These figures indicate a positive relation between host crops in general and damage caused by Rhizoctonia root-rot. They also indicate a closer relation between sugar beets as preceding crops and the occurrence of Rhizoctonia than between this disease and other host crops.

A comparison of small grain and corn show the latter to be more effective in reducing Rhizoctonia than the former. One or more successive small grain crops were associated with a damage of 4.52%, while a like number of successive corn crops resulted in a loss of 4.07%.

The preceding loss figures are small and the differences are also small, however, we believe that they indicate real trends and suggest cultural means of reducing losses due to Rhizoctonia root-rot. This belief is based on the fact that similar relations are indicated year after year in these studies.

BORAX AS A CONTROL FOR HEART ROT OF SUGAR BEETS[1]

R. L. Cook[2]

Heart rot of sugar beets was first attributed to an insufficient supply of soil boron by Brandenburg (1) of Germany in 1931. For years prior to that date the disorder had been classed as a disease and many attempts had been made among European investigators to isolate the causative organism.

Since Brandenburg's experiments were reported, other workers both in Europe and in this country have verified his findings that heart rot is caused by a deficiency boron. Kotila and Coons (4) reported the presence of heart rot in Michigan beets in 1935. A study of symptoms of the disorder and the results of preliminary field surveys and experiments were reported by the author (2) in 1937. Since that date many Michigan farmers have learned to recognize heart rot, and some state that they have experienced losses from this cause for many years. It is the purpose of this paper to report further progress in the experiments performed to determine the effectiveness of borax as a control for heart rot of sugar beets.

Occurrence and Symptoms of Boron Deficiency

For the benefit of those not acquainted with the break down of sugar beet tissue caused by an insufficient supply of boron, it seems advisable to briefly review the subject from the standpoint of soil characteristics on which the disorder occurs and plant symptoms exhibited.

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The results of surveys conducted during the last three years show that heart rot occurs more often on the rolling Miami loam, silt loam, and clay loam soils than on the level Brookston soils of similar texture. Furthermore, it has been found that occurrence on the rolling soils is usually confined to the higher places in the fields. On the level soils, where sugar beets are commonly grown in Michigan, signs of boron deficiency occur most often in areas of lighter texture and higher organic matter content, or in areas underlaid by sand and gravel fairly close to the surface.

These places of heart rot occurrence indicate that leaching has some influence on the supply of boron in the soil. Chemical tests, however, have failed to reveal low percentages of boron in the areas where sugar beets have suffered from lack of the element. This is an indication that leaching has the effect of quickly removing the available boron as it is released from the minerals by weathering and that it is not effective in rapidly reducing the total boron content of the soil. This seems to be a logical conclusion, because boron minerals weather slowly.

Chemical tests show that heart rot occurs more often on alkaline than on acid soils and that the positive correlation exists between heart rot occurrence and the active calcium content of the soil. The results of these experiments have been recently presented for publication. (3)

The first signs of heart rot appear in July or early August, in extreme cases, and later in areas where the supply of available boron is somewhat greater. Leaf symptoms are first noticed. The blackened and checked petioles are positive signs of heart rot. Shortened and twisted petioles and large numbers of small leaves are also reliable signs.

An insufficient supply of boron results in a break down of the tissue in certain portions of the plant. In the sugar beet the death of the growing center of the crown and the production of such beets has resulted in the name heart rot. Later in the season some beets send out a large number of leaves from around the edge of the crown. These leaves may die or they may continue to grow until harvest time when they practically cover the dead heart.

All sugar beets suffering from an insufficient supply of boron do not exhibit the same symptoms of deficiency. Some show leaf symptoms only while others suffer break down of the root tissue.

In occasional fields individual beets afflicted with heart rot are found well scattered among healthy beets but usually the disorder occurs in patches varying in size from a few square yards to an acre or more. In one case the soil is an alkaline sandy loam containing 14 per cent organic matter and underlaid by a layer of sand at a shallow depth. These conditions appear to be ideal for the development of heart rot.

EXPERIMENTAL

Pot Culture Experiments

In the study of boron deficiency symptoms the use of pot cultures has proved to be very valuable. By the use of a screened room, without glass and adjacent to the greenhouse, it is possible to grow plants in season under fairly constant conditions.

