A STUDY OF SOIL PORE SPACE AND FERTILITY EFFECTS FOR SUGAR BEETS ON BROOKSTON CLAY SOIL

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Sugar beets are known to require good soil physical condition or tilth for normal growth. The harmful effects of high bulk density and low pore space has been reported by Baver (2), Cook (4) and Pendleton (6). Generally, these results pertained to medium textured soils. Pendleton has reported that the proportion of pore space for good growth may vary considerably for different soils. Poor tilth conditions are usually associated with soil crust formation and crusted conditions may affect sugar beet production through reduced emergence. Low pore space may also directly impede sugar beet growth and result in lower yields and poorly shaped roots. It has also been considered that good soil tilth improves the effectiveness of fertilizer (3).

Sugar beet production in Ontario is located mainly in the southwestern section of the province and a large part of the acreage is located on soils with a high clay content. The Brookston clay soil predominates in acreage in this area and sugar beet yields have generally been lower on this soil than on the medium textured soils in this region. Brookston clay has approximately 40 per cent clay content (particles with less than 2 u diameter) in the surface 4 inches and the clay content increases to over 40 per cent at lower depths. In addition to the fine texture, the level topography and poor drainage characteristics result in a soil considered to be problematic with regards to physical conditions.

The production of inter-tilled crops in this area has reduced pore space and drainage capacity from original levels and has reduced yields, particularly where fertility was low. In farming systems where legumes could be profitably grown the soil tilth was maintained to some extent. Experiments with corn at Woodslee indicated that soil physical conditions resulting from row crop systems are adequate for this crop provided that fertility needs are met. In the corn experiments soil conditioners were used to improve soil tilth and to test the effect of improved soil physical condition on corn yield and nutrient use.

Soil conditioners have been used on many soils to test the effect of soil physical improvement for the sugar beet crop. Haise, et al., (5) reported a yield decrease for sugar beets where VAMA and HPAN soil conditioners improved soil physical characteristics on a loam soil. Baird, et al., (1) reported improved sugar beet emergence on clay soil from conditioner application. Where soil conditioner was used to improve the structure of a fine sandy loam Smith (7) reported that the percentage sucrose was increased by conditioner application in one of the two years.

The present experiment was established in 1960 to help define some of the soil physical requirements for the sugar beet crop on Brookston clay soil. This information should aid in predicting satisfactory cropping systems for sugar beet production. Cropping systems and cultural practices are the only practical means for improving and maintaining soil tilth.

In this experiment two levels of soil physical condition were established. The one level was the condition that existed where many inter-tilled crops had been grown. The other level was one where soil pore space had been increased by application of VAMA soil conditioner. Each pore space level was established in combination with three fertility levels

MATERIALS AND METHODS

The area selected had grown many inter-tilled crops and during the three years before this experiment was established the test site had grown one crop of oats followed by one crop of sweet clover and had then been summer fallowed one season. The test was established using a randomized block design with four replications.

VAMA soil conditioner was applied to one half of the plots at .10 per cent concentration in 1960 and was incorporated within the surface 6" depth of soil by rotary tillage. Fertilizer (4-24-12) was applied in the spring of 1961 and 1962 at two rates, these being 200# and 600# per acre, each rate being applied on conditioner treated and untreated plots. Additional nitrogen was added to the 200# and 600# fertilizer rates to increase the total nitrogen applied to 30# and 90# per acre, respectively. A check fertilizer treatment was established on the conditioner treated and untreated plots.

The area was fall plowed each year and received one or two diskings in combination with leveling in the spring before planting was carried out. Monogerm seed was used and was planted at 1½" spacing within the rows. The rows were later thinned to give a plant population of 22,000 plants per acre.

The soil physical condition on the treated and untreated plots was assessed by measurement of aeration and total pore space. Soil moisture was also measured on the 3" diameter core samples obtained for porosity measurement. Plant emergence was measured by counting the number of plants in 1 yard of row in five locations in each plot. Plant growth was evaluated by leaf measurement and reported as leaf area in square centimetres. Leaf and petiole samples were obtained at thinning, during the mid-growth period and again before harvest. Nitrate nitrogen was determined on petiole samples but are not reported since no significant differences were obtained.

Table 1. Effect of Soil Treatment on Pore Space and Moisture on Brookston Clay Soil, Woodslee, 1961-62

Treatment	Air pore	Total pore	Moisture
	%	%	%
No fertilizer - no VAMA	15.6	50.2	23.6
No fertilizer - .1% VAMA	19.2	54.2	24.9
200# 4-24-12 + 22#N - no VAMA	15.7	50.5	23.4
200# 4-24-12 + 22#N - .1% VAMA	18.0	54.3	25.2
600# 4-24-12 + 66#N - no VAMA	14.5	50.1	23.6
600# 4-24-12 + 66#N - .1% VAMA	17.5	52.4	23.7
L.S.D. (0.05)	2.7	1.7	1.2
(0.01)	3.6	2.2	1.6

Table 2. Effect of Soil Conditioner and Fertility Treatments on Sugar Beet Growth on Brookston Clay Soil, Woodslee 1961-62

Treatment	Emergence 5 wks.	Leaf Area 2 mos.
	Plants / yard	$(cm)^2$
No fertilizer - no VAMA	16.2	153.3
No fertilizer - .1% VAMA	18.1	163.7
200# 4-24-12 + 22#N - no VAMA	17.3	173.4
200# 4-24-12 + 22#N - .1% VAMA	20.7	162.1
600# 4-24-12 + 66#N - no VAMA	18.4	194.8
600# 4-24-12 + 66#N - .1% VAMA	21.0	204.9
L.S.D. (0.05)	2.0	20.1
(0.01)	2.7	26.8

