.37	.40	2.48	2.74	.098	.133	.072	.084
87,46	250	250	1.930	1.951	.032	.032	.55	.55	2.64	2.81	.104	.148	.072	.072
81,4	100	300	1.932	1.735	.034	.030	.55	.42	3.44	2.87	.124	.130	.100	.064
101,28	150	300	1.698	1.922	.026	.027	.47	.40	2.52	2.51	.102	.125	.070	.064
113,16	300	300	1.567	1.698	.030	.030	.60	.55	3.67	2.74	.118	.136	.075	.052
68,53	350	350	1.752	1.684	.024	.024	.60	.50	2.88	2.55	.116	.128	.070	.052
92,3	50	400	1.670	1.688	.026	.029	.30	.32	2.74	2.61	.104	.125	.072	.072
100,39,36	100	400	1.869	1.882	.034	.029	.45	.37	2.64	2.64	.093	.131	.055	.060
106,67,25	200	400	1.808	1.748	.034	.029	.50	.50	2.75	2.72	.100	.132	.052	.060

TABLE 10 (Continued)

Plot Nos.	Lbs/A		N		Ca		P		K		Mg		Na	
	P_2O_5	K_2O	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
72,24	250	400	1.990	1.718	.043	.027	.60	.50	3.44	2.64	.122	.137	.088	.068
86,65,17	300	400	2.014	1.839	.027	.027	.55	.52	2.37	2.84	.099	.126	.060	.064
59,45	350	400	2.097	1.752	.037	.030	.60	.55	3.22	2.98	.102	.124	.080	.060
112,41,34	400	400	1.691	1.624	.037	.030	.55	.55	3.22	2.94	.107	.138	.068	.056
114,22	150	450	1.950	1.877	.040	.030	.45	.45	3.00	2.75	.111	.156	.076	.052
64,48	200	500	1.940	1.792	.038	.033	.50	.47	2.05	2.84	.106	.143	.072	.052
85,33	250	500	1.943	1.812	.041	.037	.52	.57	3.28	2.94	.113	.142	.060	.060
71,6	350	500	1.644	1.554	.034	.030	.55	.50	3.22	2.64	.098	.135	.092	.052
79,51,30	100	600	1.762	1.886	.037	.035	.37	.45	3.22	2.79	.100	.133	.092	.060
76,35	150	600	2.003	2,054	.043	.032	.50	.45	3.50	2.79	.145	.133	.096	.052
77,62,37	200	600	1.956	1.980	.044	.032	.50	.55	3.28	2.89	.120	.140	.096	.052
110,11	250	600	1.661	1.631	.041	.035	.55	.52	3.44	3.11	.108	.135	.076	.060
108,61,5	300	600	1.799	1.577	.040	.035	.60	.55	3.38	3.05	.114	.133	.092	.048
97,63,21	400	600	1.970	1.822	.046	.034	.65	.57	3.56	3.11	.120	.131	.088	.048
95,29	200	700	1.704	1.973	.035	.040	.50	.47	2.98	3.28	.104	.128	.072	.056
105,44	300	700	1.990	1.836	.044	.034	.60	.50	3.44	2.98	.106	.151	.092	.056
78,12	350	700	1.866	1.902	.046	.027	.65	.57	3.56	3.05	.105	.149	.084	.056
80,26	250	750	1.906	1.574	.040	.035	.60	.47	3.33	3.16	.108	.171	.084	.052
83,52,23	100	800	1.950	1.718	.040	.029	.50	.40	3.62	2.94	.114	.156	.088	.112
90,55,14	200	800	1.899	1.704	.041	.029	.57	.47	3.50	2.94	.113	.155	.080	.064
94,42,38	300	800	1.942	1.852	.040	.035	.57	.55	3.50	3.11	.114	.145	.068	.076
93,75,18	400	800	1.838	1.778	.041	.033	.57	.55	3.38	2.98	.113	.147	.096	.060
111,31	300	900	1.644	1.366	.041	.029	.57	.47	3.38	2.98	.111	.135	.088	.080
60,15	400	900	1.792	1.638	.041	.033	.62	.55	3.50	3.22	.088	.145	.088	.068

