Seed-Borne Phoma and Its Relation to the Origin of Sugar Beet Seed Lots

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Among seedling diseases of sugar beets the form caused by *Phoma Betae* (Ond.) Frank is unique in that the casual organism is seed-borne, whereas other types of seedling diseases are caused by soil-inhabiting fungi.

In Central California damping-o.ff caused by *Pythium ultimum* Trow is considered to be the most widespread and destructive seedling disease. The beet water mold seedling disease caused by *Aphanomyces cochlioides* Drechsler, however, is often more destructive in the mid-season or late-planted fields in peat or semi-peat soils of the Delta region. *Rhizoctonia solani* Kuhn causes a large part of the infection in some fields, especially following beans or potatoes. Late-planted fields with abundant moisture occasionally suffer severe infection from *Pythium ophanidermatum* (Eds.) Fitzp. All the four species mentioned in 1 his paragraph are soil-borne organisms.

Phoma infection of seedling beets in severe form has been observed by the writer only in connection with a few lots of seed, and therefore an attempt was made to determine the factors associated with these severe infections.

European sugar beet seed is known to carry *Phoma betac* on many seed lots. In 1934 Schmidt *(9)*[2] reported that this fungus was regularly present on ordinary commercial seed to the extent of 40 to 100 percent, its prevalence being directly proportionate to the humidity of the climate in the area of seed production. Edson *(2)* found *Phoma* to be present on all the imported seed lots he examined.

Infection on domestic seed was also reported by Edson (3) and *by* Pool and McKay *(6)*, who observed heavy infection of seed crops growing in Idaho and Colorado in 1912 and 1913 and of beet seed balls produced in these fields. Coons *(1)* reported *Phoma* infection on seed grown in isolation plots in Michigan.

Early increases of domestic seed in southwestern United States, however/appeared to be free from infection. In 1940 the writer (3) reported that among 19 lots of domestic seed grown in Southern California and Arizona which were examined by microscopic observation of incubated seeds, none showed *Phoma* infection. At the same

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[2]Italic numbers in parenthesis refer to literature cited.

time 52 lots of European seed were examined in a similar manner. More than half the lots showed some *Phoma*, infection and eight showed more than 10 percent of the seed balls infected.

During the following year, however, *Phoma* infected seedlings were found in greenhouse plantings of domestic seed in sterile soil. In 1042 specimens of sugar beet seed stalks infected by *Phoma* blight and bearing infected flowers and seed balls were received from Oregon and Northern California. Similar specimens were identified by Dr. F. P. McWhorter of the Oregon Agricultural Experiment Station.

Determination of Seed Infection

To test the incidence of *Phoma* infection on seed used for planting in California, a large number of samples were obtained from the sugar companies and from seed-producing companies. A limited number of samples were also furnished by companies operating in other areas. Seed from each lot was planted in pasteurized soil in the greenhouse and seedlings were examined for damping-off or root infection. Isolations from infected seedlings served to identify the causal organism.

Among 125 seed lots examined, 24 lots were found heavily infected, while the remainder showed light to moderate infection or appeared to be disease free *(4).* Results with 91 lots identified as to origin are shown in table 1.

Severity of infection was apparently related to the summer rainfall or moisture in the seed-producing areas, being heavy on several seed lots from the Willamette Valley of Oregon where overhead

Table 1.—Relation of origin of seed to Phoma infection on seedlings in pasteurized soil

Seed produced	Precipitation June-Sept. (Inches)*	Temperature July mean F° *	No. of seed lots showing Phoma infection: Percent of seedlings infected				
			none	0.1-5%	5-20%	20-50%	over 50%
California							
Hemet Valley	0.53	77.6	5	14	2	0	0
Shasta Valley	1.83	72.7	1	2	5	0	1
Oregon							
Medford	2.03	72.0	2	8	12	3	4
Klamath Falls	1.71	68.2	0	3	0	0	0
Willamette Valley	3.48	65.0	0	1	1	1	16
Utah							
St. George	2.60	82.0	1	0	3	2	1
Ogden	3.55	74.7	0	1	1	1	0

*Data from Climate and Man. U. S. Dept. Agr. Yearbook, 1941.

irrigation of sugar beet seed crops was practiced; light to moderate on seed from Medford, Ore.; Shasta Valley, Calif.; and St. George. Utah; and extremely light on seed from Hemet Valley, Calif. Heavily infected lots were also identified from Colorado and Michigan but not enough samples were tested from these or other areas to justify any generalizations.

The practice of harvesting two successive seed crops from the same roots often resulted in several times as much *Phoma* infection on the second, called the "carry-over" crop, as on the first crop. In fact all the heavily infected lots from the Medford, Ore., area were from ''carry-over'' crops.

