EFFECT OF APPLIED NUTRIENTS ON THE CHEMICAL COMPOSITION OF SOIL AND GREEN SUGAR BEET TISSUE AND THE YIELD AND SUCROSE CONTENT OF SUGAR BEET ROOTS

By

GEORGE ROBERT McQUEEN

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan
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Approved: R. L. Cook

ABSTRACT

Field experiments on sugar beets were conducted at 17 locations in the Saginaw valley - Thumb area of Michigan. The effect of several factors on the chemical composition of leaf petioles, the yield of roots, and the percent sucrose was determined. These factors included (1) heavy fertilizer applications for the establishment of nutrient levels, (2) foliar application of nutrients, (3) fertilizer ratios and rates of application, and (4) deep plowing and rates of fertilizer application.

Treatments of 0, 750, and 1500 pounds per acre of ammonium nitrate; 2208, 3680 and 5520 pounds per acre of 49 percent treble superphosphate; and 1785, 3675, and 4725 pounds per acre of 60 percent nuriate of potash did not establish field levels of these nutrients corresponding to laboratory fixation tests of the soil. Soil nitrate levels were increased by the heaviest application of ammonium nitrate but phosphorus levels were not affected by phosphorus applications. Soil potassium was increased by potassium applications to levels higher than desired but application of the heaviest amount resulted in no higher level than the medium application.

Nitrates in the petioles from areas receiving the two higher nitrogen applications were increased markedly but phosphorus was decreased.

The yield of roots was significantly increased by the addition of nitrogen but percent sucrose was decreased. The interaction of nitrogen and potassium was significant in that, at the lowest nitrogen level, the addition of potassium reduced yield of roots but, with the higher amounts of nitrogen applied, yield of roots was not reduced.

The lack of agreement of soil test values reached in the laboratory and the field together with lack of correlation of chemical composition to nutrient levels in the soil was probably due to the nutrient supplying and fixing power of the soil, the physical condition of the soil and/or weather conditions.

The application of phosphorus to a soil low in phosphorus or as a foliar spray increased the phosphorus concentration of the tissue. Nitrogen applications resulted in a decrease in the phosphorus concentration of the tissue. Foliar sprays of phosphorus tended to increase the concentration of phosphorus in the tissue in proportion to the amount applied but did not appear to appreciably influence the yield of roots or percent sucrose.

Where various ratios of fertilizer were applied, precise correlations could not be made due to variability with respect to soil type, soil tests, and fertilizer amounts and ratios. However, the following general trends are suggested. On soils medium or low in potassium the concentration of potassium and sodium in the petiole increased during the growing season and usually increased with increasing amounts of applied potassium fertilizer. On soils low in phosphorus the concentration of phosphorus in the tissue increased with increasing amounts of applied potassium fertilizer.

The differences between yield of roots from areas where various fertilizer ratios were applied were small except in one case. In this case where the soil was low in phosphorus and low to medium in potassium, increasing the amount of K_2O applied from 0 to 80 pounds per acre resulted in an increased yield of roots of about 46 percent. This would indicate that an x-2-1 ratio of fertilizer is probably adequate for these soils.

The effect of date of sampling on chemical composition of the petiole varied with location and would fall into four categories; (1) no distinct trend, (2) increase, (3) decrease, and (4) highest concentration at intermediate dates.

Soil penetrometer data indicate that soil compaction is an important deterrent to high yields.

Plowing to a depth of sixteen inches decreased the soil pH and the percent of sprangly roots but tended to increase soil moisture retention.

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VITA

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Final examination, May 13, 1958, 10:00 A.M., Room 210, Agriculture Hall

Thesis:

Effect of Applied Nutrients on the Chemical Composition of Soil and Green Sugar Beet Tissue and the Yield and Sucrose Content of Sugar Beet Roots.

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One paper accepted for publication

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INTRODUCTION

Yield responses of sugar beets to applications of nitrogen, phosphorus, and potassium fertilizers have varied from several tons per acre to an actual decrease, particularly when high rates of nitrogen have been applied. Excess quantities of nitrogen may also decrease the percent of sucrose in the roots.

Therefore, fertilization of sugar beets should be concerned with increasing tonnage or increasing percent sucrose or both.

This paper presents data from studies of some of the variables involved in fertilization of sugar beets and suggests practices for more efficient and effective use of fertilizers.

REVIEW OF LITERATURE

Wiley (16*) found that soil variation produced large differences in yield of sugar beet roots but had little effect upon the sugar percentage. Andrlik (2) observed that heavy applications of nitrogen decreased percent sucrose in sugar beet roots, heavy applications of manure produced no injurious effect and addition of potash and phosphorus largely reduced the injurious effect of applications of up to one thousand pounds per acre of nitrate of soda. Lill and Rather (5) reported that heavy applications of phosphate or a combination of phosphate and sodium nitrate profitably increased sugar beet yields following alfalfa in a rotation, but sodium nitrate alone did not increase yields. Roboz (7) found that, as the quantity of phosphate and potash applied to the soil increased, the sucrose percentage of beet roots was increased. However, beets growing on plots receiving insufficient amounts of phosphate and potash contained a lower content of sugar.

Analysis of the plant tissue of sugar beets by Zitkowski, Potvliet and Reed (17), Andrlik and Urban (3), U. S. D. A. (14), and Wilfarth and Wimmer (15) showed that a positive correlation existed between the phosphorus content and percent sucrose of the root. However, as the phosphorus content in

* Numbers in parentheses refer to literature cited.

the beet tops decreased the percent sucrose in the roots increased. Alexander, et.al. (1) noted a nitrogen - phosphorus interaction in the foliar tissue at late sampling dates. Schropp and Arenz (8) and Andrlik and Urban (3) also found that sulfur was a major factor in improving percent sucrose. A probable explanation is that the sulfur decreased the non-protein nitrogen content of the plant.

The use of plant and soil analysis for the determination of optimum nutrient application and utilization has been studied and reported quite extensively in recent years. Ulrich (13) correlated sugar beet weight with the concentration of nutrients in the tops. His findings indicated that plants possibly had three levels of nutrition for each nutrient: 1) an adequacy or luxury concentration at which no increase in plant growth is found with increasing concentrations, 2) level of transition or poverty adjustment, and 3) level of starvation at which the nutrient concentrations are relatively constant but yields differ in accordance with the nutrients available.

Carlson (4) recognized through soil tests on two soil types and tissue tests of the tops and roots of sugar beets that phosphate influenced top and root development. Skuderna and Doxtator (10), Tolman (12) and Skuderna (9) found that results from application of various ratios of fertilizers varied with the location and levels of fertility of the fields investigated. Heavy rates of application were found to be uneconomical.

