Incidence of Rhizoctonia Crown Rot of Sugar Beets in Irrigated Crop Rotation[1]

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Received for publication February 5, 1960

Introduction

The incidence of sugar beet crown and root rot in crop rotation has been reported by several investigators (1, 3, 7, 8, 9)[3]. These reports cited above are based for the most part on surveys and are not the result of planned rotation experiments to observe the specific diseases associated with crop rotations. Results on the incidence of Rhizoctonia crown and root rot reported in our paper and elsewhere confound to some extent the effect of the preceding crop and time between sugar beet crops on the incidence of Rhizoctonia induced crown and root rot.

Crown and root rot, an important disease of half-grown or nearly mature sugar beets (*Beta vulgaris* L.) in western Nebraska and other areas is caused by *Rhizoctonia solani* Kuhn, (*Pellicularia filamentosa* (Pat.) Rogers). *R. solani* has a wide host range and comprises numerous parasitic strains. This characteristic of the pathogen and the fact that *R. solani* survives in the soil influences the use of control measures, such as crop rotation. The effects of crop rotations on crown rot of sugar beets at the Scotts Bluff Experiment Station, Mitchell, Nebraska, were determined for the years 1933 and 1934 and for the period 1946 to 1949. More recently experiments on cross inoculations were made with *R. solani* isolates to ascertain the possible relationship of parasitic strains to the effectiveness of crop rotation in controlling the disease. Data from crop rotation and cross inoculation experiments are incorporated in this paper.

Materials and Methods

The rotation plots used in this investigation are located at the Scotts Bluff Experiment Station, Mitchell, Nebraska, on the North Platte reclamation project in western Nebraska. The elevation of the Station is approximately 4000 feet. These rotations were inaugurated in 1912 and deal with various methods of utilizing irrigated land. They were carried out as originally planned from 1912 to 1941. During this 30-year period the

[1] Published with the approval of the Director as paper No. 1012, Journal Series, Nebraska Agricultural Experiment Station, Lincoln, Nebraska.
The research was supported in part by The Great Western Sugar Company, Denver, Colorado.

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[3] Numbers in parentheses refer to literature cited unless indicated otherwise.

rotation experiments dealt primarily with the use of farm manure and legumes (alfalfa and sweet clover) for maintaining soil productivity.

A new rotation put into effect from 1942 to 1949, included manure, mineral fertilizer (chiefly ammonium sulphate and treble superphosphate), alfalfa as green manure, and sweet clover as a pasture and green manure. Barley replaced oats. The other crops in the rotation were alfalfa, sweet clover, sugar beets, potatoes, and field beans (Table 1).

Table 1.—New Rotation Numbers, Crop Sequences and Fertilization at the Scotts Bluff Experiment Station, Mitchell, Nebraska.

New Rotation No.	Crop Sequence and Fertilization[1]
2	beets
2D	beets (NP)
20	beets, potatoes
20C	beets (NP[2]), potatoes (NP[2])
21	beets (M), potatoes
33	beets, barley-sweet clover, potatoes
33B	beets (M), barley-sweet clover, potatoes
35	beets, barley, potatoes
35B	beets (M), barley, potatoes
35C	beets (NP[2]), barley, potatoes (NP[2])
41	beets, barley-alfalfa, alfalfa, potatoes
41B	beets (M), barley-alfalfa, alfalfa, potatoes
41C	beets (NP), barley-alfalfa, alfalfa, potatoes (P)
43B	beets (M), barley, beans, potatoes
43C	beets (NP[2]), barley, beans, potatoes (NP[2])
49	beets, barley-sweet clover, sweet clover pasture, potatoes
49C	beets (NP), barley-sweet clover, sweet clover pasture, potatoes
49D	beets (NP), barley-sweet clover, sweet clover cut, potatoes (P)
63	beets, barley-alfalfa, alfalfa (3 yrs.), potatoes
63B	beets (M), barley-alfalfa, alfalfa (3 yrs.), potatoes
63C	beets (NP), barley-alfalfa, alfalfa (3 yrs.), potatoes (P)
66B	beets (M), barley-alfalfa, alfalfa (2 yrs.), potatoes, beans
66C	beets (NP), barley-alfalfa, alfalfa (2 yrs.), potatoes (P), beans

[1] (M) farm manure applied at rate of 12 tons per acre.
(NP) 102 pounds of nitrogen and 56 pounds of P_2O_5 per acre.
(NP[2]) 51 pounds of nitrogen and 56 pounds of P_2O_5 per acre.
(P) 56 pounds of P_2O_5 per acre.
Previous to 1945, the application of nitrogen amounted to 20 pounds per acre.

