Effects of Aphanomyces cochlioides and Pythium ultimum, Alone and as Complexes, with Heterodera schachtii on Sugarbeet

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Root-rot disease complexes of sugarbeet caused by *Heterodera schachtii* Schm. and soil-borne pathogens have not been investigated extensively. However, Price and Schneider (2)[2] observed that losses in yield caused by *H. schachtii* and *Rhizoctonia solani* Kühn as a complex were greater than the combined losses of each alone. Polychronopoulas *et al.,* (1) reported that damage to sugarbeet seedlings caused by the same complex appeared to be synergistic.

This study was initiated to determine the effects of the sugarbeet nematode in combination with soil-borne organisms on sugarbeet yield. Subsequent tests were conducted to determine if the effects of the *H. schachtii-Aphanomyces cochlioides* Drechs. complex observed in naturally infested soil in the initial test were synergistic.

Materials and Methods

Tests conducted in Salinas, California, during 1966, 1968, and 1969 will be referred to as tests 1, 2, and 3, respectively. The tests were made under field conditions by growing sugarbeets (F_1 hybrid F58-554H1) in 2.5 gal (approximately 14,000 g) of soil in 3 gal crocks placed on concrete blocks. Virus yellows infection was present in the beets of all treatments. The seed were surface disinfested for 20 min in 20% Chlorox[3] plus 0.15% Triton[3] X-100 (iso-octyl phenoxy polyethoxy ethanol) and 10 seed planted in each of two rows in each crock of soil. Four weeks later each crock was thinned to one plant in test 1 and two in test 2 and 3. The design was completely randomized with 25 replications for each treatment in tests 1 and 2 and 45 in test 3.

In test 1, three soils free of the sugarbeet nematode were selected and designated as soils 1, 2, and 3. The soil type and cropping sequence of each soil is given in Table 1. The soil

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[2] Numbers in parentheses refer to literature cited.

[3] Use of trade names is for identification, and does not constitute an endorsement or guarantee of the product by the U. S. Department of Agriculture to the exclusion of others of suitable composition.

Table 1.—Soil type and cropping sequence for each soil, test 1.

Soil	Soil type	Cropping sequence				
		1965	1964	1963	1962	1956
1	Camphora sandy clay loam	Nasturtiums	Barley	Beets		
2	Chualar sandy loam	Barley/vetch	Fallow	Barley	Fallow	Beets
3	Camphora sandy clay loam	Beets	Beans	Barley	Beets	

treatments were: 1) steam-treated soil (7 hrs at 5 lbs pressure); 2) steam-treated soil to which 24,600 nematode larvae were added at the rate of 1,000, 2,000, 4,000, 8,000, and 9,600 each succeeding week for five weeks following planting; 3) field soil; and 4) field soil plus nematode larvae at the same rate as treatment 2. The nematode larvae for the inoculations were hatched and partially surface disinfested (4).

For tests 2 and 3 sugarbeet nematode larvae and *A. cochlioides* were added to non-agricultural soil (loamy sand) to establish the four treatments: 1) control; 2) nematode; 3) *A. cochlioides;* and 4) a complex of the two organisms. Twenty thousand larvae were added to the soil of the seed row or around the plants after emergence. Two, 3, 4, 5, and 6 thousand larvae were added each succeeding week for 5 weeks after planting.

A. cochlioides zoospores used as inoculum were from cultures isolated from infected plants from test 1. The isolates were maintained on cornmeal agar and zoospores were obtained by the method of Schneider (3). With the aid of a cement mixer 35 and 28 zoospores per g of soil were mixed with the soil in tests 2 and 3, respectively.

Approximately 145 days after planting, beets were harvested, weighed, checked for sprangled roots, and soil samples taken. A bioassay of soil samples in test 1 was conducted. Equal numbers of surface disinfested seed were planted in each soil and plants damping-off assayed by the water culture method. A bioassay of fallowed soil from the original site for soil 3 was also made. Cysts from ten- 100g samples were washed from each soil and counted with the aid of a dissecting microscope. Percent sucrose was determined for beets from 10 and 20 replications of each treatment for tests 2 and 3, respectively.

Results

Bioassays of soil samples from test 1 showed that *Pythium ultimum* Trow. predominated in soils 1 and 2 with equal amounts of *P. ultimum* and *A. cochlioides* in soil 3. The bioassay of fallowed soil from the original site for soil 3 showed *A. cochlioides* to be the predominant pathogen, Table 3.

In all three tests the yield losses due to the complex of *A.*

Table 3.—The total number of sugarbeets damping-off, number and percent from each cause.

Soil	Total	*P. ultimum*		*A. cochlioides*		Unknown	
1[a]	89	77	86.5%	5	5.6%	7	7.9%
2[a]	100	87	87.0%	5	5.0%	8	8.0%
3[a]	163	85	52.1%	78	47.9%	0	0.0%
3[b]	54	9	16.7%	41	75.9%	4	7.4%

[a] Soil from crocks
[b] Soil from the original site

cochlioides and *H. schachtii* were slightly more than additive, however, when the data were summed over years, no significant interaction was shown. This was partially due to the large variation within treatments. The percent loss of the complex exceeded the combined losses of each alone by 9.4%, 6.9%, and 4.1% for tests 1, 2, and 3, respectively, Tables 2 and 4.

