ONE-PASS INSECTICIDE, FUNGICIDE, AND STARTER FERTILIZER APPLICATIONS: AN EVALUATION OF SUGARBEET ROOT MAGGOT CONTROL AND PLANT SAFETY

Mark A. Boetel, Associate Professor
Peter C. Hakk, Research Specialist
Reed R. Thoma, Graduate Research Assistant

Department of Entomology, School of Natural Resource Sciences, North Dakota State University, Fargo, ND

Introduction:

The practice of combining pesticide and fertilizer applications into a single implement pass through the field, either during planting operations or after emergence of the crop, can be a valuable and cost-effective strategy for producers. However, the impacts of such combinations on plant health or pest control efficacy should be thoroughly investigated before the practices can be recommended for implementation.

Insect pests that attack the roots of sugarbeet, including the sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), springtails, wireworms, and white grubs are annual threats to the crop throughout much of the Red River Valley (RRV) production area. Producers typically manage these pests by applying a prophylactic insecticide during sugarbeet planting. This at-plant protection usually involves a granular or sprayable liquid insecticide, insecticide-treated seed, or a combination of these tools. In situations where high SBRM fly activity and associated risk of economic loss due to larval feeding pressure are expected, most producers also supplement at-plant insecticide(s) with a postemergence granular or sprayable liquid insecticide application.

Fungicides are also frequently used to manage soil-borne root diseases of sugarbeet such as Rhizoctonia damping off, crown rot, and root rot, all of which are caused by the pathogen *Rhizoctonia solani* Kühn. Similar to the insecticides used to manage root-feeding insect pests, fungicides targeting Rhizoctonia management in sugarbeet also can be delivered as planting-time and/or early-season postemergence applications.

The use of starter fertilizer at planting time is also a common practice of the region's sugarbeet producers. There is strong interest among producers in combining the application of these materials into single passes across the field at sugarbeet planting; however, little is known about the crop safety of the combinations or if they either complement or impair pesticide performance. If demonstrated as safe for the crop and at least neutral with respect to the impacts on pest management performance, consolidating the delivery of these products into tank-mixed combinations or concurrent (i.e., single-pass) applications would provide major time savings and reduce application-associated input costs for sugarbeet growers. This project involved two studies that were carried out to evaluate the impact of multicomponent application systems on sugarbeet root maggot control. A secondary objective was to monitor for any potential symptoms of phytotoxic effects of the treatment combinations, including impacts on plant emergence and survival.

Materials and Methods:

These experiments were conducted during the 2024 growing season in a commercial sugarbeet field site near St. Thomas in rural Pembina County, ND. Study I was planted on May 20, 2024, and Study II was planted on May 17. Betaseed 8018, a glyphosate- and Cercospora leaf spot-tolerant seed variety, was used for all treatments in both experiments. 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 was used to plant the trial. Plots were six rows (22-inch spacing) wide by 35 ft long with the four centermost rows treated. The outer "guard" row on each side of the plot served as an untreated buffer. Thirty-five-foot tilled, plant-free alleys were maintained between replicates throughout the growing season. Both experiments were arranged in a randomized complete block design with four replications.

<u>Planting-time insecticide applications</u>. Planting-time applications of Counter 20G in both experiments were applied 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 planter-mounted SmartBox™ electronic insecticide delivery system that had been calibrated on the planter before all applications.

Planting-time liquid spray applications applied concurrently to the Counter applications in Study I included AZteroid fungicide (active ingredient: azoxystrobin), either alone or tank-mixed with starter fertilizer (i.e., either 6-24-0 or 10-34-0), and they were delivered by using dribble in-furrow (DIF) placement. Dribble in-furrow treatments were applied in a 3:2-gallon ratio of three gallons starter fertilizer to two gallons water spray solution, and the applications were made by orienting a microtube (1/4" outside diam.) directly into the open seed furrow. An electric ball valve system, equipped with inline Teejet™ No. 20 orifice plates was used to propel spray output from the microtubes at a finished volume of five gallons per acre (GPA).

