The Effect of Certain Soil-Row Treatments on Damping-off of Sugar Beet Seedlings Caused by Specific Fungi

F. J. HILLS AND L. D. LEACH[1]

It is usually possible to obtain a healthy stand of sugar beet seedlings in California with seed treatment alone. There are times, however, when damping-off is too severe to be controlled by this method. This usually occurs in late spring plantings subjected to high soil moisture from rains or irrigation. The organisms most frequently involved *in* such attacks are *Pythium ultimum* Trow, *Rhizoctonia solani* Kuhn, or *P. aphanidermatum* (Eds.) Fitsp.

The beet water mold organism, *Aphanomyces cochlioides* Drechs., is an important causal agent in soils of the delta region of the Sacramento and San Joaquin rivers which have a high water-holding capacity and are acid to neutral in reaction. Fortunately, this fungus is more or less confined to that area. It has not been possible to achieve adequate control of this organism through seed treatment. It would be desirable to have a method of controlling severe incidences of damping-off which could be applied to initial plantings of fields with a history of severe attacks and in replanting other fields when stands are destroyed.

Recent experiments by Hildebrand, Koch and McKeen (2)[2] (3) (4) have shown that a soil-row treatment with certain fungicides is a promising means of controlling damping-off. Their greenhouse work reported to date has been with naturally infested soils in which *A. cochlioides* appears to be the primary causal organism. Compounds such as Arasan (50% tetramethyl thiuramdisulphide) have been applied at rates of three to four pounds per acre mixed with commercial fertilizers of low nitrogen analysis. From 300 to 400 pounds per acre of such a mixture was applied in the field (4) through planter fertilizer attachments so as to place the material as close as possible *in* the zone through which the seedlings emerge. These workers point out (2) (4) that the degree of control is closely associated with the extent to which the fungicide can be incorporated with the soil around and above the seed and that it is difficult to obtain such placement with the usual planter attachments. A limitation to the use of this method of application in California is the wide-spread use of high nitrogen fertilizers which cannot be placed close to seed without impairing germination.

Based on the considerations above, it seemed desirable, before attempting field trials with soil-row treatments, to investigate the effectiveness of promising fungicides in protecting seedlings against attacks by each of the organisms involved and to explore methods of application more suitable to local conditions.

This paper presents the results of a series of greenhouse trials with the above objectives in mind. From the standpoint of eventual field use two methods of fungicidal application were considered for greenhouse work: (a) Dry applications, mixing the fungicides with non-toxic carriers such as gypsum or sugar factory lime, to be applied through planter attachments.

[1] Respectively, Extension Agronomist and Plant Pathologist, University of California, Davis. The senior author was Agronomist, Spreckels Sugar Company, when most of this work was carried out.

[2] Numbers in parentheses refer to literature cited.

(b) Spraying suspensions or solutions of a fungicide into the rows by means of spray nozzles attached immediately behind the planter shoes. The latter method has been stressed as it promises to give good placement of the fungicide.

Methods

To test the effect of treatments on specific organisms, soil was steam sterilized, then infested with the fungus under consideration. Six rows with forty seed units each were planted per flat. Processed seed (decorticated and sized 7 to 10/64th of an inch) of a standard commercial variety, usually U. S. 15, was used. For comparisons with soil-row treatments a sample of the same seed was treated with Phygon paste or Phygon XL, 0.25 percent by weight, the commercial treatment most commonly used in California. Treatments were applied to individual rows and were replicated from three to twelve times (usually six), depending upon the experiment. Generally a randomized block design was used with each flat constituting a block- Seedlings were counted daily. Diseased seedlings were cultured periodically to check on the pathogen involved. Each experiment was conducted over a period of four or five weeks after which the seedlings were dug and rated as to infection. "Healthy" indicated no sign of infection or that the seedling had materially recovered. Analyses of variance were used to evaluate results whenever data were suitable for such treatment.

Dry fungicide applications were made by mixing the fungicide with gypsum or soapstone and sprinkling the mixture into the row while covering the seed with soil so that the material was fairly well distributed throughout the replaced soil. Fungicidal solutions or suspensions were sprayed into the row by means of a hand atomizer. As with dry applications, sprays were applied so that the soil around and above the seed was well mixed with the fungicide.

Results and Discussion

The results of the various experiments are summarized in Tables 1 through 5.

