Response of Sugarbeet Lines to Isolates of *Fusarium oxysporum* f. sp. *Betae* from the United States

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ABSTRACT

Nine isolates of *Fusarium oxysporum* Schlechtend.Fr. f. sp. *betae* (Stewart) Snyd & Hans, that cause Fusarium yellows of sugarbeet (*Beta vulgaris* L.), were tested for their interaction with different sugarbeet lines. Two isolates were tested in the presence or absence of the sugarbeet cyst nematode, *Heterodera schachtii* (Schmidt). In the absence of the cyst nematode, differences in disease severity were detected in sugarbeet lines depending upon the isolates. A small number of lines showed reduced disease response to several isolates, but for the some lines, responses varied, depending upon the pathogen isolate. In the presence of *H. schachtii*, two isolates of *F. oxysporum* f. sp. *betae* increased disease severity in some lines and decreased it in others. This variability in host response may explain some of the variable results growers report after planting sugarbeet lines with resistance to Fusarium yellows.

Additional key words: Fusarium yellows, Fusarium wilt, germplasm.

The causal agent of Fusarium yellows in sugarbeet (*Beta vulgaris* L.) is *Fusarium oxysporum* Schlechtend.Fr. f. sp. *betae* (Stewart) Snyd & Hans. (FOB). The disease is characterized by wilting and interveinal yellowing of the leaves, usually starting with older leaves, and petioles

that turn tan in color. In some cases, half of the leaf will show symptoms first. As the disease progresses, leaves die and the petioles wilt around the crown of the plant. Internal symptoms consist of brown or gray-brown vascular discoloration (Schneider & Whitney 1986, Franc et al. 2001). Fusarium yellows causes significant reduction in root yield, as well as reduced sucrose percentage and juice purity (Schneider & Whitney 1986). The disease has been a problem in the western United States for many years (Schneider & Whitney 1986) and is an increasing problem in other growing areas (Windels et al. 2005).

Genetic resistance is the primary means of controlling Fusarium yellows (Franc et al. 2001). While genetic resistance can provide good control, producers in different parts of the country have reported control failures when growing allegedly resistant cultivars (Godby, personal communication). Variable resistance could indicate presence of races in the pathogen. Races occur in a number of *formae speciales* of *Fusarium oxysporum* (Armstrong et al. 1978, DeVay et al. 1997, Gordon & Martyn 1997, Migheli et al. 1998, Ribeiro & Hagedorn 1979). Diversity in virulence has been reported in FOB (Ruppel 1991). The only proposed separation for races in *F. oxysporum* pathogenic on sugarbeet is based on cross pathogenicity among isolates from beet and spinach. It has been suggested that FOB and *F. oxysporum* f. sp. *spinaciae* (FOS) be combined into FOS, with the designation of two races based on host specificity (Armstrong and Armstrong 1976). However, no races have been reported within FOB.

Only one report has been published (Jorgenson 1970) on the effect of *Heterodera schachtii* (Schmidt) on development of Fusarium yellows and results indicate no synergistic interaction between the pathogens. However, research by Jacobsen et al. (unpublished) show increased disease severity in the presence of the sugarbeet cyst nematode on the cultivar Monohikari (Jacobsen and Kiewnick, unpublished data). Other Fusarium wilts have been significantly affected by nematodes (DeVay et al. 1997, Francl and Wheeler, 1993, Garber et al. 1979, Mai and Abawi, 1987, Uma Maheswari et al. 1997, Wang and Roberts, 2006), indicating an interaction could occur with FOB.

The purpose of this research was to examine the interaction of different FOB isolates with diverse sugarbeet diploid lines to determine whether there was a race-type interaction, defined as FOB isolates causing differing levels of disease on host lines possessing varied genotypes. The potential interaction with *Heterodera schachtii* also was examined using two FOB isolates and 19 sugarbeet lines to assess whether *H. schachtii* affects the severity of FOB infection.

