SCREENING EXPERIMENTAL INSECTICIDES FOR SUGARBEET ROOT MAGGOT CONTROL

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) continues to rank as the most economically damaging insect pest of sugarbeet in the Red River Valley (RRV) production area. Unfortunately, growers have a very limited number of insecticide tools currently registered by the U.S. Environmental Protection Agency (EPA) for managing this pest. Another major, long-standing concern has been that, of the small number of insecticide options available for insect management in sugarbeet, most have involved the same insecticide mode of action (i.e., acetylcholinesterase [ACHE] inhibition). As a result, this insecticide group has been heavily relied upon for SBRM management for nearly five decades.

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 has exerted intense selection pressure for the development of resistance in RRV root maggot populations to this insecticide class. Research on alternative tools and tactics for SBRM management is critically needed to preserve the long-term sustainability and profitability of sugarbeet production for growers affected by this pest. This experiment was carried out to achieve the following objectives: 1) screen several natural and/or botanical insecticides for efficacy at managing the sugarbeet root maggot; and 2) evaluate commercially available EPA-labeled chemical insecticides that are currently not registered for use in sugarbeet to determine if their performance warrants the pursuit of labeling for use in the crop as SBRM control options.

Materials and Methods:

This experiment was carried out on a grower-owned field site near St. Thomas (Pembina County), ND during the 2021 growing season. The trial was planted on May 12, and all plots were planted with glyphosate-resistant seed (i.e., Betaseed 8961) by using a 6-row Monosem NG Plus 4 7x7 planter set to plant at a depth of 1¼ inch 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. The granular application rate was regulated by using a planter-mounted SmartBox™ computer-controlled insecticide delivery system calibrated on the planter immediately before all applications.

Planting-time liquid insecticides screened in this trial included the following: 1) Asana XL (active ingredient: esfenvalerate, a pyrethroid insecticide); and 2) a tank-mixed combination of Asana XL plus Exponent (pyperonyl butoxide [PBO], an insecticide synergist). At-plant liquid treatments were delivered in 3-inch T-bands over the open seed furrow by using a planter-mounted, CO_2-propelled spray system equipped with TeeJet™ 400067E nozzles. The planting-time liquid insecticide delivery system was calibrated to apply a finished spray volume output of 5 GPA.

<u>Postemergence insecticide applications</u>. Postemergence insecticide treatments evaluated in this experiment included the following sprayable liquid products: 1) Dibrom Emulsive (a conventional organophosphate insecticide); 2) Ecozin Plus 1.2%ME (azadirachtin, a neem tree-derived insect antifeedant and growth disruptor); 3) Endigo ZCX (a combination insecticide product containing lambda-cyhalothrin [a pyrethroid] and thiamethoxam [a

neonicotinoid]; 4) Evergreen Crop Protection 60-6EC (pyrethrum + a synergist); 5) Vydate C-LV (a carbamate insecticide); and 6) Yuma 4E, a sprayable liquid formulation of chlorpyrifos, applied at 1 and 2 pts product per acre. Yuma 4E was included as a postemergence chemical insecticide standard because chlorpyrifos-based products have been the most commonly used postemergence liquid insecticides used by RRV growers for SBRM for several years. All postemergence sprays were applied 2 d before peak SBRM fly activity from a tractor-mounted, CO_2-propelled spray system equipped with an 11-ft boom that was calibrated to deliver a finished spray volume output of 10 GPA through TeeJet™ XR 110015VS nozzles. All insecticide treatments, irrespective of whether an at-plant or postemergence insecticide, were single, stand-alone applications. In other words, 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 4, 2021. 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 September 22. 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: All data from root injury ratings and harvest samples were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2012). 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. Therefore, the results of this trial should be interpreted with discretion and with the understanding that this research was conducted to determine if any of these products have the potential of providing supplemental SBRM suppression or control as part of future integrated management programs involving both planting-time and postemergence insecticide applications.

The combined results for 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 8.83 on the 0 to 9 scale of Campbell et al. (2000), which clearly demonstrated that a severe 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, 2021

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G	B	7.5 lb	1.5	6.87 d
Counter 20G	B	8.9 lb	1.8	7.00 d
Asana XL + Exponent	3" TB	9.6 fl oz 8 fl oz		8.03 c
Endigo ZCX	2 d Pre-peak Broadcast	4.5 fl oz	0.031	8.03 c
Yuma 4E	2 d Pre-peak Broadcast	2 pt	1.0	8.20 bc
Evergreen Crop Protection	2 d Pre-peak Broadcast	16 fl oz		8.33 abc
Vydate C-LV	2 d Pre-peak Broadcast	34 fl oz	1.0	8.43 abc
Ecozin Plus	2 d Pre-peak Broadcast	56 fl oz		8.47 abc
Dibrom	2 d Pre-peak Broadcast	1 pt	1.65	8.60 abc
Yuma 4E	2 d Pre-peak Broadcast	1 pt	0.5	8.63 abc
Asana XL	3" TB	9.6 fl oz		8.77 ab
Check	---	---	---	8.83 a
LSD (0.05)				0.609

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 somewhat rare to observe SBRM root injury ratings that approach a 9.0 on the zero to 9 scale in field research trials that rely on natural pest infestations. The analysis showed that both rates of Counter 20G (i.e., 7.5 lb and 8.9 lb product per acre) provided significantly greater protection (i.e., lower SBRM feeding injury ratings) than any other treatment in the experiment. Other insecticides that provided significant levels of protection from larval feeding injury in comparison to the injury recorded for the untreated check included the following: 1) Asana XL, tank mixed with Exponent and applied as a 3" T-band at planting; 2) Endigo ZCX, applied as a postemergence broadcast; and 3) Yuma 4E postemergence broadcast-applied at its high (2 pts/ac) rate. Interestingly, the average SBRM feeding injury recorded for the combination treatment of Asana XL plus Exponent synergist was significantly lower (i.e., better root protection) than when Asana was applied without the synergist.