Soil infested with *Rhizoctonia solani.* In trial number 1, Table 1, it can be seen that both Arasan and Dithane were effective in improving control over the standard seed treatment with Arasan giving better conrol

Table 1.—Effects of Soil-row Treatments on Damping-off Caused by *Rhizoctonia Solani.*

Treatments[1]			Trial 1[2]		Trial 2[3]	
Material	Amt. per acre	How applied	Emergence	Healthy survivors	Emergence	Healthy survivors
			(seedlings per 100 seed units			
Control	..	....	77	15	46	16
Arasan	3 lbs.	dry	136	86	—	—
Dithane	2.3 qts.	soil row drench	131	50	—	—
Arasan SF	2 lbs.	spray	—	—	100	83
Vancide 51	2 lbs.	spray	—	—	88	60
Vancide 51	4 lbs.	spray	—	—	97	85
Significant difference. 19:1			29	15	21	14
Calculated F value			13.36[4]	64.81[4]	12.92[4]	46.22[4]

[1] All seed treated with Phygon paste (.25 gms. per 100 gms. seed)
[2] Means of six, eighty-seed unit, replicates.
[3] Means of six, forty-seed unit, replicates.
[4] Exceeds the 1% level of significance.

of post emergence damping-off. Trial number 2 indicates that Arasan SF at two pounds per acre* and Vancide 51 at four pounds per acre, applied as soil-row sprays, gave equally good control of damping-off caused by this organism.

Soil infested with *Pythium ultimum.* **In** this experiment (Table 2) seed treatment was as effective as the soil treatments in controlling the pre-emergence phase of the disease but did not control post-emergence damping-off as well as any of the soil treatments. Arasan, Arasan SF and Ceresan M appeared to be equally effective and all were better than Lignasan, which contains a soluble form of ethyl mercury phosphate.

Table 2.—Effects of Soil-row Treatments* on Damping-off Caused by *Pythium Ultimum.*^

Treatments[2] Material	Amt. per acre	How applied	Emergence	Healthy Survivors
			(seedlings per 100 seed units)	
No soil or seed treatment			84	16
Seed treated with Phygon			131	69
Arasan	3 lbs.	dry	133	98
Arasan SF	2 lbs.	spray	146	96
Ceresan M	1 lb.	dry	145	104
Lignasan	0.68 lbs.	spray	141	84
Significant difference 19:1			20	10
Calculated F value			12.23[3]	15.06[3]

[1] Means of six, forty-seed unit, replicates.
[2] The Arasan compounds were applied to supoly equal amounts of TMTD. Ceresan M and Lignasan applications contain equal amounts of mercury.
[3] Exceeds the 1°£ level of significance.

Soil infested with *Pythium aphanidermatiim.* **In** the first experiment (trial number 1) summarized in Table 3 the infestation was extremely severe. This is shown by the fact that, without soil treatment, only one seedling survived from the 960 treated and non-treated seed units planted. The Arasan SF soil-row spray treatment was, however, clearly superior to

Table 3.—Effects of Soil-row Treatments on Damping-off Caused by *Pythium aphanidermatum.*

Treatments[1] Material	Amt. per acre	Trial 1[2] Emergence	Trial 1[2] Healthy Survivors	Trial 2[3] Emergence	Trial 2[3] Healthy Survivors
		(seedlings per 100 seed units.)			
A—No soil or seed treatment		2			-
B—Seed treated with Phygon		47	0.2	63	4
C—Arasan SF	2 lbs.	94	20	....	....
D—Vancide 51	2 lbs.	....	...	133	63
E—Vancide 51	4 lbs.	....	....	118	65
F—Vancide 51	8 lbs.	..	....	152	90
Significant difference, 19:1		20[4]	....[5]	45	....[6]
Calculated F value		24.21[7]	....	6.01[8]	0.26

[1] All soil-row treatments were applied as sprays.
[2] Means of twelve, forty-seed unit, replicates.
[3] Means of three, forty-seed unit, replicates.
[4] Applies only to difference between treatments B and C. Too few seedlings in treatment A to include in analysis of variance.
[5] Analysis of variance obviously cannot be applied. The observed differences are probably highly significant.
[6] Analysis of variance applies only to difference between soil-row treatments. All are probably better than seed treatment.
[7,8] Exceeds the 5% and *1%* levels of significance respectively.

Table 4.—Effects of Soil-row Treatments on Damping-off Caused by *Aphanomyces Cochlioides* (Trials 1 and 2).

Treatments[1]	Trial 1[2] Emergence	Trial 1[2] Survivors on 12th day	Trial 1[2] Final survivors[4]	Trial 2[3] Emergence	Trial 2[3] Survivors on 19th day	Trial 2[3] Final survivors[4]
	(seedlings per 100 seed units)					
No soil or seed treatment	162	64	0	155	95	5
Seed treated with Phygon	159	66	0	141	99	8
Arasan SF—2 lbs. per acre	151	120	1.3	115	92	21
Ceresan M—1-2 lbs. per acre[5]	162	95	0	136	102	5
Phygon XL—3 lbs. per acre	131	96	6.8	116	107	20
Significant difference 19:1	19	20	[6]	20	NS	10
Calculated F values	3.57[7]	16.85[8]	....	5.63[8]	0.38	6.86[8]

[1] All soil-row treatments were applied as sprays.
[2] Means of six, forty seed unit, replicates.
[3] Means of five, forty seed unit replicates.
[4] The majority of the surviving seedlings were at least moderately infected.
[5] One pound per acre in trial 1 and two pounds per acre in trial 2.
[6] Too few seedlings survived to analyze by analysis of variance.
[7,8] Exceeds the 5% and *1%* levels of significance respectively.

seed treatment in controlling damping-off caused by this pathogen. In trial number 2 Vancide 51 appears to give good control of this organism.