Analytical methods

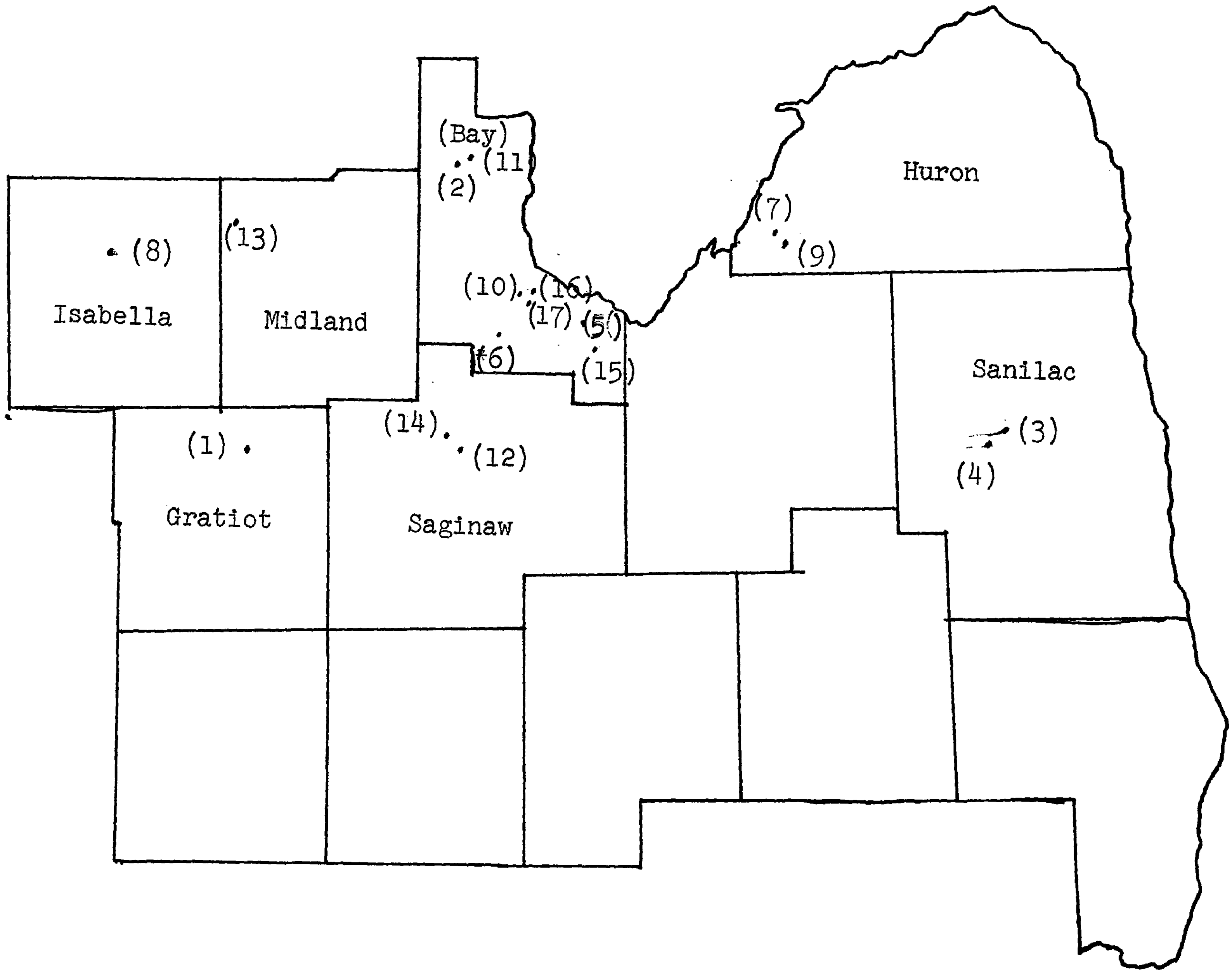
Soil samples were analyzed for pH, nitrates, phosphorus, and potassium by either the Spurway reserve or the Spurway active testing procedures (11).

Green tissue samples consisted of petioles from young, fully expanded leaves from each of fifteen sugar beet plants.

Samples consisting of ten grams of thinly sliced tissue taken from the petiole approximately one-third of the distance from the base to the leaf blades were analyzed. This material was added to 100 ml. of distilled water and one-fourth teaspoon of activated charcoal and then mascerated in a Waring Blendor for a period of two minutes. After passing through Whatman No. 1 filter paper the filtrate was analyzed directly for K and Na using a Perkin-Elmer flame photometer. Phosphorus was determined by adding six drops of a standard ammonium molybdate - hydrochloric acid solution to 10 ml. of extract, then reducing with three drops of F-S reducing agent. The solution was allowed to stand 15 minutes. A Coleman colorimeter equipped with a red filter and utilizing a wave length of 565 mu was used to determine colorimetrically the amount of phosphorus in the solution. Five drops of ten percent Brucine (alkaloid) in chloroform was added to three ml. of extract, followed by the addition of six ml. of concentrated sulfuric acid (specific gravity 1.84). The solution was allowed to stand twenty minutes. A Coleman colorimeter equipped with a blue filter and utilizing a wave length of 420 mu was used to determine colorimetrically the amount of nitrate in the solution. Calcium and magnesium were determined with a Beckman flame photometer.

Yields were taken by weighing the topped roots harvested from the center two rows of four-row plots.

Plate I. Locations of farms included in this study in the Saginaw valley and Thumb area of Michigan



Legal descriptions of farms and soil types

included in this study

1. C. Bobit farm - Gratiot county; Bethany township;
   T12N, R2W, sec. 26.
   Parkhill loam.

2. C. Charboneau farm - Bay county; Fraser township;
   T16N, R4E, sec. 30.
   Kawkawlin loam.

3. H. Draher farm - Sanilac county; Elmer township;
   T11N, R13E, sec. 6.
   Capac loam

4. H. Draher farm - Sanilac county; Moore township;
   T12N, R13E, sec. 32.
   Capac loam and silt loam.

5. O. Foret farm - Bay county; Hampton township;
   T14N, R6E, sec. 27.
   Essexville sandy loam.

6. H. Geiser farm - Bay county; Monitor township;
   T14N, R4E, sec. 30.
   Sims loam.

7. H. Gremel farm - Huron county; Sebewaing township;
   T15N, R9E, sec. 9.
   Sims clay loam and Kawkawlin loam.

8. R. Hauck farm - Isabella county; Nottawa township;
   T15N, R5W, sec. 15.
   Nester loam.

9. A. Kurzer farm - Huron county; Sebewaing township;
   T15N, R9E, sec. 32.
   Kawkawlin sandy loam and Sims sandy loam.

10. Meylan and Streffling farm - Bay county; Monitor township;
    T14N, R4E, sec. 13.
    Kawkawlin loam.

11. P. O'Laughlin farm - Bay county; Fraser township;
T16N, R4E, sec. 29.
Kawkawlin loam.

12. E. Rader farm - Saginaw county; Saginaw township;
T12N, R4E, sec. 34.
Wisner clay loam.

13. E. Sprenger farm - Midland county; Geneva township;
T15N, R2W, sec. 2.
Kawkawlin loam.

14. W. Steckert farm - Saginaw county; Saginaw township;
T12N, R4E, sec. 20.
Kawkawlin loam and Brookston loam.

15. A. Timm farm - Bay county; Portsmouth township;
T13N, R6E, sec. 5.
Whittemore sandy clay loam - Whittemore sandy loam.

16. R. Wackerle farm - Bay county; Monitor township;
T14N, R4E, sec. 10.
Sims clay loam.

17. W. Wieland farm - Bay county; Monitor township;
T14N, R4E, sec. 13.
Sims clay loam and Kawkawlin loam - Bannister sandy loam smears.

PART I. NUTRIENT LEVELS

Procedure

Soil fixation tests utilizing the Spurway active testing method for NO_3, P, and K were made on Wisner clay loam (location 12) in order to estimate the nutrient application rates for the establishment of field soil levels of 25, 50, and 75 p.p.m. of NO_3; 5, 10, and 15 p.p.m. of P; and 15, 30, and 45 p.p.m. of K. Treble superphosphate containing 49 percent P_2O_5 at rates of 2208, 3680, and 5520 pounds per acre and potassium chloride containing 60 percent K_2O at rates of 1785, 3675, and 4725 pounds per acre were broadcast on the surface of the soil on May 1. The plots were harrowed twice with a spring tooth harrow to mix the fertilizer with the soil. Ammonium nitrate containing 33.5 percent N was side-dressed in bands on the soil surface on July 27th and 29th at rates of 0, 750, and 1500 pounds per acre.

Sugar beet seed (var. 216X226) was planted May 3rd, but emergence was slow. The beets emerged following 0.87 inches of rainfall on May 22nd and 23rd, but beets in the field adjoining had emerged shortly after planting. The beets were blocked and thinned June 15th, and harvested October 21st. The plots were each 0.01 acre in area and each treatment was replicated 6 times in a modified latin square design.

The soil was sampled by taking eight cores to a depth of 6 inches from each plot on June 29th, August 29th, and September 6th, and analyzed by the Spurway active method for NO_3, P, and K.

Results and discussion

Table 1. The effect of applied nutrients on soil test values, percent sucrose and yield of roots and gross sugar, Rader farm.