Plan of Pot Cultures—Sugar beets were grown in two gallon glazed earthenware jars, each filled with 8 kgm. of Thomas sandy loam. Treatments were replicated six times. Three sugar beet plants were transplanted into each pot soon after emergence from the quartz sand in which the seeds were germinated. The six control pots were then treated with a complete nutrient solution. The effect of copper, manganese, boron, and magnesium on the development of sugar beets on this particular soil was determined by omitting, in turn, each of the elements from the nutrient solution. The effect of doubling each of the first three elements was also studied. The treatments in this experiment are listed in Table 1. The moisture content of all the cultures was kept uniform by frequently bringing them up to weight by additions of distilled water.

Results—As shown by the data presented in Table 1, all the plants grown in cultures without boron were affected with heart rot while all cultures which received boron in the nutrient solution produced healthy plants. The elimination of the other elements from the nutrient solution had no effect on the development of heart rot.

As further indicated by the data presented in Table 1, boron applied as borax at the rate of 10 pounds per acre, increased the yield of roots from 46.7 gms. to 90.4 gms. per pot and the yield of tops from 109.0 gms. to 131.4 gms. per pot. The sucrose content of the roots was increased from 15.4% to 17.0%. As shown by the analysis of variance these differences are significant to the 1% point in the case of yields and to the 5% point in the case of sucrose content. No significant differences in yields or sucrose content were obtained by eliminating any other nutrient element or by applying double quantities of any element. In fact, there was a slight indication that 20 pounds of borax per acre actually reduced the yield of roots below the yield obtained as a result of the control treatment.

Field Experiments

Before recommendations may be made regarding the field use of such a material as borax, it is necessary to try out the material by means of field experiments. The experiments discussed in this paper were started in 1936 and have been continued since that date. During the first two years it happened that heart rot did not occur on any of the fields in which the experiments were located, but in 1938 and 1939 better luck was experienced in locating the experiments and the results of those tests are presented in the following pages:

Plan of Field Experiments—The field experiments were so planned that information would be obtained as to the quantities of borax necessary to control heart rot on different soils and as to the quantities which might be applied without injuring the beets. Quantities of borax ranging from 10 to 80 pounds per acre were applied broadcast and in contact with the seed. In 1939 the heaviest rate of application was made in a band beside the seed. In all of the experiments the beets were uniformly treated with 2-12-6 fertilizer. The borax was applied with the fertilizer. All plats were arranged in randomized blocks with treatments replicated from four to six times.

Effect of Borax on Stand and Yields—Experiments with several crops have shown great variability in the quantity of borax which may be applied without causing injury to germination or decreases in yields. Sugar beets are not easily injured. Stand counts made after the beets were blocked showed that during the three years 1937 to 1939, borax applied broadcast at rates up to 80 pounds per acre had no effect on the stand of sugar beets. Stand counts on the broadcast experiments are not presented but the data presented in Table 2 shows that in 1938 yields were not reduced by the heaviest applications of borax. Experiments were performed on eight fields during the three years. The soils varied widely in pH and percentage of organic matter and in texture from sandy loam to silt loam. Further reference to Table 2 reveals a trend toward increased yields as a result of borax applications. The heaviest application on the Miami soil and the 20 to 80 pound applications on the Napanee soil apparently increased the yields by 1.0 to 1.1 tons per acre, and while, according to the analysis these increases were not significant, they come so near significance that it is believed significance would have resulted if the errors of the experiment could have been better controlled.

Where borax was applied in the row, significant differences in stand were obtained. As shown by the data presented in Table 3, as much as 40 pounds of borax was applied with the seed on Brookston soil in 1938 without injury to stand, but on Napanee and Miami the 40 pound application significantly reduced the stand. In no case was there an injury as a result of the 20 pound application. The weather conditions during the season of 1938 were favorable for the growth of sugar beets. There was plenty of moisture during the early part of the growing season, which probably accounts for the fact that injuries from high applications of borax were rather slight.

During the season of 1939, the rainfall varied considerably in different parts of the sugar beet area. The Miami soil was very dry for a considerable period after planting. This is reflected in the stand counts recorded in Table 4. All applications of borax caused significant reductions in stand on this soil. On the Napanee soil only the 80 pound contact treatment injured the stand. On the Thomas soil injury resulted from applications of 40 pounds per acre. On the Onaway and Posen soils, located in the Upper Peninsula of Michigan, significant injury occurred with the 20 pound application on the Onaway soil. These 1939 data illustrate very nicely the variability in results which may be obtained on different soils during the same season.

