BENEFITS OF SUGAR BEET ROOT APHID RESISTANCE IN NORTH AMERICAN SUGAR BEET PRODUCTION

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Abstract:

Sugar beet root aphid (SBRA, *Pemphigus betae*) is a devastating insect pest in many North American sugar beet production areas and can only be controlled using genetic resistance. SBRA pressure can cause reductions in sugar content (POL) and recoverable sugar per acre (RSA) and can cause storage losses. Proprietary trials in Minnesota in 2013 showed that while performance of both SBRA resistant and susceptible hybrids were similar in the absence of SBRA pressure, heavy SBRA infestation resulted in a 13% relative loss in RSA of susceptible hybrids. Official Variety Trial (OVT) results from Michigan have also shown that SBRA rating had a correlation of –0.53 with RSA and –0.63 with RST. A 2013 storage trial (Michigan Sugar OVT) revealed high correlations between SBRA ratings and external rot (79%) and internal rot (83%). Results from a Red River Valley yield trial in 2012 showed that sugar beets damaged by SBRA had approximately a 60% reduction in POL by 30 days after harvest (DAH) and an 80% reduction at 90 DAH relative to beets with minimal SBRA damage. Consequently, extractable sugar per ton in the same trial, had reductions at 30 and 90 DAH of approximately 77% and 88%. Although the direct cause of these losses is unknown, it is likely due in part to postharvest rots resulting from SBRA infestations. Due to a lack of biological, chemical, and cultural controls, genetic resistance provides the only option for producers to avoid preharvest and postharvest losses in sugar beets and for many years has allowed producers to grow successful crops despite SBRA pressure.

Introduction:

Sugar beet root aphid (SBRA, *Pemphigus betae*) is one of the most widespread insect pests of sugar beet in North America, occurring in many different production areas. Infestations of SBRA are noticeable due to the presence of a white waxy substance secreted by the aphids (Picture 1) which not only serves to protect the aphids from excess water, but also may inhibit water uptake by the sugar beet. The aphids can also contribute more directly to losses in sugar beet quality as a result of damage caused by sucking sap from the roots (Hein et al., 2009). Although the primary sugar beet production areas which have historically had problems with severe SBRA infestations are the Rocky Mountain and Great Lakes regions, they have also been observed and periodically caused problems in many other growing areas, most notably in North Dakota and Minnesota, especially during droughts.

Picture 1 (M. Rekoske). Sugar beet colonized with SBRA and showing characteristic white, waxy secretion. Picture taken from field adjacent to a Betaseed yield trial in Polk County (MN).

Infestation with SBRA may impact sugar beet production in several ways, affecting both producers and processors. High SBRA pressure in Minnesota in 1990 was associated with a reduction in root yield of up to 10 tons/Acre, up to a 50% reduction in percent sugar content, and over a 50% reduction in RSA (Hutchison and Campbell, 1991). Hein et al. (2001) showed an average loss of 3% sugar content and 3,000 lbs/acre sugar yield in susceptible varieties. Additionally, SBRA damage is suspected to have severe consequences on the storability of beets, based on preliminary data (Boetel et al., 2014).

No current chemical control options are available for SBRA, thus genetic resistance is critically important. Resistance to SBRA is conferred by a single gene (Leijman, 2011). Hybrids with resistance to SBRA are currently available in all North American sugar beet production areas (Bradshaw and Hein, 2013).

Methods:

Sugar beet yield data was compiled from various sources, including OVTs from several growing areas and yield trials conducted by Betaseed, Inc. SBRA ratings were taken from the Betaseed,

Inc. SBRA nursery (Shakopee, MN) and a 1 to 4 scale is used, with 1 = no noticeable aphid presence and 4 = severe aphid infestation noticeable throughout the pot (Picture 2). Plants are grown and infested in the greenhouse and 30 plants are used per hybrid for each evaluation.