Stock seeds used for plantings in Oregon and California from 1940 to 1942 appeared to be disease free or only lightly infected. The seed, therefore, can not be considered the primary source of inoculum for the heavily infected seed crops produced during that period. In 1943, however, four heavily infected lots of stock seed were planted in Hemet Valley. Observations by Dr. John T. Middleton showed no evidence of leaf spot or stalk blight on the seed crops produced in 1944 from these lots. Comparative tests of the stock seed and the commercial crops produced from them are shown in table 2. Blended

Table 2. Comparison of seed-borne Phoma on stock seed planted and on seed produced in Hemet Valley, Calif., 1943-4.

		Seed planted		Seed produced Hemet Valley, Calif.	
Variety	Stock seed produced	Lot No.	Phoma inf. (Percent)	Lot No.	Phoma inf. (Percent)
U. S. 215 x 216	Willamette Valley, Oregon	2380	46.3	404	0.0
U. S. 215 x 216	Willamette Valley, Oregon	2391	70.2	416	0.8
Imperial 40	Willamette Valley, Oregon	2323	58.8	406	1.8
Imperial 40	Willamette Valley, Oregon	2337	67.1	444	0.0
U. S. 22	Avon, Utah	4202	2.1	323	0.3
U. S. 33	Gazelle, Calif.	4203	0.0	331	0.3

seed from lots 2380 and 2391, both heavily infected, were planted to produce lots 404 and 416 which showed practically no infection. In the same way a blend of lots 2323 and 2337, both heavily infected, produced lots 406 and 444 with little or no infection. In the previous year seed lot 4202 (U. S. 22) with 2 percent *Phoma* infected seedlings and lot 4203 (U. S. 33) with no apparent infection produced seed lots showing less than 1 percent infected seedlings. Such low percentages of infection may have resulted from contamination after harvest and do not necessarily indicate field infection. It is evident that the combination of seed treatment (New Improved Ceresan) and environmental conditions unfavorable for the fungus practically eliminated the possibility of transmission of *Phoma betae* on seed produced in the Hemet Valley.

Circumstantial evidence indicated that in areas favorable for infection much of the inoculum originated in adjacent seed fields maturing at the same time the next year's crop was being planted or from remnants of a previous crop on the same field. Survival of the fungus on fragments of seed stalks for more than a year after harvest was demonstrated in one field in the Shasta Valley.

During 1944 when most of the seed crops in the Willamette Valley were produced in new areas and without overhead irrigation, the amount of infection on the seed was much less than in the previous 3 years.

Some lots of seed were found to carry *Phoma* in a viable form 5 1/2 years after harvest. Successive trials showed, however, that in most seed lots the amount of infection dropped sharply within 2 or 3 years.

Seed Disinfection and Seedling Protection

Several methods of eliminating *Phonm betac* from beet seed balls have been proposed. Edson (2) found that Peter's method of heating the seed in water at 60° C. for 10 minutes on 2 successive days was very effective but did not consider this method practical for field use. Miss Rumbold (8) described the disinfection of beet seed with formaldehyde vapor and steam. This method was used to a limited extent between 1019 and 192:5. In 1944 McWhorter and Miller *(5)* advocated vapor heat as a practical means of disinfecting seeds.

To determine the disinfecting power of several of the newer chemicals, beet seed carrying heavy *Phoma* infection was soaked in solutions or suspensions of the chemicals listed in table 3 for either

Table 3.—Liquid disinfectants for control of seed-borne Phoma.

Material	Dilution	Time (Minutes)	Emergence per 100 s.b.*	Infection (Percent)
Nontreated	.....	..	121	81.4
New Improved Ceresan	1-1200	5	147	2.8
New Improved Ceresan	1-1200	20	147	1.8
New Improved Ceresan				
+ 1% wetting agent	1-1200	5	162	2.0
+ 1% wetting agent	1-1200	20	151	0.4
Lignasan	1-1500	5	148	2.8
Lignasan	1-1500	20	161	0.4
Wettable Phygon	1-800	20	152	16.7
Wettable Phygon	1-200	60	142	21.1
HE-175	1-200	20	171	8.6
Nontreated	......	.	103	83.1

*Seedlings per 100 seed ball.

5 or 20 minutes and were then dried and planted in pasteurized soil. The results in table 3 show that ethyl mercury phosphate obtained from New Improved Ceresan or from Lignasan was highly effective in

eliminating *Phoma* from beet seeds. Subsequent tests showed that a 20-minute dip in a 1-1500 solution of Lignasan, equivalent to 40 p.p.m. of ethyl mercury phosphate, completely eliminated *Phoma* infection from 28 of the 32 seed lots tested. This treatment also provided protection against soil-borne damping-off fungi. Wettable Phygon (dichloro-naphthaquinone) and He-175 (disodium ethylene bisdithiocarbamatc) appeared to be less effective than the organic mercury compounds.

All wet treatments have the disadvantage of requiring drying of the seed and therefore have limited application unless special equipment is used. Several dust fungicides are effective against *Phoma betae* either because they destroy the fungus on or in the seed ball or because they retard growth of the fungus enough to prevent seedling infection.

Comparisons between several dust fungicides are shown in tables 4 and 5. Ceresan and New Improved Ceresan appeared to be the most effective, with Phygon and Arasan also giving a high degree of control in most cases. Spergon, Fermate, and Yellow Cuprocide provided only partial control.

