The Sodium-Potassium Nutrition of Sugar Beets Produced on Organic Soil[1]

L. N. Shepherd, J. C. Shickluna and J. F. Davis[2]

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Introduction

The yield response of some crops to sodium has been known for nearly one hundred years. Voelcker as cited by Lehr (3)[3], obtained yield increases by treating mangels with sodium chloride as early as 1865. Harmer and Benne (2) were the first in Michigan to study the effect of salt applied to organic soil on the yield and chemical composition of crops. They reported in 1941, a six year average increase of 4.3 tons of sugar beets per acre from 500 pounds of sodium chloride (salt) where the average annual potash rate was 136 pounds per acre.

Information obtained in the forties at the newly developed Michigan Muck Experimental Farm and reported by Davis (1) in a summary statement show sugar beet yield increases of 1 to 1.8 tons from salt where the potash rate was 300 pounds per acre and no response from salt where the potash rate was doubled. Reports from growers have indicated inconsistent results from the application of salt to sugar beets and the data obtained over the years indicate the yield response from salt to be related to the level of soil potassium or the use of potash fertilizer.

This study was initiated on existing plots at the Muck Experimental Farm to determine the yield response of sugar beets to salt at various soil levels of potassium as measured by soil test and to determine yield response of sugar beets to salt when additional potassium was applied as fertilizer across soils varying in levels of potassium.

Procedure

An investigation involving the response of crops to salt at varying rates of potash was established on Houghton muck located at the Michigan Muck Experimental Farm in 1951. The soil had a pH of 6.3 and contained 85 percent organic matter as determined by loss on ignition. Potash was applied at four rates: 100, 200, 300, and 600 pounds per acre annually. Each block was split and to one-half, 500 pounds of salt were applied annually. Celery and table beets were grown on these plots from 1951 through 1954. Soil tests were taken in the spring of 1955. These tests indicated uniform levels of phosphorus

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[2] Soil Science Department, Michigan Agricultural Experiment Station, East Lansing, Michigan.

[3] Numbers in parentheses refer to literature cited.

across all plots in the experiment and a uniform potassium level for each of the four rates of potash applied.

In 1955, the plots were split a second time. One-half of each plot received the regular application of potash while the other half was left unfertilized.

The plots were cropped with US 400 sugar beets for two consecutive years, 1955 and 1956. Soil samples were taken each fall and spring and tests for phosphorus and potassium were made by the Spurway Active method.[4] The planting dates were May 20, in 1955 and June 2, in 1956. The harvest dates were November 8, in 1955 and November 7, in 1956.

At harvest the fresh weights of the tops and roots were recorded and samples for chemical analysis were taken.[5]

Results

As shown by the data in Table 1, the yields of tops were fairly uniform across all treatments with no significant differences in weight apparent. Likewise, no significant differences in the percent of sucrose resulted from treatment. Potash did, however, cause significant increases in root yields. Yields from plots receiving 200 pounds of potash were significantly higher than those from the plots treated with 100 pounds. Also, the yields from the plots treated with 600 pounds of potash were significantly higher than those from plots treated at the 200 pound rate. The salt did not significantly increase yields on the fertilized plots, but the data indicate a yield response from the salt where the two lowest levels of potash were used.

Considering the plots which were not fertilized in 1955, significantly higher yields of sugar beets were obtained from the plots previously treated with the 600 pound rate of potash than from any other potash level. Also, the residual potassium from plots previously treated with 200 or 300 pounds of potash, produced yields of beets that were significantly higher than the yields from plots treated at the 100 pound rate.

Salt applied on the plots not fertilized in 1955 was as effective in increasing the yield of beets as was the 1955 potash treatment.

The data in Table 2 show that 1956 yields and sugar percentages were considerably different than those of 1955.

In 1956 the yields of roots from plots receiving the three highest rates of potash (200, 300, and 600) were significantly higher than the yields from plots receiving the 100 pound rate. Also, the plots where either 100 or 200 pounds of potash were

[4] .018 normal acetic acid extract.
[5] Sodium and potassium analyses supplied by E. J. Benne and the staff of the Agricultural Chemistry Department.

Table 1.—The Effect of Sodium Chloride at Varying Rates of Potash on the Yield and Sucrose Content of Sugar Beets, 1955.