Picture 2 (B. Stanton). Example of 1-4 rating scale used in Betaseed, Inc. SBRA greenhouse nursery (Shakopee, MN). Pictured from left to right: Ratings of 2, 3, and 4.

Results:

Betaseed yield trials have shown that even in growing regions which have not traditionally been associated with high SBRA pressure, losses from aphid damage can still be severe. Potential new hybrid components were tested in the Red River Valley (RRV) using both a SBRA resistant and a SBRA susceptible tester in one location showing severe SBRA infestation and locations without noticeable SBRA presence and although the sugar content was nearly identical, the sugar yield was dramatically impacted in the hybrids without SBRA resistance, when under heavy SBRA pressure (Figure 1). Hybrids with a non-SBRA tester had an average loss in RSA of 14% compared to the equivalent hybrid developed with a SBRA tester, with losses reaching 39%.

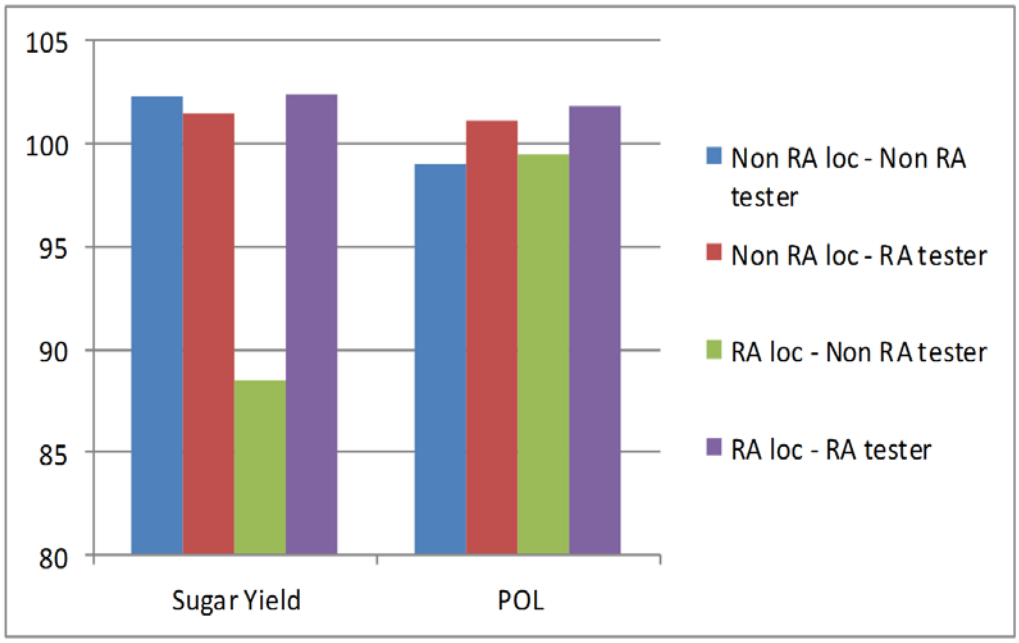
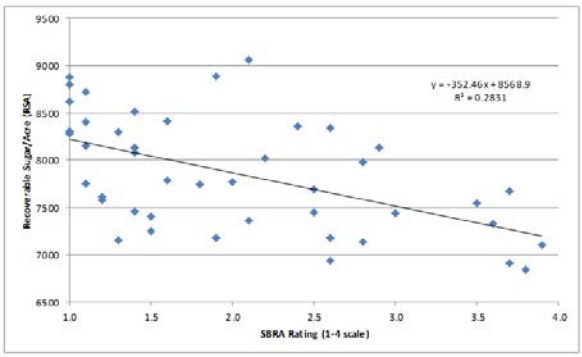
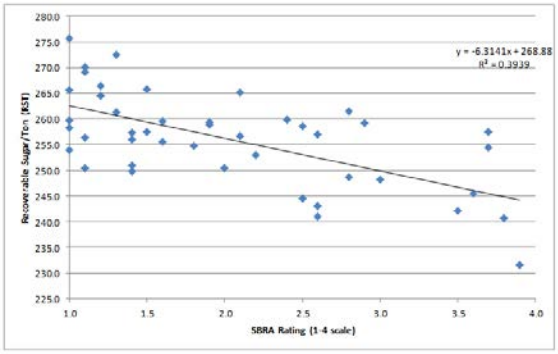


Figure 1. 2012 Betaseed, Inc. yield trial in Minnesota. Values are relative to check means. N=20.

