ASSESSING EXPERIMENTAL INSECTICIDES FOR SUGARBEET ROOT MAGGOT CONTROL

Mark A. Boetel[1], Peter C. Hakk[2], and Reed R. Thoma[3]

[1]Professor and Sugarbeet Extension Entomologist, School of Natural Resource Sciences, North Dakota State University, Fargo, ND; [2]Research Specialist, School of Natural Resource Sciences, North Dakota State University, Fargo, ND; and [3]Graduate Research Assistant, School of Natural Resource Sciences, North Dakota State University, Fargo, ND

Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) is a serious economic insect pest of sugarbeet in the Red River Valley (RRV) production area that borders North Dakota and Minnesota. For several decades, growers that produce sugarbeet in the United States have had a limited number of insecticide tools currently registered by the U.S. Environmental Protection Agency (EPA) for managing the SBRM. Another concern has been that, of the small number of insecticide options available for insect management in sugarbeet, the most widely used insecticides for controlling the SBRM and other insect pests during that time have belonged to the same insecticide action mode (i.e., acetylcholinesterase [ACHE] inhibition). In areas where economically damaging SBRM infestations develop on an annual basis, a common control approach involves two to three applications of ACHE-inhibiting insecticides within the same growing season to protect the crop from major economic loss. This long-term pattern of repeated use of ACHE inhibitors for root maggot control has exerted intense selection pressure for the development of insecticide resistance to these insecticides in RRV root maggot populations. Therefore, research is needed to develop alternative tools for SBRM management for preserving the long-term sustainability and profitability of sugarbeet production for growers affected by this pest. This experiment was carried out to screen several insecticide products that are either not EPA-registered at all, or are not currently registered for use in sugarbeet, for efficacy against sugarbeet root maggot in the RRV growing area.

Materials and Methods:

This experiment was conducted on a grower-owned field site near St. Thomas (Pembina County), ND during the 2025 growing season. Planting was done on May 7 with glyphosate-resistant seed (i.e., Betaseed 8018) by using a 6-row Monosem NG Plus 4 7x7 planter set to deposit seed at 1¼ inch depth and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. The outer "guard" rows (i.e., rows one and six on the planter) on each side of the plot served as untreated buffers. Each plot was 35 feet long, and 35-foot tilled alleys were maintained between replicates throughout the growing season. The experiment was arranged in a randomized complete block design with four replications of the treatments.

<u>Planting-time insecticide applications</u>. Counter 20G, applied at moderate and maximum labeled rates (i.e., 7.5 and 8.9 lb product/ac) was used for comparative purposes as a planting-time standard chemical insecticide in the experiment. Counter was applied by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. Granular delivery rate was regulated by using a planter-mounted SmartBox™ electronic insecticide delivery system that was calibrated shortly before applications.

Experimental planting-time insecticides evaluated in the experiment included the following: 1) Abba Ultra (active ingredient: abamectin, a fermentation product of a soil-dwelling bacterium), 2) Aztec 4.67G (active ingredients: tebupirimifos [an organophosphate insecticide] and cyfluthrin [a pyrethroid insecticide]); 3) Delegate WG (active ingredients: spinetoram-J and spinetoram-L, nicotinic acetylcholine receptor modulators); 4) Ecozin Plus (active ingredient: azadirachtin, a botanical insecticide derived from neem tree extract); 5) Index (active ingredients: chlorethoxyfos [an organophosphate] and bifenthrin [a pyrethroid]); 6) Smart Choice 5G (active ingredients: chlorethoxyfos and bifenthrin [a pyrethroid insecticide]); and 7) Verimark (active ingredient: cyantraniliprole [a anthranilic diamide insecticide]). All planting-time liquid insecticides were applied by using dribble in-furrow (DIF) placement, which involved orienting microtubes (1/4" outside diam.) directly into the open seed furrow. Inline Teejet™ No. 20 orifice plates were used to provide backpressure for stabilizing the output rate of spray solutions from the microtubes. Insecticide/water solutions were delivered in a finished spray volume of 5 gallons per acre (GPA). Water was used as the carrier for all planting-time liquid insecticide applications, and it was adjusted to pH 6.0 before use.

Postemergence insecticide applications. Pilot 4E (active ingredient: chlorpyrifos, an organophosphate insecticide) was used as the postemergence broadcast SBRM management standard because similar chlorpyrifos-based products have been the most commonly used postemergence liquid insecticides for SBRM control by RRV sugarbeet growers for decades. Experimental postemergence insecticides evaluated in this trial included the following sprayable liquid products: 1) Abba Ultra (described above in at-plant treatments); and 2) Exirel (active ingredient: cyantraniliprole [a anthranilic diamide]. All postemergence sprays were applied on June 4 (i.e., about 3 days before peak SBRM fly activity) from a tractor-mounted, CO_2-propelled spray system equipped with an 11-ft boom calibrated to deliver a finished spray volume output of 10 GPA through TeeJet™ XR 110015VS nozzles. All at-plant and postemergence insecticides were single, stand-alone applications. That is, there was no postemergence insecticide included in plots assigned to receive an at-plant insecticide treatment, and vice versa.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in this trial on August 5, 2025. Rating procedures involved randomly selecting ten beet roots per plot (five from each of the outer two treated rows), hand-washing them, and rating them in accordance with the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Treatment performance was also compared according to sugarbeet quality and yield by harvesting all plots on October 2. Foliage was removed from plots immediately before harvest by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were extracted from the soil using a mechanical harvester, and weighed in the field using a digital scale. A random subsample of 12-18 roots was collected from each plot and for subsequent sucrose content and quality analyses.

