POTENTIAL OF HOST-PLANT RESISTANCE AS AN ALTERNATIVE CONTROL MEASURE FOR SUGARBEET ROOT MAGGOT

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Introduction:

The sugarbeet root maggot (*Tetanops myopaeformis* von Röder) (SBRM), a native of North America, is a significant economic pest on two-thirds of the sugarbeet (*Beta vulgaris* L.) acreage in the United States. Yield reductions sometimes are the result of stand loss early in the season, but more frequently are due to larval feeding on the root surface (Hein, et al., 2009). The primary control is chemical insecticides that reduce larval populations in sugarbeet fields (Campbell et al., 1998; Boetel et al., 2015). No commercially viable alternatives are available to sugarbeet growers. Development of root maggot-resistant hybrids would provide a more environmentally sustainable alternative, and perhaps provide more consistent control than the currently used insecticides (Campbell, 2005).

The first publically available sugarbeet germplasm line with SBRM resistance, F1015, was released in 1996 (Campbell et al., 2000); followed by the release of F1016 in 1998 (Campbell et al, 2000) and F1024 in 2009 (Campbell et al., 2011). In two trials encompassing six environments, four sugarbeet root maggot resistant pollinators (including F1015 and F1016), and five elite susceptible cytoplasmic male sterile (cms) female lines, the yield loss attributed to root maggot feeding in hybrids with a root maggot resistant pollen parent was substantially less than the corresponding yield loss in adapted susceptible hybrids (Campbell and Niehaus, 2008; Campbell et al., 2008).

This report summarizes additional comparisons between hybrids formed by crossing root maggot resistant pollinators with susceptible cms lines and hybrids with only susceptible parents. In addition, information about a new unique source of SBRM resistance will be presented.

Methods and Materials:

Nine experimental hybrids were planted on 6 June 2013 and 28 May 2014 at a site near St. Thomas, North Dakota with a history of high SBRM pressure. The experimental design was a randomized complete block with three replicates. Individual experimental units were four rows wide and 8.5 m long with 56 cm row spacing. The two center rows of each plot (experimental unit) were harvested for yield on 23 September 2013 and 24 September 2014. None of the plots received any insecticide treatments. Two SBRM resistant lines, F1015 (PI 605413) and F1016 (PI 608437), and one susceptible line, F1010 (PI 535818) developed by USDA-ARS, Fargo, ND, were crossed as pollinators with three SBRM susceptible cms lines. The cms parents were L53cms (PI 590842), FC504cms (PI 590824), and SP-69550-01; lines developed by USDA-ARS programs in Utah, Colorado, and Beltsville, MD, respectively.

Two breeding lines selected from a cross between PI 179180 and C564aa are being considered for release as unique sources of SBRM resistance. PI 179180, a line with red globe-shaped roots that was identified as resistant by Callenbach et al. (1972; 1973), was originally collected near Gemlik, Turkey by Jack Harlan in 1948. C564aa is a SBRM susceptible, monogerm, self-fertile, O-type line segregating for Mendelian male sterility. After eight cycles of mass selection for maggot resistance, full-sib families were formed and subjected to four addition cycles of selection among and within families. The two lines being considered for possible release are descendants of two full sib families.

All SBRM performance trials and breeding nurseries depend upon natural infestations by root maggots for comparisons and receive no insecticide. SBRM feeding is assessed in late July or early August. Roots are hand-dug, washed, and evaluated in the field and selected roots are increased in the greenhouse. SBRM damage was rated on a 0 to 9 scale where 0 equaled no feeding and 9 indicated between 75 and 100% of root surface covered with feeding scars.

Results and Discussion:

In all comparisons involving a common susceptible cms parent, damage ratings for hybrids with a SBRM resistant pollinator (F1015 and F1016) were lower than damage ratings for hybrids with the susceptible pollinator (F1010). In general, hybrids with L53cms or SP69550-01 as the female parent had less visible damage than hybrids with FC504cms as a parent, regardless of the resistance or susceptibility of the pollinator parent (**Table 1**). The average root yields of all six hybrids with a resistant pollinator were greater than the average yield of any of the three hybrids with F1010 as the pollinator. F1010 is in the parentage of F1015 and F1016 (Campbell et al., 2000) so it is unlikely these differences are primarily due to differences in combining ability among the three pollinators and not related to SBRM resistance. Having a SBRM resistant pollinator resulted in a 24% increase in root yield in the absence of insecticides. In both years, late planting due to wet conditions resulted in lower root yields than are typical for the area.

Table 1. Sugarbeet root maggot (SBRM) damage ratings (2014 only) and average root yield of hybrids with a susceptible and two maggot resistant pollinators and three susceptible cms lines, St. Thomas, ND, 2013 and 2014.