MATERIALS AND METHODS

Nine isolates of *Fusarium oxysporum* f. sp. *betae* were used in these tests (Table 1). They originally were obtained from diseased sugarbeet tissue and shown to be pathogenic on sugarbeet in greenhouse tests (Hanson and Hill 2004, Windels et al. 2005). All fungal isolates were maintained on potato dextrose agar (PDA, Becton, Dickinson and Co., Sparks, MD). For long-term storage, isolates of *F. oxysporum* were stored dried on sterile filter paper at -20°C as described by Peever and Milgroom (1992), and modified by Hanson and Hill (2004).

Three screening tests were done. The first test involved 20 sugarbeet lines with six FOB isolates (indicated with an "f" on Table 1). This test was used to narrow down the number of lines for more detailed screening. The second involved seven sugarbeet lines that had good seedling emergence and were representative of the types of responses observed in the larger screen. These were tested with four FOB isolates (indicated with an "s" in Table 1). The third involved two FOB isolates with or without the sugarbeet cyst nematode, *H. schachtii*. Each test

Table 1. *Fusarium oxysporum* f. sp. *betae* isolates used in Fusarium yellows and nematode interaction screens. Isolates were collected from diseased sugarbeet in different years in various locations.

Isolate	Screen used†	State of Origin	Year collected	Collector
Fob13	f	Oregon	1998	R. Harveson
Fob220a	s	Colorado	1998	H. Schwartz
Fob216c	f, n	Colorado	1998	H. Schwartz
F19	f, s	Oregon	2001	L. Hanson
Fo28	s	Minnesota	2003	C. Windels
Fo37	f	Minnesota	2003	C. Windels
H7	f, n	Montana	2004	B. Jacobsen
H8	n	Montana	2004	B. Jacobsen
Flynn	f	Montana	2004	B. Jacobsen
F05-284	s	Michigan	2005	L. Hanson

† Indicates the screening test in which isolates were used, either the first (f) large scale screen with 20 sugarbeet lines, the second (s) smaller screen with seven sugarbeet lines, or the nematode (n) screen in which isolates were coinoculated with sugarbeet cyst nematodes.

was done twice following the methods described below.

For the first screening test, 20 diploid sugarbeet lines were evaluated (Table 2). Lines were generously provided by all of the major sugarbeet seed companies, including American Crystal, Holly Hybrids, KWS, Syngenta, and Seedex (now SesVanderHaave. Sugarbeet germplasm,

Table 2. Sugarbeet lines tested for their response to different isolates of *Fusarium oxysporum* f. sp. *betae* in greenhouse inoculation.

Code	Fusarium information[†]	Source[‡]
01A54-01	Susceptible	Company experimental
01A55-01	Resistant	Company experimental
SY03040938	Resistant	Company experimental
SY92060005	Resistant	Company experimental
SY95060017	Resistant	Company experimental
SY02040243	Resistant	Company experimental
SY02058004	Resistant	Company experimental
FC716	Susceptible	USDA-ARS germplasm
9300184	Resistant	Company experimental
BTS-FUS1	Resistant	Company experimental
BTS-FUS2	Mixed	Company experimental
BTS-FUS3	Mixed	Company experimental
BTS-FUS4	Susceptible	Company experimental
BTS-FUS5	Resistant	Company experimental
BTS-FUS6	Susceptible	Company experimental
BTS-FUS7	Resistant	Company experimental
BTS-FUS8	Resistant	Company experimental
BTS-FUS9	Resistant	Company experimental
BTS-FUS10	Resistant	Company experimental
FuR005	Resistant	Company experimental

[†] Information about *Fusarium* response of the lines from the suppliers. Resistant indicates the line was provided as a *Fusarium*-resistant line. Mixed indicates the line was reported by the sender to have shown resistance in some tests, and susceptibility in others. Susceptible indicates no resistance was reported for the given line.

[‡] Companies providing experimental lines include American Crystal, Holly Hybrids, KWS, Syngenta, and Seedex (now SesVanderHaave).

