SCREENING ALTERNATIVE CHEMICAL TOOLS FOR SUGARBEET ROOT MAGGOT CONTROL

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is the most important insect pest of sugarbeet in the Red River Valley (RRV) growing area of North Dakota and Minnesota. Infestations of this pest in the RRV have been on an upward trend for well more than a decade, and they have also increased in geographic distribution. Successful SBRM management in areas affected by high to severe SBRM infestations typically requires aggressive insecticide-based control programs that consist of a granular insecticide and/or an insecticidal seed treatment at planting, followed by at least one postemergence insecticide application. Currently, RRV sugarbeet producers have a limited number of insecticide product options to use for both at-plant and postemergence SBRM control. This research was undertaken to evaluate registered and experimental insecticides, as well as an insecticide synergist, for efficacy at controlling this serious economic pest of sugarbeet.

Materials and Methods:

This report presents the findings from two field trials on registered and experimental insecticides for sugarbeet root maggot control. Both trials were conducted on a commercial sugarbeet field site near St. Thomas, ND during the 2023 growing season. Glyphosate- and Cercospora leaf spot-resistant seed (i.e., Betaseed 8018 CR+) was used for all treatments in both trials. Persistent early-season soil moisture delayed planting of both trials. Study I was planted on June 1 and Study II was planted on May 28. All plots were planted using a 6-row Monosem NG Plus 4 7x7 planter set to deliver seed 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" row on each side of the plot served as an untreated buffer. Each plot was 35 feet long, and 35-foot tilled alleys were maintained between replicates throughout the growing season. Both experiments were arranged in a randomized complete block design with four replications of the treatments.

<u>Planting-time insecticides</u>. Counter 20G was the planting-time granular insecticide standard used in both trials, and it was applied at either a moderate rate of 7.5 lb product per acre or its maximum labeled rate of 8.9 lb/ac. Counter 20G 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 output was regulated by using a planter-mounted SmartBox™ electronic insecticide delivery system that had been calibrated on the planter before all applications.

Additional planting-time insecticides evaluated in Study I included Poncho Beta insecticidal seed treatment, and four sprayable liquid insecticides: Asana XL, Midac FC, Mustang Maxx, and Verimark, which all represented alternative insecticide classes to the organophosphate group that has been used for decades to control the sugarbeet root maggot. Asana XL and Mustang Maxx belong to the pyrethroid insecticide class, Midac FC is a neonicotinoid, and Verimark belongs to the diamides, a relatively new class of insecticides that involves a completely novel mode of action to that of the other classes.

All planting-time insecticides in Study I 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 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.

<u>Postemergence insecticide applications</u>. The postemergence component in the only dual insecticide (i.e., planting-time + postemergence) program treatment in Study I involved a broadcast application of Mustang Maxx (active ingredient: zetacypermethrin). In Study II, postemergence insecticides evaluated included Asana XL, Exirel Insect Control, and Mustang Maxx. Treatments in Study II that included postemergence insecticides involved both single and dual postemergence spray applications, a combination of Mustang Maxx and Asana, and comparisons of the two pyrethroid insecticides (Asana XL and Mustang Maxx) that were either applied alone or in a tank mixture

with Exponent. Exponent is a synergistic product that can increase the effectiveness of pyrethroid insecticides by interfering with the ability of insects to detoxify insecticides.

The aforementioned delayed planting that resulted from excessive spring soil moisture, combined with slow seedling emergence and unseasonably early SBRM fly emergence, led to corresponding delays with executing postemergence insecticide applications in both Studies I and II. The first postemergence applications in these studies were made 6 days after peak SBRM fly activity. Additionally, one treatment combination in Study II included a 10-day post-peak application of Asana XL, which was the second application in a rotated postemergence insecticide regime in plots that had received an initial application of Mustang Maxx at 6 days post-peak. All postemergence liquid insecticides were applied with a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ XR 110015VS nozzles calibrated to deliver applications in a finished output volume of 10 GPA.

