Mineral Assimilation of Sugar Beets[1]

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The rate of mineral assimilation during plant growth can be approximately followed by knowledge of the quantity found in plants taken at intervals throughout the growing season, a procedure which was followed in this investigation. There are comparatively few instances, however, where such a study has been applied to sugar beets. Cerny (1) has studied sugar beets in a somewhat similar manner, and reported the results on a fresh basis but purely as percentage of composition. Other studies have reported comparisons of yields of beet roots or of sugar content and purity of sugar to the fertilizer treatment. However, none of them points out the requirements of sugar beets for the main nutrients at different fertilization levels.

Materials and Methods

Three one-fourth-acre plots of corn-stubble ground, having several years of practically identical previous cropping history, were selected at the Huntley Field Station for this study. Previous crop yields indicated that the soil had a low level of fertility, with nitrogen most deficient and phosphate probably a limiting factor for crop production after the nitrogen was supplied. For this field test one-half of each of these one-fourth-acre plots was manured, and the whole area cultivated and levelled. Both the manured and unmanured areas were then divided into 12 subplots in each of which were planted six rows of beets. The plantings were randomized to give three replications of the four treatments as listed in table 1. An account of the weather data appears in table 2. The fields were spring-plowed about May 1, levelled and planted to beets on May 11. All fertilizers were side-dressed at approximately 2 inches on either side of the seed. Thinning occurred on June **16** and **17.**

Sampling and Methods of Analysis

Samples were collected from the inside four rows of each six-row subplot on June 16, July 11, August 7, September 3, and October 16. On June 16, approximately 250 plants were selected as a sample, whereas on each subsequent date approximately 30 beets were taken. In all cases such samples were immediately cleaned and topped in the usual manner. Fresh weights were taken separately on tops and roots. A thin slice from the center of each sugar-beet root, and a small angular wedge from each crown, including all leaves attached to it, constituted the samples taken for analysis.

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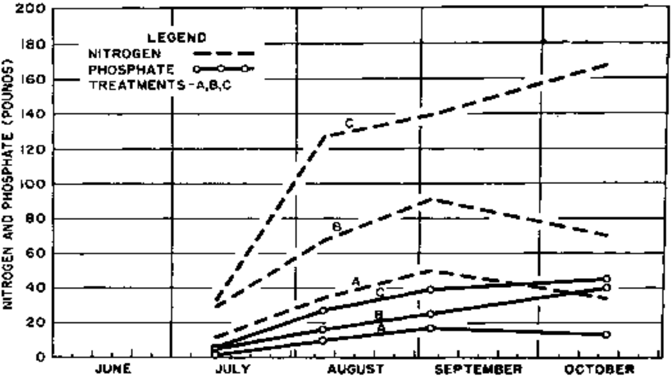

Figure- 1.—Shows the pounds per acre of N and P_2O_5 taken up by the beet crop during the growing season from soil treatments A, B, C.

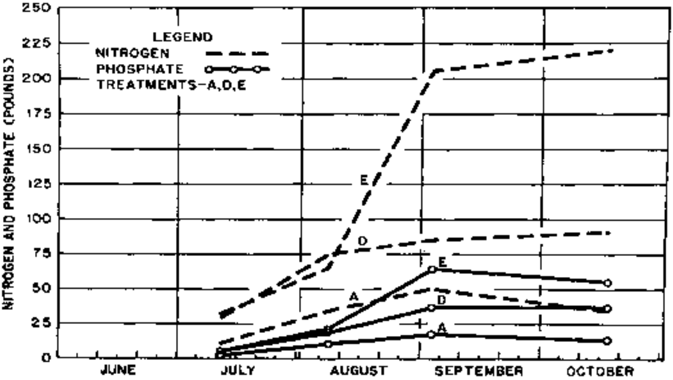

Figure 2.—Shows the pounds per acre of N and PaO_5 taken up by the beet crop during the growing season from soil treatments A, D, E.

Such samples were immediately weighed, dried in a force-draft oven at 55°-65° C, and again weighed when dry. Samples were ground to pass a 1 mm. sieve.

Nitrogen—Total nitrogen was determined by the Kjeldahl method with metallic Hg (mercury) as catalyst.