The land had not been cultivated prior to the establishment of the Station in 1910. The soil of the experimental area is Tripp very fine sandy loam, a typical soil of the extensive areas of the terraces north of the North Platte River. It is readily permeable to water and well drained. Each crop in the rotation was grown each year; there were as many plots for each rotation as there were years in the cycle of the rotation. As far as possible, the same cultural treatments were given to all plots of the same crop. All plots in sugar beets were planted each year for the 1946-1949 period to the variety GW 526; a variety very susceptible to crown rot. The variety used in 1933 and 1934 is not known. It may or may not have been from seed grown in Europe.

Plots 2 and 2D were each one-eighth acre in size. All others were one-fourth of an acre. The rows were 132 feet long. Crown rot data for 1933 and 1934 have been obtained from sugar beet root samples taken at random just prior to harvest. The method of sampling consisted of taking five samples of 20 beets each from 40 inside rows of each plot. Ten beets were taken from each 4 rows. Eight rows comprised one sample. The data for the 1946-1949 period were taken from six specific and uniformly distributed inside rows in each plot. Observations and data on the incidence of crown rot were made twice during the growing season and at harvest time. About 700 beets per plot were observed per season.

The modified toothpick method (10) of inoculation was employed in greenhouse and field trials to determine the host range of *R. solani* strains. Potatoes (variety Progress) and field corn (variety Nebr. 501-B) were inoculated in the first node. Field beans (variety U.I. 59) were inoculated in the tap root. The field corn, beans, and potatoes were about one month old at time of inoculation.

An attempt was made to determine the inoculum potential of soil from the rotation plots by planting seed in soil samples under greenhouse conditions. Adequate checks consisted of steam sterilized soil and normal greenhouse soil. Each soil sample was tested in duplicate in 6-inch clay pots in each of which 25 sheared sugar beet seed were planted. The air temperature of the greenhouse was 85° F.

Experimental Results

The percentage of diseased sugar beets in the rotations for 1933 and 1934, 22 and 23 years after the rotations were established, was present at a low level in rotations from 2 to 6 years in length as well as in the continuous sugar beet plot at this time. The maximum percentage was about 3 percent for any one period. A disease trend related to rotation length and type was not evident in 1933 and 1934.

The data for the 1946-1949 period indicated a definite trend in disease incidence (Table 2). The incidence of crown rot of sugar beets was the highest in the continuous cropping of sugar beets, rotations 2 and 2D; lowest in the four- and six-year rotations, rotations 41 through 66C. In general as the length of rotation decreased the incidence of crown rot increased.

Table 2.—Prevalence of Crown Rot of Sugar Beets in Irrigated Rotations in 1946 to 1949 at the Scotts Bluff Experiment Station, Mitchell, Nebraska.

Rotation No.[1]	Percent of Crown Rot				
	1946[2]	1947	1948	1949	Average
2	53	80	62	56	63
2D	70	64	48	40	56
20		27	37	33	32
20C		13	28	14	18
21		4	34	28	22
33		12	7	15	11
33B		7	9	13	10
35		21	11	12	15
35B		8	15	10	11
35C		8	10	8	9
41		7	18	17	14
41B		4	11	4	6
41C		6	12	14	11
43B		7	9	12	9
43C		7	12	5	8
49		2	8	15	8
49C		5	7	12	8
49D		9	11	14	11
63		13	3	17	11
63B		3	17	11	10
63C		5	14	12	10
66B		9	8	9	9
66C		14	14	18	15

[1] See Table 1 for description of rotations.

[2] Data not obtained for plots other than for 2 and 2D.

Considering all rotations, the application of either farm manure or commercial fertilizer decreased the Rhizoctonia disease (Table 3). In continuous sugar beet cropping commercial fertilizer decreased the percentage of crown rot from 63 to 56 for the four-year period, 1946-1949. In the two-year rotation for a three-year period, 1947-1949, the incidence of disease de-

Table 3.—Average Percent of Crown Rot of Sugar Beets for the Fertilization Treatments in Different Lengths of Rotation for the 1946-1949 Period.

Length Rotation in Years	Non-fertilized	Manure	(NP)
continuous	63		56
2	32	22	18
3	13	11	9
4	11	8	10
6	11	10	13
Average	28	13	21

creased from 32 to 22 and 18 with the application of farm manure and commercial fertilizer, respectively. There was little difference between the non-fertilized and fertilized plots in three-, four- and six-year rotations.