Some North American sugar beet producing areas have more severe SBRA pressure on a year-to-year basis. One of these, Western Sugar Cooperative, has implemented a requirement for approval and in 2020, Michigan Sugar Company (MSC) will follow suite, having already included SBRA resistance as a component in their approval process indirectly for several years by including it as a criteria in their points-based approval system. SBRA data is still pending for the 2014 OVT, but a comparison of 2013 OVT performance results with the 2013 SBRA screening conducted by Betaseed, Inc. showed a correlation of –0.53 between RSA and SBRA rating (Figure 2) and a correlation of –0.63 between recoverable sugar per ton (RST) and SBRA rating (Figure 3).





Figures 2 and 3. 2013 Michigan Sugar Company OVT results compared to SBRA rating from Betaseed, Inc. greenhouse nursery. Rating scale is a 1-4 scale where 1 = no noticeable aphid presence and 4 = severe aphid infestation noticeable throughout the pot.

In addition to resulting in lower performance for producers, SBRA damage may also contribute to poor storability of harvested sugar beets, although the impact is not yet well-characterized. Recent high SBRA pressure in the RRV have been the subject of recent preliminary investigations (Boetel et al, 2014). Sugar beets subjected to high levels of SBRA damage in a 2012 yield trial in the RRV were compared to those with minimal aphid damage at 30 days and 90 days after harvest (DAH). The respiration rates (mg CO_2 /kg/hr) were over 2.5-fold higher in aphid damaged beets at both 30 DAH and 90 DAH. Additionally, the sugar content of the SBRA damaged beets was reduced by approximately 60% and 80% relative to healthy beets at 30 DAH and 90 DAH, respectively. Differences in RST closely mirrored those of sugar content, with reductions of approximately 77% and 88% at 30 DAH and 90 DAH respectively.

MSC conducts a storage trial with the goal of identifying prospective varieties with a tendency for poor storage quality. As a part of their variety approval process, MSC has also contracted root aphid screening to seed companies (including Betaseed, Inc.). A comparison of the results of their 2013 storage trial and the root aphid ratings for the corresponding hybrids shows high correlations of 79% and 83% between root aphid rating and external (results not shown) and internal root rot severity, respectively (Figure 4).