Desired level (p.p.m.)			Tested level (p.p.m.)*			Tons per acre **	Percent sucrose **	Pounds gross sugar per acre
NO_3	P	K	NO_3	P	K			
25	5	15	0	3.1	32	17.1	19.2	6559
25	5	30	0	4.0	67	16.4	18.9	6176
25	5	45	2	3.6	69	14.3	18.7	5330
25	10	15	3	3.4	36	16.4	19.3	6326
25	10	30	1	3.8	51	15.6	18.8	5853
25	10	45	2	3.7	64	13.9	18.9	5246
25	15	15	6	3.4	38	15.6	19.0	5913
25	15	30	1	3.4	49	15.6	18.5	5766
25	15	45	0	3.7	59	14.5	18.5	5357
50	5	15	1	3.8	46	18.4	15.3	5651
50	5	30	1	4.0	60	17.6	15.2	5419
50	5	45	5	3.7	63	17.1	14.8	5054
50	10	15	1	3.6	40	18.6	14.9	5539
50	10	30	3	3.6	64	17.1	15.1	5133
50	10	45	1	3.5	64	18.1	15.5	5592

Table 1. (continued)

Desired level (p.p.m.)			Tested level (p.p.m.)*			Tons per acre **	Percent sucrose **	Pounds gross sugar per acre
NO_3	P	K	NO_3	P	K			
50	15	15	0	3.7	31	17.8	15.1	5365
50	15	30	9	3.5	60	18.1	15.1	5457
50	15	45	1	3.7	67	16.9	14.6	4917
75	5	15	31	3.5	34	17.0	14.5	4901
75	5	30	33	3.6	67	18.0	14.1	5044
,75	5	45	28	3.8	51	18.2	14.1	5096
75	10	15	35	3.5	51	16.4	14.3	4662
75	10	30	12	3.6	60	15.6	14.3	4425
75	10	45	103	3.6	68	17.6	14.9	5271
75	15	15	19	3.6	50	17.9	14.5	5167
75	15	30	11	3.7	64	16.3	14.1	4572
75	15	45	33	3.9	54	18.6	13.8	5142
Adjacent field			3	3.2	3			

* Average of two samples.

** Average of six replications.

Petiole samples were taken August 29th, September 8th, and September 11th by removing young, fully expanded petioles from fifteen plants.

Table 2. The effect of applied nutrients on the chemical composition of green beet petioles at three different dates, Rader farm.

Desired soil nutrient level (p.p.m.)			Nutrient content in green petiole tissue (p.p.m.)								
			August 29			September 8			September 11		
NO_3	P	K	NO_3	P	K	NO_3	P	K	NO_3	P	K
25	5	15	0	134	7300	0	86	7290	0	125	7480
25	5	30	0	87	7640	0	104	7600	0	86	7630
25	5	45	0	61	7700	0	81	7800	0	87	7620
25	10	15	0	105	7300	0	70	7800	0	107	7720
25	10	30	0	100	7720	0	136	7800	0	93	7670
25	10	45	0	95	7300	0	89	7930	0	111	7580
25	15	15	0	86	7540	0	144	7830	0	138	7670
25	15	30	0	103	7300	0	105	7900	30	123	7620
25	15	45	0	117	7720	0	87	7800	0	96	7760
50	5	15	120	48	6840	300	43	7850	480	61	6580
50	5	30	300	37	7760	240	103	7800	300	57	7210
50	5	45	750	64	6670	300	63	7800	360	63	7350
50	10	15	360	74	6960	210	123	7720	330	62	7300
50	10	30	360	72	7260	300	64	7720	360	57	7210
50	10	45	540	55	6530	600	74	7800	300	64	7440
50	15	15	600	84	7380	180	63	7720	360	47	7530
50	15	30	450	79	7640	30	80	7720	600	61	7670
50	15	45	150	59	7440	150	81	7580	600	90	7530

Table 2. (continued)

Desired soil nutrient level (p.p.m.)			Nutrient content in green petiole tissue (p.p.m.)								
			August 29			September 8			September 11		
NO_3	P	K	NO_3	P	K	NO_3	P	K	NO_3	P	K
75	5	15	300	46	6440	450	52	7800	300	52	7120
75	5	30	150	31	7260	360	93	7530	360	22	7350
75	5	45	510	68	7720	360	84	7850	540	76	7760
75	10	15	660	58	6900	360	78	7260	240	56	6800
75	10	30	420	74	7440	450	31	7900	480	51	7400
75	10	45	300	61	7350	360	79	7620	240	81	7530
75	15	15	600	63	6900	270	64	7620	390	61	6960
75	15	30	240	47	7220	450	80	7620	360	58	7530
75	15	45	150	50	7800	360	87	7560	480	71	7800
Adjacent field (check)						0	47	7650	0	59	7280

Yields of roots were taken from each plot and the per-cent sucrose determined.

Table 3. Final analysis of variance table for 1950.

Source	DF	Yield of roots		Per cent sucrose		Gross sugar
		Sums of squares	Mean squares	Sums of squares	Mean squares	Mean squares (x 1000)
total	161	674.0		765.9		
replicates	5	53.4		30.2		
P	2	8.9	4.5	2.6	1.3	445
rep. x P	10	86.2	8.6	10.2	1.0	572
K	2	13.4	6.7	2.2	1.2	1,694*
rep. x K	10	22.9	2.3	5.9	.6	266
P x K	4	10.2	2.5	4.2	1.1	448
rep. x P x K	20	60.4	3.0	16.2	.8	376
N	2	152.9	76.4**	647.9	324.0**	11,358**
N x K	4	61.7	15.4**	1.3	.3	2,059**
rep. x N, rep. x N x K	30	68.1	2.3	11.5	.4	414
N x P	4	12.5	3.1	.5	.1	246
N x P x K	8	18.3	2.3	1.6	.2	308
rep. x N x P x K, remainder	60	105.3	1.8	31.5	.5	215

* Significant at the 5% level.

** Significant at the 1% level.

The data in Table 1 show that the desired or predicted nutrient levels in the soil were not obtained. The applications of phosphate showed no significant differences due to rates, and only a slight increase over the phosphorus found in the untreated field samples. Potassium levels were increased markedly over the untreated field samples. The potassium levels obtained, however, were about twice as high as desired for levels of 15 and 30 p.p.m. Soil tests for the 45 p.p.m. predicted level were only slightly higher than for the 30 p.p.m. level. The nitrate levels indicated by the soil tests from field samples were lower than the predicted levels except in one case where levels of 75, 10, and 45 p.p.m. of NO_3, P, and K respectively were attempted. These differences from the desired levels could be due in part to insufficient mixing of the phosphorus and potassium carriers with the soil and subsequent difficulty in obtaining a representative sample. The failure to account for all of the nitrogen added to the soil apparently was due to its rapid and almost complete uptake by the sugar beet plants as shown by the green tissue tests in Table 2.

The yield data in Tables 1 and 3 show that the yield of roots was significantly increased at the one percent level by the addition of nitrogen, but the highest level of nitrogen was no better than the medium. Both percent sucrose and gross sugar, however, were significantly reduced at the one percent level by the addition of either the medium or highest level of nitrogen.

Phosphorus applications had no effect on yield of roots, percent sucrose, or gross sugar.

The application of potassium significantly decreased gross sugar per acre at the 25 p.p.m. and 50 p.p.m. levels. The interaction of nitrogen and potassium was significant at the one percent level on yield of roots and gross sugar per acre (Table 1).

The data in Table 2 show that the plant tissue was very high in nitrates throughout the season where nitrogen was applied at the 50 and 75 p.p.m. rates. The resulting increase in top growth observed could account in part for the failure to find nitrates by the soil test.

No marked differences were found in phosphorus content of petioles where different amounts of phosphate were applied. Where nitrogen was applied at levels of 50 and 75 p.p.m., the phosphorus content was lower ~~higher~~ in tissue where nitrate was present than where it was absent.

The potassium content of the tissue samples from the plots was not materially different from that obtained from the adjacent field. However, the tissue sampled from beets growing on plots receiving 30 and 45 p.p.m. levels did not differ from each other but tended to show a higher potassium concentration than where the 15 p.p.m. treatment was applied.