FC716 (Panella et al. 1995), developed in Fort Collins, CO for resistance to Rhizoctonia root rot, was included because it had been used for initial *Fusarium* pathogenicity screening (Hanson and Hill 2004). For the smaller screening a subset of seven lines was selected because they showed varied responses to the FOB isolates in the major screen.

Fusarium yellows test

Fusarium inoculum was prepared by transferring a 4 mm diameter plug of hyphae from the actively growing edge of a colony on PDA to half-strength V8 agar (Singleton et al. 1992). Plates were incubated under 10 hr light/14 hr dark at 22-25°C for 2 weeks. Sterile distilled water was added and the surface of the agar was scraped with a sterile bent glass rod to remove hyphae and spores. The contents of several plates were poured through sterile cheesecloth into a beaker to remove agar and large fragments of mycelium. The spore concentration was determined with a hemacytometer and adjusted to approximately 10^4 conidia per ml of sterile water. Sporulation was poor for isolates H7 and Fo37 in one of the experiments and only 10^3 conidia per ml were collected. Because preliminary tests (data not shown) revealed that isolate F19 caused rapid plant death at 10^4 conidia per ml of water, this isolate was diluted to 10^3 conidia per ml in the screening. For the screen using seven lines, all isolates were applied at approximately $4x10^4$ spores per ml.

Sugarbeet seed was dusted with a 4:1 (v/v) graphite/metalaxyl (Apron, Gustafson, Plano, TX) to control damping-off by *Pythium* species. Sugarbeet seeds were planted into pasteurized potting mix (Scotts MetroMix 200, Marysville, OH) supplemented with Osmocote 14-14-14 (Scotts, Marysville, OH) in 12-cm diameter plastic pots. Two weeks after planting, five seedlings free of symptoms of seed-borne pathogens were transplanted to 12 cm diameter plastic pots containing pasteurized potting mix to standardize the number of plants and allow fairly uniform, vigorous seedlings to be used in the experiment. Osmocote plus, with micronutrients, was added to each pot after transplanting. Plants were maintained for an additional 3 weeks in a greenhouse at 22C ± 5ºC with 16 hr light/8 hr dark and watered as needed to maintain healthy growth. Insects were controlled with a systemic insecticide (Marathon, Olympic Horticultural Products, Mainland, PA) or with Conserve (Dow AgroSciences, Indianapolis, IN).

For inoculations, plants were removed from soil and rinsed under running tap water with all plants for an experiment combined. Ten plants per treatment were randomly selected from the pooled plants and roots were soaked in a spore suspension of each isolate for 8 min.

The spore suspension was shaken approximately every 60 sec. Control plants were soaked in sterile water. Plants were replanted into saturated pasteurized potting mix with five plants per pot and 10 plants per treatment. Plants were transferred to a greenhouse at 24 ± 5°C to promote disease development. Plants were watered when soil was dry on the surface. Disease ratings of individual inoculated plants were recorded weekly for 6 weeks for foliar symptoms of Fusarium yellows using a modified rating scale (Hanson & Hill 2004) of 0 to 5 where 0 = no visible disease, 1 = leaves may be wilted, small chlorotic areas on lower leaves, but most of leaf green, 2 = leaves showing interveinal chlorosis, with entire leaves chlorotic, 3 = leaves with necrotic spots or becoming necrotic and dying, but less than half of the leaves affected, 4 = half or more of the leaves dead, plants stunted, most living leaves showing some symptoms, and 5 = death of the entire plant. The area under the disease progress curve (AUDPC) was calculated for the 6-week period for each plant and the mean AUDPC determined for each isolate. In addition, the number of plants out of the total number planted was counted at 2, 4, and 6 weeks after inoculation; the percentage of plants dead on these dates was calculated for each isolate. Tests on the percentage of plants killed also were performed at Montana State University, with the exception that isolates Fo24 and Fo25 from Minnesota were individually tested instead of isolate Fo37, and isolates H7 and H8 were combined, since both were originally recovered from the same field in Montana.