Table -1.—Dust fungicides for control of seed-borne Phoma.

		Seed lot A		Seed lot B	
Material	Dosage (Percent)	Emergence*	Infected seedlings (Percent)	Emergence*	Infected seedlings (Percent)
Nontreated	....	129	70.2	173	45.4
Spergon	1.00	154	61.5	.....	.....
Fermate	1.00	143	23.6	.....	.....
Arasan	1.00	169	10.1	.....	.....
Yellow Cuprocide	1.50	.....	.....	163	22.7
Ceresan	1.00	153	0.0	204	0.6
New Improved Ceresan	0.375	.....	.....	201	0.7
Significant difference 19:1 odds		25.0	.....	12.3	.....

*Seedlings per 100 seed balls.

Effect of Seed-Borne *Phoma* on Latoratory Germination

With lightly infected seed lots, *Phoma hetae* does not reduce the emergence of seedlings in soil or the germination of seed in laboratory tests. Certain heavily infected seed lots, however, show severe pre-emergence damping-off, especially at low temperatures. Porter and Rice (7) found that in three beet seed samples from Sweden, *Phoma betae* prevented the germination of many untreated seeds in blotters and the emergence of many seedlings in both sand and soil.

Table 5.—Dust fungicides for control of seed-borne Phoma.

Material	Dosage (Percent)	Seed lot A Emergence*	Seed lot A Infected seedlings (Percent)	Seed lot C Emergence*	Seed lot C Infected seedlings (Percent)	Seed lot D Emergence*	Seed lot D Infected seedlings (Percent)
Non-treated	none	215	82.9	185	50.7	162	19.0
Arasan	0.25	157	19.6	211	5.7	178	0.0
Arasan	0.50	164	4.7	221	3.9	188	1.4
Arasan	1.00	175	12.7	203	4.7	179	0.0
Ceresan	1.00	177	3.7	217	1.7	177	0.0
Phygon	1.00	.....	.....	198	2.6	182	1.4
Significant difference 19:1 odds		26.6	.....	22.6	.....	n.s.	.....

*Seedlings per 100 seed balls.

The results of our germination tests with a heavily infected seed lot on blotters, in sand, and in soil are shown in table 6 in comparison with the same seed disinfected by immersion in an ethyl mercury phosphate solution. The greatest depression of germination occurred in sand and in soil at low temperature.

Table 6.—Effect of seed disinfection upon germination of Phoma-infected seed on blotters, in sand, and in soil.

	Laboratory germination* Blotter Percent	Laboratory germination* Blotter Seedl./100†	Laboratory germination* Sand Percent	Laboratory germination* Sand Seedl./100†	Soil germination 50° F. Seedl./100†	Soil germination 80° F. Seedl./100†
Non-treated	71.5	120	67.5	100	100	122
Treated	77.0	130	75.5	128	138	142

*A11 laboratory germination tests wore conducted by the California Seed Laboratory.
†Seedlings per 100 seed balls.

A comparison of the laboratory germination on blotters and in sand of three infected seed lots, both treated and non-treated, is presented in table 7. The emergence of each lot in an irrigated field planting is also shown.

These results suggest that to obtain a true measure of the potential germination of some *Phoma* infected seed lots it may be necessary to disinfect the seed balls for either laboratory or soil germination tests.

Summary

Seed-borne infection of *Phoma betae* has been found to occur on a number of sugar beet seed lots, especially those produced in

Table 7.—Laboratory germination and field emergence of treated and non-treated Phoma-infected lots of sugar beet seed.

		Laboratory germination*				
		Blotter		Sand		Field emergence
Seed lot	Treatment	Percent	Seedl./100†	Percent	Seedl./100†	Seedl./100†
A	Non-treated	78.75	128	66.50	105	82
A	Treated	84.50	132	79.00	128	112
B	Non-treated	87.75	163	82.00	154	123
B	Treated	94.00	194	92.50	185	164
C	Non-treated	77.75	149	72.00	148	80
C	Treated	85.25	167	81.00	164	142

*A11 laboratory germination tests were conducted by the California Seed Laboratory.

†Seedlings per 100 seed balls.

regions with showers or high humidity during the period of seed maturity and harvest.

Examination of 125 seed lots by germination in greenhouse flats containing pasteurized soil showed that infection was heavy on several lots from Willamette Valley, Ore., where overhead irrigation of sugar beet seed crops was practiced; light to moderate on seed from Medford, Ore., Shasta Valley, Calif., and St. George, Utah; and extremely light on seed from Hemet Valley, Calif.

Disinfection of sugar beet seed by immersion in a solution of ethyl mercury phosphate was highly effective for elimination of *Phoma* infection.

As dust fungicides, Ceresan and New Improved Ceresan appeared to be the most effective, although Phygon and Arasan also afforded good control.

Disinfection of some *Phoma-mfected* seed lots increased their germination on blotters and their emergence in sand and in soil.

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