It is interesting to note the difference between the stand counts obtained from contact and side band applications. On two of the soils, 80 pounds of borax in a band 1½ inches to the side of, and 1 3/4 inches below the seed had no effect on stand while the same quantity of borax with the seed reduced the stand to about one-third that of the control. It seems that the advisability of side band placement of fertilizer will be greater when borax is included in the mixtures.

As shown by the data presented in Tables 5 and 6 borax applied in the row reduced the yields in cases where the applications were heavy. In general, the reductions in yields correspond to injuries in stand. There were exceptions to this in 1939 when the 10 and 20 pound applications on the Miami soil reduced the stand but did not significantly lower the yields. The same was true in the case of the 20 pound application on the Onaway soil. On the Thomas soil a significant drop in yield occurred as a result of the 20 pound application although the reduction in stand was not significant.

There were no significant increases in yield as a result of applying borax in the row. On some of the fields increases in yield did occur with the lighter applications. On the Onaway and Posen soils in 1939, heart rot was quite prevalent and in both cases, as shown by the data in Table 6, the areas treated with 10 pounds of borax yielded more than did the control areas but the increases in yield were not large enough to be significant. Very good control of heart rot was obtained by the use of borax on these areas and it would seem that greater increases in yield should have resulted. Perhaps better results would have been obtained from a still smaller application. This is doubtful however since in only one case was the stand injured by the 10 pound rate. In a large number of fertilizer experiments with sugar beets, conducted at the Michigan Station during the past six years, it has been impossible to keep the errors of the experiments below a figure approximately equal to 10% of the total yields. Much of the error probably is due to soil differences, although great care has been exercised in selecting fields with uniform soil. Perhaps it is too much to suppose that, except in extreme cases, borax should increase the yields as much as 10%.

The fact that such increases may be obtained in extreme cases is illustrated by the results obtained from a sidedressing of borax, made on June 29 on Thomas sandy loam soil. An application of 9 pounds of borax per acre on this area where heart rot was particularly bad resulted in a very significant increase in yield. As shown by the data presented in Table 7, the yield of all beets was increased from 43.8 pounds to 62.8 pounds per plat while the yield of normal beets was increased from 10.0 to 23.8 pounds per plat. If the borax had been applied at planting time, the increases in yield would have been even greater. This seems certain because on soil taken from this same area and placed in pots in the greenhouse an application of 10 pounds of borax completely prevented heart rot. This experiment has already been described. The application made in the field on June 29 was too late to prevent the appearance of heart rot on many of the plants and it is believed that the help from the borax came mostly through the recovery of the already affected plants. Past work in the greenhouse has shown that beets affected with heart rot will completely recover if borax is applied before the breakdown of tissue is too far advanced.

Effect of Borax on Heart Rot Occurrence--As indicated by counts made of plants showing heart rot symptoms, borax has been very effective in controlling this disorder. As shown by the data presented in Tables 8, 9 and 10, all applications of borax, 10 to 80 pounds per acre, reduced the number of beets showing heart rot symptoms significantly below the number reported for the control. In only one case, that of a broadcast application on the Napanee soil, was there a significant difference between the counts obtained on the plats treated at the rate of 10 pounds per acre and on one receiving a heavier application. That would indicate that 20 pounds was enough to apply in any case whether the application was to be made broadcast or in the row. As already mentioned there is a possibility that fairly good control could be obtained with less than 10 pounds per acre applied in the row.

The Effect of Heart Rot on Sucrose Content and Purity--The profit from an application of any fertilizer to sugar beets may come through larger yields or through an increase in sugar percentage. As already reported, large increases in yield from a few pounds of borax can only be expected in extreme cases. It is believed, however, that the sugar content will be appreciably increased wherever borax is effective in preventing the occurrence of heart rot.

This belief is the result of the data reported in Table 11. For three years, attempts were made at the Michigan Station to find out whether or not an application of borax would affect the sugar content and purity of sugar beets. Samples were gathered at random from treated and untreated plats, without regard to heart rot symptoms. This was perhaps an inaccurate way of taking samples as it seems only logical that borax could only affect the sugar content of those beets which would, without the treatment, have developed heart rot. It is impossible to predict with certainty whether or not any particular beet will develop heart rot so another method of approach was adopted in 1939.