Phosphorus—Total phosphorus was determined by the method given by Wall (2) for plant material.

Potassium—Total potassium was determined by the method of Wilcox (3).

Sodium—Total sodium was determined by the method of Kolthoff and Barber (4) as modified by McCormick and Carlson (5).

Calcium, magnesium, total ash and acid insoluble ash were determined by the official methods.

Discussion of Results

The choice of the various fertilizer treatments as presented in table 1 was based on the following calculations: The corn stubble was calculated to provide 50 pounds of nitrogen and 15 pounds of phosphate to a beet crop of 10 tons per acre. Treatment D was calculated to make available to the beets on each acre an additional 40 pounds of nitrogen and 18 pounds of phosphate, and to increase beet yield to about 17 tons per acre. The inorganic fertilizer, treatment B, with 80 pounds of nitrogen and 115 pounds of P_20_5, was calculated to equal the manure applied. Treatments C and 111 were calculated to equal each other in all respects, and to provide 160 to 180 pounds of nitrogen, and 55 to 65 pounds of P_2O_5, to a yield in both cases of well over 20 tons. The calculated and also actual results as given in table 1 agree closely. Exceptions are phosphate, in the cases of treatments C and 1). and nitrogen in the case of E.

Figure 1, which plots the nitrogen and P_2G_5 intake for treatments A, B, and C. shows a rapid absorption of nitrogen by the beets during the latter part of July and during August, whereas phosphate in general was more uniformly absorbed throughout the season. Figure 2 presents the intake by beets with treatments A, D, and E. When manure was used, the nutrients were taken up more slowly. In any case, however, the greater part of all nutrients was assimilated previous to September 1. Table 2 shows unfavorable growing conditions in September, and may be part of the reason for cessation of growth.

It is possible to calculate the recovery of the nutrients added by manure and inorganic fertilizers from this data. For example, the maximum content of N and P_2O_5, for treatment A (see table 1) occurred on September 3, and was 50 pounds of N and 17 pounds of P_2O_5 per acre. The maximum quantities from treatment B, on the other hand, were 91.5 pounds of N per acre on September 3, and 40 pounds of P_2O_5 on October 16. Since the amounts added were 80

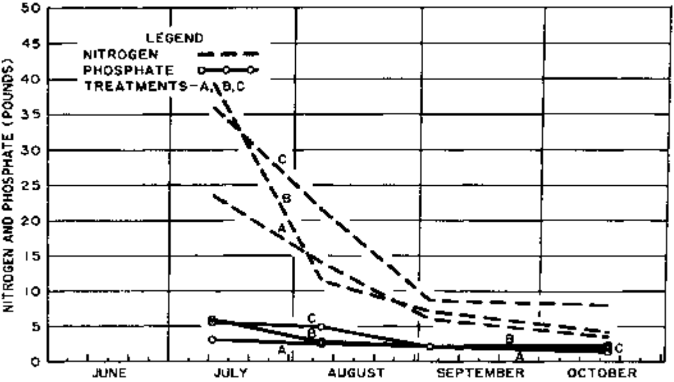

Figure 3.—The pounds N and P_2O_5 found in the beet crop (tops and roots) per ton of crop when sampled at various times during the growing season for treatments A, B, C.

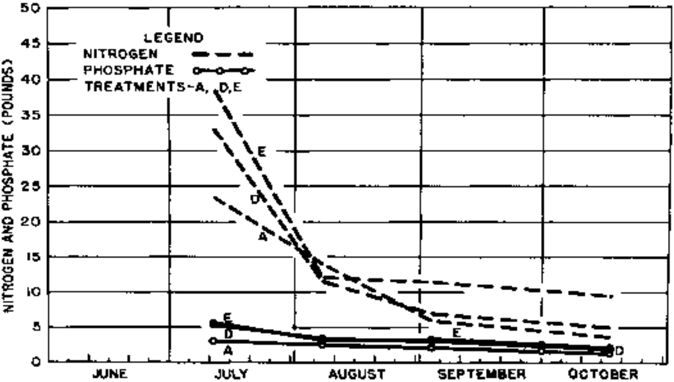

Figure 4.—The pounds N and P_2O_5 found in the beet crop (tops and roots) per ton of crop when sampled at various times during the growing season for treatments A, D, E.

pounds of X and 115 pounds of P_2O_5, the recoveries were about. 50 percent and 20 percent, respectively. The remainder of these recoveries was calculated and appears in table 1. The average recovery of the added P_2O_5, regardless of the source, was 17.6 percent and of nitrogen 57 percent, both being slightly lower than the calculated, which was 18 percent and 60 percent, respectively.