Soil infested with *Aphanomyces cochlioides.* While the results of the four experiments summarized in Tables 4 and 5 indicate that certain soil-row treatments have possibilities of improving the control of damping-off caused by this organism, it is apparent that this pathogen is much more difficult to control than the other three. It should be noted that the "survivors" in these experiments include "moderately" infected as well as healthy seedlings. Very few seedlings could be classified disease-free (healthy) in these trials. It is questionable as to how many of the moderately infected seedlings would survive under field conditions. It should also be noted in Table 4 that certain of these soil-row treatments may reduce total emergence. Note the effect of Phygon XL, in trial 1 and Phygon XL and Arasan SF in trial 2. Unlike the other causal agents of this disease *Aphanomyces* causes little pre-emergence damping-off. Only in trial number 3 (Table 5) did and soil-row treatment improve emergence over non-treated or treated seed.

Table 5.—Effects of Soil-row Treatments on Damping-off Caused by *Aphanomyces Cochlioides* (Trials 3 and 4).

Treatments[1]	Trial 3[2] Emergence	Trial 3[2] survivors on 12th day	Trial 3[2] Final survivors[5]	Trial 4[3,4] Emergence	Trial 4[3,4] survivors on 16th day	Trial 4[3,4] Final survivors[5]
	(seedlings per 100 seed units)					
No soil or seed treatment	134	77	7		....	—
Seed treated with Phygon	130	85	6	113	63	3
Arasan SF—2 lbs. per acre	149	116	26	116	103	18
Vancide 51—2 lbs. per acre		....	....	113	102	10
Vancide 51—4 lbs. per acre	....	....	....	107	97	11
Significant differences 19:1	13	13	5	NS	17	NS
Calculated F values	5.57[6]	21.30[6]	42.65[6]	0.58	10.24[6]	2.05

[1] All soil-row treatments were applied as sprays.
[2] Means of twelve, forty seed unit, replicates.
[3] Means of six, forty seed unit, replicates.
[4] All seed in this trial was treated with Phygon.
[5] The majority of the surviving seedlings were at least moderately infected.
[6] Exceeds the *1%* level of significance.

The fungus attacks largely after the seedlings emerge and causes severe post-emergence damping-off. It is also apparent that infection by this organism is more chronic than is the case with the other pathogens. These characteristics of delayed and prolonged attack partially explain why seed treatment has failed to give control and why any type of fungicidal control may be relatively more difficult. Despite the greater difficulty of control, however, Tables 4 and 5 indicate that soil-row treatments substantially reduce post-emergence damping-off. The difference between seedling emergence and those surviving from 12 to 19 days after planting show that considerably less post-emergence damping-off occurred when soil-row treatments were used.

Field Trials

Equipment for applying soil-row sprays in field trials has been built by R. A. Kepner[3], for small scale plots, and by Austin Armer (1) for large scale trials. A limited number of field trials have been conducted but additional trials are necessary under a wider range of conditions before conclusions can be drawn.

Summary and Conclusions

Greenhouse trials were conducted to determine the effectiveness of certain soil-row spray treatments in controlling damping-off caused by each of the soil-borne pathogens of this disease in California. On the basis of these experiments it is felt that;

1. Compounds such as Arasan SF and Vancide 51 when used as soil-row spray treatments are superior to the standard seed treatment now in use for controlling damping-off caused by any of the pathogens.
2. Of the four soil-borne organisms, *Pythium ultimum, Rhizoctonia solani, P. aphanidermatum* and *Aphanomyces cochlioides*, the latter appears to be the most difficult to control.
3. Spraying a fungicide in the row as the seed is planted appears to be a promising method of application.

Literature Cited

(1) ARMER, A. A.
1952. Soil-row treatment at planting time. Proceedings Am. Soc. Sug. Beet Tech. pp. 611-613.

(2) HILDEBRAND, A. A., W. E. MCKEEN and L. W. KOCH.
1949. Row treatment of soil with tetramethylthiuram disulphide for control of blackroot of sugar beet seedlings. I. Greenhouse tests. Can. Jour. Agr. Res. C, 27:23-43.

(3) ______.
1950. Continued greenhouse experiments in row treatment of soil for control of blackroot of sugar beet seedlings. Proc. Am. Soc. Sug. Beet Tech. 509-514.

(4) HILDEBRAND. A. A. and W. E. MCKEEN.
1950. Field results in 1949 following row treatment of soil with tetramethylthiuram disulphide for control of blackroot of sugar beet seedlings. Proc. Am. Soc. Sug. Beet Tech. 515-518.

[8] Assistant Professor of Agr. Eng., University of California, Davis.