The beets from an area where damage from heart rot was severe were divided into three lots, those which did not have symptoms of heart rot, those which had symptoms only on the leaves and those which had root symptoms as well as leaf symptoms. Six samples of each of these lots were taken from two different soils. As shown by the data (Table 11) the beets with heart rot contained significantly less sugar than did the normal beets. Further, the beets with symptoms on both leaves and roots contained less sugar than did those with only leaf symptoms. This difference was significant in one soil. These results would indicate that the occurrence of symptoms on both leaves and roots is an indication of an advanced stage in the tissue breakdown.

A significant drop in the coefficient of purity was also found in beets grown on the Thomas soil. Normal beets showed a purity of 85.4% as compared to a purity of 76.4% in beets with both types of symptoms.

It has already been shown by the data reported in Table 1 that borax applied to pot cultures completely controlled heart rot and increased the sucrose content of the beets from 15.4% to 17.0%.

Discussion

It is believed that sufficient data have been reported to prove that an application of a few pounds of borax per acre may be expected to prevent the occurrence of heart rot in sugar beets either in the field or in the greenhouse. From greenhouse experiments in which it is believed that at least certain errors may be better controlled than in the field, and from field trials on areas where heart rot was severe, the conclusion may be drawn that in cases where heart rot is prevented by borax applications, yields will be increased as a result of the treatment.

Even in areas where heart rot is less severe, it seems logical that borax should increase sugar beet yields. In the experimental work presented in this paper the increases were statistically insignificant but it is believed that actual increases in yield would have been shown if it had been possible to control the experimental errors more closely. It is plainly evident that a beet which suffers tissue breakdown and a drop in sugar percentage as the result of a lack of boron, cannot possibly produce the sugar which it would have produced had it remained healthy.

At the sugar factories it is necessary to store sugar beets in large piles for varying lengths of time. Smith (5) has stated that only sound healthy beets should be placed in these piles. In many cases the tissue breakdown caused by boron deficiency is followed by rot resulting from the entrance of some organism. Such roots would be unfit for storage in large piles.

Summary and Conclusions

Sugar beets, grown in Thomas sandy loam pot cultures, were supplied with a complete nutrient solution as a control treatment. Copper, manganese, magnesium, and boron were separately omitted from, and doubled in quantity in, the control treatment solution to ascertain the effect of each of these elements on the development of the sugar beet plant.

During the years 1937, 1938, and 1939 field experiments were conducted in 10 fields located on 6 different soil types. Borax, included in 2-12-6 fertilizer, was applied broadcast and in the row at rates ranging from 10 to 80 pounds per acre. In one experiment borax was applied as a sidedressing. The effect of heart rot on sucrose and purity percentages was determined by collecting samples from fields not included in the experiments.

The results from these experiments may be summarized as follows:

1. Borax, applied to Thomas sandy loam pot cultures at the rate of 10 pounds per acre, prevented heart rot, practically doubled yields, and significantly increased the sucrose content of sugar beets.

2. Copper, manganese, and magnesium did not prevent heart rot nor affect the yield and sucrose content of sugar beets.

3. Borax applied broadcast, in the field, at rates as high as 80 pounds per acre did not injure stands nor reduce yields.

4. Borax applied with the seed at the rate of 10 pounds per acre injured the stand on one field in 1939 but did not affect the stand on seven other fields in 1938 and 1939.

5. As much as 40 pounds of borax per acre applied in the row did not reduce the stand of beets on some soils.

6. Borax applied in a band to the side but not in contact with the seed was much less harmful to stand than was borax applied with the seed.

7. Borax applied broadcast or with the seed did not significantly increase sugar beet yields. It is believed that significance would have resulted in some cases had it been possible to better control experimental errors.

8. Borax applied as a side dressing on an area where heart rot was very severe significantly increased total sugar beet yields and more than doubled the yield of normal beets.

9. Borax applied in the row at the rate of 10 pounds per acre almost completely prevented heart rot occurrence. Broadcast applications at the same rate were somewhat less effective and on one field the 20 pound application produced significantly better results than did the 10 pound application.

10. Sugar beets having heart rot contained less sucrose than did normal beets.

11. On one field, the sugar beets having heart rot had a lower percentage purity than did normal beets.

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Table 1. The effect of borax on heart rot occurrence and the yield and sucrose content of sugar beets in Wauseon sandy loam pot cultures.