<u>Plant stand counts</u>: Treatments in each study were evaluated on the basis of plant stand establishment and survival by conducting precise visual counts at several points in the growing season. This effort was undertaken to screen for any potential insecticide impacts on seedling emergence or on protection from plant losses due to SBRM feeding injury. Stand counts involved quantifying all living plants within the four 35-ft-long rows of each plot. Stand counts were carried out in Study I on June 29 and on July 6, 11, and 18, 2023, which were 28, 35, 40, and 47 days after planting (DAP), respectively. Stands were counted in Study II on June 30, July 10, and July 17, 2023, which equated to 33, 43, and 50 DAP, respectively.

<u>Root injury ratings</u>. Sugarbeet root maggot feeding injury ratings were conducted in Test I on July 27 and in Test II on July 26, 2023. A random sample of ten beet roots (five from each of the outer two treated rows) was collected from each plot, hand-washed, and scored 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).

<u>Harvest</u>. Treatment performance was also compared on the basis of sugarbeet yield parameters. Both studies were harvested on October 2, 2023. 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.

<u>Data analysis</u>. All data from root injury ratings and harvest samples were subjected to analysis of variance (ANOVA) according to the general linear models (GLM) procedure (SAS Institute, 2012). Treatment means were compared by using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

<u>Study I</u>. Stand count data from Study I are presented in Table 1. At the first stand count (28 DAP), the highest stand counts in this experiment were recorded in plots that received the treatment combination of Poncho Beta-treated seed plus a planting-time application of Midac FC followed by a postemergence application of Mustang Maxx. Excellent plant stands were also recorded for the following entries, all of which were not statistically different from the top-ranked treatment in the experiment (listed in descending order of surviving stand count):

1) Counter 20G (planting-time band, 7.5 lb product/ac) + Asana XL (DIF, 9.6 fl oz/ac);
2) Poncho Beta-treated seed + Midac FC (DIF, 13.6 fl oz/ac);
3) Verimark (DIF, 10 fl oz/ac); and
4) Counter 20G (planting-time band, 7.5 lb product/ac).

Those same treatments continued to provide excellent stand protection through all remaining stand count dates, with no significant differences among them at any date. Additionally, plots protected by Poncho Beta seed treatment resulted in surviving plant stands that were not significantly different from any of the aforementioned treatments at the remaining three stand evaluations (35, 40, and 47 DAP). At the final (47 DAP) stand count, the lowest plant densities per 100 row feet included the untreated check, Mustang Maxx, Mustang Maxx plus Exponent, Midac FC, Counter 20G plus a tank-mixed combination of Asana XL and Exponent, and Verimark at its lower (5 fl oz/ac) rate. Plant stands did not differ significantly among any of these treatments.

Table 1. *Plant stand counts* from an evaluation of experimental and registered insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023							
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Stand count[b] (plants / 100 ft)**			
				28 DAP	**35 DAP**	**40 DAP**	**47 DAP**
Poncho Beta + Midac FC + Mustang Maxx	Seed DIF 6d Post-peak Broad.	 13.6 fl oz 4 fl oz	68 g a.i./ unit seed 0.18 0.025	190.4 a	189.5 a	195.5 a	197.9 a
Counter 20G + Asana XL	B DIF	7.5 lb 9.6 fl oz	1.5 0.05	178.9 abc	175.9 ab	185.0 ab	188.9 ab
Poncho Beta + Midac FC	Seed DIF	 13.6 fl oz	68 g a.i./ unit seed 0.18	181.4 ab	180.5 a	191.8 a	188.6 ab
Verimark	DIF	10 fl oz	0.13	176.1 a-d	176.6 ab	185.7 ab	181.8 abc
Counter 20G	B	7.5 lb	1.5	172.5 a-e	173.0 abc	176.1 abc	179.1 a-d
Poncho Beta	Seed		68 g a.i./ unit seed	153.9 b-f	162.0 a-d	170.2 abc	173.0 a-e
Verimark	DIF[b]	5 fl oz	0.065	161.6 a-f	167.0 a-d	175.7 abc	169.1 b-e
Counter 20G + Asana XL + Exponent	B DIF	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	147.7 c-f	147.5 bcd	153.9 bcd	160.0 cde
Midac FC	DIF	13.6 fl oz	0.18	144.6 def	147.7 bcd	155.7 bcd	159.5 cde
Mustang Maxx + Exponent	DIF	4 fl oz 4 fl oz	0.025 0.25	140.2 f	144.3 cd	148.8 cd	153.6 de
Mustang Maxx	DIF	4 fl oz	0.025	141.1 ef	143.2 d	150.4 cd	151.6 de
Check	-----	----	-----	135.0 f	137.5 d	133.8 d	146.3 e
LSD (0.05)				32.0	29.6	32.2	27.8

