Correlation Between Sugar Beet Crop Losses and Greenhouse Determinations of Soil Infestation by Aphanomyces Cochlioides[1]

H. C. FINK AND W. F. BUCHHOLTZ"

Damping oft of seedlings and rot of fleshy roots o£ sugar beets caused by *Aphanomyces cochlioides* Drechsler is a limiting factor in the production of that crop in many areas of the United States.

Aphanomyce cochliodes was described and named by Drechsler in 1928 and 1929 (5, 6)[3], when he found that pathogen causing severe damping off of sugar beet seedlings in Michigan. That the fleshy root as well as the seedling is subject to pathogenesis by *A. cochlioides* was observed in northern Iowa in 1938 by JBuchholtz and Meredith (3, 4) . Since that time this fungus has been reported as an active pathogen in other sugar beet-producing areas of the United States (1, 7, 8, 10).

The sporadic prevalence of *A. cochlioides* in the Wisconsin drift soils of north centraf Iowa has been a major factor in the abandonment of sugar beets as a crop in that area. Lack of other adequate control measures prompted consideration of the possibility that heavy crop losses could be avoided by planting in fields not at the time infested with *A. cochlioides.* Such a possibility depends upon successful estimation of soil infestations by *A. cochlioides* and a close correlation of such estimates with crop failures by this fungus.

Such an approach to avoidance of crop depredation by a soil-borne root pathogen is not new to sugar beet culture. Leach and Davey (9) were successful in estimating the sclerotial populations of *Sclerotium rolfsii* Sacc. in soil from the numbers of sclerotia washed and screened from soil samples. Their estimates of sclerotial populations were correlated with relative number of beets infected in the fields sampled. Further use of this method was made in determining fluctuations of populations of viable sclerotia in crop rotation studies.

This paper presents two seasons' results of greenhouse determinations of degrees of infestations by *Aphanomyces cochlioides* in soil samples taken from northern Iowa sugar beet fields and the correlation of degrees of infestation with crop losses and yields *in* the respective fields.

Procedures

Determination of degree or intensity of soil infestation by *Aphanomyces cochlioides* for a particular field consisted essentially in growing a stand of

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[2] Formerly Research Fellow, and Associate Professor of Botany and Plant Pathology, respectively.

[3] Numbers in parentheses refer to literature cited.

sugar beet seedlings in the greenhouse in a soil sample taken from that field and determining how many of the badly diseased seedlings were infected by *A. cochlioides.* Each soil sample was a composite of small samples taken to a depth of six inches. All the soil taken from a field was placed in a new double-layered flour sack, in which it was transported. The soil in each sack was thoroughly mixed before being placed in pots. The potting bench was washed with tap water and a brush before each soil sample was placed upon it.

One pot of soil from each sample was steamed at 15 pounds pressure for four hours and served as a check. As additional checks, five pots of unsteamed greenhouse soil were included. Twenty seed clusters treated with ethyl mercury phosphate (to preclude infection with other damping off fungi (2)) were planted about one-half inch deep in each pot. The pots containing the unsteamed field samples and the greenhouse soil were arranged in five randomized blocks so that each soil sample was represented in each block. The pots containing the steamed samples were arranged in a sixth randomized block.

Total number of seedlings and number of diseased seedlings per pot were recorded daily for 30 days. Each day the diseased seedlings were collected, washed with a camel's hair brush to remove all soil and floated in 10 to 15 cc. of distilled water in sterile petri dishes, one seedling per dish.

Almost without exception, *in* 24 hours extramatrical mycelium and sporangia of *A. cochlioides* had developed on the seedlings infected by that fungus. *A. cochlioides* was distinguishable from other fungi by the presence of encysted zoospores adhering to the tips of its sporangia. If no *A. cochlioides* had grown from the beet seedlings in 24 hours, or if the identity of other fungi growing from them into the water could not be determined, the seedlings were removed from the water, placed between sheets of filter paper to remove the excess water and transferred to petri dishes containing 2 percent agar. After 24 hours the fungi present could be identified and recorded. In only a very few cases was the presence of *A. cochlioides* recorded after seedlings had been transferred to agar plates.