It is also possible to calculate the relation of the pounds of sugar beets produced to the amount of plant nutrients applied, by-dividing the increase in fresh weight of the beets by the pounds of nutrients added as fertilizers. These data appear in table 3. and show that 1 pound of P_2O_5 added in the manure, treatment D, produced 170 pounds of beets, whereas 1 pound of P_2O_5 added in the manure and phosphate fertilizer, treatment E produced only 100 pounds of beets. This, however, is considerably higher than the 58 pounds of beets per pound of P_2O_5 as given by the German worker Gericke (6).

Figures 3 and 4 show the pounds of plant nutrients found in the sugar-beet crop, including the tops and roots for each ton of beets at various times during the season. These show that about 2 pounds of P_2O_5 and 6 pounds of nitrogen are needed to produce 1 ton of beets on October 16. However, the pounds of P_2O_5 vary less than the pounds of nitrogen. The high-fertility treatments, C and E, appear to take more of both nutrients to produce a ton of beets than did B and D.

Summary and Conclusions

1. The calculations and actual results demonstrate that fertilizers can be added in nearly correct amounts when enough of the factors which control production can be evaluated.
2. Manure alone, at the rate of 16 tons per acre, produced an increased yield per acre of 8 tons of sugar beets under the conditions of this experiment, and 400 pounds of ammonium sulfate, together with 250 pounds of treble superphosphate gave similar increase in yield.
3. The efficiency of fertilizers to produce sugar beets was relatively lowered when the beet-tonnage per acre was high.
4. In these tests 1 pound of P_2O_5 as added in treatment D produced 170 pounds of beets. This was reduced to 100 pounds of beets per acre when fertilizer treatment E was used.
5. One hundred pounds of treble superphosphate produced increased yields of 3.5 and 2.5 tons of beets over the untreated plots in the case treatments B and C, respectively.
6. Phosphate and nitrogen recoveries by the crop averaged 17.6 percent and 57 percent, respectively.

Table 1.—Mineral assimilation by sugar beets

Treatment No.	Fertilizer treatment per acre: N lb.	P_2O_5 lb.	Manure tons	Yield tons	Nutrient Constituent	Dates of Sampling: 6/16	7/11	8/7	9/3	10/16	Maximum recovery of added nutrients
						Pounds per acre					Percentage
A	0	0	0	9.0	N	.11	10.5	34.0	50.0	84.0	
					P_2O_5	.08	1.4	9.8	17.0	13.5	
					K_2O	.19	13.7	71.0	121.0	91.0	
					Na_2O	.080	7.0	47.5	71.5	59.0	
					MgO	.033	2.6	8.2	26.5	28.5	
					CaO	.070	2.8	15.0	31.5	36.0	
					Acid Ins. Ash	.020	2.9	25.8	91.0	124.0	
					Total Ash	.67	43.0	405.0	485.0	430.0	
					Dry Matter	2.9	220.0	2020.0	4800.0	5750.0	
B	80	115	0	17.0	N	.20	28.5	66.5	91.5	70.0	50
					P_2O_5	.04	4.3	16.0	25.0	40.0	20
					K_2O	.29	35.0	100.0	112.5	107.0	
					Ash	1.07	142.0	560.0	1020.0	710.0	
					Acid Ins.	.02	6.1	26.9	25.5	95.0	
					Dry Matter	4.2	780.0	5570.0	10750.0	10150.0	
C	180	230	0	21.0	N	.22	32.0	127.0	130.0	165.0	65
					P_2O_5	.04	4.9	27.0	39.0	18.0	13.5
					K_2O	.40	47.0	159.0	101.0	279.0	
					Na_2O	.17	35.0	135.0	210.0	230.0	
					MgO	.065	10.8	22.4	53.0	70.0	
					CaO	.085	10.2	37.0	50.0	70.0	
					Total Ash	1.10	192.0	650.0	910.0	1200.0	
					Acid Ins.	.04	12.2	68.5	96.0	117.0	
					Dry Matter	4.4	800.0	4800.0	8750.0	13000.0	
D	0	0	16*	17.5	N	.17	20.0	75.0	85.0	91.0	28.5
					P_2O_5	.04	1.8	18.5	37.0	37.0	20.0
					K_2O	.28	46.5	78.5	134.0	250.0	
					Na_2O	.14	48.0	53.0	80.0	143.0	
					MgO	.050	11.3	10.5	47.0	54.5	
					CaO	.085	10.0	28.0	50.0	90.5	
					Total Ash	1.0	18.8	770.0	705.0	860.0	
					Acid Ins.	.008	5.1	20.8	158.0	——	
					Dry Matter	3.95	925.0	3790.0	8050.0	11100.0	
E	115	180	16*	23.0	N	.26	32.0	65.0	205.0	220.0	85
					P_2O_5	.08	4.8	21.0	64.0	54.0	17
					K_2O	.48	53.5	118.0	398.0	340.0	
					Na_2O	.26	40.0	88.5	305.0	390.0	
					MgO	.083	10.7	18.5	92.0	104.0	
					CaO	.100	7.3	29.5	77.5	70.0	
					Total Ash	1.5	18.5	745.0	1790.0	1590.0	
					Acid Ins.	.02	4.9	24.5	155.0	208.0	
					Dry Matter	5.6	845.0	3903.0	13800.0	13700.0	

