Survival of Phoma betae in Soil

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ABSTRACT

In field plots, the highest numbers of propagules of *Phoma betae* were found in April of the first year following sugar beet culture. Soils were sampled from naturally infested plots of six crop rotations used in this region. The fungus was recovered as long as 26 mo after sugar beets had been planted, but not in the third year following sugar beets.

Phoma betae invaded the roots of lambsquarters (*Chenopodium album*) growing in cultivated fields and sugar beet storage yards. The fungus rarely invaded the roots of oats. The fungus was present in soil from sugar beet storage yards throughout the Red River Valley of North Dakota and Minnesota. Populations decreased during the summer, but the fungus was still present when roots from the new crop were being stored.

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Additional key words: Beta vulgaris, Pleospora bjoerlingii, sugar beet storage rot, weed hosts.

In 1915, Pool and McKay (6) determined that *Phoma betae* Frank survived in sugar beet leaves for 5-8 mo when the leaves were buried in soil. Since then, little information has been added to our knowledge of factors affecting the survival of *Phoma betae.* This fungus is an important pathogen of sugar beets throughout the world. These investigations were initiated to determine: (i) the population of *P. betae* in soil during the growing season at selected sites in the Red River Valley of Minnesota and North Dakota; (ii) what effect crop rotations used in the valley have on the survival of *P. betae*; and (iii) if weed and crop hosts affect the survival of this pathogen.

MATERIALS AND METHODS.—Populations of *P. betae* were estimated by counting colonies on soil-dilution plates. Soil samples were collected from the top 10 cm, air-dried, then screened through a 2-mm soil sieve. Ten-gram soil samples were shaken in 100 ml of sterile distilled water for 15 min. One-milliliter samples were taken from soil suspensions agitated by a magnetic stirrer and dispensed to each of 10 sterile petri plates. Ten- to 15-ml portions of a molten (50 C) selective agar medium were poured into the plates. Colonies were counted after incubation at 22 C for 2 wk.

The selective medium consisted of: 4 g K_2HPO_4; 1.5 g KH_2PO_4; 25 ml soil extract; 2 mg boric acid; 100 mg each of streptomycin sulfate, chlorotetracycline, and benomyl; 10 g sucrose; 17 g agar; and 1,000 ml distilled water. It was adjusted to pH 7.0 with HCl before autoclaving. Sucrose and the antibiotics were added to the molten agar (50 C) after autoclaving (1). The undersides of the culture dishes were examined for *P. betae* colonies, because it has been shown that this fungus produces unique hyphal masses upon contact with the glass (4). These hyphal masses turn dark brown to black in the selective medium, and can be observed with the naked eye (1). Hyphal masses have been isolated, cultured, and identified as *P. betae.* Pathogenicity has been determined on sugar beet roots in storage (1).

Wheat, barley, oats, and rye were planted in a plot that had been in continuous sugar beets for the previous 5 yr at the North Dakota Agricultural Experiment Station, Fargo. After harvest, 25 randomly selected plants of each crop were lifted from the soil. The roots were washed, cut into pieces 1-2 cm long, and bulked. The root pieces were treated with 2% sodium hypochlorite for 2 min, followed by two rinses in sterile distilled water. Ten root pieces were plated on each of five plates. A similar procedure was followed for weed root systems that were collected from storage sites and sugar beet plot areas.

Soil samples were taken in July from rotation plots located at the University of Minnesota Agricultural Experiment Station at Crookston. This was the seventh year, in the second cycle of a 4-yr rotation. There were six rotations, each consisting of four crops grown sequentially for one yr in the following sequences: (i) sugar beet, wheat, barley, black fallow; (ii) sugar beet, wheat, barley, sweetclover fallow; (iii) sugar beet, wheat, barley, alfalfa fallow; (iv) sugar beet, potato, wheat, barley; (v) sugar beet, wheat, barley, soybean; and (vi) sugar beet, wheat, barley, oats. The sweetclover and alfalfa crops were plowed down about mid-July. The plots were 10.1 m wide by 13.7 m long, replicated three times. Soil was collected from four to eight locations in each plot and bulked. Total wt of the sample from each replicate ranged 0.9 to 1.4 kg.

RESULTS.—*Population of P. betae in soil from rotation and continuous sugar beet plots.*—Soil samples from the Fargo plot that had been continuously cropped to sugar beets for 5 yr contained a population in April, May, June, July, and August of 380, 62, 64, 5, and 1 propagules/g soil, respectively.

In rotation plots, *Phoma betae* was present in soil planted to wheat or barley 1-2 yr after sugar beets. The population ranged from 2-20 propagules/g soil. The fungus was present in soil planted to potato 1 yr after sugar beets. It was never found the third yr after sugar beets. *Phoma* was not found in any of the soils of rotation number five, which included soybeans. The highest populations (19-20 propagules/g) of *P. betae* were found the first yr after sugar beets, in soil planted to wheat. Rotation number three was the only one in which *P. betae* was present in soil the same yr in which sugar beets were planted.