Treatment	Plants showing heart rot	Green weight per pot[1]		Sucrose content of roots[2]
		Roots	Tops	
	Per cent	grams	grams	Per cent
Complete nutrient (control)	0	90.4	131.4	17.0
Complete nutrients, less copper	0	101.9	145.0	16.0
Complete nutrients, double copper	0	97.7	139.8	16.4
Complete nutrients, less manganese	0	99.4	120.0	16.5
Complete nutrients, double manganese	0	102.3	135.6	16.3
Complete nutrients, less boron	100	46.7*	109.0*	15.4*
Complete nutrients, double boron	0	81.7	136.6	17.3
Complete nutrients, less magnesium	0	91.2	133.5	17.8
Difference required for significance		17.7	18.3	1.06
F		8.97	3.31	5.64
F (5% point)		2.29	2.29	3.80
F (1% point)		3.22	3.22	7.02

*Significantly less than control

[1]Yields are averages of six replicates

[2]For sucrose determinations it was necessary to combine the roots from three pots. The percentages then represent duplicate samples. One missing figure was supplied.

Table 2. The effect of borax applied broadcast on the yields of sugar beets in 1938.

Treatment in addition to 2-12-6 fertilizer.	Yields - Tons per acre. Averages of four replicates.	
	Miami silt loam	Napanee silt loam
No borax (control)	6.7	9.8
10 Pounds borax before planting	6.9	10.5
20 Pounds borax before planting	6.5	10.9
40 Pounds borax before planting	7.1	10.9
80 Pounds borax before planting	7.7	10.8
Difference required for significance	1.23	1.29
F	1.27	1.24
F (5% point)	3.26	3.26
F (1% point)	5.41	5.41

Table 3. The effects of borax applied in the row on the stand of sugar beets in 1938.

Treatment in addition to 2-12-6 fertilizer	Plants por 200 feet of row Averages of five replicates		
	Brookston silt loam	Napance silt loam	Miami silt loam
No borax (control)	161.4	172.8	179.0
10 Pounds borax with seed	182.0	172.8	173.6
20 Pounds borax with seed	192.8	171.4	165.6
40 pounds borax with seed	171.0	151.8*	102.8*
80 Pounds borax with seed	131.0*	112.0*	40.4*
Difference required for significance	19.6	14.5	32.4
F	13.00	29.60	26.74
F (5% point)	3.01	3.01	3.01
F (1% point)	4.77	4.77	4.77

*Significantly less than control.

Table 4. The effect of borax applied in the row on the stand of sugar beets in 1939.

Treatment in addition to fertilizer[4]	Plants per 200 feet of row				
	Miami[1] silt loam	Napanee[2] silt loam	Onaway[3] loam	Posen[3] loam	Thomas[1] sandy loam
No borax (control)	209.0	164.8	250.4	216.4	160.4
10 Pounds borax with seed	176.8*	191.2	216.0	201.0	162.2
20 Pounds borax with seed	169.3*	186.9	204.4*	198.4	135.4
40 Pounds borax with seed	57.3*	160.8			110.0*
80 Pounds borax with seed	69.3*	64.8*			52.6*
80 pounds borax with side band	159.5*	163.4			155.4
Difference for required significance	29.5	20.1	32.88	19.68	25.9
F	37.7	45.7	6.34	2.94	22.84
F (5% point)	2.60	2.71	5.14	5.14	2.60
F (1% point)	3.86	4.10	10.92	10.92	3.86

[1]Averages of 6 replicates
[2]Five replicates.
[3]Four replicates.
*Significantly less than control.

[4]42-12-6 on Miami, Napanee, and Thomas, and 2-16-8 on Onaway and Posen soils.

Table 5. The effect of borax applied in the row on the yield of sugar beets in 1938.

Treatment in addition to 2-12-6 fertilizer.	Yield - Tons per acre. Averages of five replications.		
	Brookston silt loam	Napanee silt loam	Miami silt loam
No borax (control)	13.3	12.2	5.8
10 pounds borax with seed	13.9	12.0	5.4
20 pounds borax with seed	14.0	12.9	5.6
40 pounds borax with seed	13.1	10.9*	4.2
80 pounds borax with seed	8.9*	8.8*	3.0
Difference required for significance	1.23	1.21	1.00
F	26.40	16.05	12.83
F (5% point)	3.01	3.01	3.01
F (1% point)	4.77	4.77	4.77

*Significantly less than control

Table 6. The effect of borax applied in the row on the yield of sugar beets in 1939.