Postemergence insecticide applications. Postemergence foliar liquid insecticides evaluated (Study II only) included Mustang Maxx (active ingredient: zeta-cypermethrin) and Pilot 4E (active ingredient: chlorpyrifos), and the fungicides tank-mixed with them included either Elatus (active ingredients: a combination of azoxystrobin and benzovindiflupyr), Excalia (active ingredient: indiflin), or Quadris (active ingredient: azoxystrobin). Treatment combinations that included postemergence insecticides and fungicides in Study II were applied on June 11, which was about five days before peak SBRM fly activity (i.e., "pre-peak"). Postemergence liquid treatments were delivered with a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ XR 110015VS nozzles. The system was calibrated to deliver a finished output volume of 10 GPA.

Plant Stand Counts: To determine at-plant treatment impacts on seedling emergence and survival throughout the growing season, surviving plant stands were counted in Study I on May 30, June 25, July 8, and July 17 2024 (i.e., 10, 36, 49, and 58 days after planting [DAP], respectively). Those assessments involved counting all living plants within each 35-ft-long row. Raw stand counts were then converted to plants per 100 linear row feet for the analysis.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in Study I on August 8, 2024 and in Study II on August 9, 2024. Sampling consisted of randomly collecting ten beet roots per plot (five from each of the outer two treated rows), hand-washing them, and scoring 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 on the basis of sugarbeet yield parameters. Study I was harvested on October 2 and Study II was harvested on October 3, 2024. 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 plant stand counts, 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. The results from a series of four counts of surviving plant stands in Study I are shown in Table 1. At the first stand count, which was carried out at 10 days after planting (DAP), most treatments, including the untreated check, hovered at around 45 to 55% of expected stand, and there were no significant differences among treatments. At the second stand count (36 DAP), the lowest stands were recorded in the 6-24-6 and 10-34-0 fertilizer controls, and the 10-34-0 control plots had significantly lower stands per 100 ft than the untreated no-fertilizer untreated check. There were no other consistent treatment-related responses involving the fungicide/insecticide/ fertilizer combination treatments at the second stand count date.

There were no significant stand count differences among treatments, including the fertilizer controls, at the third (49 DAP) and fourth (58 DAP) stand count dates. However, trends suggest that 6-24-6 starter fertilizer is safer and less negatively impactful on seedling survival than 10-34-0 fertilizer. Stand count data from the last two dates also suggests that tank mixing AZteroid fungicide with 10-34-0 starter fertilizer and combining the application with a planting-time application of Counter 20G could reduce surviving plant populations, although the observed differences were not statistically significant.

Table 1. *Plant stand counts* from an evaluation of at-plant insecticide, azoxystrobin fungicide, and starter fertilizer combinations in sugarbeet, St. Thomas, ND, 2024 (Study I)							
Treatment/form.	**Placement[a]**	**Rate[b] (product/ ac)**	**Rate (lb a.i./ac)**	**Stand count[c] (plants / 100 ft)**			
				10 DAP[c]	**36 DAP[c]**	**49 DAP[c]**	**58 DAP[c]**
Counter 20G + 6-24-6	B DIF	7.5 lb 5 GPA	1.5 ---	108.4 a	215.4 ab	219.3 a	211.3 a
Counter 20G + 6-24-6	B DIF	8.9 lb 5 GPA	1.8 ---	114.6 a	214.1 abc	216.6 a	208.8 a
Counter 20G + AZteroid FC 3.3 + 6-24-6	B DIF DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.15 ---	98.0 a	210.9 abcd	223.0 a	208.6 a
Counter 20G + AZteroid FC 3.3 + 6-24-6	B DIF DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15 ---	96.3 a	217.9 ab	214.1 a	207.5 a
Counter 20G	B	7.5 lb	1.5	98.9 a	221.1 a	220.5 a	206.3 a
Counter 20G	B	8.9 lb	1.8	101.4 a	219.1 ab	219.5 a	206.3 a
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8 ---	95.4 a	208.0 abcd	214.1 a	202.3 a
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5 ---	103.9 a	211.8 abc	215.2 a	201.6 a
Untreated	---	---	---	103.6 a	211.3 abc	204.5 a	201.1 a
6-24-6	DIF	5 GPA	---	88.0 a	201.4 cd	201.4 a	198.4 a
Counter 20G + AZteroid FC+ 10-34-0	B DIF DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15 ---	80.0 a	206.3 bcd	209.5 a	197.3 a
Counter 20G + AZteroid FC 3.3 + 10-34-0	B DIF DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.15 ---	84.6 a	208.2 abcd	209.8 a	196.3 a
10-34-0	DIF	5 GPA	---	90.5 a	197.3 d	202.3 a	190.4 a
LSD (0.05)				NS	13.6	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; DIF = dribble in-furrow.
[b]At-plant sprays were delivered in a 10-34-0 or 6-24-6 starter fertilizer/water carrier (3:2 gal. H_2O to fertilizer) at an output volume of 5 GPA.
[c]Surviving plant stands were counted on May 30, June 25, July 8, and July 17, 2024 (i.e., 10, 36, 49, and 58 days after planting [DAP], respectively).

