SUGARBEET ROOT MAGGOT CONTROL BY USING MULTIPLE-COMPONENT MANAGEMENT REGIMES

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is a severe insect pest threat to sugarbeet production in central and northern portions of the Red River Valley (RRV) of North Dakota and Minnesota. Previous research has shown that the SBRM is capable of causing more than 45% yield losses in the absence of effective control measures (Boetel et al. 2010). The high root maggot infestation levels that commonly occur in the RRV often require aggressive management programs to ensure adequate protection of the sugarbeet crop. As such, SBRM management programs in areas at high risk of economic loss from this pest usually consist of planting-time protection, in the form of a granular, liquid, and/or seed treatment insecticide, followed by an additive postemergence insecticide application (i.e., either a granular or sprayable liquid product) when the SBRM infestation level warrants it. Broadcast applications of sprayable liquid insecticides, applied on an as-needed, rescue basis, are the most commonly used postemergence tools for SBRM control in the region. An advantage of postemergence sprays is that they allow growers to use a “wait and see” approach to make informed decisions on whether rescue insecticide treatments are needed based on current fly activity levels in their fields.

This project involved two experiments. The objectives of Study I were to: 1) compare Counter 20G granular insecticide with Poncho Beta seed treatment for at-plant SBRM control; 2) assess the efficacy of combining Poncho Beta with Counter 20G at planting time for a one-pass SBRM control system; 3) determine the impacts of additive postemergence applications of Thimet 20G to plots initially treated with either Counter 20G or Poncho Beta seed treatment for SBRM control; 4) measure the performance of Counter 20G as a postemergence control option; and 5) determine if SBRM control can be maximized by employing a three-component (i.e., seed treatment insecticide + at-plant or postemergence granular insecticide + postemergence liquid spray) management program.

The objectives of Study II were to: 1) measure the impacts of NipsIt Inside seed treatment and Counter 20G (at differing application rates) on root maggot control in dual-insecticide programs comprised of postemergence broadcast spray applications of Asana XL insecticide; 2) evaluate the SBRM control provided by rotated applications of Asana XL and Mustang Maxx; 3) assess the impact of tank mixing Exponent insecticide synergist with Asana XL on SBRM management; and 4) compare the SBRM control efficacy of at-plant and postemergence applications of Asana XL.

Materials and Methods:

Both of these experiments were conducted on a commercial sugarbeet field site near St. Thomas (Pembina County), ND during the 2022 growing season. Betaseed 8961 glyphosate-resistant seed was used for all entries in both experiments, and a professional seed preparation company (Germains Seed Technology, Fargo, ND). Study I was planted on May 25, and Study II was planted on May 26, 2022. All plots were planted 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. No insecticide was applied to the outer “guard” rows (i.e., rows one and six) of each plot, as those rows served as untreated buffers. Each plot was 35 feet long, and 35-foot alleys between replicates were maintained weed-free throughout the growing season by using tillage operations. Both experiments were arranged in a randomized complete block design with four replications of the treatments.

Planting-time insecticide applications: Counter 20G was applied in both trials by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. Granular application rates were regulated by using a planter-mounted SmartBox™ computer-controlled insecticide delivery system that was calibrated on the planter immediately before all applications. In Study II, planting-time liquid insecticide treatments, which included Asana XL and a combination of Asana XL with Exponent, spray solutions were applied by using dribble in-furrow (DIF) placement. This involved directing the spray solution into the open seed furrow through microtubes (1/4" outside diam.). Inline Teejet™ No. 18 orifice plates were used to stabilize the spray volume output rate, and the system was calibrated to deliver a finished spray output volume of 5 gallons per acre (GPA).

Postemergence insecticide applications: Postemergence insecticides in Study I consisted of two granular materials (i.e., Counter 20G and Thimet 20G) that were both band-applied (Post B) on June 13 (i.e., 2 days before peak SBRM fly activity). Delivery of postemergence banded granules was achieved by using Kinze™ row banders that were attached to a tractor-mounted tool bar and adjusted to a height to deliver the insecticides in 4-inch bands. Similar to at-plant insecticide applications, postemergence granular output rates were also regulated by using a SmartBox™ system mounted on a tractor-drawn four-row toolbar. Granules were incorporated by using two pairs of rotary tines that straddled each row on the tool bar. A paired set of tines was positioned ahead of each bander, and a second pair was mounted behind the granular drop zone of each row unit. This system effectively stirred soil around the bases of sugarbeet seedlings and incorporated granules as the unit passed through each plot.