PART II. PHOSPHORUS - NITROGEN INTERACTION AND FOLIAR APPLICATIONS

Procedure

A location having a history of marked crop response to phosphate was selected on Parkhill loam (location 1). Phosphate as 18 percent superphosphate was applied at rates of 0, 60, or 120 pounds of P_2O_5 per acre. Certain plots received 10 weekly or 5 bi-weekly foliar sprays of a saturated water solution of 18 percent superphosphate amounting to 2.8 pounds per acre for each spraying. Other plots received two foliar applications of urea at a rate of 10 pounds per acre. Nitrogen was applied to the soil surface of all plots at the time of blocking and thinning at rates of 0, 50, or 100 pounds of nitrogen per acre. All plots received 60 pounds of K_2O at the time of planting.

Sugar beet seed was planted May 18, 1951, using the disease-resistant variety 48B3-00. The beets were blocked and thinned June 12th. Green tissue samples of the sugar beet petioles were taken October 15th and analyzed colorimetrically for phosphorus. The plots were 0.01 acre in size and the treatments duplicated. Yields were taken by harvesting the center two rows from each plot on October 18th and percent sucrose was determined.

Radioactive phosphorus, P^{32}, as PO_4 in 0.043 N HCl at a concentration of 0.3% of H_3PO_4 was applied at two locations as a foliar spray to sugar beets. The original P^{32} source was used throughout the test. Treatments consisted of 1, 2, and 3 sprays at two-week intervals with the final spray applied two weeks before taking green tissue samples on August 28th. Each plot was 0.005 acre in area and each treatment was replicated six times in a randomized block design.

The green tissue was oven dried, compressed into uniform discs one inch in diameter and weighing two grams each. The disc were placed in an autoscaler and specific activity measured during four time intervals.

Results and discussion

Table 4. The effect of applied phosphate and nitrogen on the phosphorus content of green sugar beet petioles sampled October 15, 1951, Bobit farm.

Pounds P_2O_5 per acre (soil)	Pounds P_2O_5 per acre (spray)	Pounds urea per acre	p.p.m. Phosphorus		
			Pounds N per acre		
			0	50	100
0	0	0	79	39	87
120	0	0	171	247	165
120	14 (5 sprays)	0	243	200	137
120		20 (2 sprays)	238	147	140

The increase in phosphorus concentration in the green tissue with applications of phosphorus to the soil is apparent. The differences shown in Table 4 are in agreement with the data (Table 2) showing the interaction between nitrogen and phosphorus concentrations in green tissue in that, when nitrogen is applied, the concentration of phosphorus in the green tissue decreases. The apparent inconsistency in phosphorus concentration at the 50 pound nitrogen and 120 pound P_2O_5 application might be due to experimental error.

It is doubtful if this inverse nitrogen:phosphorus ratio is a "dilution" factor attributable to stimulated tissue growth due to the applied nitrogen. No differences in top growth were apparent between any of the plots at these two rates of nitrogen application nor between the two rates ~~(Plate 1)~~.

Table 5. The effect of soil applications of phosphate and foliar applications of phosphate and urea at three nitrogen levels on the yield of sugar beet roots, percent sucrose, and gross sugar per acre, Bobit farm, 1951.

Pounds P_2O_5 per acre (soil)	Pounds P_2O_5 per acre (spray)	Pounds nitrogen per acre	Tons roots per acre*	Per cent sucrose*	Pounds gross sugar per acre*
0	0	0	19.5 (1)	17.6	6864
		50	11.8**	16.4	3846
		100	12.3**	15.7	3890
60	0	0	16.5	18.4	6055
		50	16.4	16.6	5429
		100	16.1	16.2	5202
120	0	0	17.3	18.1	6229
		50	18.2 (1)	17.2	6260
		100	18.0 (1)	15.9	5724
120	14 (5 sprays)	0	15.1	17.4	5223
		50	18.8	16.3	6129
		100	19.3	16.1	6181
120	28 (10 sprays)	0	17.5	17.6	6142
		50	18.2	16.8	6116
		100	20.4	17.5	7127
120	20 (urea) (2 sprays)	0	16.4	18.2	5936
		50	17.8	16.7	5951
		100	19.2	16.5	6316

* average of two replications
** poor stand
(1) one plot yield only

Yield results (Table 5) show a possible interaction of nitrogen and phosphorus in the yield and sucrose content of roots. With the addition of each increment of nitrogen at the higher rates of phosphate application to the soil, the yield of roots increased and the percent sucrose decreased. With the addition of each increment of phosphorus and phosphate sprays the yield increased and, with the weekly spraying of phosphate, the percent sucrose apparently was maintained at levels nearly as high with the application of nitrogen as without added nitrogen.

This might indicate that, if the phosphorus content of the plant can be maintained at a high concentration just prior to harvest, the percent sucrose could be at a high level even if nitrates were available to the plant. From the results of Part I this would appear to be best accomplished by one or two phosphate sprays applied one to two weeks prior to harvest. Further experimental work should establish the best spray material and time of spraying.

Table 6. The effect of one, two and three foliar sprays of P^{32} on specific activity of sugar beet petioles at two locations, 1952.

Pounds P_2O_5 per acre (spray)	Number of sprays	Specific activity of plants*, c.p.m.	
		Rader farm	Wieland farm
1.7	1	3090	955
3.4	2	4708	1809
5.1	3	4479	2566

* average of twelve samples (counts per minute)

In another experiment the P^{32} spray was applied to the plant in three different ways; (1) to one-half of the plant, (2) to the crown, and (3) to the new growth. The counts found in petioles taken from various positions on the plant are shown in Table 7.

Table 7. The effect of applied P^{32} to various portions of the sugar beet plant on the specific activity of sugar beet petioles.

Position of tissue sample	Region of Application					
	One-half of plant		Crown		New growth	
	Rader farm	Wieland farm	Rader farm	Wieland farm	Rader farm	Wieland farm
	Specific activity (counts per minute)					
new leaves	2145	2040	1430	1324	1490	1331
mature leaves	477	500	455	598	884	471
mature leaves (sprayed)	2458	1760				

The data in Tables 6 and 7 show that phosphorus accumulates in the sugar beet petioles with successive sprayings, and the amount accumulated is related directly to the amount applied. The applied phosphate accumulates in new tissue regardless of the plant portion to which it is applied. Therefore, to achieve the highest concentration of phosphate in the green tissue, the entire plant should be sprayed.

PART III. FERTILIZER RATIOS

Procedure

A number of fields on farms in the Saginaw valley and Thumb area of Michigan were fertilized at various rates of phosphate and potash to study such effects on the yield of roots and chemical composition of the green tissue of sugar beets. Soil tests were by the Spurway reserve method (11).

Duplicate plots in the fields were planted and harvested. Duplicate green tissue samples were taken at various times during the season with the last sample taken as near to harvest as practical. They were analyzed for N, P, K, and Na.

The results from individual farms together with the soil tests in the plot area are shown in Tables 8 through 20.

Penetrometer (6) readings were taken at each location.

Table 8. The effect of fertilizers on the chemical composition of sugar beet petioles (three sampling dates), percent sucrose and yield of roots and gross sugar per acre on Whittemore sandy clay loam and sandy loam, Timm farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue					
N	P_2O_5	K_2O	Aug. 9	Aug. 28	Sept. 21	Aug. 9	Aug. 28	Sept. 21
			N			P		
62	115	115	98	161	200	36	108	125
62	115	78	0	180	192	53	127	111
62	78	115	99	187	198	86	134	117
40	40	40	168	190	200	41	119	108
			K			Na		
62	115	115	3210	3960	4920	1120	1390	1390
62	115	78	3680	3600	4560	1465	1245	1510
62	78	115	2990	3870	5010	990	1280	1510
40	40	40	2850	3300	3980	840	1340	1560

N	P_2O_5	K_2O	Tons roots per acre	Percent sucrose	Pounds gross sugar per acre
62	115	115	11.4	20.6	4677
62	115	78	11.8	20.5	4813
62	78	115	12.2	20.5	4973

Soil tests for pH, pounds P and K per acre: 7.6; 205; 48 and 7.9; 138; 11 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4 and 0-6 inches was 40 and 60 pounds respectively.

