Sugar Beet Fertilization in Wisconsin

K. C. BERGER[2]

Although sugar beets have a relatively high requirement for nitrogen, potassium, and boron, in general only a small amount of fertilizer has been used on sugar beets in the past in Wisconsin. As a result, yields of sugar beets are low, with the state yield average around 9 to 10 tons per acre. Because of this, soil fertility investigations with sugar beets as reported in this paper were initiated in 1940. Experiments were conducted in the field in most of the years since that time.

During the course of the investigations, nutrient disorders of sugar beets, involving potassium deficiency, boron deficiency, nitrogen deficiency, nutrient unbalance and the effect of acid soils have appeared in the soil. The low yields in the state can, to quite an extent, be attributed to the above unbalanced fertility conditions. A number of experiments were conducted during this period to study the effect of soil reaction, nutrient balance, high potash fertilizers, effect of boron fertilization and the effect of salt. The results of these investigations are reported here.

A part of the investigations reported here have been previously reported in annual progress reports (1) (2) (3) (4).[3]

Procedures

In all field experiments, 4 replications of each treatment were made in a randomized block arrangement. Individual plots were 4 rows wide and 60 feet long. The fertilizer applied in the row was applied in 2 bands about 1 1/2 inches to the side of the seed and slightly below with a shoe-type fertilizer beet drill. Fertilizers applied broadcast were weighed out for each plot and applied by hand after plowing and then were disced thoroughly into the soil. The broadcast application of fertilizer was double disced so as to mix it with the top 3 to 5 inches of soil.

For harvest, 5 feet were removed from each end of the plot and the center 2 rows 50 feet long were taken for yield. The beets were hand-topped and weighed in the field and the yields were calculated to an acre basis. The amount of sugar was determined in each case.

Available phosphorus and potassium determinations and the pH of the soil were determined by the Truog quick test procedure. Available boron was determined by the Berger-Truog quinalizarin method. Soil samples were taken from each plot before fertilizers were applied and 3 to 5 cores to the depth of the plow layers were taken for each sample.

Effect of Soil Acidity on Yield

Preliminary observations have indicated that the pH of the soil affected the yield of sugar beets considerably. It was observed that yields were quite commonly higher on neutral or alkaline soils than they were on soils of strong to medium acidity, even though beets were fertilized alike. Results

[1] Contribution from the Department of Soils, University of Wisconsin, Madison 6, Wis. Published with the permission of the Director of the Wisconsin Agricultural Experiment Station.

[2] Professor of Soils.

[3] Figures in parentheses refer to "Literature Cited."

given in Table 1 show the influence of soil reaction on yield of beets at three different fertility levels. These results were obtained in eight different experiments, conducted in different years with 4 of the experiments located on soils more acid than pH 5.9 and the other 4 on soils which were neutral or alkaline. In each field the treatments were replicated 4 times and were randomized and the average yields are given in Table 1. When no fertilizer was applied the beets on the acid soils yielded about 11 tons to the acre, while those on the neutral or alkaline soils yielded about 15 to the acre.

Table 1.—Yield of sugar beets on neutral and medium acid soils with various fertility levels.

	Acre yield in tons[1]		
Soil Reaction	No fertilizer	Fertilizer at[2] side of seed Borax broadcast	Fertilizer at[3] side of seed Borax plus high potash fertilizer broadcast
Lower than pH 5.9	11.1	14.2	18.5
Higher than pH 7.0	15.1	18.1	23.0

[1] Average of 4 fields at each pH level with 4 randomized replications in each test.
[2] Fertilizer application 150 to 200 pounds of 3-12-12 at side of seed plus 25 lbs. borax broadcast.
[3] Fertilizer application 800 to 1,500 lbs. of 6-6-18 or its approximate equivalent and 25 lbs. borax broadcast. Row application of 150 to 200 lbs.; 3-12-12 in addition. Broadcast fertilizer composition changed from year to year but in each case the fertilizer was the same on the acid and neutral soil.