Six weeks after inoculations and the final visual rating of plants, or when all plants in a pot were dead (whichever occurred first) plants were harvested and roots examined for vascular discoloration. Tap roots were collected from at least two randomly selected plants from each treatment. Roots were washed under running tap water, cut into sections of approximately 0.5 cm, and surface disinfested in 0.5 % sodium hypochlorite for 30 sec. Root tissue was placed onto dishes containing PDA and incubated as previously described for the *Fusarium* isolates, and examined daily for fungal growth. Fungi isolated from inoculated plants were identified to species (Booth 1977, Nelson et al. 1983) and compared phenotypically to the isolate used for inoculations. All experiments were done twice.

Co-inoculation experiments with FOB and *Heterodera schachtii*

Nematode by FOB isolate interaction experiments were done with a subset of the FOB isolates and sugarbeet lines tested above. FOB inoculations were performed as described for the Fusarium yellows screening (i.e. roots soaked in a spore suspension) with isolates H7 and H8 mixed together (H7/8) and Fob216c tested separately. Nematode inoculations

were done by sieve extraction of cysts, which were crushed in a Pyrex Tenbroek tissue grinder. Viable eggs and juveniles were counted and mixed with a 1:1 mason sand: Montana State University (MSU) soil mix to achieve three viable eggs and juveniles/cc of soil mix. Sugarbeet lines tested are summarized in Table 4. Control plants were transplanted into pasteurized MSU soil mix. Plastic pots containing 500 cc of soil mix were used for all experiments. All plants were grown for 6 weeks on a screened bench top in a glasshouse maintained at 24°C day and 18°C night with a 16 hour photoperiod. Pots were arranged in a completely randomized design with five replications and 10 plants per replication. Controls included plants exposed to nematodes without FOB and plants exposed to FOB without added nematodes. Experiments were done twice.

Statistical Analysis:

Statistical analyses were performed using SAS (SAS Institute. Cary, NC). Analyses of variance were performed for AUDPC and when significant, mean separations were made using the macro PDMIX800. sas (Saxton 1998) with Tukey's honestly significant differences adjustments for Fusarium yellows tests. For coinoculation experiments, Fisher's least significant difference (FLSD) was used. Correlation coefficients were determined for diseases severity ratings of isolates in the repeats of each experiment.

RESULTS

In the initial, larger screening test, a range of foliar symptoms were observed on the various sugarbeet lines, and the severity for particular isolates differed (Fig. 1). For example, while F19 caused severe symptoms on several lines (Fig. 1A, B, and C), on others, symptoms were much reduced (Fig. 1D). Because no significant direct effects or interactions were found for the pot in which plants were grown ($P > 0.05$), plants were analyzed individually. Differences could be observed for the percent of plants killed by the isolates (Fig. 2). For example, line 01A55-01 had less than 30% of plants dead for all *Fusarium* isolates, while line BTS-Fus8 showed as little as 0% plants dead with isolates such as Fo37 and Fob13, and as high as 100% plants dead with Fo28.

Isolates differed significantly in disease severity on the sugarbeet lines ($P=0.05$). Isolates that were more virulent (average AUDPC 40 or higher on susceptible sugarbeet lines) tended to give more consistent results across experiments than did isolates with lower virulence ratings. For example, a highly virulent isolates, F19, had a higher

Fig. 1. Fusarium yellows symptoms on four sugarbeet lines (A-D) following inoculation with four isolates of *F. oxysporum* f. sp. *betae*. Plants in each frame, clockwise, from upper left were inoculated with isolates F05-284, F0b220a, Fo28, and F19 respectively. Varieties differed in response to isolates. For example, varieties indicated as A and B showed extensive damage with F19 or Fo28, variety C still had severe damage with F19, but much less damage with Fo28, and variety D showed less severe symptoms for both F19 and Fo28.