Fertilizer Grade	Fertilized Annually[1]				Unfertilized 1955[2]			
	Tons per Acre			Percent Sucrose	Tons per Acre			Percent Sucrose
	Tops	Roots	$\bar{X}$		Tops	Roots	$\bar{X}$	
0-10-10 + Salt[3]	13.9	16.8		11.7	14.5	14.4		10.8
			15.3				12.8	
0-10-10	14.2	13.8		11.8	12.7	11.3		11.5
0-10-20 + Salt[3]	12.9	21.7		11.8	15.7	19.4		12.2
			20.2				17.0	
0-10-20	14.5	18.7		12.3	15.1	14.6		11.5
0-10-30 + Salt[3]	15.4	22.3		12.0	15.3	20.6		12.0
			21.5				18.9	
0-10-30	14.3	20.7		12.2	15.6	17.2		12.4
0-10-60 + Salt[3]	12.2	23.0		11.9	15.9	25.1		11.0
			23.2				23.8	
0-10-60	14.6	23.5		11.8	15.9	22.5		11.4
LSD (5% level)	N.S.		2.3	N.S.	N.S.		3.3	N.S.

[1] Fertilized from 1951 through 1955 at 1000 pounds per acre of grade indicated, 100 to 600 pounds K_2O.

[2] Fertilized from 1951 through 1954 at 1000 pounds per acre of grade indicated but not fertilized in 1955.

[3] 500 pounds of salt per acre (sodium chloride).

applied and which received salt, produced higher beet yields than did the corresponding plots which did not receive salt. By grouping the data from all plots which received potash, it was possible to show that salt caused significantly higher sucrose contents.

In 1956, the yield of beets from the fertilized plots was considerably higher than those unfertilized. The data from the unfertilized plots show that in every case sugar beet yields were increased by salt. These data indicate that a yield response of sugar beets to the application of salt may be related to potassium level in the soil or to the rate of potash applied, with response to salt decreasing with increased potassium level in the soil.

The data in Figure 1 show the potassium level of the soil in the spring of 1955 and the potassium level in the spring of 1957 following the two-years cropping with sugar beets. The loss of potassium from the soil unfertilized in 1955 and 1956 as a result of cropping is apparent. The highest soil test level in a two-year period dropped from about 300 pounds of potassium per acre to less than 50 pounds.

Table 2.—The Effect of Sodium Chloride at Varying Rates of Potash on the Yield and Sucrose Content of Sugar Beets, 1956.

Fertilizer Grade	Fertilized Annually[1]				Unfertilized 1955 and 1956			
	Tons per Acre			Percent[1] Sucrose	Tons per Acre			Percent Sucrose
	Tops	Roots	$\bar{X}$		Tops[2]	Roots[2]	$\bar{X}$	
0-10-10 + Salt[3]	13.1	10.6		14.9	13.5	8.6		14.0
			9.9				7.2	
0-10-10	10.8	9.2		14.1	8.2	5.8		14.1
0-10-20 + Salt[3]	13.3	12.2		15.3	13.0	8.0		13.9
			11.6				7.1	
0-10-20	13.3	11.1		15.2	9.1	6.3		14.3
0-10-30 + Salt[3]	11.8	11.8		16.5	11.0	8.7		14.5
			11.7				8.0	
0-10-30	13.4	11.5		15.1	11.1	7.4		14.4
0-10-30 + Salt[3]	11.1	11.8		16.0	11.4	9.9		13.9
			12.1				8.7	
0-10-60	12.5	12.5		14.4	10.0	7.6		13.6
LSD (5% level)	N.S.		1.7				1.7	N.S.

[1] Significantly higher sugar content in favor of salt treatment (5% level).
[2] Significantly higher root and top yields in favor of salt (5% level).
[3] 500 pounds of salt per acre (sodium chloride).

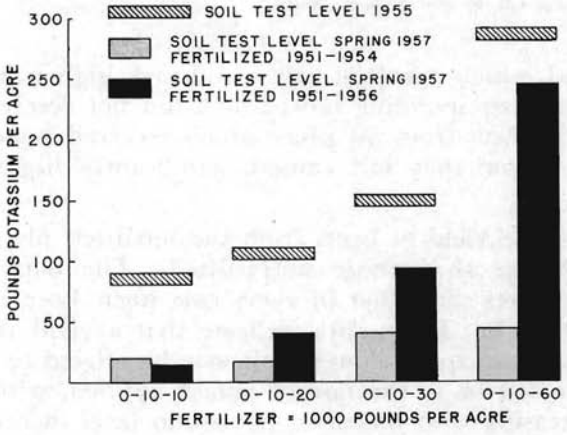

Figure 1.—The effect of two consecutive years of sugar beet cropping on the potassium level in the soil.