After 30 days the number of diseased seedlings which yielded growth of *A. cochlioides* was recorded for each soil sample. That number was divided by the total number of seedlings. The resulting quotient was multiplied by 100. The percentage so obtained is the estimated intensity of infestation by *A. cochlioides* for the soil samples. In all future references to this percentage, the term "intensity of soil infestation" will be used in lieu of "percentage of seedlings infected by *A. cochlioides*" or "estimated intensity of soil infestation by *A. cochlioides.*"

In 1946, soil samples were collected in the fall from 19 Iowa fields, among which were fields in which there had been no, a few, or many root-rotted beets during the 1946 growing season.

During April, 1947, soil samples were collected from 24 fields in which sugar beets were to be planted that year. All but five of these 24 fields were visited in June, before thinning time. One hundred seedlings were dug and carefully examined at each of three places per field. Diseased seedlings were taken to the laboratory and the presence of *A. cochlioides* in their tissues were determined by the method described.

During August an estimate of crop loss caused by *A. cochlioides* was made for each field. This estimate was based on stand and relative abundance of beets showing evidence of root rot and was recorded as percentage of crop loss.

In October, 300 beets were dug and topped in each of the 24 fields. The normal shaped beets and those obviously deformed by disease were weighed separately. The percentage of deformed roots, by weight, was calculated for each field.

In an attempt to contribute information on the effect of crop rotation on abundance and effect of *A. cochlioides* in the soil, farmers were asked for cropping histories of the fields from which soil samples were taken. Unfortunately, definite cropping history was available for only half the fields.

Soils in the fields from which soil samples were taken were classified to determine whether the pathogen tends to be prevalent in particular types or classes of soil.

Results

Two major experiments comprised these investigations. The first, which was somewhat exploratory, consisted of 1. Sampling the soil in 19 northern Iowa sugar beet fields in the fall of 1946 after the crop had been harvested; 2. Estimating the intensity of infestation by *Aphanomyces cochlioides* of each sample according to the method described, 3. Correlating these estimates with previously reported field losses from "root rot."

The second experiment, in 1947, consisted of: 1. Sampling the soil in 24 northern Iowa and southern Minnesota sugar beet fields; 2. Estimating the intensity of infestation of each sample by *A. cochlioides;* 3. Estimating subsequent crop loss in these fields caused by *A. cochlioides;* 4. Weighing 300 beets from each field and determining the percentage of deformed roots (by weight) , and 5. Correlating intensities of soil infestation with estimated crop losses, percentage of deformed roots and weights of 300 beets from each field.

The results of these two experiments will be presented separately.

Reported Crop Losses and Intensity of Soil Infestation, 1946

The intensities of soil infestation by *Aphanomyces cochlioides* in soil samples taken from 19 northern Iowa sugar beet fields in 1946, together with the previously reported crop loss in each field from "root rot," are listed in Table 1. The crop loss reports weis those of sugar company field men and farmers, based upon observations made by them during the 1946 growing season.

In all but three cases (fields 4, 8 and 11) the crop loss reported for the field was comparable to the intensity of soil infestation by *A. cochlioides* according to greenhouse and laboratory determinations. In Field 4 the soil sample was taken from a small portion of the field in which there had been much loss of stand, while the crop loss report was based upon observation of the entire field. In Field 8 the beets were plowed up early in the season after a heavy loss of the stand by damping off, but no *A. cochlioides*-infected seedlings were found in the stand of beets grown in the soil sample collected from that field. In Field 11 the crop was not harvested because the beets failed to reach marketable size. The intensity of infestation by *A. cochlioides* was estimated to be only 11 percent, or light. It should be kept in mind that there was no opportunity to determine the nature of the "root rot" reported as the cause of crop loss in this or any other field in 1946.

Soil Infestation and Damage in the Field by *Aphanomyces Cochlioides* in 1947

Intensities of infestation by *Aphanomyces cochlioides* in the respective soil samples and estimated crop losses *in* 24 northern Iowa and southern Minnesota sugar beet fields sampled are presented in Table 2. There was a correlation of 0.926 between estimated crop loss and intensity of soil infestation by *A. cochlioides.* This coefficient is significant at the 1 percent level. The regression of estimated crop loss of intensity of soil infestation was calculated and is expressed in the equation, $Y = 0.786X — 3.09$. This regression line, together with individual observations, is plotted in Figure 1.

