IMPACTS OF INSECTICIDE, FUNGICIDE, AND STARTER FERTILIZER COMBINATIONS ON PLANT SAFETY AND YIELD IN SUGARBEET

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Introduction:

Combining pesticide and fertilizer products into complex spray mixtures for a single implement pass through the field can be a valuable, input cost saving strategy for producers. Although this practice has become somewhat commonplace on many farms for both planting-time operations and after emergence of the crop, the impacts of such combinations on plant health or pest control efficacy should be thoroughly investigated before they are recommended for implementation on the farm.

Several insect pests, including wireworms, springtails, white grubs, and the sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) are annual threats to sugarbeet production in the Red River Valley (RRV) growing area. These root-feeding pests are often controlled 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 larval feeding pressure are expected, most producers also supplement the initial at-plant insecticide(s) with a postemergence granular or sprayable liquid insecticide application.

Fungicides are sometimes also used to manage soil-borne root diseases of sugarbeet such as Rhizoctonia damping off and Rhizoctonia crown and root rot, both of which are all 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. Starter fertilizer, applied at planting time, is also commonly used by RRV sugarbeet producers. However, little is known about the crop safety of combining these applications or if they either complement or impair pesticide performance. If demonstrated as safe for the crop and have a neutral or positive impact on pest control 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.

Two experiments, one focused on planting-time combinations and one on postemergence tank mixtures, were carried out to evaluate the impact of multicomponent application systems on sugarbeet seedling emergence, plant health, and resulting harvest yield and quality. Several treatment combinations, based on the following application groupings, were evaluated within these experiments:

1) Counter 20G insecticide, banded at planting (7.5 lb or 8.9 lb product/ac) with a concurrently applied (i.e., at same time through a separate delivery system) dribble-in-furrow application of 10-34-0 or 6-24-6 starter fertilizer, either with or without AZteroid (azoxystrobin) fungicide; and
2) Pilot 4E (chlorpyrifos) or Mustang Maxx (zeta-cypermethrin) insecticide applied as a postemergence band in a tank mixture with either Elatus (azoxystrobin and benzovindiflupyr), Excalia (inpyrfluxam), or Quadris (azoxystrobin) fungicide.

Materials and Methods:

This project involved two experiments (i.e., Study I and Study II) that were conducted during the 2025 growing season at the NDSU Prosper Experiment Farm near Prosper in rural Cass County, ND. Plots were planted on May 27, 2025, and Betaseed 8018 glyphosate-tolerant seed 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.

Planting-time applications. Planting-time applications of Counter 20G (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 (Study I) were delivered by using dribble in-furrow (DIF) placement. Dribble in-furrow treatments were applied in a 3:2 gallon ratio of three gallons 10-34-0 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. Pressurized CO_2-was used to propel spray output through the delivery system that was equipped with inline Teejet™ No. 24 orifice plates to achieve a finished output volume of five gallons per acre (GPA).

Postemergence insecticide applications. Additive postemergence insecticides applied in Study II included Pilot 4E and Mustang Maxx. Those applications, which included respective insecticide-only spray solutions, as well as either Pilot 4E or Mustang Maxx insecticide with either Elatus, Excalia, or Quadris fungicide, were made on June 24, which coincided with most plants being in the 4-leaf stage of development.

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. Postemergence granular insecticide output rates were regulated by using a SmartBox™ system mounted on a tractor-drawn four-row toolbar, and placement of insecticide in 4-inch bands was achieved by using Kinze™ row banders. Granules were incorporated into the soil by using two pairs of metal rotary tines that straddled each row. One pair of tines was positioned ahead of each bander, and a second pair was mounted behind it.

Plant Stand Counts: To determine treatment impacts on seedling emergence and survival throughout the growing season, surviving plant stands were counted in Study I on 26 June and 8 July, 2025 (i.e., 30 and 42 days after planting [DAP], respectively, and counts were carried out in Study II on 8 and 18 July (i.e., 42 and 52 DAP). Plant stand 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.