When a small amount of starter fertilizer was applied at the side of the seed, together with Borax, these yields were increased about 3 tons to the acre, but the difference between limed and unlimed soils remained constant. When heavy applications of high potash fertilizer were applied broadcast, in addition to the row fertilizer, the yield was increased about 4 tons in the case of the acid soils, and about 5 tons in the case of the neutral soils.

In one experiment on a strongly acid soil, 2,000 pounds of finely powdered dolomitic limestone were applied broadcast at seeding time and in this experiment the yield was increased 3 tons per acre by the application of lime. This comparison was made with the high fertility level and yields increased even though the lime probably did not dissolve completely in the soil.

These soils varied from 10 to 50 pounds of available phosphorous per acre and from 110 to 200 pounds of available potassium per acre. The acid soils ranged in pH from 5.3 to 5.9 while the neutral or alkaline soils varied from pH 7.0 to 8.0.

The figures given in Table 1 show the great importance of liming under Wisconsin conditions.

Influence of Soil Fertility on Yield

Early in the experimental work it was found that under Wisconsin conditions maximum yields could not be obtained with the application of 150 to 200 pounds of fertilizer at the side of the seed in the row. Because beets are heavy users of nitrogen and of potash while using only relatively small amounts of phosphorus, experiments were initiated in which heavy applications of high potash fertilizers were applied broadcast. These experiments

were conducted on Superior clay loam, Carrington silt loam, and Miami silt loam, the three most important soil types for sugar beets in Wisconsin. The Superior clay loam is a red soil of lacustrine origin, usually neutral or slightly alkaline in reaction, containing from 150 to 250 pounds per acre of available potassium and 40 to 50 pounds of available phosphorus per acre.

The Carrington silt loam is usually high in organic matter and is a Prairie soil derived from calcareous glacial drift. This soil is usually acid, ranging in pH from 5.2 to 5.7, containing 10 to 50 pounds of available phosphorus per acre and 110 to 150 pounds of available potassium.

Table 2.—Yield of sugar beets as influenced by three levels of fertility on various soil types.

Soil Type	Acre yield in tons[1]				
	No fertilizer	150 to 200[2] pounds 3-12-12 side-seed	Broadcast[2] plus 150 to 200 3-12-12 side-seed	Broadcast fertilizer Pounds	Grade
Superior clay loam	16.5	21.0	24.0	1000	0-10-25
Carrington silt loam	8.2	11.8	17.7	1000	0-10-25
Superior clay loam	16.5	20.7	26.8	1000	0-10-30
Carrington silt loam	15.2	18.0	21.1	1000	0-10-30
Carrington silt loam	9.9	14.2	18.1	1600	5-7.5-22.5
Miami silt loam	10.9	13.0	17.2	1600	6-6-20
Miami silt loam	7.5	10.3	14.7	1200	6-6-20
Miami silt loam	9.3	12.5	17.6	1200	6-6-18
Average	11.8	15.2	19.2		

[1] Average of 4 randomized replications.
[2] Borax applied at the rate of 25 pounds per acre broadcast.

The Miami silt loam is derived from calcareous glacial till, and was developed under deciduous forest. This soil has a pH of between 5.7 and 7.2, containing 40 to 50 pounds of available phosphorus and 125 to 170 of available potassium.

The data given in Table 2 show that in every case, on these soils, yields were increased over the untreated plots by the application of 3-12-12 at the side of the seed. For all the experiments this amounted to an average of 3 1/2 tons of beets per acre. When additional high potash fertilizer was applied broadcast, the yields were increased over the row application alone in every case also, the average increase being 4 tons per acre, with the largest increase being about 6 tons on one experiment. In this experiment the broadcast plus the row application of fertilizer resulted in a yield of 26.8 tons of beets per acre. In the first experiments, phosphate and potash were broadcast but later nitrogen deficiencies have appeared and better results have been obtained with some nitrogen in the fertilizer. In recent years, the fertilizer giving the best results for broadcast application with sugar beets has been the 6-6-18 mixture applied at the rate of 800 to 1,200 pounds per acre.