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; DIF = dribble in-furrow; Post-Peak Broad. = postemergence broadcast at 6 days after peak SBRM fly activity.
[b] Surviving plant stands were counted on 29 June, and 6, 11, and 18 July, 2023 (i.e., 28, 35, 40, and 47 days after planting [DAP], respectively).

Sugarbeet root maggot feeding injury ratings in the untreated check plots in Study I averaged 5.00 on the 0 to 9 scale of Campbell et al. (2000) (Table 2), suggesting that a moderate SBRM infestation was present. Most insecticide treatment combinations evaluated resulted in significant reductions in sugarbeet root maggot feeding injury when compared to the untreated check.

Table 2. *Larval feeding injury* in an evaluation of experimental and registered insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023				
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Counter 20G + Asana XL	B DIF	7.5 lb 9.6 fl oz	1.5 0.05	1.00 e
Counter 20G + Asana XL + Exponent	B DIF	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	1.78 de
Counter 20G	B	7.5 lb	1.5	1.85 de
Poncho Beta + Midac FC	Seed DIF	68 g a.i./ unit seed 13.6 fl oz	68 g a.i./ unit seed 0.18	2.48 cd
Mustang Maxx + Exponent	DIF	4 fl oz 4 fl oz	0.025 0.25	2.78 bcd
Poncho Beta +	Seed	68 g a.i./ unit seed	68 g a.i./ unit seed	2.88 bcd

Midac FC + Mustang Maxx	DIF 6d Post-peak Broad.	13.6 fl oz 4 fl oz	0.18 0.025	
Poncho Beta	Seed	68 g a.i./ unit seed	68 g a.i./ unit seed	3.10 bc
Midac FC	DIF	13.6 fl oz	0.18	3.20 bc
Verimark	DIF	10 fl oz	0.13	3.20 bc
Verimark	DIF[b]	5 fl oz	0.065	3.50 bc
Mustang Maxx	DIF	4 fl oz	0.025	3.90 ab
Check	-----	----	-----	5.00 a
LSD (0.05)				1.19

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; DIF = dribble in-furrow; Post-Peak Broad. = postemergence broadcast at 6 days after peak SBRM fly activity.

The best root protection from SBRM feeding injury in Study I was provided by the treatment combination of Counter 20G (7.5 lb product/ac) plus a DIF application of Asana XL applied at its maximum labeled rate (9.6 fl oz/ac) at planting time. Other treatments that performed well with respect to protection from SBRM feeding injury included the triple-component planting-time treatment of Counter 20G (7.5 lb/ac) plus the tank mixture of Asana XL and Exponent (the insecticide synergist), and Counter 20G at 7.5 lb alone. It appears that the most impactful common component in the best-performing treatments in this trial was the planting-time application of Counter 20G. The only treatment that failed to provide a significant reduction in SBRM feeding injury in comparison to the untreated check was the single, at-plant DIF application of Mustang Maxx. Combining Mustang Maxx with Exponent resulted in much lower levels of root maggot feeding injury than those observed in the Mustang Maxx-only plots; however, the reduction was not statistically significant.