The postemergence spray applications of Mustang Maxx (Studies I and II) and Asana XL (Study II) were broadcast-applied on June 17 (i.e., 2 days after peak SBRM fly activity). Sprays were applied from a tractor-mounted CO_2-propelled spray system equipped with an 11-ft boom that was calibrated to deliver a finished spray output volume of 10 GPA through TeeJet™ 11001VS nozzles.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed for these experiments on August 1 (Study I) and August 2 (Study II). Rating procedures consisted of randomly collecting ten sugarbeet roots (i.e., five from each of the outer two treated rows) per plot, hand-washing them in a bucket of water, and scoring each 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 on the basis of sugarbeet yield parameters. Both studies were harvested on October 5. 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 soil using a mechanical harvester, and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

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), and treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

Study I. Results from sugarbeet root maggot feeding injury ratings for Study I are presented in Table 1. The level of root injury sustained by roots in the untreated check plots (mean = 6.43 on the 0 to 9 scale of Campbell et al. [2000]) suggested that a moderately high infestation of SBRM larvae was present for the experiment. Although the SBRM larval feeding pressure was not severe, differences among treatments with regard to root damage provided valuable insights associated with treatment program performance in managing this pest.

Significantly lower levels of SBRM feeding injury were recorded in all insecticide-protected treatments in Study I when compared to the untreated check. This showed that all insecticide treatments, including the stand-alone Poncho Beta seed treatment, a single at-plant application of Counter 20G insecticide, and the multiple-component insecticide combinations, provided significant levels of protection from SBRM feeding injury.

The greatest root protection (i.e., lowest overall SBRM larval injury) in Study I occurred in plots planted with Poncho Beta insecticide-treated seed and treated at planting with Counter 20G at its moderate (7.5 lb product/ac) rate, then subsequently treated with a postemergence application of Thimet 20G at its high rate (7 lb product per acre). Although that treatment sustained the lowest average SBRM feeding injury, it was not statistically superior to the following entries that also provided excellent root protection:

1) Poncho Beta + Counter 20G (8.9 lb/ac, at-plant band) + Thimet (7 lb/ac banded, 2d before peak fly); and

2) Counter 20G (8.9 lb/ac, at-plant band) + Thimet (7 lb/ac, 2d pre-peak) + Mustang Maxx 2d post-peak.

All triple-component control regimes in this trial resulted in significantly greater root protection from root maggot feeding injury when compared to the single-component treatments. Similarly, trends suggested that dual-component programs also tended to perform better with respect to root protection from SBRM feeding injury than single-component programs, although differences were not universally significant. The results from SBRM root injury ratings also showed that single-component control programs are not sufficient to protect the crop from moderately high root maggot infestations such as that which developed for this trial.

Table 1. *Larval feeding injury* in an evaluation of planting-time insecticide granules or seed treatments, combined with postemergence insecticides, for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study I)

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Poncho Beta + Counter 20G + Thimet 20G	Seed B 2 d Pre-peak Post B	 7.5 lb 7 lb	68 g a.i./ unit seed 1.5 1.4	1.70 e
Poncho Beta + Counter 20G + Thimet 20G	Seed B 2 d Pre-peak Post B	 8.9 lb 7 lb	68 g a.i./ unit seed 1.8 1.4	1.80 e
Counter 20G + Thimet 20G + Mustang Maxx	B 2 d Pre-peak Post B 2 d Post-peak Broadcast	8.9 lb 7 lb 4 fl oz	1.8 1.4 0.025	2.40 de
Counter 20G + Thimet 20G +	B 2 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	2.87 cd
Poncho Beta + Counter 20G +	Seed B	 8.9 lb	68 g a.i./ unit seed 1.8	2.90 cd
Poncho Beta + Counter 20G +	Seed 2 d Pre-peak Post B	 8.9 lb	68 g a.i./ unit seed 1.8	3.03 cd
Counter 20G	B	8.9 lb	1.8	3.33 c
Poncho Beta	Seed		68 g a.i./ unit seed	4.43 b
Check	---	----	---	6.43 a
LSD (0.05)				0.758

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 band; Post B = 4-inch postemergence band; Seed = insecticidal seed treatment

