

SCREENING FOR VARIETAL RESISTANCE TO SUGAR BEET ROOT APHID

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Introduction

The sugar beet root aphid is commonly seen throughout all of the sugar beet growing areas of the Rocky Mountain region. Because of the aphids relationship to narrowleaf cottonwood, its overwintering host that is only found in the Rocky mountains, the risk level from this insect is higher here than nearly all other sugar beet production regions. Sugar beet varieties vary greatly in the level of resistance to root aphid feeding. Data collected from variety trials in Nebraska and Colorado indicate that varieties that were susceptible to root aphids had yield reductions of as much as 30% compared to those varieties with a high level of resistance.

The significant impact of this insect on sugar beet yield has resulted in the development of a number of varieties that are completely resistant to the aphid. However, there are a number of varieties that are only partially resistant and varying percentages of fully susceptible plants make up the varietal mixture along with other fully resistant plants. This segregation of resistance occurs at varying levels for different varieties. We have measured commercial varieties with segregation levels of 30-80% resistant plants. The most widely used segregating variety is Beta 4546. Our screening data indicate that this variety is made up of about 70% resistant plants and 30% susceptible plants. Therefore, segregation level is an important component to a varieties level of resistance. In order to establish the level of resistance for a variety, a consistent test must be available to determine the resistance level of the variety. In the past, lab or greenhouse results have often been too variable to obtain consistent results. The objective of our study was to develop improved methods for greenhouse screening that will provide more consistent data and allow better prediction of how a variety will perform in the field.

Methods

During the winter of 2002-03 and 2003-04, sugar beet varieties from Western Sugar Cooperative, plus several sugar beet root aphid (SBRA) resistant and susceptible checks, were screened for SBRA resistance in a greenhouse trial at the University of Nebraska Panhandle Research and Extension Center. During 2002-03, 20 varieties from Western Sugar were screened in 10 replications (plants). The 2003-04 screen included 19 varieties from Western Sugar replicated 12 times. Varieties that were categorized as moderately resistant and moderately susceptible were tested further to determine their level of segregation by testing an additional 20 replications (plants). Based on our current ability to sustain a SBRA colony for uniform infestation and the availability of space with optimal lighting, we can only run three replications with up to 24 entries per replication in a given run. This requires four runs to complete the main variety screen (12 replications). Additional runs are required to provide the segregation data required for some varieties. One run requires eight weeks to complete, but runs can be overlapped by five weeks allowing three weeks between infestations for SBRA colony

numbers to regenerate.

The screen was conducted in three inch pots by initially planting six seeds of a variety in each pot. As plants emerge and grow they are thinned to a single sugar beet plant which develops roots. The screen technique requires the establishment of earthen root cells within the root-ball where aphids will develop. This was accomplished by inserting two glass tubes (ca. ½-inch dia) into the moist soil of each 3-inch pot when the beets were three weeks old, leaving them for two days, then removing the glass tube and sealing the cells with a natural cork. These beets developed for two weeks resulting in a significant mass of roots extending into each cell. Five aphids were placed in each cell (10 aphids per pot or plant), and the corks were immediately replaced to seal the cells. Aphids were allowed to multiply in these closed cells for three weeks, and then the study was evaluated.

The visual rating of each variety was accomplished by removing the soil and root-ball from the pot and breaking open the ball so that both of the root cells were split and visible. The extent to which the aphids were present and filled the cells is the basis of the visual rating system: 0) No aphids; 1) Isolated aphids; 2) Small colony, up to ¼ of cells; 3) Cells ¼ to ½ full; 4) Cells ½ to ¾ filled; 5) Cells ¾ full to full; 6) Cells excessively full. In addition to visual rating, the root balls from each sample were placed in Berlese funnels and all of the aphids in the root ball extracted and counted.

Results

A strong correlation exists between the root rating and the actual number of aphids counted in the samples for both years (Fig. 1 and 2). The strength of this relationship indicates that the resistance rating system that is being used is a good representation of the level of resistance for a variety. Varieties that are more resistant produce considerably fewer aphids than those that are more susceptible.

Tables 1 and 2 summarize the root cell ratings and segregation data from the screens. The resistance levels as categorized in the tables are as follows:

1. Resistant: root cell rating of 0.5 or less
2. Moderately resistant: root cell rating from 0.51 to 1.5
3. Moderately susceptible: root cell rating from 1.51 to 3.0
4. Susceptible: root cell rating of 3.0 or greater.