Yield and gross economic return (i.e., excluding product and application costs) results from Study I are presented in Table 3. The highest recoverable sucrose yield and root tonnage in Study I were observed in plots treated with the single-component treatment of Counter 20G at 7.5 lb product per acre. Excellent performance, with regard to yield parameters, was also observed in the following treatments, which were not significantly different from the Counter-only treatment or each other in recoverable sucrose yield or root yield produced:

1) Counter 20G (planting-time band, 7.5 lb product/ac) + Asana XL (DIF, 9.6 fl oz/ac) + Exponent (8 fl oz/ac);
2) Poncho Beta-treated seed + Midac FC (DIF, 13.6 fl oz/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac);
3) Counter 20G (planting-time band, 7.5 lb product/ac) + Asana XL (DIF, 9.6 fl oz/ac);
4) Verimark (DIF, 10 fl oz/ac); and
5) Verimark (DIF, 5 fl oz/ac).

Although the two Verimark treatments resulted in yields that were not statistically different from the 7.5-lb rate of Counter 20G, it should be noted that neither rate of Verimark resulted in a significant increase in sucrose or root yield when compared with the untreated check, thus suggesting that this product provides moderate SBRM control. Other treatments that produced yields that were not significantly different from the check included Poncho Beta plus Midac FC, Poncho Beta alone, Mustang Maxx plus Exponent, Mustang Maxx alone, and Midac FC alone.

Table 3. *Yield parameters* from an evaluation of experimental and registered insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023

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	7.5 lb	1.5	12,073.5 a	37.8 a	16.98 a	2,943
Counter 20G + Asana XL + Exponent	B DIF	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	11,132.2 ab	36.2 ab	16.40 a	2,618
Poncho Beta + Midac FC + Mustang Maxx	Seed DIF 6d Post-peak Broad.	13.6 fl oz 4 fl oz	68 g a.i./ unit seed 0.18 0.025	10,964.2 abc	35.4 abc	16.55 a	2,597
Counter 20G + Asana XL	B DIF	7.5 lb 9.6 fl oz	1.5 0.05	10,943.4 abc	35.2 abc	16.58 a	2,603
Verimark	DIF	10 fl oz	0.13	10,907.5 a-d	34.8 a-d	16.70 a	2,612

Verimark	DIF[b]	5 fl oz	0.065	10,842.9 a-d	34.7 a-d	16.70 a	2,592
Poncho Beta + Midac FC	Seed DIF	13.6 fl oz	68 g a.i./ unit seed 0.18	10,297.2 bcd	33.3 bcd	16.48 a	2,431
Poncho Beta	Seed		68 g a.i./ unit seed	10,050.5 bcd	32.2 bcd	16.55 a	2,396
Mustang Maxx + Exponent	DIF	4 fl oz 4 fl oz	0.025 0.25	9,894.2 bcd	32.1 bcd	16.38 a	2,333
Mustang Maxx	DIF	4 fl oz	0.025	9,845.0 bcd	31.6 cd	16.50 a	2,343
Midac FC	DIF	13.6 fl oz	0.18	9,377.1 cd	31.3 cd	16.08 a	2,145
Check	-----	----	-----	9,293.5 d	30.6 d	16.25 a	2,156
LSD (0.05)				1,623.4	4.5	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; DIF = dribble in-furrow; Post-Peak Broad. = postemergence broadcast at 6 days after peak SBRM fly activity.