Yield data from Study I are presented in Table 2. All insecticide treatments in this experiment, including the single-component treatments involving Counter 20G or Poncho Beta, resulted in statistically significant increases in recoverable sucrose yield when compared to the untreated check. As observed in root injury rating results, the top-performing entry with regard to recoverable sucrose yield and gross economic return involved planting Poncho Beta insecticide-treated while applying Counter 20G at its moderate (7.5 lb product/ac) rate, combined with a postemergence application of Thimet 20G at its high rate (7 lb product per acre). That entry generated a gross revenue of $1,978/ac, which was $1,161/ac greater revenue than the untreated check plots. It also grossed $339 more revenue than plots protected solely by the planting-time application of Counter at 8.9 lb/ac and $556 more revenue than the single-component Poncho Beta treatment.

The following entries in Study I also provided excellent yields and gross economic returns, and were not statistically outperformed in relation to sucrose yield or root tonnage by the aforementioned top-performing treatment (i.e., Counter 20G at planting [7.5 lb/ac] + Thimet 20G [2d before peak fly, 7 lb/ac]):

1) Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb/ac, 2d before peak fly) + Mustang Maxx (4 fl oz/ac, 2d after peak fly);
2) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb/ac, 2d before peak fly);
3) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting);
4) Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb/ac, 2d before peak fly);
5) Counter 20G (8.9 lb/ac, banded at planting); and
6) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting).

Although these control programs resulted in numerically lower gross economic return than the aforementioned top-yielding treatment, they still generated between $822 and $1080/ac more gross revenue than that recorded for the untreated check plots. Additionally, these revenue increases would have easily paid for the product and application costs associated with their use, and also would have provided excellent net returns in revenue per acre for a producer.

Table 2. *Yield parameters* from an evaluation of planting-time insecticide granules or seed treatments, combined with postemergence insecticides, for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study I)

Treatment/ form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Poncho Beta + Counter 20G + Thimet 20G	Seed B 2 d Pre-peak Post B	 7.5 lb 7 lb	68 g a.i./ unit seed 1.5 1.4	10,311 a	31.8 a	17.13 a	1,978
Counter 20G + Thimet 20G + Mustang Maxx	B 2 d Pre-peak Post B 2 d Post-peak Broadcast	8.9 lb 7 lb 4 fl oz	1.8 1.4 0.025	9,869 a	30.3 a	17.21 a	1,897
Poncho Beta + Counter 20G + Thimet 20G	Seed B 2 d Pre-peak Post B	 8.9 lb 7 lb	68 g a.i./ unit seed 1.8 1.4	9,459 a	30.0 a	16.67 ab	1,768
Poncho Beta + Counter 20G	Seed B	 8.9 lb	68 g a.i./ unit seed 1.8	9,358 a	29.6 a	16.81 ab	1,754
Counter 20G + Thimet 20G +	B 2 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	9,082 ab	29.4 a	16.48 bc	1,665
Counter 20G	B	8.9 lb	1.8	8,898 ab	27.6 ab	16.99 ab	1,698
Poncho Beta + Counter 20G +	Seed 2 d Pre-peak Post B	 8.9 lb	68 g a.i./ unit seed 1.8	8,834 ab	28.3 ab	16.66 ab	1,639
Poncho Beta	Seed		68 g a.i./ unit seed	7,578 b	23.9 b	16.74 ab	1,422
Check	---	----	---	4,594 c	15.3 c	15.99 c	817
LSD (0.05)				1,555.7	4.56	0.647	

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 band; Post B = 4-inch postemergence band; Seed = insecticidal seed treatment

There were no significant differences in sucrose yield or root tonnage between dual- and triple-component control programs in Study I; however, all three triple-component insecticide programs generated numerically more sucrose yield, root tonnage, and gross revenue than dual- and single-component programs. Also, the addition of Mustang Maxx to plots initially established with an at-plant application of Counter 20G at its moderate (i.e., 7.5 lb product/ac) rate, combined with a postemergence application of Thimet 20G (7 lb product/ac) resulted in a numerical increase of 1,229 lb in recoverable sucrose yield (a 13.5% improvement) and $232 in additional revenue per acre when compared to the similar entry that lacked the Mustang.