Yield data from this trial, shown below in Table 2, corresponded well with root injury rating results. For example, the two Counter treatments resulted in significantly greater recoverable sucrose yields than all other insecticide treatments in the experiment. Other entries that provided significant increases in both recoverable sucrose yield and root tonnage when compared to the untreated check included the following (listed in descending order of recoverable sucrose yield): 1) Asana XL plus Exponent, applied as a 3" T-band at planting; 2) Yuma 4E, applied as a postemergence broadcast at 2 pts/ac; and 3) Ecozin Plus, applied postemergence broadcast. All of these treatments, I except Yuma 4E, resulted in significantly greater root tonnage yields than the untreated check. Root yield increases from the treatments that differed statistically in comparison to the untreated check ranged from 2.6 tons/ac for plots treated with Ecozin Plus to well over 5 tons/ac for the two planting-time Counter 20G treatments. It also bears noting that Dibrom, Evergreen Crop Protection, Asana XL alone (i.e., without Exponent), Yuma 4E (1 pt/ac), Vydate C-LV, and Endigo ZCX failed to provide significant increases in either recoverable sucrose yield or root tonnage over that recorded for the untreated check.

Table 2. *Yield parameters* from an evaluation of experimental at-plant and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2021

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 20G	B	8.9 lb	1.8	4,615 a	16.6 ab	15.42 a	670
Counter 20G	B	7.5 lb	1.5	4,595 a	17.3 a	14.83 bc	628
Asana XL + Exponent	3" TB	9.6 fl oz 8 fl oz		3,747 b	14.1 bc	14.89 abc	515
Yuma 4E	2 d Pre-peak Broadcast	2 pt	1.0	3,611 bc	13.3 cd	15.22 ab	511
Ecozin Plus	2 d Pre-peak Broadcast	56 fl oz		3,546 bcd	14.0 bc	14.24 def	452
Endigo ZCX	2 d Pre-peak Broadcast	4.5 fl oz	0.031	3,388 b-e	12.9 cd	14.68 b-e	456
Vydate C-LV	2 d Pre-peak Broadcast	34 fl oz	1.0	3,364 b-e	12.7 cd	14.75 bcd	457
Yuma 4E	2 d Pre-peak Broadcast	1 pt	0.5	3,061 b-e	11.6 cd	14.79 bcd	417
Check	---	---	---	2,960 cde	11.4 cd	14.61 cde	391
Asana XL	3" TB	9.6 fl oz		2,908 cde	11.6 cd	14.11 ef	368
Evergreen Crop Protection	2 d Pre-peak Broadcast	16 fl oz		2,817 de	11.5 cd	13.91 f	342
Dibrom	2 d Pre-peak Broadcast	1 pt	1.65	2,754 e	11.2 d	13.89 f	335
LSD (0.05)				739.8	2.68	0.576	

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

Plots protected by single, planting-time band applications of Counter 20G provided gross revenue increases ranging from $237 (7.5 lb product/ac) to $391/ac (8.9-lb rate) when compared to the untreated check. Also, the combination of Asana XL and Exponent, applied as a T-band at planting, generated $515/ac in total gross revenue, which was an increase of $147/ac over that achieved by Asana XL without the synergist. Another interesting result with regard to revenue was that the maximum rate of Yuma 4E (2 pts product/ac) generated a total of $511/ac in gross revenue, which was $94 more in economic return than when Yuma was applied at 1 pt/ac.

As mentioned above, it is important to remember 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, it was employed this trial to isolate the performance 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 typical occur in a commercial sugarbeet production system. However, the results were somewhat encouraging. Most notable was the fact that Exponent, the insecticide synergist, provided consistent benefits in relation to protection from SBRM feeding injury, recoverable sucrose yield, and root tonnage.

NOTE: it is critical that producers and crop management advisors understand that, although piperonyl butoxide (PBO) synergist products are not actual insecticides, they are EPA-regulated and labeled in the same manner as insecticide products. Therefore, users must comply with PBO product labeling and confirm that a material is labeled for the following 1) tank mixing with the insecticide to be used; and 2) the crop to which it will be applied. Another important thing to realize is that most PBO products are labeled for enhancing the performance of pyrethroid insecticides, so using one to improve the activity of an insecticide belonging to another class would likely result in unsatisfactory performance. The application could also, depending on the product's label, be illegal.

The performance of Ecozin Plus and, to a lesser extent, Endigo ZCX, 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 help prevent or delay 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 recent EPA revocation of all food crop tolerances for insecticides containing chlorpyrifos (e.g., Lorsban, Yuma, etc.) illustrates and underscores the importance of this research, and provides strong impetus for the identification of viable alternatives for SBRM management in the future.

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