Table 9. The effect of fertilizers on the chemical composition of sugar beet petioles (three sampling dates), percent sucrose and yield of roots and gross sugar per acre on Essexville sandy loam, Foret farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue					
N	P_2O_5	K_2O	Aug. 9	Aug. 28	Sept. 21	Aug. 9	Aug. 28	Sept. 21
				N			P	
25	100	100	94	94	194	78	141	128
25	100	50	93	179	192	78	166	146
25	50	100	96	175	195	62	168	127
				K			Na	
25	100	100	3120	2810	3320	450	790	900
25	100	50	2610	2510	3320	410	690	850
25	50	100	2910	2780	3740	370	710	690

N	P_2O_5	K_2O	Tons roots per acre	Percent sucrose	Pounds gross sugar per acre
25	100	100	12.4	--	--
25	100	50	11.4	--	--
25	50	100	11.9	--	--

Soil tests for pH, pounds P and K per acre: 7.7; 193; 55 and 7.8; 103; 31 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4 and 0-7 inches was 40 and 70 pounds respectively.

Table 10. The effect of fertilizers on the chemical composition of sugar beet petioles (three sampling dates), percent sucrose and yield of roots and gross sugar per acre on Sims loam, Geiser farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue					
N	P_2O_5	K_2O	Aug. 10	Aug. 30	Sept. 22	Aug. 10	Aug. 30	Sept. 22
				N			P	
16	65	65	120	40	181	103	140	158
16	65	33	172	34	187	110	88	178
16	33	65	195	0	185	111	75	177
				K			Na	
16	65	65	3110	3440	4020	880	1260	1260
16	65	33	3000	2630	4590	930	910	1260
16	33	65	3120	2630	4580	830	860	1120

N	P_2O_5	K_2O	Tons roots per acre	Percent sucrose	Pounds gross sugar per acre
16	65	65	13.5	19.5	5255
16	65	33	12.8	18.9	4819
16	33	65	13.0	19.4	5043

Soil tests for pH, pounds P and K per acre: 7.3; 130; 136 and 7.7; 48; 79 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4 and 0-7 inches was 40 and 65 pounds respectively.

Table 11. The effect of fertilizers on the chemical composition of sugar beet petioles (three sampling dates), percent sucrose and yield of roots and gross sugar per acre on Kawkawlin loam, Meylan and Streffling field, 1956.

Pounds per acre				p.p.m. of nutrient in green tissue					
N	P_2O_5	K_2O		Aug. 10	Aug. 30	Sept. 22	Aug. 10	Aug. 30	Sept. 22
				N			P		
12	48	48	(K_2O)	189	25	189	168	171	155
39	117	0		196	0	178	224	159	192
39	117	100	(KCl)	196	0	190	224	159	142
39	117	50	(KCl)	196	0	145	224	159	218
39	117	50	(K_2SO_4)	196	0	73	224	159	84
				K			Na		
12	48	48	(K_2O)	4480	4030	5270	620	950	1060
39	117	0		3500	3570	3840	600	950	1050
39	117	100	(KCl)	3500	3570	4710	600	950	1180
39	117	50	(KCl)	3500	3570	4320	600	950	1120
39	117	50	(K_2SO_4)	3500	3570	1730	600	950	620
				Tons roots per acre		Percent sucrose		Pounds gross sugar per acre	
12	48	48	(K_2O)						
39	117	0		13.5		18.3		4941	
39	117	100	(KCl)	13.1		19.1		5004	
39	117	50	(KCl)	12.8		18.8		4813	
39	117	50	(K_2SO_4)	12.9		18.0		4644	

Soil tests for pH, pounds P and K per acre: 7.3; 133; 87 and 7.4; 138; 16 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4, 0-6, 0-8, and 0-11 inches was 35, 50, 56, and 60 pounds respectively.

Table 12. The effect of fertilizers on the chemical composition of sugar beet petioles (four sampling dates), percent sucrose and yield of roots and gross sugar per acre on Capac silt loam, Draher farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue							
N	P_2O_5	K_2O	Aug. 2	Aug. 14	Aug. 31	Sept. 19	Aug. 2	Aug. 14	Aug. 31	Sept. 19
			N				P			
20	80	120	196	144	123	3	96	62	69	71
20	80	80	202	190	188	76	191	92	61	43
20	80	40	197	195	152	93	96	78	34	35
20	80	0	198	172	107	179	99	47	49	22
			K				Na			
20	80	120	2960	3060	1660	3860	610	710	630	1170
20	80	80	3140	2700	2340	2450	790	810	740	880
20	80	40	3060	2640	1830	1990	520	640	630	940
20	80	0	3660	2760	1830	1520	460	620	670	630

N	P_2O_5	K_2O	Tons roots per acre	Percent sucrose	Pounds gross sugar per acre
20	80	120	10.1	18.2	3749
20	80	80	10.8	18.0	3636
20	80	40	9.1	17.8	3026
20	80	0	7.4	18.7	2618

Soil tests for pH, pounds P and K per acre: 7.0; 41; 99 and 7.5; 15; 39 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4 and 0-8 inches was 35 and 60 pounds respectively

Table 13. The effect of fertilizers on the chemical composition of sugar beet petioles (three sampling dates), percent sucrose and yield of roots and gross sugar per acre on Kawkawlin loam, O'Laughlin farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue					
N	P_2O_5	K_2O	Aug. 10	Aug. 30	Sept. 18	Aug. 10	Aug. 30	Sept. 18
			N			P		
13	50	50	173	0	93	103	74	138
13	50	25	196	0	125	114	53	81
13	25	50	141	97	188	66	121	117
			K			Na		
13	50	50	3050	2120	2220	775	870	880
13	50	25	3090	2320	1590	830	1000	630
13	25	50	3090	2900	2700	930	980	1430

N	P_2O_5	K_2O	Tons roots per acre	Percent sucrose	Pounds gross sugar per acre
13	50	50	--	21.0	--
13	50	25	--	21.4	--
13	25	50	--	20.4	--

Soil tests for pH, pounds P and K per acre: 7.1; 30; 67 and 7.7; 181; 39 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4, 0-7, and 0-10 inches was 30, 60, and 70 pounds respectively.

Table 14. The effect of fertilizers on the chemical composition of sugar beet petioles (four sampling dates), percent sucrose and yield of roots and gross sugar per acre on Kawkawlin loam, Sprenger farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue							
N	P_2O_5	K_2O	Aug. 3	Aug. 15	Sept. 7	Sept. 18	Aug. 3	Aug. 15	Sept. 7	Sept. 18
			N				P			
65	100	150	200	181	91	179	200	99	153	173
65	100	100	71	187	93	89	63	97	100	88
65	100	50	196	182	0	143	200	120	103	164
65	100	0	198	157	93	180	158	97	112	143
			K				Na			
65	100	150	4020	3420	3630	2910	580	1150	1110	930
65	100	100	4140	3120	2030	2350	790	1110	730	960
65	100	50	4200	2840	2260	2510	960	1170	1120	1020
65	100	0	3120	2760	3160	2790	1070	1280	1210	1220

N	P_2O_5	K_2O	Tons roots per acre	Percent sucrose	Percent purity	Pounds gross sugar per acre
65	100	150	11.4	18.7	86	3667
65	100	100	10.6	17.8	84	3160
65	100	50	11.0	17.8	85	3329
65	100	0	11.4	18.1	85	3508

Soil tests for pH pounds P and K per acre: 7.3; 193; 267 and 7.2; 151; 79 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4, 0-8, and 0-12 inches was 25, 45, and 55 pounds respectively.

Table 15. The effect of fertilizers on the chemical composition of sugar beet petioles (four sampling dates), percent sucrose and yield of roots and gross sugar per acre on Nester loam, Hauck farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue							
N	P_2O_5	K_2O	Aug. 3	Aug. 15	Sept. 7	Sept. 18	Aug. 3	Aug. 15	Sept. 7	Sept. 18
			N				P			
35	130	210	181	165	182	191	28	116	97	95
30	120	120	0	139	0	191	107	105	92	128
30	120	60	194	194	93	98	142	110	117	153
30	120	0	193	182	82	28	163	122	88	62
			K				Na			
35	130	210	3990	3770	2450	2160	1010	1010	1020	1220
30	120	120	4020	3200	2720	2550	650	890	1030	1130
30	120	60	2940	2280	2500	2150	820	1040	1140	1140
30	120	0	3480	2580	2450	2160	840	930	1120	1030

N	P_2O_5	K_2O	Tons roots per acre	Percent sucrose	Percent purity	Pounds gross sugar per acre
35	130	210	12.8	15.6	83	3315
30	120	120	12.4	15.5	82	3152
30	120	60	13.6	17.1	87	4047
30	120	0	14.0	15.7	89	3912

Soil tests for pH, pounds P and K per acre: 6.5; 44; 166 and 7.5; 4; 16 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4, 0-8, and 0-12 inches was 25, 35, and 45 pounds respectively.

