Resistance and Soil Treatments for Control of Rhizoctonia of Sugar Beets[1]

M. M. AFANASIEV AND H. E. MORRIS[2]

Rhizoctonia root rot of sugar beets is a common disease of beets. Often only a trace of this disease is present, but sometimes severe epidemics occur which are very destructive. In 1949 at the Huntley Branch Station in Montana this disease caused more than 90 percent loss of stand in one field, and at harvest time there were only a few surviving beets free of infection. In previous years only a small amount of rhizoctonia occurred in this field. The outbreak of this disease gave an impetus to start investigations, conducted during 1950 and 1951, in which the effect of different nutrients, various nitrogenous compounds and fungicides was studied on the severity of infection of sugar beets with rhizoctonia. Resistance of beet varieties to this disease was also studied. These tests were conducted under greenhouse and field conditions.

Greenhouse Experiments

The soil from the infected plot at the Huntley Station and disinfected (N. I. Ceresan), segmented sugar beet seeds (U. S. 22 and 268) were used in these experiments. Beets were usually grown six weeks. Several times during this period and also at harvest time readings of healthy and diseased plants were made.

1. Effect of nutrients on the infection of beets with Rhizoctonia.

The soil was distributed into eight flats (20 inches by 12 inches by 3 inches) and was fertilized with the following substances:

Flat	Fertilizer	Disease developed percent	Flat	Fertilizer	developed Disease percent
1	NPM	69.5	5	N	65.2
2	NP	90.3	6	P	87.7
3	NM	68.1	7	M	70.8
4	PM	86.5	8	Check	74.1

Nitrogen was applied in the amount of 7.1 grams (mixture composed of one-half sodium nitrate and one-half ammonium sulphate); phosphorus, 7.1 grams of treble superphosphate, and manure (M), one-fifth of the volume of the soil. Three rows of seeds, 40 seeds per row, were planted in each flat of soil.

A considerable amount of disease occurred in all flats. The highest infection (90.3 percent) occurred in the soil treated with NP and the lowest in one treated with N (65.2 percent). On the whole, the addition of various nutrients had very little differential effect on the severity of the disease.

2. Effect of Arasan on the infection of beets with Rhizoctonia.

Sugar beets were planted in the same flats used in the first experiment. No additional fertilizers were added to the soil. Each flat was divided crosswise into two equal parts by insertion of a wooden partition in the box. Each half of the soil in all flats was treated with Arasan and the other half

[1] Contribution from Montana State College Agricultural Experiment Station. Paper No, 258, Journal Series.

[2] Plant Pathologist and Head, respectively, Department of Botany and Bacteriology, Montana State College.

left untreated. Arasan was used at the rate of 3 pounds per acre and the amount applied was prorated on the basis of linear feet of sugar beet row per acre. The chemical was mixed with fine sand and uniformly spread over the surface of 2-inch-wide strips, where the seeds were to be planted. The soil in these strips was worked to a depth of $11^1/_4$ inches. The seeds were planted $^1/_2$ inch in depth in the center of these strips.

In several flats plants grown in treated soil showed considerably less disease than in non-treated soil. But the reverse situation was also present, i.e., beets had more disease in treated soil than in non-treated. Also, in several flats the difference in disease of beets grown in treated and non-treated portions of soil was not significant. In general it is quite evident that treatment of soil with Arasan had some beneficial effect in controlling seedling disease of sugar beets.

3. **Effect of nitrogenous fertilizers on the infection of beets with Rhizoctonia.** Hills and Axtell (1),[3] in their experiments with fertilization of sugar beets with various forms of nitrogen (sodium nitrate, calcium nitrate, ammonium sulphate, uramon and ammonium nitrate), reported that there were no significant differences in beet yield, sugar production and sucrose concentration due to the type of nitrogen used. But there was a relation of various forms of nitrogen to the incidence of dry-rot canker of sugar beets caused by rhizoctonia. Their results show that the smallest incidence of rhizoctonia was in beets fertilized with calcium nitrate and the highest in those fertilized with sodium nitrate. Beets grown in check plots had the highest incidence of rhizoctonia.

The effect of the above-mentioned forms of nitrogen, and in addition a mixture composed of one-half sodium nitrate and one-half ammonium sulphate, was studied on seedling diseases of sugar beets in a soil highly infected with rhizoctonia.

Two series of eight-inch pots were used in this test. To each pot of one series only the nitrogenous fertilizers, calculated on the basis of 0.65 gr. of nitrogen were added. To the other series, in addition to nitrogenous fertilizers, 3.55 gr. of treble superphosphate were also added. Twenty-five seeds were planted in each pot of soil and the experiment was run in duplicate.