Harvest: Treatment performance was also compared on the basis of sugarbeet yield parameters. All plots in both experiments were harvested on September 16, 2025. 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 2025), and treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

Results from both Study I and Study II are considered preliminary, as they are part of a multi-year project and both studies are anticipated to be repeated in at least one additional growing season. The results from two counts of surviving plant stands in Study I, presented in descending order of plant stands recorded at the final stand count (42 DAP), are shown in Table 1. At the first stand count (30 DAP), all treatments had favorable plant stands that hovered around 210 to 220 plants per 100 linear row feet; however, there were no significant differences between any of the treatments in this trial. The highest average stand counts (i.e., 231.7 plants/100 row ft) in Study I were observed in plots treated at planting time with Counter 20G at its moderate rate of 7.5 lb product per acre as a stand-alone treatment (i.e., no fungicide or starter fertilizer). Similarly, relatively high stands (i.e., 224.5 plants/100 row ft) were also observed in the stand-alone treatment of Counter 20G at its high labeled rate (8.9 lb/ac). The lowest stands recorded at 30 DAP in Study I, although not exceptionally low, occurred in the treatment comprised of Counter 20G insecticide at 7.5 lb/ac applied concurrently with a dribble in-furrow (DIF) tank mixture of 6-24-6 starter fertilizer and AZteroid fungicide.

Plant population patterns in the second stand count (42 DAP) were similar to those of the first count, including the finding of no statistically significant differences in surviving plant stands between any of the treatments. The highest plant stands recorded in the experiment occurred in the treatment comprised of Counter 20G at 8.9 lb/ac with a concurrent application of 6-24-6 starter fertilizer (without fungicide). Other treatments with relatively high surviving plant densities included the following: 1) Counter 20G insecticide applied at 8.9 lb/ac concurrently with a DIF-applied tank mixture of 6-24-6 starter fertilizer and AZteroid fungicide; 2) Counter 20G at its moderate rate of 7.5 lb product per acre as a stand-alone treatment (i.e., no fungicide or starter fertilizer); and 4) Counter 20G at 8.9 lb product per acre. The lowest average plant stands in Study I were observed in the treatment combination of Counter 20G insecticide at 7.5 lb/ac applied concurrently with a tank mixture of 6-24-6 starter fertilizer and AZteroid fungicide. The untreated check plots produced plant stand averages that remained roughly in the middle among all treatments, further supporting the indication that there were no significant pesticide or fertilizer impacts on sugarbeet plant stand establishment or survival in this experiment.

Table 1. *Plant stand counts* from an evaluation of azoxystrobin and starter fertilizers mixed with at-plant insecticides in the absence of insect pest pressure, Prosper, ND, 2025 (Study I)

Treatment/form.[a]	Placement[a]	Rate[b] (product/ ac)	Rate (lb a.i./ac)	Stand count[c] (plants / 100 ft)	
				30 DAP[c]	42 DAP[c]
Counter 20G 6-24-6	B DIF	8.9 lb 5 GPA	1.8 ---	219.5 a	228.3 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 ---	221.4 a	225.0 a
Counter 20G	B	7.5 lb	1.5	231.7 a	223.3 a
Counter 20G	B	8.9 lb	1.8	224.5 a	221.4 a
Counter 20G 10-34-0	B DIF	8.9 lb 5 GPA	1.8 ---	207.1 a	218.8 a
Counter 20G 6-24-6	B DIF	7.5 lb 5 GPA	1.5 ---	221.7 a	217.9 a
Untreated	---	---	---	217.6 a	216.7 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 ---	216.9 a	216.4 a
Counter 20G 10-34-0	B DIF	7.5 lb 5 GPA	1.5 ---	216.9 a	214.5 a
10-34-0	DIF	5 GPA	---	215.5 a	214.3 a
Counter 20G AZteroid FC+ 10-34-0	B DIF DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15 ---	213.1 a	213.6 a
6-24-6	DIF	5 GPA	---	211.0 a	213.3 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 ---	206.9 a	205.2 a
LSD (0.05)				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]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; Post B = postemergence band (i.e., 4-inch width for granular products; 10-inch width for sprayable liquid formulations); DIF = dribble in-furrow
[c]Surviving plant stands were counted on June 26 and July 8, 2025 (i.e., 30 and 42 days after planting [DAP], respectively).

Yield data from Study I are presented in Table 2. The yield data from this experiment should be interpreted with the understanding it was planted later than a typical planting date for sugarbeet in the Red River Valley growing area. As such, yields of all treatments were accordingly lower than those a grower would usually achieve, but, the later planting date did not appear to affect treatment comparisons or the overall outcomes in this study. Another thing that is important to acknowledge, is that there were no statistically significant differences between any treatments in this experiment. However, some interesting and somewhat concerning patterns were evident with some of the combination treatments.