Table 16. The effect of fertilizers on the chemical composition of sugar beet petioles (four sampling dates), on Capac loam, Draher farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue							
N	P_2O_5	K_2O	Aug. 2	Aug. 14	Aug. 31	Sept. 19	Aug. 2	Aug. 14	Aug. 31	Sept. 19
			N				P			
63	75	37	196	65	147	58	117	86	123	69
63	75	75	198	43	118	30	120	71	77	31
63	75	150	152	128	107	138	61	85	87	74
63	75	225	197	65	0	0	102	89	71	71
63	150	37	0	67	120	42	20	67	89	46
63	150	75	0	71	92	107	38	84	82	71
63	150	150	34	63	74	131	65	87	117	88
63	150	225	195	64	70	152	105	106	72	51
63	225	37		116	39	4		71	94	70
63	225	75		74	110	90		82	77	38
63	225	150		96	124	79		84	106	38
63	225	225		74	122	67		73	105	72

Table 16. (continued)

Pounds per acre			p.p.m. of nutrient in green tissue									
N	P_2O_5	K_2O	Aug. 2	Aug. 14	Aug. 31	Sept. 19	Aug. 2	Aug. 14	Aug. 31	Sept. 19	Aug. 31	Aug. 31
			K				Na				Ca	Mg
63	75	37	4470	3460	3960	4370	790	990	1380	1560	60	330
63	75	75	4710	4380	4280	3650	760	1210	1380	1230	50	300
63	75	150	4470	4620	4550	5240	750	1300	1420	1590	60	320
63	75	225	4590	4630	4530	4520	810	1010	1420	1450	50	310
63	150	37	4260	4340	3560	4170	1010	1300	1520	2070	60	330
63	150	75	4530	4020	4200	4580	750	1060	1280	1440	50	290
63	150	150	4200	4710	4490	4760	630	1220	1320	1530	60	330
63	150	225	3870	5280	4690	4700	710	1160	1170	1570	60	350
63	225	37		3490	3780	4200		930	1260	1840	50	290
63	225	75		4410	3960	3430		1270	1440	1520	50	320
63	225	150		4760	4090	2430		1300	1490	1270	50	340
63	225	225		4360	4420	4540		900	1200	1120	70	330

Soil tests for pH, pounds P and K per acre: 6.7; 24; 169 and 7.1; 32; 95 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4 and 0-8 inches was 35 and 60 pounds respectively.

Table 17. The effect of fertilizers on the chemical composition of sugar beet petioles (three sampling dates), percent sucrose and yield of roots and gross sugar per acre on Kawkawlin loam, Charboneau farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue					
N	P_2O_5	K_2O	Aug. 10	Aug. 30	Sept. 18	Aug. 10	Aug. 30	Sept. 18
				N			P	
47	186	186	162	0	141	72	118	98
47	186	161	97	39	96	62	117	149
47	161	186	191	0	84	94	111	66
				K			Na	
47	186	186	2970	2800	1740	1060	112	990
47	186	161	3270	2980	3060	1110	970	1190
47	161	186	3200	3200	1590	910	1050	510
			Tons roots per acre		Percent sucrose			Pounds gross sugar per acre
47	186	186	--		21.0			--
47	186	161	--		20.8			--
47	161	186	--		20.6			--

Soil tests for pH, pounds P and K per acre: 7.4; 76; 71 and 7.7; 7; 39 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4, 0-6, and 0-8 inches was 40, 55, and 65 pounds respectively.

Table 18. The effect of fertilizers on the chemical composition of sugar beet petioles (four sampling dates), percent sucrose and yield of roots and gross sugar per acre on Sims clay loam, Wieland farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue							
N	P_2O_5	K_2O	July 27	Aug. 10	Aug. 30	Sept. 22	July 27	Aug. 10	Aug. 30	Sept. 22
			N				P			
20	80	80	188	200	155	98	63	97	91	69
20	80	40	196	182	124	172	138	99	113	35
20	40	80	194	196	0	185	105	97	84	56
			K				Na			
20	80	80	3570	2940	3270	3250	1150	1020	1220	1200
20	80	40	3120	3110	3680	2520	1030	1140	1270	1310
20	40	80	3870	3410	3320	4490	960	1140	1300	1580

N	P_2O_5	K_2O	Tons roots per acre	Percent sucrose	Pounds gross sugar per acre
20	80	80	12.4	20.1	4985
20	80	40	12.2	20.2	4929
20	40	80	12.8	20.1	5146

Soil tests for pH, pounds P and K per acre: 7.5; 87; 59 and 7.5; 169; 16 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4 and 0-6 inches was 40 and 60 pounds respectively.

Table 19. The effect of fertilizers on the chemical composition of sugar beet petioles (four sampling dates), percent sucrose and yield of roots and gross sugar per acre on Sims clay loam to Pickford clay loam, Wackerle farm, 1956.

Pounds per acre			p.p.m. of nutrient in green tissue							
N	P_2O_5	K_2O	July 27	Aug. 10	Aug. 30	Sept. 18	July 27	Aug. 10	Aug. 30	Sept. 18
			N				P			
18	72	72	200	102	0	0	93	59	109	118
18	72	36	196	197	188	196	93	111	122	139
18	36	72	196	200	89	0	108	94	100	79
			K				Na			
18	72	72	2550	2760	2610	2760	1340	1120	1170	1220
18	72	36	2670	2700	2990	2850	1030	1060	1200	1230
18	36	72	3060	2750	2810	2780	1000	1030	1300	1310

N	P_2O_5	K_2O	Tons roots per acre	Percent sucrose	Pounds gross sugar per acre
18	72	72	15.5	19.0	5898
18	72	36	15.3	19.8	6071
18	36	72	15.4	19.8	6090

Soil tests for pH, pounds P and K per acre: 7.2; 72; 103 and 7.4; 157; 55 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4, 0-8, and 0-11 inches was 30, 45, and 60 pounds respectively.

Table 20. The effect of fertilizers on the chemical composition of sugar beet petioles (two sampling dates), percent sucrose and yield of roots and gross sugar per acre on Kawkawlin loam, Steckert farm, 1956.

Pounds of N	p.p.m. of nutrient in green tissue							
	Aug. 30	Sept. 22	Aug. 30	Sept. 22	Aug. 30	Sept. 22	Aug. 30	Sept. 22
	N		P		K		Na	
65	0	194	113	187	4530	4370	1130	1260
105	0	173	141	168	4130	4160	1180	1250
25	0	160	126	141	4510	3680	1220	780

Pounds of N	Tons roots per acre	Percent sucrose	Pounds gross sugar per acre
65	8.4	18.8	3161
105	9.0	18.7	3366
25	8.4	18.4	3090

The penetrometer pressure required to insert 0-4 and 0-6 inches was 35 and 55 pounds respectively.

The data shown in Tables 8 through 20 were variable in respect to soil type, soil tests and fertilizer application and subsequently no precise correlations could be made. However, the following general observations were evident.

The data in Tables 8 and 9 show that, on soils very high in P but low in K, the concentration of N, P, K and Na in the petiole increased during the growing season. The amount of K in the tissue tended to correlate with the amount of K applied in the fertilizer. Fertilizers had no apparent effect on yield of roots or percent sucrose.

The data in Tables 10 and 11 show that on soils very high in P but medium in K the concentration of K and Na in the petiole increased during the growing season but the concentration of P in the petiole was variable with respect to date of sampling and amounts of phosphate and potash applied. The very low values obtained on the September 22nd tissue test for the K_2SO_4 application probably was due to experimental error. Fertilizer did not affect yield of roots and percent sucrose to any appreciable degree.