Sugarbeet root maggot feeding injury results from Study I appear in Table 2. The average SBRM feeding injury sustained in the no-fertilizer untreated check plots (6.0, respectively, on the 0 to 9 scale of Campbell et al. [2000]) indicated the presence of a moderate SBRM larval infestation for the experiment. Root maggot feeding injury in the 6-24-6 and 10-34-0 fertilizer controls averaged 5.7 and 5.9 on the 0 to 9 scale, respectively, neither of which was significantly different from the untreated control. This suggests that the fertilizer applications did not have a negative or positive effect on SBRM larval survival or feeding behavior.

All insecticide-treated entries in the trial provided significant reductions in SBRM feeding injury when compared to the untreated check and the fertilizer-only check; however, the feeding injury sustained by roots in the treatment combination of Counter 20G at 7.5 lb product per acre plus a concurrent application of AZteroid tank mixed with 10-34-0 starter fertilizer was not significantly different from the feeding injury that occurred in the 10-34-0 fertilizer-only control. This could indicate that the fungicide/10-34-0 combination could have interfered with the performance of Counter 20G. The lowest overall average SBRM feeding injury (i.e., the highest level of root protection) in Study I was observed in plots that received the combination of a planting-time application of Counter 20G at its high labeled rate (8.9 lb product/ac) with a concurrent application of AZteroid FC that was tank mixed with 6-24-6 starter fertilizer. This was an encouraging result, as it suggests that 6-24-6 starter fertilizer could be safer and less phytotoxic on sugarbeet seedlings than 10-34-0 when tank mixed with an a strobilurin fungicide like AZteroid FC.

Table 2. ***Larval feeding injury*** **in an evaluation of at-plant insecticide, azoxystrobin fungicide, and starter fertilizer combinations in sugarbeet, St. Thomas, ND, 2024 (Study I)**

Treatment/form.	Placement[a]	Rate[b] (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + AZteroid FC 3.3 + 6-24-6	B DIF DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15 ---	3.1 d
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5 ---	3.3 cd
Counter 20G + 6-24-6	B DIF	7.5 lb 5 GPA	1.5 ---	3.5 cd
Counter 20G	B	8.9 lb	1.8	3.5 cd
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8 ---	4.0 cd
Counter 20G + AZteroid FC 3.3 + 6-24-6	B DIF DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.15 ---	4.1 cd
Counter 20G + 6-24-6	B DIF	8.9 lb 5 GPA	1.8 ---	4.1 cd
Counter 20G	B	7.5 lb	1.5	4.1 cd
Counter 20G + AZteroid FC+ 10-34-0	B DIF DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15 ---	4.2 cd
Counter 20G + AZteroid FC 3.3 + 10-34-0	B DIF DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.15 ---	4.5 bc
6-24-6	DIF	5 GPA	---	5.7 ab
10-34-0	DIF	5 GPA	---	5.9 ab
Untreated	---	---	---	6.0 a
LSD (0.05)				1.3

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]At-plant sprays were delivered in a 10-34-0 starter fertilizer/water carrier (3:2 gal. H_2O to fertilizer) at an output volume of 5 GPA.
[b]B = 5-inch at-plant band; DIF = dribble in-furrow.