Five of the 20 varieties tested in the 2002-03 screen were found to be resistant, and 11 of the 20 were found to be susceptible. The remaining varieties were intermediate in resistance and segregation levels for these ranged from 40-90% resistant. Five of the 19 varieties tested in 2003-04 were resistant, and seven of the 19 were susceptible. The remaining varieties had intermediate resistance with segregation levels between 17 and 88% resistant.

Because of the success of known segregating varieties such as Beta 4546, it is important to know the level of segregation of those varieties with intermediate levels of resistance. Varieties with intermediate resistance levels were chosen from the SBRA screen to be further evaluated for their level of segregation. The segregation data are also shown in Tables 1 and 2. These segregation data provide a much more complete picture of the resistance level of a variety.

The procedures presented here are a considerable improvement over previously demonstrated greenhouse screening procedures. Variability with these screening procedures is reduced considerably; however, there is inherent variability in the screening process because a

number of varieties are segregating for resistance.

Problems remaining in the screening procedure are primarily associated with getting a consistent stand of young beets that produce a uniform level of roots in the cells. Occasionally diseases and other unknown factors stunt beets minimizing root production in the root cells and negatively affect aphid reproduction. Soil and pot sterilization, fertilization, and lighting are being carefully monitored to enhance the health of the beets for the screening process. Another important factor is maintaining consistent temperature conditions for root and plant growth. We have seen that greenhouse warming in the spring is very detrimental to optimum aphid growth on the roots. Therefore, it is more difficult to rear and screen aphids during this time because it is hard to regulate daytime temperatures in the greenhouse. However, by paying attention to these factors, and trying to optimize the micro-environmental conditions for the aphids, the screening process can be run much more consistently from trial to trial.

Fig. 1. Root aphid production vs. root aphid rating, greenhouse screen 2002-03.

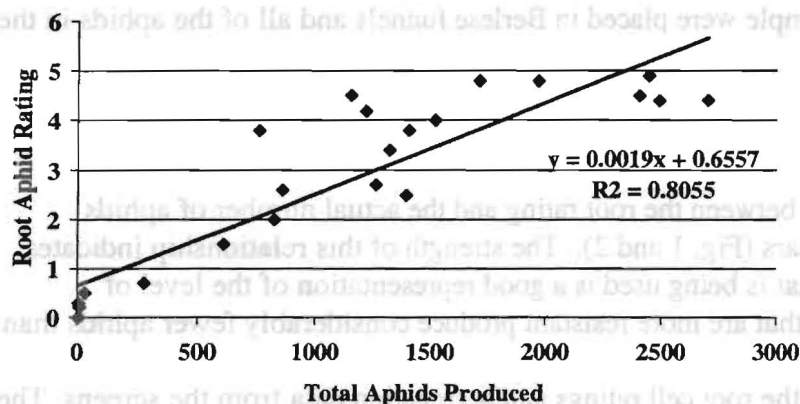


Fig. 2. Root aphid production vs. root aphid rating, greenhouse screen 2003-04.

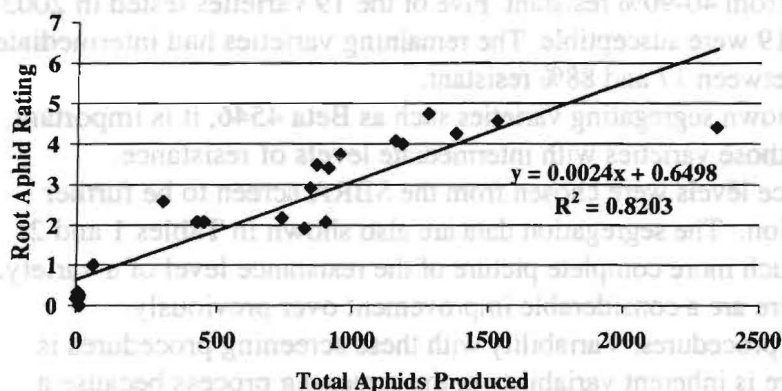


Table 1. Sugar beet root aphid greenhouse screen summary, PREC, Scottsbluff, NE (2002-03).