Data analysis: Data from root injury ratings and yield samples were subjected to analysis of variance (ANOVA) via the general linear models (GLM) procedure (SAS Institute 2025). Treatment means for all four response variables were separated by using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

As mentioned above, all insecticide entries in this trial were single-component control tools (i.e., none of the planting-time insecticide treatment plots received any postemergence insecticide protection, and none of the postemergence treatment plots had any planting-time protection). This practice is not recommended in high-risk areas such as St. Thomas, where severe SBRM infestations are common; however, these single-product applications were necessary to assess the efficacy of each product individually. The results from assessments of sugarbeet root maggot feeding injury in this experiment appear in Table 1. The average level of SBRM larval feeding injury recorded for the untreated check was 7.75 on the 0 to 9 scale of Campbell et al. (2000), which suggested that a high SBRM infestation was present for the experiment.

Table 1. *Larval feeding injury* in an evaluation of experimental at-plant and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2025

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G	B	8.9 lb	1.8	4.52 h
Index	DIF	17.1 fl oz	0.37	4.80 gh
Counter 20G	B	7.5 lb	1.5	5.02 fgh
Verimark	DIF	10 fl oz	0.13	5.28 efg
Ecozin Plus	3 d Pre-peak Broadcast	56 fl oz	0.04	5.70 def
Delegate WG	DIF	6 fl oz	0.09	5.78 de
Exirel Insect Control	3 d Pre-peak Broadcast	20 fl oz	0.13	5.82 de
Smart Choice 5G	B	7.4	0.37	5.85 de
Pilot 4E	3 d Pre-peak Broadcast	2 pt	1.0	5.90 cde
Abba Ultra	DIF	10 fl oz	0.02	6.08 cd
Aztec Smartbox 4.67G	B	4.45	0.21	6.18 cd
Pilot 4E	3 d Pre-peak Broadcast	1 pt	0.5	6.55 bc
Abba Ultra	3 d Pre-peak Broadcast	10 fl oz	0.02	6.95 b
Untreated check	---	---	---	7.75 a
			LSD (0.05)	0.693

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch at-plant band; 3" TB = 3-inch band over open seed furrow at planting

All insecticide treatments provided significant (P < 0.05) reductions in SBRM feeding injury when compared to that recorded in the untreated check plots. The highest level of protection from root maggot feeding injury (i.e., lowest average root rating) was provided by Counter 20G applied at 8.9 lb product per acre. Two other insecticide treatments, Index, applied at 17.1 fl oz per acre and the lower (7.5 lb/ac) rate of and Counter 20G, provided similar levels of root protection from SBRM feeding injury that were not significantly different from that of the high rate of Counter.

The aforementioned top-performing treatments (i.e., Counter 20G at 7.5 and 8.9 lb, and the experimental product, Index) resulted in significantly greater SBRM control than both rates of Pilot 4E. In addition to Index, somewhat encouraging performance was also observed with Verimark, Ecozin Plus, and Delegate, as all three products resulted in significantly lower SBRM feeding injury than that recorded from plots treated with Pilot 4E at the lower, 1-pt rate. Although Abba Ultra was one of the lower-performing treatments in the experiment, applying it using DIF placement treatment resulted in root injury ratings that averaged nearly one entire point lower on the 0 to 9 scale, suggesting that placing the product into the seed furrow may be a more effective approach than a postemergence spray with that insecticide.

Yield data from this trial, shown below in Table 2, corresponded well with SBRM root-feeding injury rating results, and were even more encouraging. General performance patterns indicated that planting-time treatments resulted in greater yield benefits than postemergence-applied treatments. The experimental insecticide Index, applied at 17.1 fl oz per acre at planting time using DIF placement, resulted in the highest recoverable sucrose yield and root tonnage in the entire experiment. The economic results from the trial indicated that Index-protected plots generated a gross revenue increase of $484/ac when compared to the untreated check. Other planting-time treatments that resulted in comparatively high root and recoverable sucrose yields that were not statistically different from Index included Counter 20G (7.5 and 8.9 lb product/ac), Delegate WG, and Verimark. Gross revenue increases over the untreated check from Counter 20G were $476/ac and $383/ac for the 8.9-lb and 7.5-lb rates, respectively. Encouraging revenue increases were also observed with Delegate WG ($313/ac), Verimark ($296/ac), Exirel ($264/ac), and Ecozin Plus ($206/ac) when compared to the check.

