Storage Rot Research

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Much sucrose is lost each year to storage rot fungi and bacteria. In the Red River Valley of North Dakota and Minnesota, the loss of sucrose to storage rots is greater than to any other disease. The fungus responsible for this loss is Phoma betae.

DISEASE CYCLE

Phoma betae is a seed-borne fungus and is a constant problem as a cause of seedling diseases if the seed was produced in a humid environment. Many seedlings that are infected with Phoma survive the seedling disease phase and go on to produce a normal, healthy looking root. But the fungus is still in the beet tissue and becomes active causing decay after the roots are harvested and stored. The fungus can survive on organic matter in the soil. This is the source of inoculum for infection of the seed crop.

PREVALENCE

The prevalence of Phoma in certain seed stocks was measured by plating 50 seeds from each entry on water agar. All but one lot of this seed had been stored for two years so the prevalence in this seed when fresh could have been higher. The list in Table 1 shows that the percent of infected seeds ranged from 0 to 24%.

Table 1. Percent of seeds infected with Phoma betae

Entry	% infected
American Crystal	
2B (1972 seed)	6
2B	8
2B (Salem)	6
3N	2
3T	24
Betaseed	
B-93	8
B-951	18
Holly	
9320-06	0
HH-10	2
Bushmono	2

The prevalence of Phoma in storage piles is greater than in seed lots. On February 4, 1972, 107 beets were randomly selected from five storage sites. The list in Table 2 shows that 51% of these roots had signs of Phoma storage rot. Doubtful cases were plated-out to verify infection by Phoma.

Table 2. The prevalence of Phoma betae in sugarbeets randomly selected from commercial piles in 1972

Storage site	Number collected	Number infected
Drayton, N. D.	35	16
East Grand Forks, Minn.	17	13
Crookston, Minn.	21	10
Hendrum, Minn.	15	3
Moorhead, Minn.	19	13
TOTAL	107	55

Infection probably spreads in the field via the leaf spot phase and fungus laden soil during the harvest. Infection in the pile could spread by contact.

PATHOGENISIS

Most fungi have elaborate enzyme systems that aid in degrading host tissue. Phoma produces two cell wall degrading enzymes in beet tissue: exopolygalacturonase (exoPG) and endopolygalacturonate transeliminase (endo PGTE). In culture, cell wall material from the susceptible cultivar A58 (fodder) induced more endoPGTE formation than the resistant 2B. But 2B induced more exoPG than A58. The data indicated that endoPGTE is important as the initial enzyme because it was found in tissue in advance of the rotted area.

The sucrose content and properties of cell walls also can affect pathogenisis. Recent research has shown that roots become more resistant to Phoma with an increase in age and sucrose content prior to harvest. After harvest, individual roots that expressed a resistant reaction to Phoma usually had a higher sucrose content. But when cell walls were used as the only carbon source in culture, Phoma produced more endoPGTE on walls from A58 (susceptible) than 3N or 2B (less susceptible). Thin slices from resistant roots also were resistant to maceration by culture filtrates of the fungus. This indicates that cell walls as well as sucrose content affects the development of decay.

CONTROL MEASURES

Chemical. The most vulnerable point in the disease cycle to control Phoma with chemicals is the seed. However, Phoma is resistant to most of the fungicidal seed treatments except the mercuries. The difficulty in eradicating Phoma from infected soil is illustrated by the method found most successful: soaking seeds in ethyl mercury phosphate. Most mercuries have lost their registration and cannot be used in this country.

Fungicidal treatment of harvested roots to control phoma storage rot appears very difficult with our present chemicals. Since Phoma is already within beet tissue at harvest, any fungicides that might be applied would have to possess systemic or tissue penetrating qualities. The systemic fungicides that are now available will move only upward within treated plants. This feature eliminates the possibility of spraying foliage prior to harvest. However, there is a possibility that fungicides could be applied to the freshly topped beet at harvest. Preliminary experiments I have conducted in the laboratory with one systemic showed little promise. This work will be continued under field situations.

Biological. A better understanding of factors controlling the survival of Phoma in its soil environment may guide us in control measures. Previous workers have shown that Phoma utilizes organic material in the soil but does not survive after the organic material has been degraded. In the Red River Valley, Phoma can overwinter quite well on sugarbeet debris. Abundant inoculum has been observed in sugarbeet tissue that was infected the previous year and left in the field. Phoma also was able to invade the roots of soybean, barley, alfalfa, and oats but to date this has been shown only in the greenhouse in sterile soil. Further tests are planned to determine if Phoma can invade and survive in "non-host" crops under field conditions.

A better method to assay soil for Phoma is needed. At present we can "seed" water agar plates with soil particles and identify Phoma from the unique structures this fungus forms on a glass surface. This is a time consuming method because of the need for microscopic observation. We are currently developing a selective culture medium that hopefully will allow us to detect the presence of Phoma in soil samples. We can then accurately assess the effect of crop rotations, soil management, etc. on the survival of Phoma.

Resistance. As with other host-pathogen combinations, resistance should give us our best opportunity to reduce sucrose loss to Phoma storage rot. In our continuing program to locate roots that are resistant to Phoma storage rot, over 3,700 roots were inoculated after harvest this year. Betaseed, Inc. contributed 1,495 roots from 18 of their breeding lines. Four of these lines looked promising because about one-third of the roots appeared resistant. A total of 232 roots were saved from this group. American Crystal was able to contribute 177 roots or a pollinator they use in producing their new high sugar variety. Four of these roots appeared resistant. In addition, over 2,000 roots from 20 entries in a "variety test" are being evaluated for resistance. Resistant selections have been planted in the greenhouse for seed production, further progeny

testing to confirm the resistance, and additional selection to improve the quality of resistance.