Influence of Boron on Sugar Beet Yield

Boron deficiencies in sugar beets were found in scattered areas soon after the work was started and, in all experiments since that time, boron has been included in the tests. When soil tests have been correlated with yields,

it was found that usually sugar beets did not respond to boron fertilization when the soils contained 2 pounds per acre or more of available boron. When the soils were lower than this increases in yields were obtained consistently with boron fertilization, even though in none of the experiments reported here boron deficiency symptoms were present.

Figures given in Table 3 show that on low boron soils the application of 25 pounds per acre broadcast or 15 pounds per acre of Borax at the side of the seed increased the yield, on the average, 2 tons per acre. The data also show that, when there is sufficient boron in the soil, yield increases were not obtained.

Table 3.—Yield of sugar beets grown of various soil types with and without boron fertilization.

Soil Type	Available boron in soil Lbs. per acre	Acre yield in tons[1] Without boron fertilization	Borax applied broadcast 25 lbs. per acre	Borax applied side seed 15 lbs. per acre
Superior clay loam	1.4	18.7	20.7	19.5
Miami silt loam	1.1	8.5	10.3	11.8
Superior clay loam	1.7	18.9	21.0	20.4
Average of low boron soils	1.4	15.4	17.3	17.2
Carrington silt loam	2.0	18.8	18.0	17.8
Miami silt loam	2.0	13.3	13.0	12.6
Carrington silt loam	2.6	11.8	11.8	
Carrington silt loam	2.2	13.1	14.2	12.8
Average of high boron soils	2.2	14.3	14.5	14.4

[1] Average of 4 randomized replications.
All plots received 200 lbs. of 3-12-12 per acre at the side of the seed.

When the Borax is applied at the side of the seed in the row and the rate, on silt or clay loam soils, increased to 40 pounds per acre, annual weeds in the row can often be controlled without injury to the sugar beets to such an extent that hand weeding is unnecessary. Deep-rooted perennial weeds, such as Canada Thistle and quack grass, will not be affected by this treatment, however. Considerable work with canning beets has been done on this method of weed control, and preliminary investigations with sugar beets have also indicated that it is successful. The Borax must be applied at both sides of the seed so that it is not in direct contact with the seed or the stand of beets will be reduced.

Use of Sodium

Several experiments were conducted in which part of the potassium in the fertilizer was replaced with an equivalent amount of sodium, and results, although not conclusive, indicate that sodium may to a certain extent replace part of the potassium needed by the sugar beets, and that in addition sodium might also have some stimulating effect on the beets. Results at present, however, are not conclusive enough to warrant presenting data.

Summary

Results presented show that soil reaction is a very important factor on sugar beet yields in Wisconsin. Yields in experimental plots averaged 4 to

4 1/2 tons higher on neutral or alkaline soils than on soils with medium acidity at three fertility levels.

Results presented show that for maximum yields of sugar beets it is necessary to apply a high potash fertilizer broadcast in addition to the row fertilizer application. This treatment resulted in an increase in yield over row fertilization of 4 tons per acre and an increase of 8 1/2 tons per acre over the unfertilized plots. The figures presented are an average of 8 different experiments conducted on different soils in different years. At the present time, a 6-6-18 fertilizer appears to give the best results when applied broadcast.

When soils contain less than 2 pounds per acre of available boron, the application of Borax, either broadcast or at the side of the seed in the row, resulted in an increase in yield of about 2 tons of beets per acre when the beets were fertilized with row fertilizer in addition to the Borax.

None of the treatments presented influenced significantly the percentage of sugar in the beets or the purity.

Literature Cited

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