TABLE 11

COMPOSITION OF TUBERS AS AFFECTED BY PHOSPHATE FERTILIZER
(Per Cent)

Lbs/A	N		Ca		P		K		Mg		Na	
P_2O_5*	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
0	1.812	2.084	.039	.026	.42	.36	2.26	2.05	.109	.093	.082	.063
25	1.832	2.004	.034	.022	.14	.38	2.08	2.06	.100	.104	.086	.074
50	1.726	1.875	.036	.023	.38	.37	2.32	2.26	.104	.111	.076	.064
75	1.600	2.128	.027	.026	.37	.40	2.48	2.74	.098	.133	.072	.084
100	1.836	1.855	.037	.027	.47	.42	2.79	2.48	.107	.120	.077	.071
150	1.866	1.947	.036	.029	.47	.44	2.83	2.60	.118	.130	.076	.061
200	1.842	1.875	.039	.031	.50	.50	2.88	2.82	.109	.133	.072	.062
250	1.886	1.737	.039	.033	.56	.52	3.23	2.93	.111	.147	.076	.062
300	1.832	1.676	.036	.031	.58	.33	3.04	2.88	.112	.134	.077	.065
350	1.840	1.723	.035	.030	.60	.53	3.22	2.80	.105	.134	.082	.055
400	1.840	1.755	.038	.031	.59	.56	3.13	2.97	.110	.136	.085	.061

*Averages of all plots receiving listed amount of fertilizer as given in Table 3.

TABLE 12

COMPOSITION OF TUBERS AS AFFECTED BY POTASH FERTILIZATION
(Per Cent)

Lbs/A	N		Ca		P		K		Mg		Na	
K_2O*	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
0	1.839	2.154	.035	.023	.49	.43	2.15	1.85	.112	.085	.079	.065
25	1.910	2.007	.037	.023	.42	.40	2.13	2.07	.100	.104	.080	.084
50	1.835	2.094	.035	.023	.45	.42	2.00	2.00	.098	.092	.075	.052
75	1.754	2.000	.032	.021	.40	.35	2.04	2.04	.092	.064	.092	.064
100	1.812	1.907	.041	.025	.45	.44	2.27	2.21	.108	.107	.066	.065
150	1.721	1.874	.036	.024	.41	.42	2.26	2.26	.111	.112	.077	.074
200	1.835	1.901	.036	.026	.48	.46	2.34	2.49	.110	.112	.073	.073
225	1.600	2.128	.027	.026	.37	.40	2.48	2.74	.098	.133	.072	.084
250	1.930	1.951	.032	.032	.55	.55	2.64	2.81	.104	.148	.072	.072
300	1.732	1.785	.030	.029	.54	.46	3.21	2.71	.115	.130	.082	.060
350	1.752	1.684	.024	.024	.60	.50	2.88	2.55	.116	.128	.070	.052
400	1.877	1.750	.034	.031	.51	.47	2.91	2.77	.104	.130	.068	.063
450	1.950	1.877	.040	.030	.45	.45	3.00	2.75	.111	.156	.076	.052
500	1.842	1.719	.038	.033	.52	.51	3.18	2.81	.106	.140	.075	.055
600	1.858	1.796	.042	.034	.53	.52	3.40	2.96	.118	.134	.090	.053
700	1.853	1.904	.042	.037	.58	.51	3.33	3.10	.105	.143	.083	.056
750	1.906	1.574	.040	.035	.60	.47	3.33	3.16	.108	.171	.084	.052
800	1.907	1.763	.041	.032	.155	.49	3.50	2.99	.114	.151	.083	.078
900	1.718	1.502	.041	.031	.60	.51	3.44	3.10	.100	.140	.088	.074

*Averages of all plots receiving listed amount of fertilizer as given in Table 3.