Yield data from Study I are presented in Table 3. All treatments in the experiment that included Counter 20G insecticide provided significant increases in recoverable sucrose yield when compared to the untreated check. Performance patterns among the various treatment combinations corresponded well with the findings from stand counts and root maggot feeding injury results. The highest overall recoverable sucrose and root tonnage yields in the experiment were recorded in plots treated with Counter 20G at its high (8.9 lb product/ac) rate and a concurrent application of 6-24-6 starter fertilizer. Other treatments in the trial that generated comparable recoverable sucrose and root yields which were not statistically different from that combination included the following:

1) Counter 20G (7.5 lb/ac), banded + AZteroid FC, tank mixed with 6-24-6 starter fertilizer, DIF;
2) Counter 20G (8.9 lb/ac), banded + 10-34-0 starter fertilizer, DIF; and
3) Counter 20G (7.5 lb/ac), banded + 6-24-6 starter fertilizer, DIF.

Although the highest yields in this experiment frequently occurred when plots were treated with a planting-time application of Counter 20G at 8.9 lb product per acre and a concurrent application of 6-24-6 starter fertilizer, one concerning contrast was observed. In similar plots that received Counter at 8.9 lb product per acre plus a concurrent application of 6-24-6 starter fertilizer, the addition of AZteroid FC fungicide to the fertilizer solution resulted in a significant reduction in both recoverable sucrose yield (i.e., 12.5% loss) and root yield (i.e., 3.7 tons/ac reduction) when compared to similar plots where the AZteroid was excluded. Slight, but not statistically significant reductions in recoverable sucrose and root yield were also observed in plots treated at planting with Counter 20G at the high (8.9 lb product/ac) rate plus 10-34-0 starter fertilizer when AZteroid FC was tank mixed with the fertilizer solution.

As mentioned above, the treatment combination of Counter 20G at its moderate (7.5 lb/ac) rate and a concurrent DIF spray of AZteroid FC tank mixed with 6-24-6 starter fertilizer was one of the highest-yielding treatment combinations in this experiment; however, there was numerical (i.e., not statistically significant) reduction in recoverable sucrose yield (i.e., a 4.7% loss) in plots treated with a similar combination, but where Counter 20G was applied at its full (8.9 lb/ac) application rate and combined with the same concurrent tank mixture of AZteroid plus 6-24-6 starter fertilizer. Despite the lack of statistical significance in that comparison, the root tonnage loss, albeit not statistically significant, was 1.9 tons per acre, and the disparity led to a revenue loss of $100 per acre.

Table 3. *Yield parameters* from an evaluation of at-plant insecticide, azoxystrobin fungicide, and starter fertilizer combinations in sugarbeet, St. Thomas, ND, 2024 (Study I)

Treatment/form.	Placement[a]	Rate[b] (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 20G + 6-24-6	B DIF	8.9 lb 5 GPA	1.8 ---	12,216.6 a	38.7 a	17.0 a	2,709
Counter 20G + AZteroid FC 3.3 + 6-24-6	B DIF DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.15 ---	11,226.5 ab	36.9 ab	16.5 a	2,388
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8 ---	11,074.0 ab	37.1 ab	16.3 a	2,304
Counter 20G + 6-24-6	B DIF	7.5 lb 5 GPA	1.5 ---	11,056.6 ab	35.9 ab	16.6 a	2,385
Counter 20G + AZteroid FC 3.3 + 10-34-0	B DIF DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.15 ---	10,986.4 b	36.4 ab	16.4 a	2,316
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5 ---	10,941.4 b	37.0 ab	16.2 a	2,254
Counter 20G + AZteroid FC+ 10-34-0	B DIF DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15 ---	10,926.1 b	35.8 ab	16.5 a	2,332
Counter 20G	B	8.9 lb	1.8	10,774.1 bc	35.1 bc	16.6 a	2,317
Counter 20G	B	7.5 lb	1.5	10,724.8 bcd	34.8 bc	16.7 a	2,317
Counter 20G + AZteroid FC 3.3 + 6-24-6	B DIF DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15 ---	10,695.2 bcd	35.0 bc	16.5 a	2,288
6-24-6	DIF	5 GPA	---	9,614.2 cde	31.8 cd	16.4 a	2,033
10-34-0	DIF	5 GPA	---	9,531.5 de	31.0 d	16.6 a	2,052
Untreated	---	---	---	9,221.2 e	31.8 cd	15.8 a	1,846
LSD (0.05)				1,205.3	3.4	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]At-plant sprays were delivered in a 10-34-0 starter fertilizer/water carrier (3:2 gal. H_2O to fertilizer) at an output volume of 5 GPA.
[b]B = 5-inch at-plant band; DIF = dribble in-furrow.