The close agreement between greenhouse and laboratory determinations of soil infestation by *A. cochlioides* and the estimated crop losses due to this pathogen is evident. Especially evident is the fact that no losses and heavy crop losses were recorded for fields with no infestations and heavy infestations, respectively. Only possible exceptions were Fields 16 and 17. Cir-

Table 1.—Intensities of Soil Infestation by *Aphanomyces cochlioides* and Previously Reported Sugar Beet Crop Losses in 19 Northern Iowa Beet Fields, 1946.

Field number	Intensity of soil infestation	Reported crop loss
1	48	entire crop
2	59	heavy
3	0	none
4	81	light
5	4	light
6	46	entire crop
7	2	none
8	0	entire crop
9	0	light
10	0	none
11	11	entire crop
12	1	none
13	0	none
14	0	light
15	29	entire crop
16	32	entire crop
17	0	none
13	39	entire crop
19	0	none
Greenhouse soil	0	

cumstances pointed to an underestimation of loss in Field 17; about half of the field had been plowed up at thinning time because of a very poor stand, cause of which was not ascertained. Loss was "estimated for the portion of the field not destroyed.

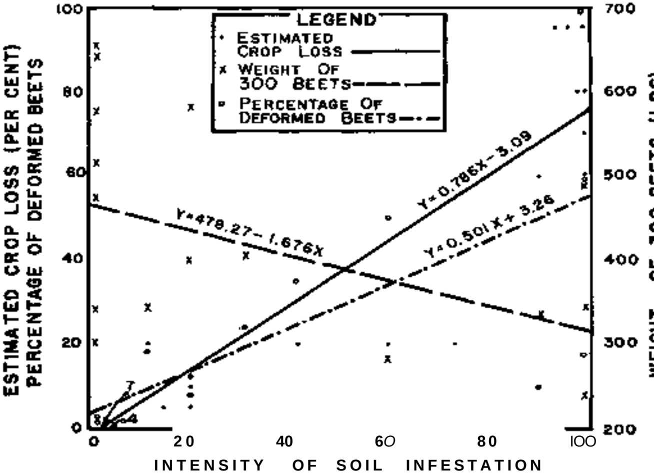

Figure 1.—Regression of estimated crop losses, weight of 300 beets and percentage of deformed beets on intensity of soil infestation by *Aphanomyces cochlioides.*

Isolations were made from ten or more diseased seedlings taken from each of 19 fields in June. In twelve cases where soil infestation by *A. cochlioides* was detected in the greenhouse and a laboratory, the fungus was recovered from seedlings collected in the fields from which the infested soil samples were taken. In seven cases where no *A. cochlioides* was detected in "the soil samples by greenhouse test, it was absent in seedlings collected from the respective fields. Fields 15, 16, 17 and 18 were not visited in June; the beets in Field 24 had been destroyed.

Percentages of deformed roots, by weight, and weights of 300 beets harvested from each of 17 fields are also presented in Table 2.

The correlation between percentage of deformed roots and intensity of soil infestation by *A. cochlioides* was found to be 0.730. This coefficient is significant at the 1 percent level. The regression of percentage of deformed roots on intensity of soil infestation was calculated and is expressed by the equation, Y == 0.501X + 3.26. This regression line, together with individual observations, is plotted in Figure 1. In field 5 the percentage of deformed roots was found to be only 16 percent, while the intensity of soil infestation was determined to be 99. A low percentage of deformed roots in relation to soil infestation was also recorded for Field 15. In these two fields, especially in Field 15, the total weight of 300 beets was low in comparison to fields in which the intensity of infestation was low or zero. Small beet size, rather than deformed roots, may have been the principal effect of *A. cochlioides* infestation in these fields.

Table 2.—Intensities of Soil Infestation by *Aphanomyces cochlioides,* Estimated Crop Losses, Percentages of Deformed Roots and Weights of 300 Beets in 24 Northern Iowa and Southern Minnesota Beet Fields, 1947.