* 16 tons of manure contain approximately 144 pounds of X and 100 pounds of PaO_5.

Table 2.—Temperature data during the growing season of 1941

Date		Maximum	Minimum	Average
May	11-17	78	46	62.0
"	18-24	73	41	57.0
"	25-31	73	46	59.5
June	1-7	67	40	53.5
"	8-15	73	46	59.5
"	16-23	89	54	71.5
"	24-30	82	54	68.0
July	1-7	87	55	71.0
"	8-15	83	52	67.5
"	16-23	94	60	77.0
"	24-31	84	59	71.5
August	1-7	92	61	76.5
"	8-15	88	60	74.0
"	16-23	84	53	68.5
"	24-31	73	48	60.5
September	1-7	70	47	58.5
"	8-15	67	41	54.0
"	16-23	65	41	53.0
"	24-30	59	35	47.0
October	1-7	53	33	43.0
"	8-15	67	32	49.5

Table 3.—Minerals in the tops and roots of sugar beets producing 1 ton of beets

Treatment Number	Fertilizers added N lb. Per Acre	Fertilizers added P_2O_5 lb. Per Acre	Fertilizers added Manure tons Per Acre	Nutrient constituent	Time of sampling 7/11 lb. Per acre	8/7 lb. Per acre	9/3 lb. Per acre	10/17 lb. Per acre	Beet roots per lb. of P_2O_5 added on Oct. 17
A	0	0	0	N	23.5	14.0	6.0	3.6	
				P_2O_5	3.1	2.5	2.2	1.4	
				K_2O	45.0	33.8	17.7	9.8	
				Na	16.8	14.9	7.8	4.7	
B	80	115	0	N	39.5	11.5	7.1	4.2	
				P_2O_5	6.0	2.8	2.0	2.4	140
				K_2O	18.5	19.5	6.7	10.4	
C	180	230	0	N	36.0	21.5	8.8	8.1	
				P_2O_5	5.5	4.8	2.3	2.3	105
				K_2O	58.5	27.5	12.8	13.3	
				Na	39.2	17.2	10.5	7.6	
D	0	0	16*	N	33.0	11.6	7.0	5.0	
				P_2O_5	5.5	3.4	3.1	1.9	170
				K_2O	30.0	27.4	17.6	14.6	
				Na	30.2	11.2	11.8	11.4	
E	115	180	16*	N	38.5	12.0	11.5	9.5	
				P_2O_5	5.7	3.3	3.5	2.3	100
				K_2O	66.5	24.9	20.0	16.4	
				Na	36.2	11.2	11.8	11.4	

* 16 tons of manure contain approximately 144 pounds of N and 100 pounds of P_2O_5.

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