Treatment in addition to fertilizer[1]	Yield - Tons per Acre. Averages of six replicates. Miami silt loam	Napanee silt loam	Onaway loam	Posen loam	Thomas sandy silt loam
No borax (control)	7.2	13.3	6.2	9.17	14.5
10 pounds borax with seed	6.9	12.6	6.7	9.67	12.6
20 pounds borax with seed	6.2	12.0	6.3	9.13	10.9*
40 pounds borax with seed	3.3*	12.0			11.6*
80 pounds borax with seed	3.21*	7.8*			6.7*
80 pounds borax in side band	5.5*	13.0			13.1
Difference required for significance	1.2	2.1	0.6	2.07	2.2
F	18.8	8.69	2.82	1.36	13.43
F (5% point)	2.60	2.71	5.14	19.33	2.60
F (1% point)	3.86	4.10	10.92	99.33	3.86

*Significantly less than control

1 2-12-6 on Miami, Napanee, and Thomas and 2-12-8 on Onaway and Posen soils.

Table 7. The effect of borax applied as a side dressing on the yield of sugar beets in 1939.

Treatment in addition to 2-12-6 fertilizer	Yield - Pounds per plat. Average of six replicates. All beets	Normal beets
No borax (control)	43.8	10.0
9 pounds borax beside row	62.8*	23.8*
Difference required for significance	10.40	4.37
F	21.90	66.10
F (5% point)	6.61	6.61
F (1% point)	16.26	16.26

*Significantly greater than control.

Table 8. The effect of borax applied broadcast on the occurrence of heart rot in sugar beets in 1938.

Treatment in addition to 2-12-6 fertilizer.	Number of beets per 200 feet of row showing heart rot symptoms. Averages of four replicates. Miami silt loam	Napanee silt loam
No borax (control)	12.3	80.8
10 Pounds borax before planting	1.0*	17.5*
20 pounds borax before planting	.3*	8.3**
40 pounds borax before planting	.3*	4.3*
80 pounds borax before planting	2.3*	2.3*
Difference required for significance	7.9	8.1
F	3.98	158.10
F (5% point)	3.26	3.26
F (1% point)	5.41	5.41

*Significantly less than control.

**Significantly less than control and 10 pounds borax.

Table 9. The effect of borax applied in the row on the occurrence of heart rot in sugar beets in 1938.

Treatment in addition to 2-12-6 fertilizer.	Number of beets per 200 feet of row showing heart rot symptoms. Averages of five replicates	
	Miami silt loam	Napanee silt loam
No borax (control)	18.8	40.6
10 pounds borax with seed	0.6*	7.6*
20 pounds borax with seed	1.0*	5.6*
40 pounds borax with seed	0 *	3.4*
80 pounds borax with seed	0 *	0.8*
Difference required for significance	4.6	6.6
F	28.62	56.30
F (5% point)	3.01	3.01
F (1% point)	4.77	4.77

*Significantly less than control.

Table 10. The effect of borax applied in the row on the occurrence of heart rot in sugar beets in 1939.

Treatment in addition to 2-16-8 fertilizer.	Number beets per 200 feet of row showing heart rot symptoms. Averages of four replicates.	
	Onaway loam	Posen loam
No borax (control)	94.5	65.5
10 pounds borax with seed	6.0*	10.0*
20 pounds borax with seed	0 *	3.0*
Difference required for significance	11.7	19.0
F	60.9	38.74
F (5% point)	5.14	5.14
F (1% point)	10.92	10.92

*Significantly less than control.

Table 11. The effect of heart rot on the sucrose content and purity of sugar beets in 1939.

Condition of beets	Percentage sucrose and purity. Averages of six samples			
	Thomas sandy loam		Wisner loam	
	Sucrose	Purity	Sucrose	Purity
Normal (control)	16.40	85.4	17.87	89.75
Leaf symptoms only	14.51*	82.5	16.28*	89.18
Leaf and root symptoms	11.38*	76.4*	16.08*	89.62
Difference required for significance	1.48	3.18	0.68	1.91
F	26.81	18.80	19.10	1.13
F (5% point)	3.68	3.68	3.68	19.42
F (1% point)	6.36	6.36	6.36	99.38

*Significantly less than control.
Some of the sugar determinations were made by F. R. Bach of the Michigan Sugar Company.