The results of these experiments showed that the highest amount of disease in both plantings occurred in soil fertilized with sodium nitrate and T.S.P. At the same time beets fertilized in the second experiment with sodium nitrate alone had a low amount of disease. The occurrence of smaller amounts of disease varied considerably in both plantings. Beets grown in check soil of the second planting had the highest amount of disease. In general, it was very difficult to establish any relationship between the type of nitrogen applied and the amount of disease shown by the beet plants.

Testing beet varieties for their resistance to Rhizoctonia

It has been mentioned that beets grown in one of the fields at the Huntley Station in 1949 were severely infected with rhizoctonia and most of them died before harvest. At harvest time the remaining beets were examined and those free of infection were harvested. These beets were

[3] Numbers in parentheses refer to literature cited.

planted in the greenhouse in Bozeman and ten of them produced seeds. These new varieties of beets were identified M-l to M-10.

In order to determine whether these beets had any resistance to rhizoctonia, an experiment was conducted to test them and also two commercial varieties (U. S. 22 and 268, and 304R) separately to three cultures of rhizoctonia isolated from diseased beets. Huntley soil was distributed in greenhouse flats and the following plan for this test was adopted:

	Flats used No.
1. Soil disinfected (chloropicrin) and inoculated. Cultures of Rhizoctonia used	
R-l	4
R-2	4
R-3	4
2. Soil disinfected (chloropicrin) and non-inoculated	4
3. Soil non-disinfected and non-inoculated	4

In each flat of soil three rows of beets were planted so that in a unit of four flats 12 beet varieties were planted. Twenty whole or forty disinfected (N. I. Ceresan), segmented beet seeds were planted in each row. Beets were grown for six weeks.

The amount of disease was high for all strains of rhizoctonia used and for all varieties of beets. The percentage of disease was well above 75 percent for all beet varieties, with the exception of M-5 and M-8 grown in soil inoculated with R-l. Variable amounts of disease were present in disinfected and non-inoculated soil. Beets grown in some of the flats were free of disease; in others they had a high degree of disease, and in some only a trace of disease was present. It appears that either chloropicrin did not disinfect the soil completely or it became contaminated after disinfection.

Beets grown in non-disinfected and non-inoculated soil also had a high degree of disease, although slightly lower than those in inoculated soil. None of the varieties tested showed any general resistance to rhizoctonia. In spite of a high percentage of disease a few of the beets grown in these flats remained free of disease, which gave a supposition that it is possible they may carry resistance to rhizoctonia. For this reason 13 healthy beet seedlings grown in soil inoculated with R-2, which showed the highest incidence of disease, were transplanted in individual pots and left in the greenhouse for seed production.

After all beets were harvested, each of the four soil flats was planted separately with the following crops: potatoes, Great Northern beans, Perfection peas and radishes. The reason for this test was to find out whether these strains of rhizoctonia were also pathogenic to some other crops besides beets. All these crops were grown in these flats for two months.

Only one potato plant out of 15 became infected with rhizoctonia. Beans had a slight amount of disease in the soil inoculated with R-l, and a moderate amount in soils inoculated with two other strains. Radishes grown in soils inoculated with strains 2 and 3 had a high amount of disease and a moderate amount in soil inoculated with strain 1. Peas had a high

amount of disease in all soils. These strains of rhizoctonia were practically non-pathogenic to potatoes, moderately so to beans, and highly pathogenic to radishes and peas. The check soils had only a small amount of disease.

Field Experiments

During the summers of 1950 and 1951 the following experiments were conducted at Huntley Branch Station:

1. Effect of fungicides on the infection of beets with Rhizoctonia.

In treating the soil the following five chemicals were used at the rate of 3 pounds per acre in 1950 and 4 and 5 pounds in 1951: Arasan (tetramethylthiuram disulphide), Thiram (tetramethylthiuram disulphide), Ceresan M (ethyl mercury P- Toluene), borax (sodium borate), and Phygon 2,3-dichloro, 1,4-naphthoquinone). Check was also used. The amounts of chemicals used were prorated on a basis of linear feet of sugar beets planted per acre.

Triplicated, randomized plots of soil consisting of two 26.2-feet-long rows of beets were used for each treatment. The whole test in 1950 was duplicated by using two different lots of seeds: a commercial (G.W. 268 and U.S. 22) and G.W.-304R. In 1951 only G.W.-304R was used. Sugar beets were planted with a commercial planter. The required amounts of chemical, mixed with sand, were evenly distributed on the top of the soil in approximately 4-inch-wide strips over the planted seeds. Those strips were lightly cultivated to incorporate the applied chemical into the upper inch of soil.