Table 2. *Yield parameters* from an evaluation of experimental at-plant and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2025

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Index	DIF	17.1 fl oz	0.37	9,572.4 a	30.1 a	16.92	1,298
Counter 20G	B	8.9 lb	1.8	9,374.9 ab	29.2 ab	17.00	1,290
Counter 20G	B	7.5 lb	1.5	8,521.3 abc	26.2 a-e	17.15	1,197
Delegate WG	DIF	6 fl oz	0.09	8,648.0 abc	26.9 abc	16.75	1,127
Verimark	DIF	10 fl oz	0.13	8,326.8 a-d	26.4 a-d	16.72	1,110
Ecozin Plus	3 d Pre-peak Broadcast	56 fl oz	0.04	8,195.4 bcd	27.0 abc	16.35	1,020
Exirel Insect Control	3 d Pre-peak Broadcast	20 fl oz	0.13	7,962.8 cde	25.0 c-f	16.82	1,078
Aztec Smartbox 4.67G	B	4.45	0.21	7,718.0 c-f	24.8 c-f	16.62	1,004
Smart Choice 5G	B	7.4	0.37	7,710.6 c-f	25.4 b-e	16.28	958
Pilot 4E	3 d Pre-peak Broadcast	2 pt	1.0	7,692.1 c-f	25.6 b-e	16.20	939
Pilot 4E	3 d Pre-peak Broadcast	1 pt	0.5	7,382.6 c-f	24.8 c-f	16.05	885
Abba Ultra	3 d Pre-peak Broadcast	10 fl oz	0.02	7,029.2 def	22.5 def	16.55	921
Abba Ultra	DIF	10 fl oz	0.02	6,805.5 ef	22.2 ef	16.25	862
Untreated check	---	---	---	6,470.2 f	21.2 f	16.38	814
			LSD (0.05)	1,349.1	3.98	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch at-plant band; 3" TB = 3-inch band over open seed furrow at planting

It is also worth noting that plots treated with a postemergence application of either Ecozin Plus or Exirel Insect Control produced numerically higher recoverable sucrose and root yields than either rate of Pilot 4E, the postemergence industry standard product in the experiment. Although those differences were not statistically significant, the gross revenue generated from a postemergence application of Exirel was $81/ac greater than that from a postemergence application of the high (2 pts/ac) rate of Pilot 4E. Similarly, the gross revenue generated from plots treated with a postemergence rescue application of Ecozin Plus was $139/ac higher than that produced by plots treated with Pilot 4E at the 2 pt/ac rate.

As mentioned above, it is important to understand that all insecticide treatments in this trial were single-applications (i.e., either at-plant or postemergence). Although this practice is not recommended in high-risk SBRM infestation areas, this approach was employed in the trial to isolate the performance level of each individual insecticide treatment. As such, all insecticide-treated plots were anticipated to sustain more SBRM feeding injury and incur greater yield loss than would typically occur in well-managed sugarbeet fields.

However, the results of this trial were very encouraging. Most notable was the performance of Index insecticide which provided the best protection from SBRM feeding injury, as well as, recoverable sucrose yield, and root tonnage in the experiment. The performance of Ecozin Plus, Delegate WG, Verimark, Exirel, and Ecozin Plus, were also encouraging. Further testing should be carried out on these and other experimental materials to identify viable alternatives to the currently used insecticides. The use of alternative insecticide active ingredients in place of the long-used ACHE inhibitors could assist with the prevention or delay of the development of resistance to those insecticides in SBRM populations. Products formulated with active ingredients belonging to these alternative modes of action could also provide viable tools for growers to sustainably and profitably produce sugarbeet in areas affected by this pest if the currently available conventional insecticides become unavailable in the future due to regulatory action or voluntary cancellations by manufacturers. The threat of losing any of these tools underscores the importance of this research and provides strong impetus for the identification of viable alternatives for SBRM management in the future. The findings presented here, while encouraging, are considered early-phase in nature. Next steps in this pursuit should include incorporating some of the better-performing experimental insecticide products into multi-component SBRM management systems that incorporate both at-plant and postemergence tools for effective, profitable, and environmentally compatible control of this major economic sugarbeet pest.

References Cited:

Boetel, M. A., R. J. Dregseth, A. J. Schroeder, and C. D. Doetkott. 2006. Conventional and alternative placement of soil insecticides to control sugarbeet root maggot (Diptera: Ulidiidae) larvae. J. Sugar Beet Res. 43: 47–63.

Campbell, L. G., J. D. Eide, L. J. Smith, and G. A. Smith. 2000. Control of the sugarbeet root maggot with the fungus *Metarhizium anisopliae*. J. Sugar Beet Res. 37: 57–69.

SAS Institute. 2025. SAS/stat user’s guide, release v 9.4. SAS Institute, Inc., Cary, NC.

Acknowledgments:

We wish to thank Wayne and Austin Lessard for allowing us to conduct this research on their farm. We also appreciate the contributions of graduate student Reed Thoma, as well as summer aides Jocelyn Bearinger, Jack Byberg, Grace Dahlstrom, Rylie Gustafson, Kameron Hanzal, Devin Lockerby, and Syed Rizvi for their assistance with plot maintenance, sample collection, and data entry. Sincere appreciation is extended to the Sugarbeet Research and Education Board of Minnesota and North Dakota for providing partial funding support for this research. This work was also partially supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, under Hatch project number ND02374.