TABLE 13

AVERAGES OF YIELD, SPECIFIC GRAVITY, PER CENT OF GRADE B, AND COMPOSITION OF TUBERS

Year	Cwt/A	Specific Gravity	Per Cent Grade B	N	Ca	P	K	Mg	Na
1956	218	1.060	6.44	1.830	.037	.51	2.84	.109	.078
1957	366	1.062	7.01	1.852	.029	.47	2.63	.124	.064

TABLE 14

PERCENTAGE CHANGE OF 1957 AVERAGES OF YIELD, SPECIFIC GRAVITY, PER CENT OF GRADE B, AND COMPOSITION OF TUBERS WITH RESPECT TO 1956 AVERAGES

Cwt/A	Specific Gravity	Per Cent Grade B	N	Ca	P	K	Mg	Na
+67.1	+0.2	+8.9	+1.2	-21.6	-7.8	-7.4	+13.8	-18.0

TABLE 15

REGRESSION RELATIONSHIPS BETWEEN THE COMPOSITION OF TUBERS AND THE LEVELS OF PHOSPHATE AND POTASH FERTILIZATION USING 51 OBSERVATIONS AND DETERMINED BY THE EQUATION

$\hat{y} = a + b_1x_1 + b_2x_2 + b_3(x_1x_2)$

			a		b_1x_1		b_2x_2		$b_3(x_1x_2)$	$\bar{R}^2$	S
Per Cent Ca 1956	$\hat{y}$	=	.037255	-	$.000031x_1$ *(.000011)	+	$.0000005x_2$ (.000006)	+	$.00000006(x_1x_2)$ *(.00000002)	.216950	.005350
Per Cent Ca 1957	$\hat{y}$	=	.022896	+	$.000007x_1$ (.000006)	+	$.000015x_2$ *(.000003)	-	$.00000001(x_1x_2)$ (.00000001)	.600605	.002971
Per Cent N 1956	$\hat{y}$	=	1.76875	+	$.000372x_1$ (.000300)	+	$.001262x_2$ (.000160)	-	$.0000006(x_1x_2)$ (.0000007)	----[a]	.145682
Per Cent N 1957	$\hat{y}$	=	2.06992	-	$.0005918x_1$ *(.000284)	-	$.003910x_2$ *(.000151)	+	$.0000005(x_1x_2)$ (.0000006)	.418710	.137672
Per Cent P 1956	$\hat{y}$	=	.422262	+	$.000410x_1$ *(.000103)	-	$.000072x_2$ (.000055)	+	$.0000004(x_1x_2)$ (.0000002)	.646759	.050173
Per Cent P 1957	$\hat{y}$	=	.370632	+	$.000594x_1$ *(.000075)	-	$.000019x_2$ (.000040)	-	$.00000009(x_1x_2)$ (.0000002)	.767078	.036190
Per Cent K 1956	$\hat{y}$	=	2.05203	+	$.000969x_1$ (.000618)	+	$.001896x_2$ *(.000329)	-	$.000001(x_1x_2)$ (.000001)	.721183	.299972
Per Cent K 1957	$\hat{y}$	=	1.91962	+	$.001761x_1$ *(.000325)	+	$.001595x_2$ *(.000173)	-	$.000002(x_1x_2)$ *(.0000007)	.854619	.157702
Per Cent Mg 1956	$\hat{y}$	=	.104732	+	$.000031x_1$ (.000023)	+	$.000011x_2$ (.000012)	-	$.00000006(x_1x_2)$ (.00000005)	----[a]	.010923

[a] Calculated to be negative numbers.