Study II. Sugarbeet root maggot feeding injury results from Study II appear in Table 4. The average SBRM feeding injury sustained in the untreated check plots was 6.0 on the 0 to 9 scale of Campbell et al. [2000]), which indicated that a moderate SBRM larval infestation was present for the experiment. NOTE: given that all insecticide-treated entries in Study II received a base planting-time application of Counter 20G at 8.9 lb product per acre, the discussion of results from this experiment will focus on the postemergence insecticide and fungicide components of each treatment. All insecticide-treated entries in the trial provided significant reductions in SBRM feeding injury when compared to the untreated check, but the lowest average SBRM feeding injury (i.e., the highest level of root protection) in Study II was observed in plots that received the postemergence tank-mixed combination of Pilot 4E plus Elatus fungicide. The average SBRM feeding injury that occurred in those plots was significantly lower than the injury sustained in plots treated at postemergence with Pilot 4E alone (i.e., no fungicide component). That finding may suggest that Elatus could have provided some level of insecticidal activity which complemented the root protection provided by Pilot 4E.

Excellent levels of root protection from SBRM feeding injury were provided by Mustang Maxx alone, the tank-mixed combination of Pilot 4E and Quadris, and the combination of Mustang Maxx plus Quadris. None of those postemergence treatment entries were significantly outperformed by the top-performing Pilot/Elatus tank mixture with respect to protection from SBRM feeding injury. However, plots treated at postemergence with a tank mixture of Pilot 4E plus Excalia sustained significantly greater levels of root maggot feeding injury than those treated with the Pilot 4E/Elatus tank mixture. Similarly, plots that received the postemergence tank-mixed combination of Mustang Maxx plus Excalia combination had significantly greater SBRM feeding injury ratings than the Mustang Maxx-only plots.

Table 4. *Larval feeding injury* in an evaluation of postemergence insecticide and fungicide tank mixtures for sugarbeet root maggot control, St. Thomas, ND, 2024 (Study II)				
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Counter 20G + Pilot 4E + Elatus	B 5d Pre-Peak Band	8.9 lb 2 pts 7.1 fl oz	1.8 1.0 0.2	1.8 e
Counter 20G + Mustang Maxx	B 5d Pre-Peak Band	8.9 lb 4 fl oz	1.8 0.025	2.1 de
Counter 20G + Pilot 4E + Quadris	B 5d Pre-Peak Band	8.9 lb 2 pts 10 fl oz	1.8 1.0 0.16	2.2 de
Counter 20G + Mustang Maxx + Quadris	B 5d Pre-Peak Band	8.9 lb 4 fl oz 10 fl oz	1.8 0.025 0.16	2.5 cde
Counter 20G + Mustang Maxx + Elatus	B 5d Pre-Peak Band	8.9 lb 4 fl oz 7.1 fl oz	1.8 0.025 0.2	2.5 cde
Counter 20G + Pilot 4E	B 5d Pre-Peak Band	8.9 lb 2 pts	1.8 1.0	2.9 bcd
Counter 20G + Pilot 4E + Excalia	B 5d Pre-Peak Band	8.9 lb 2 pts 0.64 oz	1.8 1.0 0.01	3.0 bcd
Counter 20G	B	8.9 lb	1.8	3.3 bc
Counter 20G + Mustang Maxx + Excalia	B 5d Pre-Peak Band	8.9 lb 4 fl oz 0.64 oz	1.8 0.025 0.01	3.6 b
Untreated	---	---	---	6.0 a
LSD (0.05)				1.0

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; 5d Pre-Peak = 7" postemergence band, applied five days before peak SBRM fly activity.