Field number	Intensity of soil infestation	Estimated crop loss %	Deformed roots %	Weight 300 beets lbs.
1	93	95		
2	0	0	0	479
3	0	0	0	302
4	0	0	3	666
5	99	60	16	490
6	100	80		
7	15	5		
8	12	20	19	348
9	0	0	2	347
10	0	0	1	515
11	31	20	24	405
12	0	0	0	578
13	97	95		
11	99	70	59	238
15	90	60	10	340
16	60	20	51	283
17	74	20		
18	42	20	36	199
19	0	0	0	659
20	100	95		
21	20	5	13	572
22	20	10	8	405
23	99	80	100	346
24	2	[1]		
Greenhouse soil	0			

[1] Note: The beets in Field 24 were destroyed before thinning t : in June.

The correlation between weight of 300 beets and intensity of soil infestation by *A. cochlioides* was found to be —0.473. This coefficient is significant at the 5 percent level. No data concerning soil fertility, soil moisture or thinning dates were compiled. The regression of weight of 300 beets on intensity of soil infestation is expressed by the equation, Y = 478.27 — I.676X, and this regression line, together with individual observations, is also plotted in Figure 1.

It seems apparent that there was a positive relationship and highly significant correlation between reported and estimated crop losses and intensities of soil infestation by *A. cochlioides* according to greenhouse determinations in 1946 and 1947, respectively. In the 1947 experiment, percentage of deformed roots and lack of beet size were also correlated with soil infestation.

Soil Acidity and *Aphanomyces cochlioides* Infestation

Acidity (pH) was determined for each soil sample. There obviously was no relationship between pH and the intensity of infestation by *Aphanomyces cochlioides.* estimated crop loss, percentage of deformed- beets or weight of a sample of 300 beets.

Crop Rotation and *Aphanomyces cochlioides* Infestation

For twelve fields, the crops grown one, two or three years prior to the 1947 sugar beet crop were ascertained and recorded, but no significant relationship was evident from such records.

Soil Type and *Aphanomyces cochlioides* Infestation

Soil types in all but one of the fields from which soil samples were taken in 1947 and relative intensities of *Aphanomyces cochlioides* infestation in the samples are recorded in Table 3. No soil type included was found to be free in all cases, but samples from Webster loam-heavy subsoil phase were heavily infested in three of four cases.

Table 3.—Soil Types in 23 Fields from Which Samples Were Taken in 1947 and Relative Infestation of Samples by *Aphanomyces Cochlioides.*

Field number	Soil type	Relati' infestati
1	Floyd	heavy
2	Floyd	none
3	Webster-like, over sandy out-wash	none
4	Webster silt loam and Glenco	none
5	Webster silt loam and Glenco	heavy
6	Webster loam—heavy subsoil phase	heavy
7	Webster and Glenco	light
8	Clarion, Webster and Glenco	light
9	Webster loam and Nicolet	none
10	Webster silt loam	none
11	Webster silt loam, Nicolet and Glenco	light
12	Clarion and Webster silt loam	none
13	Webster loam—heavy subsoil phase	heavy
14	Webster loam and Glenco	heavy
15	Clarion, Webster silt loam and Glenco	heavy
16	Webster and Glenco	heavy
17	Clarion	heavy
18	Clarion	light
19	Webster silt loam	none
20	Webster loam—heavy subsoil phase	heavy
21	Webster loam—heavy subsoil phase	light
22	Clarion and W^Tebster loam	light
23	Webster silt loam	heavy

Summary

The intensities of soil infestation by *Aphanomyces cochlioides* in 19 sugar beet fields in 1946 and in 24 fields in 1947 were determined as follows: A stand of sugar beet seedlings was grown in the greenhouse in a soil sample

collected from each field. The number of diseased seedlings infected by *A. cochlioides* was determined and converted to a percentage, which was recorded as the intensity of infestation of the soil in the field from which the sample was taken.

In 1946 the soil samples were collected after harvest, and the intensity of infestation in each of the 19 fields was comparable to the previously reported crop loss from "root rot" in that field.

In 1947 the soil samples were collected from 24 fields before beets were planted in the spring. The estimated intensities of soil infestation by *A. cochlioides* were significantly correlated with: 1. estimated crop losses; 2. percentages of deformed roots, and 3. weights of 300 beets harvested in these fields.

These results indicate that intensity of infestation by *A. cochlioides,* or lack of infestation, of the soil in a particular field can be determined successfully and that such determination can be useful in selecting fields in which *A. cochlioides* will not be the cause of sugar beet crop failure.

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