In 1955, with little difference in sugar content, the sugar produced per acre paralleled yield (Figure 2), thus giving higher sugar yield as a result of salt applied within the normal range of potash fertilization. In 1956, with little difference in

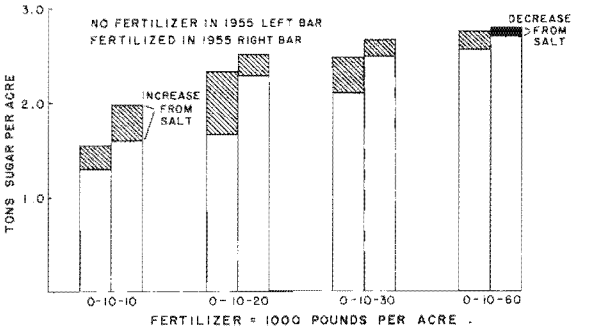

Figure 2.—The effect of sodium chloride and potash on the yield of sugar, 1955.

yield on the fertilized plots but a higher sugar content in beets from the salt treated plots, higher yields of sugar per acre were produced where salt was applied.

The potassium and sodium content of the sugar beet roots and tops are given in Tables 3 and 4. The sodium and potassium contents of sugar beet tops were considerably higher than the roots. In general there appears to be an inverse relationship between the sodium and potassium content of the tissue. The tissue with the highest content of potassium, in general contained the lowest content of sodium, and vice versa. Due to higher yields of beets where salt was applied, in general more potassium was removed per acre from plots receiving salt than from corresponding plots receiving no salt, even though the

Table 3.—The Effect of Sodium Chloride at Varying Rates of Potash on the Potassium and Sodium Composition[1] of Sugar Beet Roots, 1955.

Fertilizer Grade	Fertilized Percent		Unfertilized Percent	
	Potassium	Sodium	Potassium	Sodium
0-10-10 + Salt[2]	1.01	.90	.98	1.06
0-10-10	1.21	.39	.79	.76
0-10-20 + Salt[2]	2.22	.63	.91	2.10
0-10-20	1.55	.44	1.49	16
0-10-30 + Salt[2]	2.23	.60	2.27	1.28
0-10-30	2.34	.38	2.28	.19
0-10-60 + Salt[2]	2.75	.31	2.45	.65
0-10-60	2.97	.24	3.44	.53

[1] Chemical composition expressed at percent of the oven dry tissue.
[2] 500 pounds of sodium chloride per acre.

Table 4.—The Effect of Sodium Chloride at Varying Rates of Potash on the Potassium and Sodium Composition of Sugar Beet Tops,[1] 1955.

Fertilizer Grade	Fertilized Percent		Unfertilized Percent	
	Potassium	Sodium	Potassium	Sodium
0-10-10 + Salt[2]	2.28	3.09	4.04	2.25
0-10-10	3.20	1.76	2.87	3.07
0-10-20 + Salt[2]	5.16	2.12	3.81	2.80
0-10-20	4.72	1.62	2.91	2.61
0-10-30 + Salt[2]	5.01	2.19	4.03	2.03
0-10-30	5.39	1.32	4.06	.98
0-10-60 + Salt[2]	6.35	1.97	5.73	2.69
0-10-60	6.49	1.01	4.77	1.88

[1] Chemical composition expressed as percent of oven dry tissue.
[2] 500 pounds of sodium chloride per acre.

content of the tissue may have been slightly less. This is especially true within the range of normal potash fertilization, (200 and 300 pounds).

Summary

Tests conducted at the Michigan Muck Experimental Farm show that the yield response of sugar beets to salt applications decreased with increased rates of potash applied. Salt applied at 500 pounds per acre across plots receiving 600 pounds of potash per acre tended to depress the yield of sugar beets.

The data indicate an inverse relationship between the potassium and sodium contents of the sugar beet tissue in that high levels of potassium tended to reduce the sodium content, and vice versa. Even though this relationship existed, more potassium was removed per acre in the crop from salt treated plots at the 200 and 300 pound per acre rates of potash.

The large loss of potassium as indicated by soil test indicates the need for annual soil tests to determine fertilization recommendations for sugar beets.

Literature Cited

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