As observed with the SBRM feeding injury rating results, Counter 20G appeared to be a major factor in the success of most of the better-performing treatments in this trial. Another pattern observed in Study I was that additive insecticide applications in plots planted with Poncho Beta-treated seed provided large numerical yield and revenue increases. For example, the triple-component combination treatment that included Poncho Beta-treated seed, a planting-time application of Midac FC, and a postemergence broadcast of Mustang Maxx yielded 667 lb more recoverable sucrose and generated a revenue increase of $166/ac when compared to a similar treatment that lacked the postemergence application of Mustang Maxx. Similarly, plots protected by the triple-component treatment produced an increase of 1,082 lbs/ac in recoverable sucrose when compared to the Poncho Beta-only treatment. The revenue increase provided by Midac FC and Mustang Maxx in that comparison was $254/ac.

Study II. Stand count results from Study II are presented in Table 4. There were no significant differences between any treatments in the experiment, even though average stands between some entries differed by over 30%. That was the case in all three stand count dates. The absence of statistically significant differences, despite widely disparate average stand counts between treatments, was a product of high within-treatment variability in stand counts between replicates in the experiment.

There are some encouraging inferences that can be made on treatment performance regarding sugarbeet root maggot control, as well as some potential plant health impacts that can be at least suggested from the data in Study II. For example, numerically higher plant densities per unit row length were observed in plots protected by the following treatment combinations: Counter 20G at its moderate rate (7.5 lb product/ac) plus a postemergence application of either Mustang Maxx or Asana tank mixed with Exponent insecticide synergist, and Counter 20G (7.5 lb/ac) plus postemergence-applied Mustang Maxx, followed by an application of Asana XL. Another interesting and concerning result was that plots treated with Counter 20G at its high labeled rate (8.9 lb product/ac) had the lowest average stands in the experiment at each stand count date.

Another encouraging observation in Study II was that postemergence applications of Exirel Insect Control, a product that has never previously been evaluated for SBRM control in the Red River Valley, resulted in comparable surviving plant stands to those of several of the conventional insecticides. This was an unexpected result, because applications of Exirel, as well as those of all other postemergence insecticides in this experiment, were applied atypically late (i.e., between 6 and 10 days after SBRM peak fly activity), which was well after SBRM females had been laying eggs for over a week.

Table 4. *Plant stand counts* from an evaluation of planting-time and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Stand count[b] (plants / 100 ft)		
				33 DAP[c]	43 DAP[c]	50 DAP[c]
Counter 20G + Mustang Maxx + Exponent	B 6d Post-peak Broad.	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.25	102.7 a	103.4 a	104.3 a
Counter 20G + Mustang Maxx + Asana XL +	B 6d Post-peak Broad. 10d Post-peak Broad.	7.5 lb 4 fl oz 9.6 fl oz	1.5 0.025 0.05	102.3 a	100.1 a	103.6 a
Counter 20G Asana XL + Exponent	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	104.8 a	105.4 a	101.3 a
Mustang Maxx	6d Post-peak Broad.	4 fl oz	0.025	101.3 a	97.9 a	98.6 a
Exirel Insect Control	6d Post-peak Broad.	20 fl oz		98.0 a	95.5 a	96.4 a
Counter 20G +	B	7.5 lb	1.5	96.4 a	98.0 a	96.1 a

Mustang Maxx	6d Post-peak Broad.	4 fl oz	0.025			
Exirel Insect Control	6d Post-peak Broad.	13 fl oz		96.1 a	93.9 a	92.7 a
Counter 20G Asana XL	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz	1.5 0.05	88.6 a	91.3 a	92.1 a
Counter 20G	B	7.5 lb	1.5	85.7 a	88.9 a	89.5 a
Check	---	---	---	74.1 a	73.4 a	74.5 a
Counter 20G	B	8.9 lb	1.8	69.1 a	68.4 a	69.82 a
LSD (0.05)				NS	NS	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; Post-Peak Broad. = postemergence broadcast at either 6 or 10 days after peak SBRM fly activity.

[b]Surviving plant stands were counted on June 30, and July 10 and 17, 2023 (i.e., 33, 43, and 50 days after planting [DAP], respectively).