Readings for seedling diseases were made before thinning. Several readings for Rhizoctonia disease were also made during the summer and fall.

The results of these experiments show that soil treatments with the above-mentioned chemicals had very little effect either on the control of seedling diseases of sugar beets or on subsequent root rot of older beets.

Effect of nitrogenous fertilizers on the infection of beets with Rhizoctonia

Sodium nitrate, ammonium sulphate, uramon, calcium nitrate and ammonium nitrate were used in this test. Each fertilizer was applied to three randomized plots of soil consisting of four 26.2-feet-long rows of beets. All fertilizers were used on a basis of 50 pounds of nitrogen per acre, and were applied on the top of planted beet rows. The rows were slightly cultivated to incorporate the fertilizer.

The amount of seedling diseases varied between 25.8 percent (am. nitrate) and 37.9 percent (am. sulphate). Readings for rhizoctonia disease were also made several times during the summer and they showed that smallest amounts of root rot occurred in plots fertilized with sodium nitrate (34.3 percent). Beets grown in the plots of remaining treatments and in the check had approximately the same amount of root rot (50.3 to 61.4 percent.

Testing beet varieties for their resistance to Rhizoctonia

In the summer of 1950 seven varieties of beets were tested at the Huntley Station for their resistance to rhizoctonia. Five of these varieties

were developed in Colorado and Nebraska, and, as reported, carried some resistance to rhizoctonia. These varieties, and also G.W. Co. 304R, were sent us by R. R. Wood of the Great Western Sugar Company. A local commercial variety of beets was also included in this test. Each variety was planted in two rows 272 feet long. The results of the performance of these varieties were as follows:

Sugar beet variety Name and number	Occurrence of disease percent
G.W. Co. - 208	42.0
G.W. Co. - 526	52.3
A-1130	55.6
B - 116	52.9
B - 525	71.0
U. S. 22 and 268	57.3
G.W. Co. - 304-R	31.3

These results show that there was the smallest amount of rhizoctonia in 304R and in 208, and the highest in B-525. The remaining varieties showed approximately the same amount of disease. It appears that none of these varieties showed significant resistance to rhizoctonia.

In the spring of 1951, 37 varieties of beets were again tested at Huntley Station. Eleven of these varieties were sent us by R. R. Wood (they originally came from the USDA, Great Western Sugar Company and American Crystal Sugar Company) , and 16 varieties came from Dr. F. V. Owen and Dr. V. F. Savitsky from the U. S. Sugar Plant Field Laboratory in Salt Lake City, Utah. Ten varieties of beets were produced in Montana. The amount of seed of these varieties varied considerably, and for this reason all beet varieties, No. 1 to No. 27, inclusive, were planted in four randomized rows and the remaining 10 varieties in two rows. Regular stand counts and records of diseased beets were made during the growing season and final readings were taken at harvest time when 26.2-foot rows of beets were dug in each replication and roots were examined for the disease.

Table 1 presents the results of this test. Although all these varieties were susceptible to rhizoctonia, the percent and degree of infection varied considerably. In grading for disease, beet roots were divided into two groups, those which had rot and those which had only surface infection. The rot type of disease was considered of greatest importance. Varieties 27 and 37 showed no rot and the number of other varieties (12, 23, 32, 35) also had very little rot-type of infection. Slight surface infection produced very little damage to beets. Severe surface infection was not very prevalent, and only varieties 20, 21 and 25 had a considerable amount of this type of disease. A number of beet roots were harvested from the varieties which showed the smallest amount of disease with the purpose of producing seeds from these beets.

Present plans include expansion of the work of testing varieties of beets for their resistance to rhizoctonia. These tests are in progress now in which 48 varieties of beets are being tested in the greenhouse for their resistance to rhizoctonia, aphanomyces and fusarium wilt. For these tests soils are used in which the maximum of certain types of diseases occur under field conditions. In addition to this a sufficient amount of inoculum is being added to these soils to increase the degree of infection.

Table 1.—Testing Sugar Beet Varieties for Their Resistance to Rhizoctonia Root Rot, Huntley Station, Montana, 1951.