Variety	Mean Root Rating ^{a,b}	Aphids per plant	Segregation Levels	
			# res./total	% res.
Susceptible Varieties	(>3.0)			
HH110	4.9a	2441.5abc	0/10	0
B8749(2)	4.8a	1964.7abcde	1/10	10
B6863* (check)	4.8a	1708.3abcdef	2/26	7
1646RZ*	4.5ab	1153.2efgh	11/30	37
SXCody	4.5ab	2401.9abcd	0/10	0
B8109	4.4ab	2487.7ab	0/10	0
H120	4.4ab	2699.1a	0/10	0
B4006R	4.2ab	1219.6efgh	0/10	0
B8636	4.0abc	1519.4bcdefg	1/10	10
B8749(1)	3.8abcd	755.4fghi	2/10	20
C9612	3.8abcd	1405.1cdefg	1/10	10
C9902	3.4bcd	1321.7defgh	2/10	20
Moderately Susceptible	(1.51 to 3.0)			
B1651RZ*	2.7cde	1261.2efgh	17/25	68
Bridger	2.6de	854.4fghi	4/10	40
HMGeyser*	2.5de	1395.8cdefg	14/30	47
B4940R*	2.0ef	822.1fghi	12/30	40
Moderately Resistant	(0.51 to 1.5)			
C9906*	1.5efg	605.1ghi	19/30	63
HMTreasure	0.7fgh	278.1hi	9/10	90
Resistant	(≤0.5)			
B4595R	0.5gh	30.4i	10/10	100
HM9255	0.3gh	6.1i	10/10	100
B1775	0.2gh	7.5i	10/10	100
Monohikari* (check)	0.2gh	10.1i	18/18	100
HM1653RZ	0 h	6.1i	10/10	100
SXRanger	0 h	5.4i	10/10	100
P>F< .01; LSD _{.05}	1.3	1081		

^aMeans followed by same letter are not significantly different.

^bRoot Ratings: 0) No aphids; 1) Isolated aphids; 2) Small colony, up to ¼ of cells; 3) Cells ¼ to ½ full; 4) Cells ½ to ¾ filled; 5) Cells ¾ full to full; 6) Cells excessively full.

* Varieties chosen for segregation study.

Table 2. Summary of sugar beet root aphid greenhouse screen, University of Nebraska, 2003-04.

Variety	Mean Root Rating ^{a, b}	Aphids per plant	Segregation levels	
			# res./total	% res.
Susceptible	(>3.0)			
B8220B#2	4.75 a	1273 bcd	0/12	0
HH110 (check)	4.58 ab	1528 ab	0/12	0
B8220B#1	4.42 ab	2337 a	1/12	8
H99HX906	4.25 ab	1375 abc	1/12	8
H10HX017	4.08 abc	1152 bcd	1/12	8
B6863 (check)*	4.00 abc	1177 bcd	1/36	3
B8150R	3.75 abcd	946 bcde	1/12	8
H01HX037	3.50 abcd	863 bcde	1/12	8
SX0225*	3.42 bcde	907 bcde	4/32	12
Moderately Susceptible	(1.51 to 3.0)			
HMDILLON*	2.92 cdef	838 bcde	13/32	41
4006R	2.58 def	305 de	2/12	17
C9941*	2.17 efg	732 bcde	19/32	59
C9104*	2.08 fg	452 cde	16/32	50
C122*	2.08 fg	428 cde	21/32	66
SXPUMA*	2.08 fg	898 bcde	14/31	45
SXBLAZER*	1.92 fg	819 bcde	24/32	75
Moderately Resistant	(0.51 to 1.5)			
B7310R*	1.00 gh	60 e	28/32	88
Resistant	(≤0.5)			
SXBRONCO	0.33 h	5 e	11/12	92
Monohikari (check)	0.25 h	11 e	12/12	100
B2372	0.25 h	4.4 e	12/12	100
C9942	0.17 h	3.8 e	12/12	100
HM1652	0.17 h	7.8 e	12/12	100
HM1637	0.17 h	1.2 e	12/12	100
Monohikari (check)	0.00 h	10.3 e	12/12	100
P>F< .01; LSD _{.05}	1.29	1043		

^aMeans followed by same letter are not significantly different.

^bRoot Ratings: 0) No aphids; 1) Isolated aphids; 2) Small colony, up to ¼ of cells; 3) Cells ¼ to ½ full; 4) Cells ½ to ¾ filled; 5) Cells ¾ full to full; 6) Cells excessively full.

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