UNKNOWN STERILE FUNGI USED AS BIOLOGICAL CONTROL AGENTS FOR MANAGING MULTIPLE ROOT PATHOGENS OF SUGAR BEETS UNDER FIELD CONDITIONS

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Abstract:

Several common root diseases routinely damage sugar beets in Nebraska and other areas of the Central High Plains, and it is becoming more common to find fields infested simultaneously with multiple pathogens. Root diseases induced by these pathogens often cause more devastating losses than with foliar diseases because they are difficult to detect before serious damage occurs. Due to the lack of available chemicals for economic control of soilborne diseases, other alternative techniques, such as biological control are increasingly being sought for disease management. Over the last several years, unidentified, sterile fungi have been isolated in conjunction with infected sugar beet roots and seedlings. Several promising candidates have been identified from in vitro assays that inhibit numerous sugar beet root pathogens, including *Rhizoctonia solani*, *Aphanomyces cochlioides*, *Phoma betae*, and *Pythium* and *Fusarium* spp. Those selected isolates were tested as biological control seed treatments in a field naturally infested with multiple root diseases. Results obtained from 2006 are very promising and suggest that these fungi are providing some level of protection for the entire season against a complex of soilborne diseases. For example, plots planted with a root rot susceptible cultivar treated with the "Hall" isolate resulted in sucrose yields almost 1800 lb/a higher than untreated plots of the same cultivar, which was compatible with other cultivars possessing various combinations of disease tolerances grown under the same conditions.

Introduction:

Root diseases are major factors limiting profitable sugar beet production in western Nebraska. It is becoming more common to find several of these pathogens occurring simultaneously as a root disease complex (2,3). These types of diseases are more difficult to manage than many foliar diseases since they are difficult to detect before substantial damage has already occurred.

The lack of fungicide options for many members of the root disease complex makes economic control of soilborne diseases a challenging task. Thus, other techniques for disease management are being investigated, including seed treatments with several distinct fungicides, using resistant cultivars, and cultural practices like early planting and irrigation management. An additional non-chemical method that is showing some promise for future implementation is pathogen management through the use of antagonistic mycoparasites.

A group of as yet, unidentified, sterile fungi (presumed basidiomycetes) have been found occurring naturally in Nebraska soils associated with sugar beet root infections. These fungi have shown an ability to inhibit other fungal pathogens from multiple classes (oomycetes, basidiomycetes, deuteromycetes) from in-vitro lab assays. The most promising of these organisms were compared in field studies in 2006 and 2008 with the established biological control fungus, *Laetisaria arvalis*, which also is originally native to western Nebraska (1,4). During 2006, these same biological treatments were additionally compared with other sugar beet cultivars with varying disease packages.

Materials and Methods:

Field studies were conducted in 2006 and 2008 in a field naturally infested with multiple root diseases, including rhizomania, Rhizoctonia, Aphanomyces, and Pythium root rots, Fusarium yellows and root rot, and Phoma root rot. Studies in both years were planted mid-May with plots consisting of 2 rows, 55 cm in width and 12 m long. Plots were irrigated with sprinkler irrigation (3.5-4.0 cm/wk), and combined with rainfall exceeding 20 cm, resulted in approximately 50 cm moisture for both seasons.

During 2006, three fungal isolates were utilized as seed treatments on the rhizomania-tolerant but root rot susceptible cultivar BetaSeed 8400, including *L. arvalis*, “Hall” isolate, and “R47” isolate. In 2006, we also utilized several different cultivars varying in disease tolerance packages randomized with the biological control treatments as a comparison. During 2008, the same three biological control isolates (treatments) were used singly, and in combination, but no other cultivars were included other than BetaSeed 8400 as an untreated control.

One row of each plot was harvested by hand Oct 10-18, and roots were assigned a root disease rating (0-4) based on size and degree of root rot severity. Standard yield parameters were additionally collected, including root and sugar yields and sugar loss to molasses (SLM). The yield parameters were determined at the Western Sugar Cooperative Factory, Scottsbluff, NE.

Results:

During 2006, the inclusion of the sterile fungi resulted in reduced disease severity levels and improved sucrose yields (almost 2000 kg/ha), however these relationships were not statistically significant. From a positive standpoint, the improved yield parameters were statistically equal to the performance of several cultivars with multiple disease packages such as Beta 7310, HM 7172 and HM 7235 (Table 1).