The number of beets with sprangled roots in the complex exceeded the total number of sprangled roots in the nematode plus fungus treatments in test 1 (soil 3) and 2, but not in test 3. The number of sprangled roots in the control and nematode treatments were nearly equal in all tests, Tables 2 and 4.

A reduction in percent sucrose resulted in test 2 from the complex and in test 3 from *A cochlioides* and the complex, Table 4. Nematode reproduction based on the number of cysts recovered from 100 g of soil was variable, but in all tests the mean number of cysts per g of tap root was less in the complex than the nematode treatment alone, Table 5.

Discussion

The data suggest that the main losses in test 1, soil 3 were from *A. cochlioides* and will be discussed with tests 2 and 3. Although statistically a synergistic effect due to the complex of the nematode and *A. cochlioides* in reducing yield was not shown, it seems more than coincidental that a trend existed in all three tests. This trend was observed as greater losses in yield due to the complex than the sum of the losses caused by each organism alone. Also, that in some years sprangling of roots (test 1, soil 3, and test 2) caused by the complex was more than additive as well as losses in percent sucrose (test 2). These data suggest that small synergistic interactions between *H. schachtii* and *A. cochlioides* on sugarbeet do occur but are influenced by other factors.

Although not conclusive the effects of *P. ultimum* and *H. schachtii* as a complex appear to be independent of each other.

These data show that under moderate nematode-inoculum potential *H. schachtii* does not cause sprangling of roots but does increase sprangling under some conditions.

It appears that the rate of nematode reproduction in *A. cochlioides*-infested soils on the basis of cyst per g of tap root is re-

Table 2.—The effects on sugarbeet of *H. schachtii*, soil organisms, and a complex of the two.

Soil treatments	Soil 1				Soil 2				Soil 3			
	Steam		None		Steam		None		Steam		None	
Other treatment	None	Nema.	None	Nema.	None	Nema.	None	Nema.	None	Nema.	None	Nema.
X̄ root wt. g	183.1[a]	184.2	163.3	172.1	91.6	114.3	75.1	70.2	151.9	120.5	104.0	58.3
X̄ wt. loss g	.....	0.0	19.8	11.1	.....	0.0	16.5	21.4	.....	31.4	47.9	93.6
% loss of wt.	.....	0.0	10.8	6.0	.....	0.0	18.0	23.4	.....	20.7	31.5	61.6
No. sprangled roots/ no. harvested	1/25	1/24	4/23	5/24	2/23	2/23	4/24	3/25	2/20	2/23	8/23	15/23
% sprangled roots	4.0	4.2	17.4	20.8	8.7	8.7	16.7	12.0	10.0	8.7	34.8	65.2
X̄ no. cysts/ 100 g of soil	.....	12.6[b]	.....	10.7	.....	8.6	.....	12.3	.....	51.4	.....	2.3

[a] L.S.D. .05 = 23.9
[b] L.S.D. .05 = 19.9

Table 4.—The effects on sugarbeet of *H. schachtii*, *A. cochlioides* and a complex of the two.

	1968					1969				
	treatments					treatments				
	1[a]	2	3	4	LSD .05	1	2	3	4	LSD .05
X̄ yield/rep[b]	387.7	386.3	158.2	131.4	37.9	618.5	611.4	491.3	458.1	51.6
% loss of wt.	.....	0.0	59.2	66.1	.....	.....	1.2	20.6	25.9	.....
No. sprangled roots/total	0/50	2/50	3/45	11/44	.....	4/90	3/90	2/89	4/88	.....
% sprangled	0.0	4.0	6.7	25.0	.....	4.4	3.3	2.3	4.6	.....
% sucrose	14.76[c]	15.11	11.88	13.57	1.01	12.73	12.53	11.82	12.11	.59
X̄ no. cysts/ 100 g of soil	.....	194.0[d]	.....	21.5	38.5	.....	50.4	.....	28.4	20.7

[a] 1. Non-agricultural soil, 2. Nematode, 3. *A. cochlioides*, 4. Nematode plus *A. cochlioides*
[b] 25 replications in 1968, 45 replications in 1969
[c] Mean of 10 replications in 1968 and 20 in 1969
[d] Mean of 10/100 g samples

Table 5.—The effect of *A. cochlioides* and other organisms in reducing nematode reproduction based on cysts per gram of tap root.

	Test 1 (soil 3)		2		3	
	nema.	nema. plus fungus	nema.	nema. plus fungus	nema.	nema. plus fungus
X̄ yield of root g	120.5	58.3	386.3	131.4	611.4	458.1
X̄ no cysts/ crock	7,196	322	27,160	3,010	7,056	3,976
cysts / g of root	59.7	5.5	70.3	22.9	11.5	8.7

duced when beets are grown in naturally infested soils to which the pathogen was added. This effect was not noted in steam-treated soils (unpublished data).

Literature Cited

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