The presence of *P. betae* in soil sampled in July of the

TABLE 1. Populations of *Phoma betae* in soil at seven sugar beet storage locations in June and September, and the prevalence of *P. betae* infected roots of lambsquarters growing at these sites in September

Site	Soil infestation (Propagules/g soil)		Assay of lambsquarters roots[a]	
	June	September	No. plated	No. infected
Minnesota				
Moorhead	512	13	50	0
East Grand Forks	171	4	20	0
Crookston	148	2	20	0
Comstock	---	16	50	8
Hendrum	288	4	50	5
Warren	---	0	20	0
North Dakota				
Cummings	88	1	20	0

[a]Lambsquarters plants were collected at random. The roots were cut into pieces 1-2 cm long, bulked, and randomly selected for plating.

second yr after sugar beets showed that this fungus survived 26 mo after the sugar beets were planted.

Prevalence of P. betae in roots of crop and weed hosts.—The number of root pieces of wheat, barley, oats, and rye plated out were 405, 336, 355, and 322, respectively. *P. betae* was recovered from only one root-piece of oats. Sweetclover and potato debris were collected from the rotation plots after harvest and plated out. *Phoma betae* was not recovered from this material, even though the fungus was present in the soil of the potato plot.

The following weeds were collected from five storage sites in June 1973: *Setaria lutescens* (Weigel) F. T. Hubb. (yellow foxtail); *Polygonum aviculare* L. (knotweed); *Chenopodium album* L. (lambsquarters); *Kochia scoparia* (L.) Roth (kochia); *Agropyron repens* (L.) Beauv. (quackgrass); *Thlaspi arvense* L. (pennycress); *Brassica kaber* (DC.) L.C. Wheeler (wild mustard); *Ambrosia artemisiifolia* L. (common ragweed); *Setaria viridis* (L.) Beauv. (green foxtail); *Sonchus arvensis* L. (perennial sowthistle); *Amaranthus retroflexus* L. (redroot pigweed); *Polygonum convolvulus* L. (wild buckwheat); and *Trifolium repens* L. (white clover). *Phoma betae* was present only in the roots of lambsquarters (*C. album*). The prevalence ranged from seven of 15 plants infected from the Cummings, North Dakota site to all of the nine plants infected from the East Grand Forks, Minnesota site. Another collection of lambsquarters was made in September and the root pieces from all plants from a particular site were bulked. Only lambsquarters plants collected at the Comstock and Hendrum, Minnesota sites had roots infected with *P. betae* (Table 1).

A collection of lambsquarters also was made in May from the Fargo plot that had been in sugar beets for 5 yr. Of 38 plants collected, 20 were infected.

Twenty lambsquarters plants were randomly collected from a weed-control plot at Casselton, North Dakota. Three of these were infected with *P. betae,* but the fungus was not found in soil samples taken from the same location.

Populations of P. betae at storage sites.—The storage-pile site at Moorhead, Minnesota was sampled in May, June, and September. Samples contained a population of *P. betae* of 185, 570, and 13 propagules/g soil, respectively. Additional storage sites in the Red River Valley were sampled in June and September. The population of *P. betae* ranged from 88 to 512 propagules/g soil in June, compared to 0 to 13 propagules/g soil in September. *Phoma betae* was absent in one of the seven sites sampled in September (Table 1).

DISCUSSION.—Analysis of soils from rotation plots indicated that *P. betae* would survive in soil up to 26 mo after sugar beets have been planted. These rotations included crops and fallow practices commonly used in the Red River Valley. High populations of *P. betae* were found occasionally in soil the year after sugar beets and early in the summer in storage yards. This probably was due to the buildup of the fungus on sugar beet debris.

Sugar beet storage yards contained many roots embedded in the soil after the piles were removed and processed. These roots provided ideal organic material for the survival of *P. betae*, accounting for the very high concn of *P. betae* in early summer before the roots were decomposed. *Phoma* was still viable in the soil in September, when storage of the new crop began. It is not known how much this source of inoculum contributed towards storage rot.

Lambsquarters is a very common weed in sugar beet fields and in storage yards. The ability of *P. betae* to inhabit the roots of this weed might enable the fungus to survive a 4-year rotation. Therefore, every effort should be made to remove this weed especially if the field will be planted to sugar beets again. This weed should not be important in storage yards, where sugar beet debris is plentiful, and sites of storage are not rotated.

Wheat, barley, rye, potato, and sweetclover were not hosts of *P. betae*. The fungus was able to inhabit the roots of oats. The frequency of invasion was so low that it might be considered insignificant.

Phoma betae is seedborne and will survive in sugar beet plants that do not damp-off. This is a source of inoculum for storage rot (2). *Phoma* can be eradicated from seed by a hot water (3) or 0.2% thiram steep (5) but these methods

are not used commercially on sugar beet seed in the USA. Until adequate commercial methods are adopted and practiced, 4-yr rotations and control of lambsquarters will be of great importance. The need for control measures in storage yard soil, where *P. betae* survives continuously, must await information from studies of this soil as a source of inoculum for sugar beet storage rot.

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