The highest recoverable sucrose yield in the experiment was observed in plots that received Counter 20G at 8.9 lb/ac and a concurrent application of 10-34-0 starter fertilizer. However, in a similar treatment that also involved Counter at 8.9 lb/ac, but where AZteroid was tank mixed with the 10-34-0 starter fertilizer, recoverable sucrose yield was reduced by 3.4%. Although that difference was relatively small, the inclusion of AZteroid resulted in a gross revenue reduction of $100/acre. That disparity was not observed by adding AZteroid fungicide in a similar scenario when Counter was applied at the moderate (7.5 lb/ac) rate along with a concurrent application of 10-34-0 fertilizer. A similar pattern was also observed in plots treated with Counter 20G at its high rate and 6-24-6 starter fertilizer. In that scenario, recoverable sucrose was reduced by 7.8% when AZteroid was tank mixed with the 6-24-6 starter fertilizer. Although the difference was not statistically significant, the yield disparity that occurred from adding the fungicide was $162 per acre.

Table 2. *Yield parameters* from an evaluation of azoxystrobin and starter fertilizers mixed with at-plant insecticides in the absence of insect pest pressure, Prosper, ND, 2025 (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 10-34-0	B DIF	8.9 lb 5 GPA	1.8 ---	9,017.0 a	31.4 a	15.87 a	1004
Counter 20G 6-24-6	B DIF	8.9 lb 5 GPA	1.8 ---	8,994.9 a	31.9 a	15.69 a	961
10-34-0	DIF	5 GPA	---	8,972.1 a	32.0 a	15.56 a	947
6-24-6	DIF	5 GPA	---	8,789.5 a	32.2 a	15.21 a	859
Counter 20G AZteroid FC+ 10-34-0	B DIF DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15 ---	8,714.9 a	31.3 a	15.57 a	904
Counter 20G	B	7.5 lb	1.5	8,677.1 a	30.6 a	15.75 a	939
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 ---	8,672.5 a	30.5 a	15.73 a	940
Counter 20G 6-24-6	B DIF	7.5 lb 5 GPA	1.5 ---	8,662.3 a	30.9 a	15.58 a	911
Counter 20G 10-34-0	B DIF	7.5 lb 5 GPA	1.5 ---	8,579.2 a	31.1 a	15.32 a	867
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 ---	8,575.0 a	30.9 a	15.46 a	878
Counter 20G	B	8.9 lb	1.8	8,471.7 a	29.6 a	15.86 a	935
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 ---	8,297.4 a	30.6 a	15.11 a	799
Untreated	---	---	---	8,109.0 a	29.7 a	16.26 a	800
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]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; Post B = postemergence band (i.e., 4-inch width for granular products; 10-inch width for sprayable liquid formulations); DIF = dribble in-furrow

Data from counts of surviving plant stands for Study II are presented in Table 3. As mentioned in the Materials & Methods section of this report, all insecticide-treated entries in Study II were treated at planting with Counter 20G at its high rate of 8.9 lb of product per acre. It should also be noted that the treatments in Table 3 are listed in descending order of plant density at the second plant stand count.

Plant densities at the first stand count (42 days after planting [DAP]) ranged between about 227 and 234 plants per 100 row ft among treatments. The highest plant stands were recorded in plots that received the postemergence tank-mix combination of Pilot 4E insecticide at 2 pts per acre plus Elatus fungicide (7.1 fl oz/ac); however, there were no significant differences in surviving plant stands between this entry any of the other treatments in this experiment, including the untreated check. The untreated check plots had the lowest (numerically) average stand counts in the experiment, suggesting the possibility of a minor infestation of soil insect pests being present in the plot area. This is supported by the results of our pre-plant soil sampling for springtails (data not shown), which indicated the presence of a non-economic springtail infestation. The results of the second stand count date (52 DAP), were very similar to those from the first count in that there were no significant differences in surviving plant stands between any of the treatments, suggesting that neither the at-plant application of Counter 20G at its maximum labeled rate, nor any of the postemergence insecticides or insecticide/fungicide tank mixtures had any major impact on survivability of sugarbeet plants.