Beet	Variety Name	Theor stand[1] per-cent	Percent Rhizoctonia Total Healthy %	Total Diseased %	Total Root rot %	Type of disease Surface infection Slight %	Surface infection Severe %	Yield per acre tons	Top to Root ratio Tops %	Top to Root ratio Roots %
1	US 1170, GW A 126	89.7	52.2	47.8	16.8	25.6	5.4	13.6	41.9	58.1
2	US 1173, GW A 127	98.5	67.0	33.0	20.8	10.2	2.0	14.6	41.2	58.8
3	US 1177, GW A 123	87.8	61.7	38.3	12.3	24.9	1.1	12.7	41.1	58.9
4	AM CR 0-6040, GW A1150	100.4	68.7	31.3	13.6	15.7	2.0	13.4	44.1	55.9
5	AM CR 0-403, GW A1151	92.4	59.9	40.1	16.4	19.6	4.1	11.7	38.5	61.5
6	AM CR 0-404, GW A1152	79.4	70.2	29.8	9.9	17.6	2.3	12.4	35.9	64.1
7	GW B-525, Sel 526	88.9	58.5	41.5	15.3	23.1	3.1	15.7	41.8	58.2
8	GW B-579, Sel 304 at Scot	89.7	77.0	23.0	11.5	11.5	0.0	16.8	38.6	61.4
9	B-580, Sel 304 at Hunt	80.2	70.1	29.9	13.0	14.8	2.6	12.4	39.7	60.3
10	GW, 304-508	82.1	75.9	24.1	8.8	12.7	2.6	10.7	42.4	57.6
11	GW 359	95.4	67.8	32.2	15.0	17.2	2.0	15.6	37.2	62.8
12	Owen, 944H1	88.9	78.6	21.4	5.8	14.7	0.9	12.3	34.4	65.6
13	Owen, US 22/3, 96	95.4	76.1	23.6	13.4	10.2	0.0	13.3	39.0	61.0
14	Owen, US 35/2, 024	87.8	63.6	36.4	14.7	19.2	2.5	9.7	43.0	57.0
15	Owen, R&G, old type	85.9	48.6	51.4	25.6	22.5	3.3	13.1	33.5	66.5
16	Owen 9090H4	83.2	63.6	36.4	19.4	13.6	5.4	12.0	33.2	66.8
17	Owen 92H1	90.8	74.5	25.5	19.1	6.4	0.0	15.7	35.8	64.2
18	Savitsky 0521	68.7	50.4	49.6	13.3	28.0	8.3	7.6	40.4	59.6
19	Savitsky 0521-24	84.0	45.0	55.0	13.6	34.3	7.1	9.8	39.6	60.4
20	Savitsky 0529-2-9	73.7	28.4	71.6	26.3	34.4	10.9	6.9	41.5	58.5
21	Savitsky 0531-2-6	79.4	43.7	56.3	23.1	23.2	10.0	11.5	35.0	65.0
22	Savitsky 0531-2-5	87.0	63.0	37.0	17.0	15.5	4.5	13.7	37.0	63.0
23	Savitsky 0532-11-4	105.0	67.6	32.4	5.8	25.0	1.6	15.5	45.4	54.6
24	Savitsky 0532-1-3	99.2	68.8	31.2	14.9	14.3	2.0	14.6	47.0	53.0
25	Owen-Savitsky SLC	74.4	28.4	71.6	12.5	51.5	12.5	5.5	52.3	47.7
26	Owen-Savitsky SL-0062	40.1	53.1	46.9	15.2	31.7	0.0	3.1	48.4	51.6
27	Owen-Savitsky 9090M1	68.7	90.0	10.0	0.0	10.0	0.0	7.7	36.2	63.8
28	M-1	67.9	67.4	32.6	9.0	23.6	0.0	13.8	51.3	48.7
29	M-2	70.6	68.1	31.9	9.2	22.7	0.0	20.9	45.8	54.2
30	M-3	84.0	69.2	30.8	12.5	18.3	0.0	16.8	54.3	45.7
31	M-4	93.5	81.6	18.4	10.5	7.9	0.0	20.1	47.0	53.0
32	M-5	95.4	84.6	15.4	6.2	9.2	0.0	12.6	44.2	55.8
33	M-6	95.4	80.0	20.0	18.0	2.0	0.0	16.8	50.0	50.0
34	M-7	74.4	77.1	22.9	12.9	10.0	0.0	9.9	43.2	56.8
35	M-8	80.2	77.3	22.7	5.0	17.7	0.0	15.8	39.4	60.6
36	M-9	97.3	91.9	8.1	8.1	0.0	0.0	12.3	42.7	57.3
37	M-10	90.1	86.4	13.6	0.0	13.6	0.0	19.0	53.3	46.7

[1] On basis of 100 beets per 100 foot of row. Rows 20 inches apart.

Conclusion

The results of all the field and greenhouse experiments in which various nutrients and soil fungicides were used for controlling rhizoctonia disease of sugar beets were largely negative.

Varieties of beets tested for their resistance in rhizoctonia showed a considerable variation in respect to this disease.

Literature Cited

(1) HILLS, F. J., and J. D. AXTELL.
1950. Proc. Amer. Soc. Sug. Beet Tech. 356-361.