The data in Tables 12 and 13 show that on soils low in P and medium in K the concentration of P, K and Na in the petiole, in general, was directly related to the amounts of potash applied, but the concentration of K in the tissue tended to decrease as the season progressed. The yield of roots was increased by potash application but no effect on percent sucrose (Table 12) occurred.

The data in Tables 14, 15, 16 and 17 show that on soils either high in P and K and/or receiving heavy fertilizer applications the concentration of P and K in the petiole was not correlated with season or treatment. However, the data in Tables 15 and 16 show that Na increased in the petiole during the season. The Ca and Mg contents of the petiole were not affected by fertilization (Table 16). Data in Tables 13 and 14 indicate no apparent effect of fertilizer on yield of roots, percent sucrose or percent purity.

The data in Tables 18 and 19 show that on soils medium in P and K and receiving moderate fertilizer applications the concentration of P and K in the petiole was not correlated with season or fertilizer. However, Na did tend to increase in the tissue during the season. Fertilizers had no significant effect on yield of roots or percent sucrose.

The data in Table 20 show increasing nitrogen applications had no apparent effect on the concentration of P, K and Na in the petiole or on yield of roots and percent sucrose.

No consistent relationship is apparent between nitrogen concentration in the petiole with the amount of fertilizer applied to the soil. Instead, nitrogen concentration in the tissue would appear to be related to possible climatic factors which, in turn, would influence nitrogen availability in the soil.

The data in Tables 8 through 20 show that the only marked yield response (Table 12) was due to application of potassium fertilizer. This occurred when the concentration of K in the petiole at the later sampling dates was less than 2200 p.p.m. and the Na concentration below 1000 p.p.m.

The penetrometer data show that those fields with the highest yield of roots had the lowest readings. This might indicate that soil compaction is an important deterrent to high yields of beets.

Yield of roots, percent sucrose and nutrient concentration in the petiole could not be correlated with soil tests of samples taken at the 12 to 18 inch depth.

PART IV. DEPTH OF PLOWING

Procedure

Two experiments located on a Sims clay loam and a Kawkawlin-Sims sandy loam complex in Huron county (locations 7 and 9) were initiated in 1956 to study the effect of depth of plowing on growth of beets.

On the Gremel farm (location 7) the depths of plowing were 10 inches using a moldboard type plow and 16 inches using the disc type plow shown in Plate 2. A 5-20-20 analysis fertilizer was applied about 1 inch to the side and 2 inches below the seed at a rate of 600 to 700 pounds per acre.

Duplicate 0.24 acre plots were planted on April 17th using US 400 variety. The plots were harvested October 18th and yield of roots per acre, percent sucrose and percent purity determined.

Green tissue samples were taken from each plot at various dates during the season and the chemical composition determined. Penetrometer readings were made at different depths on August 13th and September 7th.

On the Kurzer farm (location 9) the depths of plowing were 7 inches using a moldboard type plow and 16 inches using the disc plow. A 5-20-20 analysis fertilizer was used.

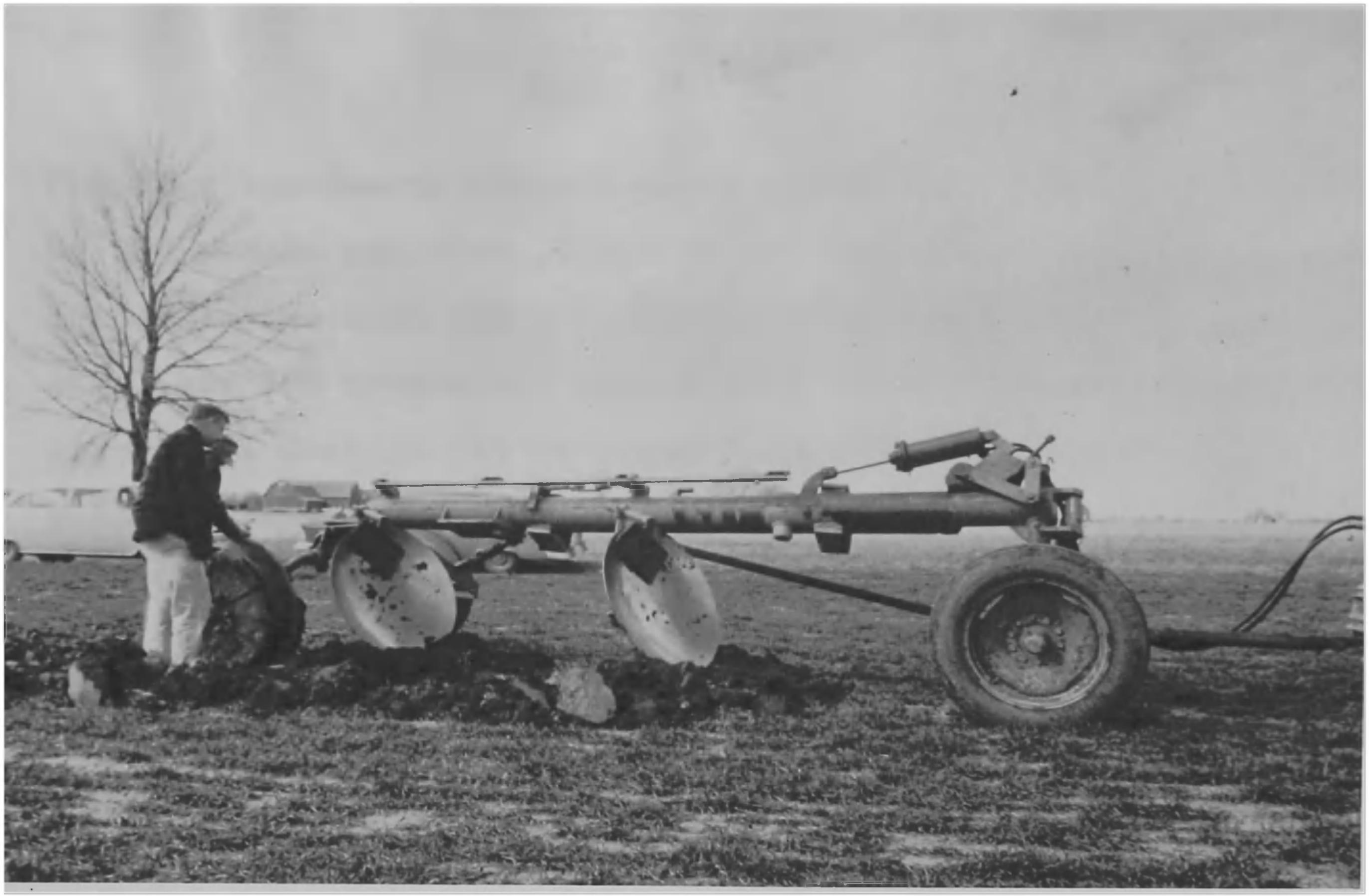


Plate 2. Equipment used for deep plowing.

The four treatments at each depth of plowing consisted of: 0; 700 pounds per acre plowed under; 700 pounds per acre 1 inch to the side and 2 inches below the seed at planting time; and 700 pounds per acre plowed under with 700 pounds per acre 1 inch to the side and 2 inches below the seed at planting time.

Three replications of each treatment were planted to sugar beets May 25th using US 400 variety and 0.005 acres of each were harvested October 18th and yield of roots per acre, percent of sprangly roots, percent sucrose, and percent purity determined.

Green tissue samples were taken at various dates during the season and the chemical composition determined. Penetrometer readings were made at different depths on September 7th. Duplicate soil moisture determinations were made at various depths on September 21st.

Table 21. The effect of depth of plowing on the chemical composition of sugar beet petioles (four sampling dates), percent sucrose and yield of roots and gross sugar per acre on Sims clay loam, Gremel farm, 1956.

Depth of plowing (inches)	p.p.m. of nutrient in green tissue							
	Aug. 2	Aug. 13	Aug. 28	Sept. 21	Aug. 2	Aug. 13	Aug. 28	Sept. 21
	N				P			
16	87	200	182	181	119	207	144	116
10	185	96	198	168	99	132	174	98
	K				Na			
16	3890	3840	3900	4440	860	690	950	1220
10	4200	3840	3350	3870	840	810	980	1340
	Tons roots per acre		Percent sucrose		Percent purity		Pounds gross sugar per acre	
16	18.4		19.4		83		5926	
10	18.3		19.4		84		5964	

Table 21. continued.