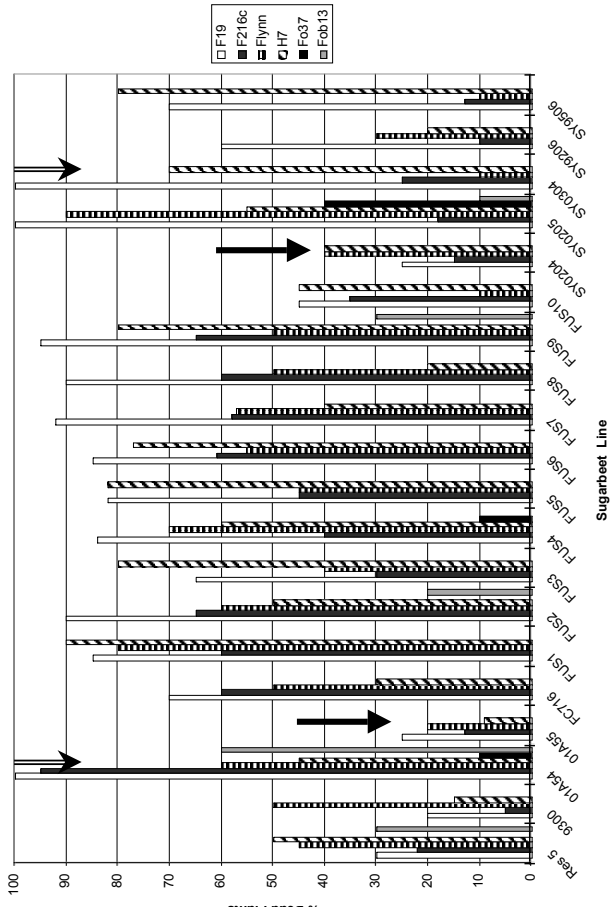

Fig. 2. Percent dead sugarbeet plants of 20 sugarbeet lines following exposure to six isolates of *Fusarium oxysporum* f. sp. *betae* (FOB), indicated as F19-Fob13. Bars are not displayed for all isolates on all lines because some isolates did not cause death of any plants on some sugarbeet lines. Some varieties showed fairly consistent responses to several isolates while others were more variable. For example, sugarbeet lines such as 01A55-01 (indicated as 01A55) and SY0204243 (indicated as Sy0204) had overall low disease levels, with no more than 40% dead plants for any isolate (solid black arrows). Other lines (open arrows) had more variable responses, such as 95% and 45% dead plants with isolates Fob216c (indicated as F216c) and H7 versus 25% and 70% dead plants for the same isolates on lines 01A54-01 (indicated as 01A54) and SY03040938 (indicated as Sy0304), respectively.

correlation coefficient between the two experiments (0.89) compared to moderately virulent isolates such as Fob13, which had a correlation coefficient between experiments of 0.31. From this test, lines were selected that showed good seedling emergence and represented different types of response to the FOB isolates to be included in a smaller screen. In addition, isolates that had been found to be highly virulent in prior screens (e.g. Hanson & Hill 2004, Windels et al. 2005) were selected.

In the smaller screen, with seven lines, an analysis of variance showed statistically significant effects of both sugarbeet line and FOB isolate, as well as a significant line by isolate interaction ($P<0.0001$ for each). When each isolate was analyzed separately on the different sugarbeet lines, the relative ranking of each line for average area under the disease progress curve varied depending upon which isolate was used (Table 3). While some lines showed apparent broad spectrum resistance to most or all of the FOB isolates, (e.g. 9300184 and FuR005) and others showed susceptibility to most or all isolates (e.g. 01A54-01), a number of lines varied significantly in their response to the different isolates. For example, line BTS-FUS7 had the highest average AUDPC for isolate F05-284 and one of the highest for isolate F19, but had the

Table 3. Response of seven sugarbeet lines to four isolates of *Fusarium oxysporum* f. sp. *betae* from different locations.