Table 3. Effect of Soil Conditioner and Fertility Treatment on Sugar Beet yield on Brookston Clay Soil, Woodslee, 1961-62

Treatment	Root yield	Sucrose	Refractive purity	Gross Sugar	Top wt. (green)	Weight per beet
	Tons/ac.	%	%	lb./ac.	Tons/ac.	lb.
No fertilizer - no VAMA	18.7	17.9	87.5	6,704	7.1	1.8
No fertilizer - .1% VAMA	21.4	18.2	87.1	7,786	7.3	2.1
200# 4-24-12 + 22#N - no VAMA	20.9	18.0	86.1	7,496	7.9	2.0
200# 4-24-12 + 22#N - .1% VAMA	20.1	17.8	85.9	7,162	7.7	2.0
600# 4-24-12 + 66#N - no VAMA	22.4	17.6	85.7	7,877	9.8	2.1
600# 4-24-12 + 66#N - .1% VAMA	25.2	17.5	85.3	8,803	10.1	2.4
+ L.S.D. (0.05)	2.0	.4	1.2	767	1.3	.2
(0.01)	2.6	.5	1.6	1,022	1.7	.3

Yield characteristics were measured as root yield, per cent sucrose, per cent refractive purity, gross sugar in pounds, top weight in tons and average weight per beet in pounds.

EXPERIMENTAL RESULTS

Results in Table one indicate that aeration pore space and total pore space were increased by VAMA soil conditioner and were maintained at a higher level during the 1961-62 period by this treatment than pore space values on the untreated plots. Pore space values on the high fertility treatment appeared to be slightly lower than on the check and low fertility applications. Pore space was increased significantly, however, by conditioner within the high fertility level. Average soil moisture by weight was higher on treated than on untreated plots within the check and low fertility treatments. Moisture on all plots, however, was high within the available soil moisture range for Brookston clay soil.

Plant emergence (Table two) was improved on the better tilth conditions effected by VAMA. Increased fertility also improved emergence. The effects of fertility and good tilth were more pronounced in 1962 where crust forming conditions were more prevalent. Plant growth, expressed as leaf area, was increased by high fertility over all other treatments and tended to be increased by improved pore space within the high fertility and within the check fertility levels.

Root yield in tons per acre was higher in 1961 than in 1962. Average yield was increased by soil conditioner, by increased fertility and by the improved tilth along with high fertility. Per cent sucrose was decreased slightly by high fertility and the lowest numerical sucrose percentage occurred in the presence of conditioner and high fertility. Per cent refractive purity was also decreased slightly by high fertility and by the improved tilth associated with VAMA application. Production of gross sugar, however, followed the same trends as did root yields. Improved tilth and increased fertility generally increased the gross sugar produced with the combined effect of high pore space and high fertility giving the highest sugar yield. There was an exception to this effect at the medium fertility level (200# 4-24-12) where fertility alone resulted in greater sugar yield than where conditioner and 200#4-24-12 were combined. Top weight of beets was increased by high fertility and VAMA application tended to further increase top weight. The high pore space conditions on the VAMA treatment was associated with the highest average weight per beet on the high and check fertility levels. Good tilth along with high fertility produced a beet of 2.4 lbs. average weight which was much greater than on all other treatments.

SUMMARY

Soil tilth was improved and maintained during 1961-62 by VAMA soil conditioner as indicated by increased pore space values on the treated soil. The resultant increase in soil pore space represented a fairly significant amelioration on the Brookston clay soil where the experiment was established. Soil moisture was also increased slightly by VAMA application in two instances but soil moisture on all treatments was well within the available moisture range.

Emergence and growth were generally increased by the improved tilth and by fertility application. Yield results would indicate that a high level of tilth along with high fertility is necessary on the Brookston clay soil to obtain maximum root and sugar yields. Although nitrate nitrogen in the petiole was not significantly affected by soil treatment the results indicate that the best roots were considerably larger where increased pore space was present along with high fertility.

The results suggest that the cropping system is an important factor in successful sugar beet production on the Brookston clay soil of southwestern Ontario. While corn and some other crops can be grown under poorer physical conditions and still produce high yi yields, this does not seem to be the case with sugar beets. Since grasses and legumes are the most practical means of improving tilth at present it would seem advantageous on Brookston clay to grow sugar beets in cropping systems that include these soil improving crops.

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Literature Cited

(1) Baird, Bruce L., Bonnemann, Joseph J. and Richards, Arch W.

1954 The use of chemical additives to control soil crusting and increase emergence of sugar beet seedlings.
Proc. Am. Soc. Sugar Beet Tech. 136-142

(2) Baver, L.D. and Farnsworth, R.B.

1940 Soil Structure Effects In The Growth of Sugar Beets.
Soil Sci. Soc. Amer. Proc. 5: 45-48

(3) Baver, L.D.

1951 The effect of physical properties of soil on the efficient use of fertilizers.
Agron. Jour. 43: 359-363

(4) Cook, R. L.

1950 Tillage Practices and Sugar Beet Yields
Proc. Am.Soc. Sugar Beet Tech. 286-293

(5) Haise, Howard R., Jensen, L.R. and Alessi, Joseph

1955 The Effect of Soil Conditioners on Soil Structure and Production of Sugar Beets
Soil Sci. Soc. Amer. Proc. 19: 17-20

(6) Pendleton, R.A.

1950 Soil Compaction and Tillage Operation Effects On Sugar Beet Root Distribution and Seed Yields

(7) Smith, C.H.

1954 Influence of Krilium Soil Conditioners On Sugar Content Of Beets
Proc. Am.Soc. Sugar Beet Tech. 144-146