The effect of crop sequence on crown rot of beets was difficult to determine. The sugar beet crop followed potatoes in all rotations except 66B and 66C where it followed beans (Table 1). The incidence of crown rot was relatively low and about equal in all six-year rotations.

Under greenhouse conditions crown rot did not develop in sugar beets planted in soil from different rotations. A considerable amount of pre-emergence damping-off was noted. No clear-cut differences, however, could be detected either between different lengths of rotation or between different treatments within the same length rotation. The average percent loss in stand for the continuous cropping and two-, three-, four- and six-year rotation was 36, 16, 40, 28 and 32. The stand loss in normal greenhouse soil was 6 percent and when sterilized no loss in stand was realized.

The temperature of 85° F. is probably too high to occur naturally during spring conditions but this temperature is common later in the season when most of the crown rot appears. The experiment bears out the fact that the soils from the rotation plots contain damping-off microflora and under certain conditions this disease may occur. The information on damping-off in the greenhouse is of dubious value from the crown rot standpoint because *R. solani* strains that cause the damping-off phase may not necessarily be capable of causing the crown rot phase of more mature sugar beets (10). A stand loss due to damping-off in the rotations did not appear to be common under field conditions.

Cross inoculations with *R. solani* isolates were made to ascertain the reaction of crops grown in the rotations. Cultures 2, 5, 8, 13 and 20 were isolated from diseased sugar beet roots and Cultures 1 and 42 were obtained from potato stems and sugar beet soil (irrigation runoff water), respectively. In 1958 greenhouse experiments Cultures 1, 2, 8, 13, 20 and 42 were found to be nonpathogenic for field beans. Cultures 2 and 42 induced only a slight discoloration in the area of inoculation. This discolored area was slightly more extensive than for the other cultures but the isolates will be classified as non-pathogenic because the spread of discoloration during a three-month period may not be due to true infection. Each of the Cultures 2, 5 and 13 killed about 75 percent of potatoes inoculated; Cultures

1, 20 and 42 were nonpathogenic for potato. Cultures 2 and 8 induced severe crown rot symptoms of sugar beets and the other four cultures were classified as nonpathogenic using the toothpick inoculation method (10) or by soil infestation in the field.

In field experiments results similar to those reported for greenhouse tests were obtained with Cultures 1, 2 and 5. In 1958 field tests Culture 1 was nonpathogenic for field corn, potatoes and field beans. Cultures 2 and 5 were definitely pathogenic for potatoes causing 100 percent kill. These cultures caused slight discoloration in inoculated areas in field corn and were classified as nonpathogenic for field beans. In 1959 field tests the results of the 1958 tests were confirmed for Cultures 1 and 2. Culture 8 was pathogenic for potatoes but not for field beans or field corn.

Soil infestation in pots with Cultures 1 or 2 in greenhouse tests resulted in host reaction comparable to data reported previously. Neither Culture 1 nor 2 affected alfalfa, a crop which was not included in toothpick inoculation experiments. Culture 23, isolated from field bean roots, proved pathogenic only for field beans because no stand was obtained in soil infested with this culture.

Discussion

In considering the effects of crop rotations on the incidence of a soil-borne disease several aspects need to be taken into account. What is the host range of the pathogen with respect to crops grown in the rotation? What is the effect of the preceding crop on the disease? What is the effect of fertilization on the occurrence of the disease?

The length of rotation definitely affected the amount of crown rot of sugar beets. Sugar beet monoculture and two-year rotations with potatoes were favorable for *R. solani* survival and development. Two-year rotations with crops such as corn, beans or alfalfa substituted for potatoes would clarify the reason for disease incidence. In other words, *R. solani* may be capable of survival as a saprophyte in the soil for two years and decrease with time. This information would present a clearer picture of the effect of length of rotation on the disease.

An explanation for the effect of crop rotations on Rhizoctonia disease was sought by a determination of the parasitic capabilities of strains of *R. solani* on crops grown in the rotations. Isolates of this fungus from sugar beets were pathogenic for sugar beets and potatoes but not for field beans, alfalfa and field corn. An isolate from potato stems was nonpathogenic for field corn, field beans, potatoes and sugar beets. This nonpathogenicity of potato stem isolates for sugar beets confirms LeClerg's work (6, 7). An isolate from field bean root was only pathogenic for field beans. A pigweed (*Amaranthus retroflexus* L.) isolate was slightly pathogenic for sugar beets. The number of isolates employed may not include the entire spectrum of parasitic capabilities represented by *R. solani* strains existant in western Nebraska. The data may be somewhat indicative of the host range of the races present, for Rhizoctonia root rot is not an economic problem on any of the crops grown under irrigation in western Nebraska other than sugar beets or potatoes.