Yield results from Study II are presented in Table 3. All treatment combinations in the experiment that included an insecticide provided significant increases in both recoverable sucrose yield and root yield when compared to the untreated check, but there were no significant differences in recoverable sucrose or root tonnage yield among the insecticide treatments or the insecticide/fungicide combinations. Generally speaking, that is a positive overall finding of this experiment, because it suggests that the insecticide/fungicide combinations evaluated in this experiment are not likely to result in serious negative consequences for producers that choose to use them for combined one-pass operations for insect and disease management in their sugarbeet crop. The gross economic return figures from this trial offer some reasons for caution and concern.

Overall patterns of performance suggest that Elatus fungicide may be a safer tank-mix partner than Quadris and, to a lesser extent, Excalia, for combining with either Mustang Maxx or Pilot 4E for postemergence foliar sprays in sugarbeet. Plots treated with a combination of Mustang Maxx plus Elatus generated numerically greater recoverable sucrose and root yield when compared to the yields obtained in the Mustang Maxx-only plots. The increased yield provided by the Mustang Maxx/Elatus combination resulted in a gross revenue increase of $15 per acre when compared to the Mustang Maxx-only treatment. Although the revenue increase observed in this comparison could be considered modest, this a positive and important finding. The fact that the experiment was conducted under moderate SBRM pressure and in the absence of any major foliar disease pressure suggests that the economic return from the Mustang Maxx/Elatus treatment combination would likely have been substantially greater in a commercial grower field scenario under more significant insect and foliar disease pressure.

Table 5. ***Yield parameters*** **from an evaluation of postemergence insecticide and fungicide tank mixtures for sugarbeet root maggot control, St. Thomas, ND, 2024 (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 + Elatus	B 5d Pre-Peak Band	8.9 lb 4 fl oz 7.1 fl oz	1.8 0.025 0.2	11,134.7 a	35.1 a	17.0 a	2,488
Counter 20G + Mustang Maxx	B 5d Pre-Peak Band	8.9 lb 4 fl oz	1.8 0.025	11,087.4 a	35.0 a	17.0 a	2,473
Counter 20G + Pilot 4E + Elatus	B 5d Pre-Peak Band	8.9 lb 2 pts 7.1 fl oz	1.8 1.0 0.2	10,904.8 a	34.3 a	17.1 a	2,442
Counter 20G + Pilot 4E + Excalia	B 5d Pre-Peak Band	8.9 lb 2 pts 0.64 oz	1.8 1.0 0.01	10,904.7 a	35.3 a	16.6 a	2,368
Counter 20G + Mustang Maxx + Excalia	B 5d Pre-Peak Band	8.9 lb 4 fl oz 0.64 oz	1.8 0.025 0.01	10,875.4 a	34.7 a	16.9 a	2,400
Counter 20G + Pilot 4E	B 5d Pre-Peak Band	8.9 lb 2 pts	1.8 1.0	10,732.3 a	35.1 a	16.5 a	2,298
Counter 20G + Mustang Maxx + Quadris	B 5d Pre-Peak Band	8.9 lb 4 fl oz 10 fl oz	1.8 0.025 0.16	10,710.6 a	34.3 a	16.8 a	2,354
Counter 20G + Pilot 4E + Quadris	B 5d Pre-Peak Band	8.9 lb 2 pts 10 fl oz	1.8 1.0 0.16	10,590.4 a	34.1 a	16.7 a	2,308
Counter 20G	B	8.9 lb	1.8	10,151.9 a	33.1 a	16.6 a	2,183
Untreated	---	---	---	9,033.7 b	28.2 b	17.2 a	2,039
LSD (0.05)				1,051	2.8	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; 5d Pre-Peak = 7" postemergence band, applied five days before peak SBRM fly activity.