	CMS parent			
Pollinator	L53	FC 504	SP-69550-01	Mean
	SBRM damage rating, 0 – 9			
F1010 (Susceptible)	5.20	5.90	4.70	**5.30**
F1015 (Resistant)	3.10	5.50	4.30	**4.30**
F1016 (Resistant)	3.60	4.30	3.60	**3.80**
Mean	**4.00**	**5.20**	**3.60**	**4.50**
	Root yield, Mg ha^{-1}			
F1010 (Susceptible)	31.5	30.8	28.3	**30.2 b***
F1015 (Resistant)	41.3	37.9	34.6	**37.9 a**
F1016 (Resistant)	41.7	36.3	32.4	**36.8 a**
Mean	**38.2 x**	**35.0 y**	**31.8 z**	**35.0**

* Differences between main effect means followed by the same letter are not significant based upon $LSD_{0.05.}$

Alternative sources of resistance to a pest or disease may be of value if the pest develops resistance to a widely used resistance source, if genes that result in undesirable traits are linked to the resistance genes, or if they have superior combining ability with specific elite parental lines. There is no reason to believe that PI 179180 is related to any of the lines in the parentage of F1015, F1016, or F1024. Based upon the recent damage ratings, it appears that the SBRM resistance derived from PI 179180 is essentially equal to the resistance of the previously released germplasm lines (**Table 2**). Based upon a single trial, both lines appear to have lower sucrose concentrations than adapted hybrids with the sucrose concentration of SBRM-PI-2 being especially low. Eliminating bolters from these lines has been difficult. Six and 4.8% of SBRM-PI-1 and SBRM-PI-2 plants, respectively, produced bolters at St. Thomas in 2014. Evaluation of these two lines will continue and one or possibly both will be released if their SBRM resistance is confirmed. Additional sucrose concentration and yield data will be obtained from trials at Fargo, ND and their response to prevalent diseases in specialized cooperative nurseries will be evaluated.

Table 2. Sugarbeet root maggot (SBRM) damage ratings of two potential unique SBRM sources of resistance, two released SBRM resistant germplasm lines, and two adapted susceptible hybrids, St. Thomas, ND, 2012 – 2014 and sucrose concentration and root yield, Fargo, ND 2014.

	Year			2014 (no SBRM)	
	2012	2013	2014	Sucrose	Yield
	— SBRM damage rating, 0 – 9 —			— $g\ kg^{-1}$ —	— $Mg\ ha^{-1}$ —
SBRM-PI-1	3.1	1.9	2.4	109	29.7
SBRM-PI-2	2.8	2.2	2.5	85	32.2
F1016	- - -	1.0	2.7	109	27.7
F1024	1.7	1.4	2.5	116	25.1
ACH-817	- - -	- - -	6.7	124	46.0
Beta-1301	6.2	5.8	- - -	119	47.4
$LSD_{0.05}$	1.2	1.1	0.7	14	7.3

Conclusions:

Under heavy SBRM pressure, the SBRM feeding damage observed on resistant germplasm is similar to the damage typically observed on susceptible commercial hybrids receiving recommended insecticide treatments (**Table 3**). Based upon the results presented in **Table 1** and previous reports (Campbell et al., 2008; Campbell and Niehaus, 2008; Campbell et al., 2011), it appears that a substantial portion of the resistance of a SBRM resistant pollinator will be expressed in hybrids with a susceptible cms parent. Differences in combining ability for resistance do not appear to be large, based upon the limited number of experimental hybrids examined. Under severe infestations, SBRM resistant hybrids would benefit from the addition of an insecticide; however, resistance might facilitate the use of reduced rates or use of compounds with reduced negative impact on the environment while providing reliable control. A combination of host-plant resistance and pesticides to control SBRM would not be different from that often recommended to control Cercospora leaf spot, Rhizoctonia, etc. Populations now in the SBRM breeding program are intended to incorporate needed disease resistance, increase sucrose concentration, and identify unique sources of SBRM resistance. There is no known relationship between the released SBRM resistance lines and the lines selected from the cross with PI 179180 (**Table 2**). However, it has not been determined if they differ in the mechanism or inheritance of resistance. One of the major obstacles to developing SBRM germplasm is the dependence upon natural infestations at sites with a consistent history of SBRM.

Table 3. Comparisons of sugarbeet root maggot (SBRM) damage ratings of three SBRM resistant germplasm lines (F1015, F1016, and F1024) to a susceptible line (F1010), two adapted hybrids, and chemical insecticides, St. Thomas, ND, 2011 – 2014.

	Year								
	2011		2012		2013		2014		Mean
	SBRM damage rating, 0 - 9								
Host-plant Resistance									
F1010	- - -		6.1	a*	- - -		5.7	ab	**- - -**
F1015	3.2	b	3.4	bc	5.5	b	3.6	c	**3.9**
F1016	2.4	c	2.7	cd	2.4	c	2.8	d	**2.6**
F1024	2.4	c	1.5	d	2.4	c	2.5	d	**2.2**
ACH-817	- - -		- - -		7.3	a	6.2	a	**- - -**
Beta-1301	4.4	a	6.2	a	6.7	a	5.3	b	**5.6**
Chemical insecticides†									
Best Insecticide	3.7	x	3.7	x	2.5	x	2.9	x	**3.2**
Non-treated check	8.3	y	7.4	y	6.5	y	6.8	y	**7.2**

† North Dakota State University, Department of Entomology registered insecticide trials .

* Differences between means followed by the same letter are not significant based upon $LSD_{0.05.}$

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