TABLE 15 (Continued)

										$\bar{R}^2$	S
Per Cent Mg 1957	$\hat{y}$	=	.089165	+	.000088x_1 *(.000022)	+	.000097x_2 *(.000011)	-	.0000002(x_1x_2) *(.00000005)	.767524	.010439
Per Cent Na 1956	$\hat{y}$	=	.080742	-	.000059x_1 *(.000027)	-	.000006x_2 (.000014)	+	.0000001(x_1x_2) (.00000006)	.090991	.013065
Per Cent	$\hat{y}$	=	.065268	-	.000005x_1 (.000025)	+	.000014x_2 (.000013)	-	.00000006(x_1x_2) (.00000005)	.015825	.012113

TABLE 16

YIELD, PER CENT DRY MATTER, AND COMPOSITION OF TOPS AS AFFECTED BY LEVELS OF PHOSPHATE AND POTASH FERTILIZATION

Plot Nos.	Lbs/A		Cwt/A	Per Cent						
	P_2O_5	K_2O		Dry Matter	N	Ca	P	K	Mg	Na
98	0	0	8.90	14.32	2.908	1.91	.25	.66	1.70	.215
70	0	0	23.64	16.12	3.100	1.57	.25	.90	1.78	.172
82,32	50	100	17.56	12.28	3.016	1.88	.27	1.76	1.69	.179
99,47	100	200	19.97	11.13	2.681	1.85	.25	3.44	1.25	.190
91.54	200	200	23.03	9.35	3.047	1.44	.42	4.38	.85	.112
69,20	300	200	17.54	10.74	2.738	1.66	.55	3.72	1.48	.135
66,27	400	200	16.77	9.69	2.574	1.63	.55	3.56	1.34	.172
101,28	150	300	16.56	10.36	2.537	1.51	.27	4.44	.98	.162
100,36	100	400	25.75	9.97	2.812	1.44	.25	5.35	.99	.157
67,25	200	400	19.15	10.53	2.238	1.60	.30	4.92	.89	.162
86,65	300	400	23.64	9.47	2.503	1.32	.45	5.92	.64	.130
112,34	400	400	23.11	9.02	2.671	1.22	.55	7.00	.57	.130
85,33	250	500	19.80	9.82	2.855	1.55	.40	5.46	.66	.125
79,30	100	600	22.91	10.51	2.400	1.51	.27	6.75	.55	.140
77,62	200	600	24.24	9.55	2.570	1.07	.45	7.00	.64	.104
108,61	300	600	23.73	9.92	2.604	1.14	.42	6.14	.66	.096
97,63	400	600	22.83	9.37	2.571	1.03	.55	5.91	.72	.092
52,23	100	800	20.09	10.36	2.472	1.25	.32	6.25	.64	.162
90,55	200	800	25.93	9.54	2.740	1.14	.40	5.91	.76	.104
94,38	300	800	25.78	8.37	2.981	.97	.50	6.38	.61	.096
93,75	400	800	25.62	9.04	2.762	.85	.52	6.63	.56	.120

TABLE 17

SOIL TEST AND YIELD, PER CENT DRY MATTER, AND COMPOSITION OF TOPS AS AFFECTED BY PHOSPHATE FERTILIZATION

Lbs/A			Per Cent						
P_2O_5*	P	Cwt/A	Dry Matter	N	Ca	P	K	Mg	Na
0	6	16.27	15.22	3.004	1.74	.25	.78	1.74	.194
50	4	17.56	12.28	3.016	1.88	.27	1.76	1.69	.194
100	6	22.18	10.51	2.591	1.51	.27	5.49	.86	.162
150	5	16.51	10.36	2.537	1.51	.27	4.44	.98	.162
200	8	23.09	9.74	2.649	1.31	.39	5.55	.78	.120
250	10	19.80	9.82	2.855	1.55	.40	5.46	.66	.125
300	8	22.68	9.63	2.706	1.27	.48	5.34	.85	.114
400	10	22.08	9.28	2.644	1.18	.54	5.39	.80	.128

*Averages of all plots receiving listed amount of fertilizer as given in Table 16.