More concerning was our observation that tank mixing Quadris with Mustang Maxx resulted in a recoverable sucrose yield reduction of 377 lb per acre when compared with the Mustang Maxx-only treatment. That disparity, although not statistically significant, translated to a gross revenue loss of $119 per acre when Quadris was tank mixed with Mustang Maxx. A similar, albeit less substantial, negative result in Study II was our finding that combining Excalia with Mustang Maxx led to a 212 lb per acre reduction in recoverable sucrose yield and a gross revenue reduction of $73 per acre when compared to the Mustang Maxx-only treatment. No apparent negative impacts on yield or revenue were observed with foliar insecticide/fungicide tank mixtures involving Pilot 4E as the insecticide component. Moreover, when Elatus fungicide was tank mixed with Pilot 4E, average recoverable sucrose yield increased by about 143 lb per acre. Although the increase was modest and not statistically significant, it suggests that combining Elatus with Pilot 4E is likely to be a safe approach as a single-pass operation for sugarbeet insect and disease management.

Summary:

The results of Study I suggest that 6-24-6 starter fertilizer appears to be a slightly safer product than 10-34-0 to apply concurrently with a planting-time application of Counter 20G, especially when Counter is applied at its high labeled rate (8.9 lb product/ac), which is commonly used in areas at risk of high SBRM infestations. These results also suggest that risk of crop injury and associated yield and revenue losses will be greater if Counter is applied at the 8.9-lb rate and AZteroid FC (or a similar strobilurin fungicide product) is included with starter fertilizer, irrespective of whether the fertilizer product used is 10-34-0 or 6-24-6. If a grower prefers combining applications of Counter 20G, a starter fertilizer, and a strobilurin fungicide at sugarbeet planting, the Counter should be applied at no more than 7.5 lb product per acre, and the starter fertilizer product should be a product with lower nitrogen and phosphorus concentrations such as 6-24-6.

In Study II, one of our most encouraging results occurred when plots that were initially treated with Counter 20G were treated with a postemergence foliar tank mixture of Pilot 4E insecticide plus Elatus fungicide, roots incurred significantly lower levels of SBRM feeding injury than when Pilot 4E was applied without Elatus. This suggests that Elatus fungicide either independently has a degree of insecticidal activity on SBRM larvae or it had a synergistic impact on Pilot 4E. However, our experiment was not designed to specifically determine the nature of this relationship. An alarming result from this experiment was that tank mixing Excalia with Mustang Maxx allowed significantly greater levels of SBRM larval feeding injury to occur than when the Excalia was excluded. This suggests at least the possibility of some form of antagonism between Excalia and Mustang Maxx that resulted in interference with the performance of the latter for protection from root maggot larval feeding injury.

Overall, the harvest results from Study II suggest that Elatus may be a safer fungicide tank-mix partner than Quadris and, to a lesser extent, Excalia, for combining with either Mustang Maxx or Pilot 4E in sugarbeet; however, statistical differences between the various insecticide/fungicide tank mixtures were lacking. The potential for augmented SBRM control by including Elatus fungicide with Pilot 4E, as well as the possible antagonism between Mustang Maxx and Excalia, should be more thoroughly investigated in future research.

The combined results from these two experiments suggest that one-pass systems for delivering starter fertilizer, insecticides, and fungicides can be effective and economically beneficial operations. However, caution and careful consideration of these results should be taken to ensure the success of the applications. Both beneficial and seriously detrimental impacts of various combinations were observed in these experiments, but statistically significant differences were not always detected. Further research on the fertilizer/insecticide/fungicide combinations evaluated in these experiments is needed to more thoroughly evaluate their safety and efficacy. It is likely that additional research will also be needed to perform similar assessments on new crop management products as they come to the marketplace for grower consideration as tools in their insect pest and disease management portfolio for sugarbeet.

Acknowledgments:

Appreciation is extended to Wayne and Austin Lessard for allowing us to conduct this research on their farm. The authors also thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for providing partial funding to support this project. We are grateful for the contributions of our summer aides, Amber Eken, Rylie Gustafson, Devin Lockerby, Hayden Vandal, and Nyla Wright, for assistance with plot maintenance, sample collection, and data entry. We also appreciate the American Crystal Quality Tare Laboratory (East Grand Forks, MN) for performing sucrose content and quality analyses on harvest samples. This work was also partially supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, under Hatch project number ND02374.

References Cited:

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. Sugarbeet Res. 37: 57–69.

SAS Institute. 2012. The SAS System for Windows. Version 9.4. SAS Institute Inc., 2002-2012. Cary, NC.