EFFECT OF NITROGEN FERTILITY ON STORAGE DECAY[1/]

It is established that excess nitrogen fertility can increase impurity levels, lower the sucrose content and impair sucrose extraction from the juice. It is also known that impurities increase during storage and that susceptibility to decay increases with storage. The objectives of this study are to: 1) measure the reaction to Phoma of roots grown under different nitrogen levels; 2) determine the impurity levels in beets grown at different nitrogen fertility levels before and after storage and 3) determine if there is a correlation between the impurity level and amount of decay caused by Phoma. Roots of American 2B were randomly collected from three nitrogen fertility demonstration plots and divided into two groups. Nitrogen was applied at 0, 50, 100, and 150 lbs/A regardless of the soil test. The first group of roots was inoculated within 3 weeks of harvest. There were no differences in decay among the nitrogen treatments. The second group of roots was inoculated after 80 days storage. The roots from farm A increased in susceptibility to Phoma during storage but there was no apparent influence of the nitrogen level (Table 3A). Farm B (Table 3B) had the highest nitrogen level and there was no significant increase in susceptibility during storage. Farm C (Table 3C) had the lowest soil test for nitrogen. But the greatest differences in storage rot occurred in this case. There was a significant increase in susceptibility to Phoma during storage at all but the highest nitrogen level. Roots that were grown under nitrogen deficiency were more susceptible before storage than those grown under the highest nitrogen level. The roots grown in the highest nitrogen level were still more resistant after storage than those grown under lower nitrogen levels. The susceptibility of roots when grown in soil with 12 to 62 lbs N/A probably can be attributed to the effects of deficiency but this cannot explain the resistant reaction of roots grown at 212 lbs N/A compared to the susceptible reaction of those grown at 112 lbs N/A. These results agree with previous work which indicated roots are susceptible to decay when grown under inadequate nitrogen supply.

An attempt was made to correlate the disease rating with sodium, potassium, or amino nitrogen content. The components plus the sucrose contents were measured in 240 roots from farm C. There was no apparent association of disease rating and N, Na, K, or sucrose content. However, those roots that were grown at the three lowest nitrogen levels and also were most susceptible, had an average impurity index of 400 and below. If further tests support an association between low impurities and susceptibility to Phoma storage rot, this feature may provide a basis in deciding which roots should be processed first.

The tissue most susceptible to Phoma is the mass of parenchyma cells located in the crown. Decay begins here first, especially if the tissue has not been removed by topping. This tissue is low in sucrose and very

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[1/] In cooperation with Mr. Ron Torkelson, Sugarbeet Extension Specialist, North Dakota State University.

Table 3A. Phoma storage rot rating and quality before and after storage of roots grown under different nitrogen levels.

Farm A							
N/A lbs	Days stored	Disease rating	Sucrose %	N ppm	K ppm	Na ppm	Impurity Index units
63[a]	0	2.1[b]	15.5	252	2999	202	693
	80	2.5	16.8	348	3058	136	693
113	0	1.7	14.9	262	3210	300	788
	80	2.4	14.3	390	3385	244	950
163	0	2.1	15.0	252	3230	356	789
	80	2.6	14.1	405	3500	275	980
263	0	2.0	14.4	305	3480	319	895
	80	2.5	14.5	462	3712	339	1039
LSD .05		0.4	1.5	63	474	126	160

[a] Pounds of nitrate-nitrogen in top 2 feet of soil before application of fertilizer: Farm A, 63 lbs; Farm B, 126 lbs; Farm C, 12 lbs.

[b] Disease rating based on approximate diameter of rotted area: 1 = 3-5 mm; 2 = 5-10 mm; 3 = 10-15 mm; 4 = 15-20 mm; 5 = 20-25 mm, 6 = 25-30 mm.

Table 3B. Phoma storage rot rating and quality before and after storage of roots grown under different nitrogen levels.

Farm B							
N/A lbs	Days stored	Disease rating	Sucrose %	N ppm	K ppm	Na ppm	Impurity Index units
126	0	2.3	15.0	160	2537	204	578
	80	2.0	13.7	298	2365	165	736
176	0	2.1	15.7	200	2672	254	604
	80	2.4	13.8	328	2962	317	862
226	0	2.3	14.3	175	2634	356	672
	80	1.8	13.9	355	2634	254	798
326	0	2.2	12.5	255	2845	540	926
	80	2.0	10.7	420	3346	785	1674
LSD .05		NS	1.9	35	NS	236	451

Table 3C. Phoma storage rot rating and quality before and after storage of roots grown under different nitrogen levels.

Farm C							
N/A lbs	Days stored	Disease rating	Sucrose %	N ppm	K ppm	Na ppm	Impurity Index units
12	0	2.3	17.2	132	2076	44	387
	80	3.1	17.9	162	1535	66	372
62	0	2.0	17.1	122	2307	94	428
	80	3.1	18.0	139	1961	77	372
112	0	2.0	17.1	188	1961	134	424
	80	2.8	17.0	169	1865	114	406
212	0	1.7	15.5	178	2461	258	570
	80	1.6	15.9	193	1922	229	518
LSD .05		0.6	1.2	NS	NS	184	142

high in impurities, a situation opposite that described in the above nitrogen fertility tests. Research using these tissues, fertility levels, and storage periods should give us a better understanding of the host's mechanisms of defense against Phoma.