During 2008, the same treatments resulted in statistically significant sucrose increases compared to the same cultivar (BetaSeed 8400) without treatment. Yield improvements during this season were closer to 3000 kg/ha (Table 2). Similar improvements were observed in root yields, root disease counts during the season, and disease severity ratings at harvest. However no improvements were seen with the treatment including all three fungi combined. For most parameters, this treatment was equal to the untreated control and was significantly poorer than the three fungal treatments individually.

Table 1. Results of biological control studies using unknown sterile fungi to manage multiple root pathogens and comparing performance with cultivars containing varying disease resistance packages 2006.

Entry	Disease Index*	Sugar (%)	Root Yield (Metric Tons)	Sugar Yield (kg/ha)	Sugar Loss to Molasses (SLM)
Beta 8400	2.30	14.9	40.8	6224.7	2.10
8400 + Hall	1.80	16.2	50.8	8220.2	1.90
8400 + Laetisaria	1.90	15.8	47.5	7758.5	1.90
8400 + R47	1.90	15.9	45.9	7393.5	1.80
Beta 4546	2.70	16.4	28.7	4737.3	2.00
Ranger	2.80	15.7	17.5	2706.5	1.70
Beta 4595	1.30	17.9	49.3	9573.5	1.60
HM 2779 RZ	1.40	17.2	45.3	7843.4	1.50
HM 7172	1.40	16.4	52.2	9287.7	1.70
Beta 7341	1.90	17.6	54.0	10233.1	1.50
Beta 7310	1.60	17.2	54.4	10335.1	1.80
Monohikari	3.40	14.6	12.3	1925.1	2.10
HM 7235 RZ	1.40	18.0	49.7	9753.2	1.30
Beta 4100	2.00	16.1	38.5	5571.8	2.10
LSD	0.65	1.6	13.6	2608.8	0.34

***** Disease Index = root disease index: a weighted average of roots rated individually at harvest on a 0-4 scale with 0 = healthy root and 4 = completely rotted root. DR = disease rating. Disease index was then calculated by the following equation: DI = (DR1*1 + DR2*2 + DR3*3 + DR4*4)/(sum DR0-4).

Table 2. Results of biological control studies using unknown sterile fungi to manage multiple root pathogens 2008.

Entry	Diseased plants	Disease Index*	Sugar (%)	Root Yield (Metric Tons)	Sugar Yield (kg/ha)	Sugar Loss to Molasses (SLM)
Control	91.8	2.40	12.9	26.2	3434.1	3.10
R47	54.0	1.80	13.2	45.3	5877.5	2.90
Laetisaria	50.8	1.40	15.3	35.8	5937.9	2.80
Hall	54.6	1.50	13.5	39.0	5105.0	3.10
All three combined	105.2	2.30	13.9	23.3	4112.4	3.20
LSD	35.0	0.56	4.7	8.5	1436.4	0.66

***** Disease Index = root disease index: a weighted average of roots rated individually at harvest on a 0-4 scale with 0 = healthy root and 4 = completely rotted root. DR = disease rating. Disease index was then calculated by the following equation: DI = (DR1*1 + DR2*2 + DR3*3 + DR4*4)/(sum DR0-4).

Conclusions:

Disease severity in plots for both years was exceedingly high, including Cercospora leaf spot, rhizomania, and other root diseases (see disease susceptible entries such as Monohikari, Ranger, and Beta 8749 from 2006 – Table 1). Therefore, the results of this study are very encouraging for the prospects of developing a novel method of root disease management using these unknown sterile fungi. Results in 2008 were even more promising due to significantly better yield and disease improvements.

All isolates utilized in these studies were found naturally-occurring in western Nebraska associated with *Rhizoctonia*-infected sugar beet roots or seedlings. The *Laetisaria arvalis* isolate was originally found in Scotts Bluff Co in the early 1960's (1,4). The Hall and R47 isolates were both found within the last five years in soil samples from Box Butte Co as a result of the root disease index testing service (2).

This concept for treating seeds with potential biological control organisms was initially conceived as a means to provide seedling protection against multiple pathogen complexes without multiple fungicide treatments. The positive yield results obtained from these studies suggest that these organisms are providing further protection during the season from the root rots induced by the same seedling pathogens. This is an unanticipated but pleasantly surprising finding. It should be also noted that rhizomania is unaffected by these fungi, thus this disease must still be addressed with other methods, such as genetic resistance. These fungi appear to most effectively protect sugar beets against root disease pathogens such as *Rhizoctonia solani*, *Aphanomyces cochlioides*, *Phoma betae*, *Fusarium oxysporum* and *F. solani*, and various *Pythium* spp. The role of these fungi in disease management will likely be optimized by integration with genetic resistance and fungicide treatments where available.

References:

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