	Fusarium oxysporum isolate			
Sugarbeet line	**F19**	**Fob 220a**	**Fo28**	**F05-284**
01A54-01	64.7 a[†]	52.4 a	47.9 ab	15.0 bc
BTS-FUS7	59.5 ab	31.0 b	37.8 c	31.3 a
BTS-FUS3	56.1 ab	25.3 b	38.4 bc	13.4 c
BTS-FUS10	54.4 b	29.6 b	42.9 bc	24.0 ab
FC716	44.4 c	47.4 a	52.6 a	15.0 bc
9300184	33.4 d	33.5 b	38.3 c	12.3 c
FuR005	32.7 d	28.4 b	38.8 bc	15.9 bc

[†] Values are the average area under the diseases progress curve for 20 plants (10 plants per treatment, replicated twice) rated weekly for 6 weeks for disease severity using a 0-5 rating scale. For inoculation, plants were soaked for 8 minutes in spore suspensions ($4x10^4$ spores per ml) of the individual isolates. Values for a given isolate (column) followed by the same letter are not significantly different by Tukey's ($\alpha=0.05$).

lowest average AUDPC for isolate Fo28. On the other hand, BTS-FUS3 also had a high average AUDPC for F19, but one of the lowest for F05-284.

For both Fusarium yellows screens, *Fusarium* was isolated from inoculated plants that was identified as FOB and was similar to the isolates used in inoculations. No *Fusarium* was isolated from non-inoculated control plants.

The use of highly virulent isolates in the second screen provided improved correlation coefficients for isolates between experiments. For example, the correlation coefficient for response to isolate Fob 220a (0.85) was similar to that found with F19 in the larger screen (0.89).

The response of sugarbeet to isolates in the greenhouse tests did not consistently match the results predicted based upon information provided by the seed suppliers (Table 2). While line 01A54-01, indicated as susceptible, generally had high percent plant kill and disease ratings, several lines that had been supplied as resistant were not consistently less susceptible than this susceptible line and varied in their response to the different isolates.

Co-inoculation experiments with FOB and *Heterodera schachtii*

In the presence of *H. schachtii,* the percent of plants dead or dying from FOB was significantly ($P < 0.05$) increased, decreased, or was not significantly affected (Table 4). There were no Fusarium yellows symptoms in the control when plants were dipped in sterile distilled water or grown in the presence of the nematode alone. Variability in disease severity on the different sugarbeet lines also was noted when highly virulent isolate combination H7/H8 was compared with the moderately virulent isolate 216C in the presence or absence of *H. schachtii*. For example, disease severity for FOB susceptible line 01A54-01 and resistant line 01A 55-01 was increased in the presence of *H. schachtii* for both FOB isolates while there were mixed effects on disease severity for other lines (Table 4). For lines BTS FUS1, 2, 3, 4, 5, 9, SY 03040938, and SY 9506-0017 there were significantly more dead and dying plants when inoculated with isolates H7/8 and for lines SY02058004 and FC716 there were a greater number of dead or dying plants when both FOB and the sugarbeet cyst nematode were present. Lines BTS FUS 1, 2, 4, 5, 6, and 9 had more dead and dying plants when inoculated with FOB isolate 216c as compared to lines BTS FUS 3, 10 and SY 02058004, SY 9206005 and SY 95060017 which had more plants dead and dying when coinoculated with FOB isolate 216c and the sugarbeet cyst nematode.

DISCUSSION

Table 4. Percentage dead or dying plants and area under the disease progress curve (AUDPC) 6 weeks after sugarbeet lines were inoculated with Fusarium oxysporum f. sp. betae (FOB) isolates H7/8 or 216c alone (-CN) or grown in soil inoculated with three viable eggs and juveniles/cc of Heterodera schachtii (+CN). No symptoms of Fusarium yellows were observed on control plants, and plants showed 0% death.