With the many strains of *R. solani* existant a general statement as to its pathogenic capabilities may be incorrect. In 1934 LeClerg (6) had found that *R. solani* isolated from potato stems and tubers were nonpathogenic for sugar beets. The isolates from potatoes are generally considered as nonpathogenic for sugar beets (3, 6). For this reason potatoes have been suggested as the crop to precede sugar beets. More recently some of the *R. solani* isolates from potato stolons were found pathogenic for sugar beets (7). On the other hand our studies have indicated that *R. solani* isolates from sugar beets may or may not be parasitic for potatoes. Thus a crop rotation effect on the *R. solani* disease may result from host selection of pathogenic strains. Strains pathogenic for sugar beets or potatoes survive because they are able to parasitize these crops. Although exact data to prove this point are not available, our studies show that in a two-year rotation the incidence of *R. solani* crown rot is decreased considerably compared to continuous cropping of sugar beets. In 1938 Goss and Afanasiev (4) reported a similar decrease in Rhizoctonia black scurf of potatoes in the same rotations. The fact that tests of isolates of *R. solani* from potato tubers are nonpathogenic for sugar beets favors the idea of selective pressures. The longer rotations are the more effective in keeping the disease in check because field beans, alfalfa and sweet clover may not favor survival and development of *R. solani* strains pathogenic for sugar beets or potatoes.

Thus, in spite of the fact that many strains of *R. solani* exist, conditions in certain localities favor the survival of some strains. In western Nebraska *R. solani* may be prevalent on sugar beets and potatoes because strains pathogenic for these crops are favored by conditions present. It is quite probable that under certain conditions the *R. solani* strains pathogenic for either field beans, alfalfa, or sweet clover may not be important on either sugar beets or potatoes.

Surveys by LeClerg (7) of sugar beet and potato fields in Colorado, Wyoming, and Nebraska for the period 1936-1938 showed that sugar beets following potatoes were, in general, relatively free from Rhizoctonia root rot compared with sugar beets followed by sugar beets. There are reports (1, 8, 9) of Rhizoctonia root rot of sugar beets following potatoes. In these instances other crops besides the one just preceding sugar beets may need be considered. In the Scotts Bluff Experiment Station rotation plots the incidence of Rhizoctonia crown rot of sugar beets was low when preceded by potatoes in a four- or six-year rotation, but was high in the shorter rotations.

Discrepancies in field survey data from different areas may, in part, be attributed to variations in pathogenicity of *R. solani* isolates. In the Scotts Bluff Experiment Station rotations, 70 and 63 percent Rhizoctonia infection occurred in four years of continuous cropped potatoes and sugar beets, respectively, while only 26 and 32 percent occurred in a two-year rotation of potatoes and sugar beets (4).

An explanation of the incidence of Rhizoctonia disease requires more information than a statement on crop sequence. Addition of fertilizers to the soil decreased the disease both in potatoes and sugar beets (5). Knowledge of fertilization practice at the time interval between susceptible crops is needed. Coons (2) presents a general review of the Rhizoctonia disease of sugar beets and Kernkamp et al., (5) present a review of the many complex problems involved in Rhizoctonia diseases of plants. The many ramifications of the problem will not be repeated in this paper.

A comparison of the data obtained in 1933 and 1934 with that in 1946-1949 indicates a cumulative increase in Rhizoctonia crown rot over a period of time. In 1933 and 1934, however, the data relate to harvested roots. Sugar beets killed early in the season during these years were ignored. Therefore, the cumulative increase may be less important than the data indicated.

Summary

A study of the effects of irrigated crop rotations on *Rhizoctonia solani* crown and root rot of sugar beets was made at the Scotts Bluff Experiment Station, Mitchell, Nebraska. In addition to continuous cropping plots, four different lengths of rotations were involved as well as different fertilization and cropping practices.

There was a tendency for an increase in disease with a decrease in length of rotation. The amount of disease was favored by continuous cropping and by a two-year rotation. The host range of several strains of *R. solani* was studied to explain the

effects of crop rotation on the disease. Crown rot was present in the rotations 22 and 23 years after inauguration of the rotations but appeared more common 34 and 36 years after the program was started.

Fertilizer applications decreased crown rot in the two-year rotation and in 3 out of 4 years of continuous cropping. Commercial fertilizer or manure did not appear to affect the disease incidence in the longer rotations.

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