Table 3 provides the results from a series of three counts of surviving plant stands conducted in Study II. All stand counts were conducted after the majority of SBRM fly activity had been completed. Therefore, it can be presumed that SBRM larval feeding injury had begun impacting plant survival before the first stand count was conducted at 28 days after planting (DAP). The highest stand counts at 28 DAP were observed in treatments that included a planting-time application of Counter 20G and/or a postemergence spray application of Mustang Maxx.

At the second stand count (42 DAP), nearly all insecticide programs provided significant levels of plant protection when compared to the stand loss incurred in the untreated check plots. The only exceptions to this were the two treatments comprised of single postemergence-only applications of Asana XL, which were applied either alone or tank mixed with Exponent insecticide synergist. NOTE: the postemergence-only applications of Asana XL (i.e., alone and mixed with Exponent) were only included in this experiment for comparative purposes. Sole reliance on a single postemergence insecticide treatment such as those evaluated in this trial are not recommended in areas where moderate to high SBRM infestations are expected.

Plant stand results from the final stand count (56 DAP) were similar to those from the 42 DAP counts, with excellent stand protection being observed in most treatments that involved dual- or triple-component insecticide programs. All insecticide regimes, except the single-component programs involving postemergence Asana, provided significant levels of plant stand protection when compared with the untreated check. The best overall final stands were recorded in plots that received a planting-time application of Counter 20G at its moderate (i.e., 7.5 lb product/ac) rate, which was combined with a postemergence application of Mustang Maxx at two days before peak SBRM fly activity; however, the following entries resulted in similar levels of stand protection that were not statistically different from that treatment:

1) Counter 20G (7.5 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d after peak fly) + Mustang Maxx (4 fl oz/ac, 8d post-peak);
2) NipsIt Inside treated seed + tank mixed Asana XL (9.6 fl oz) & Exponent (8 fl oz) 2d post-peak;
3) Counter 20G (7.5 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d post-peak) + Asana XL (9.6 fl oz, 5d post-peak) + Mustang Maxx (4 fl oz/ac, 8d post-peak);
4) NipsIt Inside + Asana XL (9.6 fl oz, 2d post-peak);
5) Counter 20G (7.5 lb/ac, banded at planting); and
6) NipsIt Inside + Asana XL (9.6 fl oz; applied dribble in-furrow [DIF] at planting).

Table 3. *Surviving Plant stand counts* from an evaluation of planting-time insecticide granules or seed treatments, combined with postemergence liquid insecticide sprays, for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study II)

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Stand count[b] (plants / 100 ft)		
				28 DAP[c]	42 DAP[c]	56 DAP[c]
Counter 20G + Mustang Maxx	B 2 d Post-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	232.1 a	215.5 a	199.3 a
Counter 20G + Mustang Maxx + Mustang Maxx	B 2 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.025	233.8 a	210.0 a	194.1 ab
NipsIt Inside Asana XL + Exponent	Seed 2 d Post-peak Broadcast	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	233.6 a	196.7 ab	190.2 abc
Counter 20G + Mustang Maxx + Asana XL + Mustang Maxx	B 2 d Post-peak Broadcast 5 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 9.6 fl oz 4 fl oz	1.5 0.025 0.025	237.4 a	217.1 a	189.1 abc
NipsIt Inside Asana XL	Seed 2 d Post-peak Broadcast	 9.6 fl oz	60 g a.i./ unit seed	228.3 ab	183.8 ab	179.5 abc
Counter 20G	B	7.5 lb	1.5	231.7 a	187.9 ab	175.0 abc
NipsIt Inside Asana XL	Seed DIF	 9.6 fl oz	60 g a.i./ unit seed	230.7 ab	189.1 ab	174.5 abc
NipsIt Inside Asana XL + Exponent	Seed DIF	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	204.5 c	175.0 b	163.6 bc
NipsIt Inside	Seed		60 g a.i./ unit seed	229.5 ab	175.5 b	160.2 c
Asana XL	2 d Post-peak Broadcast	9.6 fl oz		203.1 c	117.6 c	110.7 d
Asana XL + Exponent	2 d Post-peak Broadcast	9.6 fl oz 8 fl oz	60 g a.i./ unit seed	206.7 c	120.5 c	104.5 d
Check	---	---	---	212.4 bc	106.0 c	99.3 d
LSD (0.05)				18.48	33.80	32.30

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).