Sugarbeet root maggot feeding injury rating results from Study II appear in Table 5. Performance patterns associated with protection from SBRM larval feeding injury corresponded well with stand count data, but there were several statistically significant differences among treatments. All insecticide entries, except the lower (5 fl oz/ac) of Exirel Insect Control, provided significant reductions in SBRM feeding injury when compared to that sustained in the untreated check. The following treatments provided the greatest levels of protection from root maggot feeding injury in this experiment, and they were not significantly different from each other (listed in descending order of performance):

1) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac) + Asana XL (10-day post-peak broadcast, 9.6 fl oz/ac);
2) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac)
3) Counter 20G (planting-time band, 7.5 lb product/ac) + Asana XL (6 day Post-peak Broadcast, 9.6 fl oz/ac); and
4) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac; tank-mixed with Exponent at 4 fl oz/ac).

Interestingly, the root protection from SBRM feeding injury provided by Exirel Insect Control at its high (10 fl oz/ac) rate was not significantly different from that provided by Counter at either its moderate (7.5 lb product/ac) or high (8.9 lb/ac) rate. This result is somewhat surprising and quite encouraging because, as previously mentioned, there was no planting-time insecticide protection in the Exirel plots and the postemergence application of that insecticide was made at six days after peak SBRM fly activity.

Table 5. *Larval feeding injury* ratings from an evaluation of planting-time and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Mustang Maxx + Asana XL +	B 6d Post-peak Broad. 10d Post-peak Broad.	7.5 lb 4 fl oz 9.6 fl oz	1.5 0.025 0.05	0.73 e
Counter 20G + Mustang Maxx	B 6d Post-peak Broad.	7.5 lb 4 fl oz	1.5 0.025	1.28 de
Counter 20G Asana XL	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz	1.5 0.05	1.48 cde
Counter 20G + Mustang Maxx + Exponent	B 6d Post-peak Broad.	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.25	1.55 cde
Counter 20G Asana XL + Exponent	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	1.83 cd
Counter 20G	B	8.9 lb	1.8	2.35 bc
Counter 20G	B	7.5 lb	1.5	2.90 b
Exirel Insect Control	6d Post-peak Broad.	20 fl oz		3.13 b
Mustang Maxx	6d Post-peak Broad.	4 fl oz	0.025	3.13 b
Exirel Insect Control	6d Post-peak Broad.	13 fl oz		4.20 a
Check	---	---	---	4.93 a
LSD (0.05)				0.98

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; Post-Peak Broad. = postemergence broadcast at either 6 or 10 days after peak SBRM fly activity.

Yield, quality, and gross revenue results from Study II are presented in Table 6. Insecticide program performance patterns in relation to yield parameters corresponded closely to those from stand count and SBRM feeding injury assessments. Despite the late planting date for this experiment, yields from several insecticide-protected plots were high. The single-component treatment of Counter 20G, applied at planting at its moderate rate (7.5 lb product/ac) was the only insecticide treatment in Study II that did not provide a significant increase in recoverable sucrose yield when compared to the untreated check. The greater-performing treatments in the experiment, none of which were significantly different from each other with regard to recoverable sucrose yield, included the following (listed in descending order of performance):

1) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac; tank-mixed with Exponent at 4 fl oz/ac);
2) Counter 20G (planting-time band, 7.5 lb product/ac) + Asana XL (6-day Post-peak Broadcast, 9.6 fl oz/ac; tank-mixed with Exponent at 4 fl oz/ac);
3) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac) + Asana XL (10-day post-peak broadcast, 9.6 fl oz/ac); and
4) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac).

As observed with SBRM feeding injury results, postemergence applications of Exirel Insect Control provided encouraging yield benefits, especially when the product was applied at its high (10 fl oz per acre) rate. The only treatment combination in Study II that significantly outperformed the high rate of Exirel was the treatment comprised of Counter 20G applied at planting at its moderate (7.5 lb) rate plus a postemergence tank mixture of Mustang Maxx (4 fl oz/ac) and Exponent (4 oz/ac).