TABLE 18

SOIL TEST AND YIELD, PER CENT DRY MATTER, AND COMPOSITION OF TOPS AS AFFECTED BY POTASH FERTILIZATION

Lbs/A			Per Cent						
K_2O*	K	Cwt/A	Dry Matter	N	Ca	P	K	Mg	Na
0	44	16.27	15.22	3.004	1.74	.25	.78	1.74	.194
100	41	17.56	12.28	3.016	1.88	.27	1.76	1.69	.179
200	92	19.33	10.24	2.760	1.64	.44	3.78	1.23	.152
300	48	16.56	10.36	2.537	1.51	.27	4.44	.98	.162
400	142	22.91	9.75	2.556	1.40	.37	5.78	.77	.145
500	120	19.80	9.82	2.855	1.55	.40	5.46	.66	.125
600	134	23.43	9.84	2.536	1.19	.42	6.45	.64	.108
800	162	24.36	9.33	2.739	1.05	.44	6.29	.64	.120

*Averages of all plots receiving listed amount of fertilizer as given in Table 16.

TABLE 19

REGRESSION RELATIONSHIPS BETWEEN THE YIELD, THE PER CENT DRY MATTER, AND THE COMPOSITION OF TOPS AND THE LEVELS OF PHOSPHATE AND POTASH FERTILIZATION USING 21 OBSERVATIONS AND DETERMINED BY THE EQUATION $\hat{y} = a + b_1x_1 + b_2x_2 + b_3(x_1x_2)$

										$\overline{R}^2$	S
Cwt/A	$\hat{y}$	=	17.3402	-	.001721x_1 (.010612)	+	.007292x_2 (.005306)	+	.000012(x_1x_2) (.000023)	.292744	3.52626
Per Cent dry matter	$\hat{y}$	=	14.1801	-	.006069x_2 *(.002630)	-	.006069x_2 *(.001315)	+	.000016(x_1x_2) *(.000006)	.768135	.873853
Per Cent N	$\hat{y}$	=	3.02266	-	.001385x_1 *(.000582)	-	.000843x_2 *(.000291)	+	.000003(x_1x_2) *(.000001)	.270107	.193530
Per Cent Ca	$\hat{y}$	=	1.79734	+	.000073x_1 (.000413)	-	.000441x_2 *(.000206)	-	.000002(x_1x_2) *(.0000009)	.797702	.137202
Per Cent P	$\hat{y}$	=	.373131	+	.000831x_1 *(.000142)	-	.000027x_2 (.000071)	+	.00000004(x_1x_2) (.0000003)	.837013	.047357
Per Cent K	$\hat{y}$	=	1.09087	+	.008436x_1 *(.002406)	+	.007836x_2 *(.001203)	-	.000013(x_1x_2) *(.000005)	.827217	.799632
Per Cent Mg	$\hat{y}$	=	1.68797	-	.001294x_1 *(.000646)	-	.001534x_2 *(.000323)	+	.000002(x_1x_2) (.000001)	.733261	.214682
Per Cent Na	$\hat{y}$	=	.189507	-	.000087x_1 (.000069)	-	.000056x_2 (.000034)	-	.00000007(x_1x_2) (.0000001)	.561694	.022851

TABLE 20

SIMPLE CORRELATION COEFFICIENTS OF THE PER CENT K IN TUBERS AND TOPS AND THE APPLIED P_2O_5 FERTILIZER[1] AT CONSTANT K_2O FERTILIZER LEVELS

K_2O Level	Tubers 1956	Tubers 1957	Tops 1957
200	-.3917	.6636	-.0921
400	.4469	.8826**	.8518
600	.6304	.8685*	-.8557
800	-.9295	.4584	.6928

[1]P_2O_5 levels at constant K_2O levels listed in Tables 10 and 15.

TABLE 21

REGRESSION RELATIONSHIPS BETWEEN APPLIED P_2O_5 FERTILIZER AND ACTIVE P AND BETWEEN APPLIED K_2O FERTILIZER AND ACTIVE K USING 105 OBSERVATIONS AND DETERMINED BY THE EQUATION Y APPLIED = a + bx_{active}

					S
Y (P_2O_5)	=	191.069	+	1.95291x(active P) (2.90353)	104.852
Y (K_2O)	=	131.569	+	2.46643x(active K) *(.303586)	205.747