Soil tests for pH, pounds P and K per acre when plowed 16 inches deep: 7.0; 121; 142 and 7.3; 93; 75 respectively for the 0-7 and 8-15 inch samples; and when plowed 10 inches deep: 7.5; 37; 85 and 7.7; 66; 13 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure recorded August 13th required to insert 0-4, 0-8, and 0-12 inches was 35, 50, and 50 respectively when plowed 16 inches deep; for the same depth of insertion, 25, 35, and 40 respectively when plowed 10 inches deep. The penetrometer pressure recorded September 7th required to insert 0-4 and 0-8 inches was 35 and 60 respectively when plowed 16 inches deep; and, for the same depths of insertion, 35 and 50 respectively when plowed to 10 inches.

The data in Table 21 show that, on a Sims clay loam, medium to low in P and K, the concentration of K in the tissue at the last two sampling dates was higher where the soil had been deep plowed. Sodium concentration in the tissue increased during the season.

Where the soil was plowed 16 inches deep soil test results show a decrease in pH and an increase in P and K at both depths of sampling.

Table 22. The effect of depth of plowing on the chemical composition of sugar beet petioles (four sampling dates), percent sucrose and yield of roots and gross sugar per acre on Kawkawlin sandy loam, Kurzer farm, 1956.

Depth of plowing (inches)	Pounds 5-20-20 per acre	p.p.m. of nutrient in green tissue							
		Aug. 2	Aug. 13	Aug. 28	Sept. 21	Aug. 2	Aug. 13	Aug. 28	Sept. 21
		N				P			
16	1400	198	200	116	193	225	187	127	129
16	700	200	160	183	165	275	129	116	106
7	700	198	200	165	195	243	124	111	102
7	1400	196	94	117	200	275	117	117	122
		K				Na			
16	1400	5730	6200	5140	5600	400	200	640	820
16	700	4920	4790	3990	3620	370	420	670	760
7	700	5130	4530	3760	4940	370	460	730	1030
7	1400	5940	5570	4560	4850	350	150	750	860

Depth of plowing (inches)	Pounds 5-20-20 per acre	Tons roots per acre	Percent sucrose	Percent purity	Pounds gross sugar per acre
16	1400	13.6	20.0	84	4597
16	700	12.9	20.1	86	4481
7	700	12.1	20.4	88	4369
7	1400	14.0	20.0	85	4777
16	700 (plowed under)	10.3	20.0	88	3626
16	0	8.2	20.0	87	2853
7	0	9.4	20.0	83	3101
7	700 (plowed under)	12.1	18.0	84	3651

Table 22. continued.

Soil tests for pH, pounds P and K per acre when plowed 16 inches deep: 7.3; 84; 88 and 7.2; 72; 93 respectively for the 0-7 and 8-15 inch samples; and, when plowed 7 inches deep: 7.9; 66; 79 and 7.9; 199; 39 respectively for the 0-6 and 12-18 inch samples. The penetrometer pressure required to insert 0-4, 0-7, 10-14 and 10-17 inches was 40, 70, 40 and 65 respectively when plowed to 16 inches deep; and, for the same depths of insertion, 40, 70, 40 and 70 respectively when plowed to 7 inches deep.

The data in Table 22 show that, on a Kawkawlin-Sims sandy loam complex, medium to low in P and K, the concentration of P and K in the petiole increased with the amount of fertilizer applied. Sodium concentration in the tissue increased during the season.

Fertilizer markedly increased yield of roots. Where 1400 pounds per acre was applied the highest yield of roots with an average of 13.8 ton per acre was obtained. Where 700 pounds per acre was applied at planting time, the average yield of roots was 12.5 tons per acre. In this experiment, 700 pounds per acre of fertilizer plowed under to a depth of 7 inches was apparently nearly as effective as the application of 700 pounds per acre in a band 1 inch to the side and 2 inches below the seed.

Where plowed to a depth of 16 inches, yield of roots was reduced compared with areas plowed to a depth of 7 inches by 1.2 ton per acre where no fertilizer was applied and by 1.8 ton per acre where 700 pounds of fertilizer was plowed under but none applied at planting time.

Where the soil was plowed 16 inches deep, soil test results show a decrease in pH at both depths of sampling.

Table 23. The effect of depth of plowing on sprangling in sugar beet roots, Kurzer farm, 1956.

Depth of plowing	Percent sprangly beets
16 inches	13
7 inches	39

The data shown in Table 23 indicate that the percent of sprangly roots as shown in Plate 4 from conventional plowing was greater than those from deep plowing. This difference is indicated by the piles of roots from some typical plots on the Kurzer farm (Plate 5).

Table 24. The effect of depth of plowing on soil moisture content at various depths, September 21, 1956, Kurzer farm.

Depth of plowing	Depth of sample	Percent moisture
16 inches	4 inches	10.5
	9-12 inches	10.0
	15-18 inches	9.3
7 inches	4 inches	10.0
	9-12 inches	8.7
	15-18 inches	8.1

The data in Table 24 indicate that deep plowing may have increased moisture retention but no yield difference could be shown.

Plate 4. Sprangly beet roots on land plowed at a conventional depth.

Plate 5. Yields of sprangly and well shaped beet roots from deep and conventional plowed areas. The two piles on the left (2) are from deep plowing and on the right (1) are from normal plowing.

SUMMARY

Treatments of 0, 750, and 1500 pounds per acre of ammonium nitrate; 2208, 3680 and 5520 pounds per acre of 49 percent treble superphosphate; and 1785, 3675, and 4725 pounds per acre of 60 percent nuriate of potash did not establish field levels of these nutrients corresponding to laboratory fixation tests of the soil. Soil nitrate levels were increased by the heaviest application of ammonium nitrate but phosphorus levels were not affected by phosphorus applications. Soil potassium was increased by potassium applications to levels higher than desired but application of the heaviest amount resulted in no higher level than the medium application.

Nitrates in the petioles from areas receiving the two higher nitrogen applications were increased markedly but phosphorus was decreased.

The yield of roots was significantly increased by the addition of nitrogen but percent sucrose was decreased. The interaction of nitrogen and potassium was significant in that, at the lowest nitrogen level, the addition of potassium reduced yield of roots but with the higher amounts of nitrogen applied yield of roots was not reduced.

The lack of agreement of soil test values reached in the laboratory and the field together with lack of correlation of chemical composition to nutrient levels in the soil was probably due to the nutrient supplying and fixing power of the soil, the physical condition of the soil and/or weather conditions.

The application of phosphorus to a soil low in phosphorus or as a foliar spray increased the phosphorus concentration of the tissue. Nitrogen applications resulted in a decrease in the phosphorus concentration of the tissue. Foliar sprays of phosphorus tended to increase the concentration of phosphorus in the tissue in proportion to the amount applied but did not appear to appreciably influence the yield of roots or percent sucrose.

Where various ratios of fertilizer were applied, precise correlations could not be made due to variability with respect to soil type, soil tests, and fertilizer amounts and ratios. However, the following general trends are suggested. On soils medium or low in potassium the concentration of potassium and sodium in the petiole increased during the growing season and usually increased with increasing amounts of applied potassium fertilizer. On soils low in phosphorus the concentration of phosphorus in the tissue increased with increasing amounts of applied potassium fertilizer.

The differences between yield of roots from areas where various fertilizer ratios were applied were small except in one case. In this case where the soil was low in phosphorus and low to medium in potassium, increasing the amount of K_2O applied from 0 to 80 pounds per acre resulted in an increased yield of roots of about 46 percent. This would indicate that an x-2-1 ratio of fertilizer is probably adequate for these soils.

The effect of date of sampling on chemical composition of the petiole varied with location and would fall into four categories; (1) no distinct trend, (2) increase, (3) decrease, and (4) highest concentration at intermediate dates.

Soil penetrometer data indicate that soil compaction is an important deterrent to high yields.

Plowing to a depth of sixteen inches decreased the soil pH and the percent of sprangly roots but tended to increase soil moisture retention.

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