Sugarbeet line	Response	FOB isolate H7/8				FOB isolate 216C			
		+CN		-CN		+CN		-CN	
		%	AUDPC	%	AUDPC	%	AUDPC	%	AUDPC
FC 716	Susc.	56	1463	44	1022	16	203	11	310
01A54-01	Susc.	86	3031	47	1233	94	3087	85	3047
01A55-01	Res.	36	747	12	314	50	1134	18	386
BTS FUS1	Res.	20	700	94	3092	40	1400	60	2105
BTS FUS2	Mix	60	1771	67	1859	50	1134	63	1706
BTS FUS3	Mix	74	2250	88	3062	77	2380	29	902
BTS FUS4	Susc.	54	1736	67	1866	44	1274	58	1456
BTS FUS5	Res.	42	1400	84	3009	32	938	56	1451
BTS FUS6	Susc.	60	1841	58	1694	30	665	48	1351
BTS FUS8	Res.	30	707	27	1002	28	1106	30	897
BTS FUS9	Res.	60	1848	83	2958	58	1890	68	1848
BTS FUS10	Res.	64	1890	45	1203	74	2094	50	1390
SY 0204-0243	Res.	34	868	40	2190	26	623	20	412
SY0205-8004	Res.	60	1120	40	1756	73	1322	25	998
SY 0304-0938	Res.	42	933	70	1904	20	576	15	389
SY 9206-0005	Res.	38	945	42	2251	36	987	25	932
SY9506-0017	Res.	48	1407	100	3256	22	546	15	367
FuR005	Res.	47	1378	*		29	970	*	
9300184	Res.	60	1610	*		25	567	*	

Response indicates the reported Fusarium yellows response from supplies (as shown in Table 2). Susc. – susceptible, Res – resistant, and Mix - line was reported to show resistance in some tests and susceptibility in others.

Fisher's least significant difference (FLSD) P=0.05 for H7/8 between +CN and –CN = 6.7%

FLSD P=0.05 for 216C between +CN and –CN = 5.4%

* no data

Isolates of FOB varied considerably in their virulence on sugarbeet as has been reported in other studies, (Ruppel 1991, Hanson and Hill 2004, Windels et al. 2005). There also was variability in the response of particular sugarbeet lines to individual isolates (Table 3). The variable response of lines such as BTS-FUS7 (high AUDPC with F05-284 and F19, low for Fo28) compared to BTS-Fus3 (high AUDPC with F19, lower with Fo28 and F05-284) is the type of interaction frequently observed among races of *Fusarium oxysporum*.

Our results indicate that *H. schachtii* can increase disease severity for some sugarbeet lines. These results are similar to increases in disease severity reported for the combination of root-knot nematode and Fusarium wilt on tomato, cotton and several other crop plants compared to presence of *Fusarium* alone (Mai and Abawi, 1987; Francl and Wheeler, 1993; Wang and Roberts, 2006). On other sugarbeet lines, severity of Fusarium yellows was greater in the absence of the sugarbeet cyst nematode, similar to the results observed by Jorgenson (1970). Variability in the presence of *H. schachtii* in soils could explain some of the lack of disease control with some Fusarium yellows-resistant sugarbeet varieties when planted in different areas. Clearly, there are significant genotype by isolate by nematode interactions that provide variability in disease reaction depending on which FOB isolate is present and whether the sugarbeet cyst nematode is present. Differences in the response to the combination of the two pathogens could be due to differences in tolerance to either or both pathogen in some lines. In addition, some Fusarium isolates can be pathogenic or antagonistic to nematodes (Mennan et al. 2005) or reduce nematode damage on a crop (Dababat and Sikora 2007). It is possible that some differences in responses could be due in part to interactions between the pathogens in the soil. Further research on the interactions between FOB isolates and *H. schachtii* as well as between sugarbeet lines known to differ in their tolerance to nematode infection should be done to help to clarify this interaction.

Research is ongoing to complete crosses between sugarbeet lines that varied in their response to the different FOB isolates, to determine whether this is single gene resistance, which usually is associated with pathogenic races. Since sugarbeet lines were found that appeared to show broad spectrum resistance however, there may be more than one type of resistance in the host. This also is indicated by the sugarbeet cyst nematode x FOB isolate results (Table 4) where the various sugarbeet genotypes differed in their response to co-inoculation with the nematode, with differences from inoculation with FOB being both

positive and negative. A better understanding of the interactions between FOB, *H. schachtii* and sugarbeet could determine what type or types of resistance are available for FOB, and may allow for improved selection of resistant varieties that will provide resistance in all locations.

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Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

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