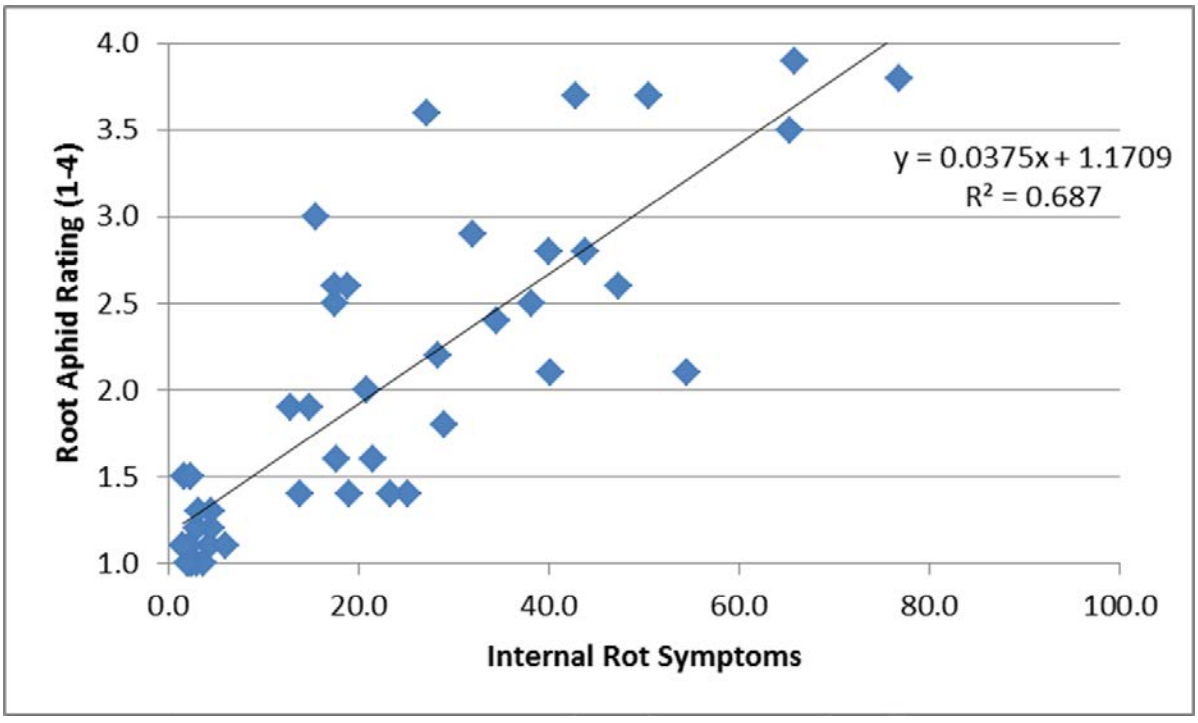


Figure 4. Comparison of the SBRA rating of 44 sugar beet varieties and internal rot severity. Root aphid ratings are on a 1-4 scale with 1 = not noticeable aphid presence and 4 = severe root aphid infestation noticeable throughout the pot, conducted by Betaseed, Inc. (Shakopee, MN). Storage trials were conducted by Michigan Sugar Company.

Conclusions:

SBRA is a severe threat to many North American sugar beet production areas, capable of causing extensive losses in years where aphid pressure is high. Additionally, preliminary investigations have suggested that SBRA damage may play a substantial role in poor storability, which would magnify losses to sugar beet processors. No biological or chemical control options are currently available and while cultural controls may help reduce aphid populations, they do not provide sufficient control. Genetic resistance provides excellent control of SBRA and is a highly effective tool to eliminate losses from SBRA. Resistant hybrids with all the other trait combinations needed to achieve high sugar yields are available in all North American sugar beet production areas and give growers the best option to control this insect pest.

References:

Bradshaw, J.D. and G.L. Hein. 2013. Insect management. Sugarbeet Production Guide.

Boetel, M.A., L.G. Campbell, A.J. Schroeder, and R.J. Dregseth. 2014. Root aphid impacts on stored roots and an outlook for 2014. 2013 Sugarbeet Research and Extension Reports. Coop. Ext. Serv. North Dakota State Univ., Fargo, ND 44.

Hein, G.L., M.A. Boetel, and L.D. Godfrey. 2009. Sugarbeet root aphid. Compendium of Beet Diseases and Pests (2nd ed.).

Hein, G.L., R. Harveson, J.A. Smith, R.G. Wilson, and C.D. Yonts. 2001. Varietal resistance to sugarbeet root aphid. Proceeding from the 31st Biennial Meeting of the American Society of Sugar Beet Technologists, Vancouver, BC, Canada, 18 February –3 March, 2001. pp 202-206.

Hutchison, W.D., and C.D. Campbell. 1991. Biology, yield impact and management of the sugarbeet root aphid in southern Minnesota: First-year results. 1990 Sugarbeet Ext. Rep. 21:151-159.

Leijman, E. 2011. Fine mapping of resistance against root aphids in sugar beet. Thesis. SLU, Alnarp, 2011. 14 Sept. 2011.

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