[a]Seed = insecticidal seed treatment; B = 5-inch band at planting; DIF = dribble in-furrow at planting

[b]Surviving plant stands were counted on June 23, July 7, and July 21 (i.e., 28, 42, and 56 days after planting [DAP], respectively).

Results from evaluations of sugarbeet root maggot larval feeding injury in Study II indicated that a high SBRM infestation developed for this trial. This is supported by the high level of root maggot feeding injury (i.e., 7.87 rating on the 0 to 9 scale) recorded for the untreated check plots (Table 4).

Most insecticide-treated entries provided significant reductions in SBRM feeding injury when compared to the untreated check, with the exceptions being the two postemergence-only Asana XL (i.e., with or without Exponent) treatments. The treatment combinations involving Counter 20G at planting, combined with postemergence applications of Mustang Maxx (single or repeated) and Asana XL (alternated with Maxx) provided the best protection from SBRM feeding injury in this trial. Counter 20G was an effective component that resulted in significant reductions in root maggot damage in this trial. The results also demonstrated the positive performance of Mustang Maxx in reducing SBRM feeding injury to plots that had initially been treated with Counter 20G.

In plots established with NipsIt Inside insecticidal seed treatment and an at-plant DIF application of Asana XL, the inclusion of Exponent, an insecticide synergist, resulted in a numerical reduction in SBRM feeding injury, but the difference was not statistically significant. Similarly, plots treated with a postemergence foliar application of Asana XL that was tank mixed with Exponent also resulted in a numerical reduction in SBRM feeding injury when compared with a similar postemergence application of Asana without the synergist; however, the difference was not significant.

Table 4. ***Larval feeding injury*** **from an evaluation of planting-time insecticide granules or seed treatments, combined with postemergence liquid insecticide sprays, for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study II)**

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Mustang Maxx	B 2 d Post-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	2.80 e
Counter 20G + Mustang Maxx + Asana XL + Mustang Maxx	B 2 d Post-peak Broadcast 5 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 9.6 fl oz 4 fl oz	1.5 0.025 0.025	3.23 e
Counter 20G + Mustang Maxx + Mustang Maxx	B 2 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.025	3.37 de
NipsIt Inside Asana XL + Exponent	Seed DIF	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	4.77 cd
NipsIt Inside Asana XL	Seed DIF	 9.6 fl oz	60 g a.i./ unit seed	4.93 c
Counter 20G	B	7.5 lb	1.5	4.97 c
NipsIt Inside Asana XL	Seed 2 d Post-peak Broadcast	 9.6 fl oz	60 g a.i./ unit seed	5.23 c
NipsIt Inside Asana XL + Exponent	Seed 2 d Post-peak Broadcast	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	5.37 bc
NipsIt Inside	Seed		60 g a.i./ unit seed	5.60 bc
Asana XL + Exponent	2 d Post-peak Broadcast	9.6 fl oz 8 fl oz	60 g a.i./ unit seed	6.77 ab
Asana XL	2 d Post-peak Broadcast	9.6 fl oz		7.13 a
Check	---	----	---	7.87 a
LSD (0.05)				1.433

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; Seed = insecticidal seed treatment; DIF = dribble in-furrow at planting

Yield results for Study II are presented in Table 5. Similar to the results from the final stand counts and the SBRM feeding injury rating data, the yield analyses showed that nearly all insecticide programs provided significant increases in both recoverable sucrose yield and root tonnage in this trial.

The highest overall recoverable sucrose yield in Study II was observed in plots initially treated at planting with Counter 20G at its moderate rate of 7.5 lb product per acre, which was followed by successive postemergence foliar applications of Mustang Maxx (4 fl oz/ac), Asana XL (9.6 fl oz/ac), and Mustang Maxx (4 fl oz) made at 2, 5, and 8 days after peak SBRM fly activity, respectively. That combination generated an average of $1,716 in gross revenue per acre, which was $869/ac more revenue than the untreated check, and at least $293/ac more than any single-component insecticide treatment in the experiment. This was an encouraging finding, because those application timings are not recommended or considered optimal for SBRM control. The late timing of those applications was due to a combination of factors. First, the plot area remained excessively wet well into mid-/late May, thus forcing exceptionally late planting. Secondly, despite the unfortunate delay for planting this trial, warm spring temperatures accelerated the accumulation of SBRM degree-day units to nearly normal levels by mid-June. The combination of those two factors resulted in abnormally young plants during mid-June when the postemergence sprays were applied, thus making plants more vulnerable to attack by newly hatched SBRM larvae. As such, the performance of the aforementioned treatment and other similar entries in the study was a positive result. Other treatments that performed at levels that were similar to, and did not differ significantly in recoverable sucrose yield from, the aforementioned top-yielding treatment included the following:

1) Counter 20G (7.5 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d after peak fly) + Mustang Maxx (4 fl oz/ac, 8d post-peak);
2) Counter 20G (7.5 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d post-peak);
3) NipsIt Inside + tank mixed Asana XL (9.6 fl oz) & Exponent (8 fl oz); applied dribble in-furrow (DIF) at planting;
4) NipsIt Inside treated seed + tank mixed Asana XL (9.6 fl oz) & Exponent (8 fl oz) 2d post-peak;
5) Counter 20G (7.5 lb/ac, banded at planting); and
6) NipsIt Inside.

As observed with both stand count and root injury rating data, the only treatments that failed to provide a statistically significant increase in recoverable sucrose or root yield when compared with the untreated check were the two treatments that involved a postemergence-only (i.e., no at-plant insecticide) application of Asana XL (i.e., when applied alone or tank mixed with Exponent).

Table 5. ***Yield parameters*** **from an evaluation of planting-time insecticide granules or seed treatments, combined with postemergence liquid insecticide sprays, for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study II)**

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 + Mustang Maxx + Asana XL + Mustang Maxx	B 2 d Post-peak Broadcast 5 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 9.6 fl oz 4 fl oz	1.5 0.025 0.025	8,786 a	26.5 ab	17.43 a	1,716
Counter 20G + Mustang Maxx + Mustang Maxx	B 2 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.025	8,632 a	27.4 a	16.73 a	1,611
Counter 20G + Mustang Maxx	B 2 d Post-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	8,510 ab	26.3 ab	17.13 a	1,631
NipsIt Inside Asana XL + Exponent	Seed DIF	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	8,499 ab	26.5 ab	16.96 a	1,616
NipsIt Inside Asana XL + Exponent	Seed 2 d Post-peak Broadcast	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	7,488 abc	23.8 abc	16.67 a	1,398
Counter 20G	B	7.5 lb	1.5	7,456 abc	23.1 bc	16.99 a	1,423
NipsIt Inside	Seed		60 g a.i./ unit seed	7,415 abc	23.3 bc	16.74 a	1,397
NipsIt Inside Asana XL	Seed 2 d Post-peak Broadcast	 9.6 fl oz	60 g a.i./ unit seed	7,199 bc	23.0 bc	16.50 a	1,339
NipsIt Inside Asana XL	Seed DIF	 9.6 fl oz	60 g a.i./ unit seed	7,055 c	22.1 c	16.84 a	1,337
Asana XL + Exponent	2 d Post-peak Broadcast	9.6 fl oz 8 fl oz	60 g a.i./ unit seed	5,126 d	16.7 d	16.27 a	934
Asana XL	2 d Post-peak Broadcast	9.6 fl oz		4,919 d	15.7 d	16.53 a	914
Check	---	----	---	4,736 d	15.7 d	15.97 a	847
LSD (0.05)				1418.5	3.94	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 band; Seed = insecticidal seed treatment

Collectively, the results of both Studies I and II demonstrate the economic significance of the sugarbeet root maggot as a major economic pest of sugarbeet in the Red River Valley. As such, the development implementation of effective control tools will continue to be critical to sustaining the profitability of sugarbeet production and maximizing economic returns in areas affected by this pest. The overall results of these trials also show that effective SBRM management can be achieved by combining at-plant insecticide protection that involves applying a granular insecticide such as Counter 20G, an insecticidal seed treatment (e.g., Poncho Beta or NipsIt

Inside), or a sprayable at-plant liquid insecticide (e.g., Asana XL), and combining it with a postemergence rescue insecticide (e.g., Thimet 20G, Mustang Maxx, or Asana XL) application.

Additionally, although differences were mostly numerical and only rarely significant, it appears that tank mixing pyrethroid insecticides with the insecticide synergist, Exponent, can result in improved SBRM control performance. Despite the relative lack of significant yield improvements with Exponent, the observed revenue increases it appeared to generate in this research suggest that it could prove to be a valuable aid in SBRM management programs. As such, further research should be conducted on Exponent to determine its future role in controlling this pest.

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