Table 6. *Yield parameters* from an evaluation of planting-time and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023

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 + Exponent	B 6d Post-peak Broad.	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.25	11,309.3 a	36.5 a	16.70 a	2,680
Counter 20G Asana XL + Exponent	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	10,808.8 ab	35.9 ab	16.25 a	2,484
Counter 20G + Mustang Maxx + Asana XL +	B 6d Post-peak Broad. 10d Post-peak Broad.	7.5 lb 4 fl oz 9.6 fl oz	1.5 0.025 0.05	10,346.5 ab	33.5 ab	16.63 a	2,444
Counter 20G + Mustang Maxx	B 6d Post-peak Broad.	7.5 lb 4 fl oz	1.5 0.025	9,660.6 ab	31.8 ab	16.37 a	2,238
Counter 20G Asana XL	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz	1.5 0.05	9,570.6 b	31.7 ab	16.32 a	2,204
Exirel Insect Control	6d Post-peak Broad.	13 fl oz		9,529.3 b	31.9 ab	16.16 a	2,169
Mustang Maxx	6d Post-peak Broad.	4 fl oz	0.025	9,367.7 bc	31.9 ab	15.90 a	2,095
Exirel Insect Control	6d Post-peak Broad.	20 fl oz		9,166.5 bc	30.7 bc	16.13 a	2,087
Counter 20G	B	8.9 lb	1.8	9,112.3 bc	31.6 ab	15.65 a	1,994

Counter 20G	B	7.5 lb	1.5	7,683.0 cd	26.1 c	15.82 a	1,723
Check	---	---	---	6,355.1 d	20.5 d	16.47 a	1,503
LSD (0.05)				1,714.8	5.40	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; Post-Peak Broad. = postemergence broadcast made at either 6 or 10 days after peak SBRM fly activity.

The results of Studies I and II should be interpreted with discretion, in large part, due to the atypically late planting dates (June 1 and May 28, respectively). In addition to late planting, seedlings were slow to emerge because of a lack of post-planting rainfall. Unfortunately, unseasonably warm spring weather accelerated SBRM development and emergence, which led to peak fly activity occurring about one weak earlier than the historical average. It is likely that a limited amount of emerged sugarbeet seedlings were available for egg deposition by adult female SBRM flies. Thus, some insecticide treatment performance results in these trials could appear more favorable than might have otherwise occurred under more average conditions. However, the root injury and yield results in both studies were encouraging with regard to planting-time-only treatment combinations (Study I) and multi-component treatments involving integrations of planting-time and postemergence treatments (Study II), despite the late (i.e., 6 and/or 10 days post-peak) timing for those additive insecticide applications.

Another finding of concern occurred in Study II, in which the high (8.9 lb product/ac) rate of Counter 20G resulted in disappointingly low plant stands when compared to those in plots treated with the moderate (7.5-lb) rate of Counter. This could suggest that, in some years, a moderate rate of Counter 20G, followed by a more aggressive approach to postemergence insecticide use, could optimize the resulting impacts on sugarbeet yield, quality, and revenue, and help avoid potential negative yield/quality effects.

Sugarbeet producers who perennially experience the threat of economically damaging SBRM infestations should consider an integrated at-plant insecticide strategy, such as combining an insecticide seed treatment with an at-plant sprayable liquid insecticide or combining a granular and seed treatment insecticide, and then following it with an aggressive postemergence liquid insecticide approach that involves one to two insecticide applications. Another viable, although more expensive, option would be to invest in equipment for applying postemergence applications of a granular organophosphate insecticide product. Finally, the results of these experiments demonstrate that the root protection, yield, and revenue benefits from additive postemergence insecticides are cost-effective control strategies that would easily pay for themselves in areas where moderately high to severe SBRM populations occur.

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