Table 3. *Plant stand counts* from an evaluation of postemergence-applied foliar insecticide-fungicide tank mixtures, Prosper, ND, 2025 (Study II)					
Treatment/form.	**Placement[a]**	**Rate (product/ ac)**	**Rate (lb a.i./ac)**	**Stand count[b] (plants / 100 ft)**	
				42 DAP[c]	**52 DAP[c]**
Counter 20G Pilot 4E + Excalia	B 10-inch Post band	8.9 lb 2 pts 0.64 oz	1.8 1.0 0.01	234.3 a	249.6 a
Counter 20G Mustang Maxx + Quadris	B 10-inch Post band	8.9 lb 4 fl oz 10 fl oz	1.8 0.025 0.16	233.6 a	242.9 a
Counter 20G Pilot 4E	B 10-inch Post band	8.9 lb 2 pts	1.8 1.0	237.1 a	237.1 a
Counter 20G Mustang Maxx	B 10-inch Post band	8.9 lb 4 fl oz	1.8 0.025	229.6 a	234.6 a
Counter 20G Pilot 4E + Elatus	B 10-inch Post band	8.9 lb 2 pts 7.1 fl oz	1.8 1.0 0.2	228.9 a	232.9 a
Counter 20G Pilot 4E + Quadris	B 10-inch Post band	8.9 lb 2 pts 10 fl oz	1.8 1.0 0.16	223.9 a	232.9 a
Counter 20G Mustang Maxx + Excalia	B 10-inch Post band	8.9 lb 4 fl oz 0.64 oz	1.8 0.025 0.01	238.6 a	232.5 a
Counter 20G	B	8.9 lb	1.8	233.9 a	231.1 a
Counter 20G Mustang Maxx + Elatus	B 10-inch Post band	8.9 lb 4 fl oz 7.1 fl oz	1.8 0.025 0.2	224.6 a	228.6 a
Untreated	---	---	---	226.8 a	218.6 a
			LSD (0.05)	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 band = postemergence band.
[b]Surviving plant stands were counted on July 8 and July 18, 2025 (i.e., 42 and 52 days after planting [DAP], respectively).

Yield results from this experiment are presented in Table 4. As noted for Study I results, the yields recorded for all treatments in Study II were also somewhat lower than those a grower would typically achieve because Study II was also planted later than typical for sugarbeet production in the Red River Valley growing area. However, all treatments in the experiment were treated identically, so any observed relative differences among treatments should be reflective of what a grower could experience in a commercial production field.

The highest average recoverable sucrose yield in Study II was recorded in plots that received the single-component treatment of Counter 20G at 8.9 lb per acre, without an accompanying postemergence spray. Treatments in which significantly lower recoverable sucrose yields were recorded than that for the stand-alone Counter application included the following: 1) Counter 20G at planting followed by a postemergence tank mixture of Pilot 4E (2 pts/ac) plus Excalia (0.64 fl oz/ac); and 2) Counter 20G at planting followed by a postemergence tank mixture of Pilot 4E (2 pts/ac) plus Quadris (10 fl oz/ac). The lowest recoverable sucrose yield and root tonnage were recorded in plots that received the base treatment of Counter at planting and a postemergence tank mixture comprised of Pilot 4E plus Quadris. This combination produced significantly lower sucrose yield and root tonnage than any other treatment in the experiment, suggesting that it should not be used by producers in their postemergence insect and plant disease management practices. Other trends observed in the experiment suggest that, overall, Mustang Maxx appeared to be a slightly safer postemergence tank-mix partner than Pilot 4E with the three fungicides evaluated in this study. Another slight trend evident in these data was that Elatus fungicide appeared to be a safer fungicide tank mix partner with Mustang Maxx and Pilot 4E than Quadris, and that Excalia was intermediate in tank mixture safety between Elatus and Quadris.

The data from both Study I and II are considered preliminary because they involve results from just one year of information from a single location. As such, these experiments should be, and are expected to be repeated. The complete lack of statistically significant differences in stand counts and yield parameters among treatments in Study I at least suggests that there may not be major risks of consistent revenue losses resulting from the treatment combinations evaluated in that experiment.

Yield impacts from some of the treatments in Study II suggest at least caution when thinking about combining postemergence foliar applications of insecticide/fungicide tank mixtures, especially when either Pilot 4E insecticide or Quadris fungicide might be considered. Applying that combination at the rates used resulted in significant yield reductions and revenue losses that amounted to $147/ac when compared to the untreated check and $238/ac when compared to the Counter-only base planting-time treatment. It should be noted that both of these experiments were conducted in the absence of a measurable insect pest infestation. In addition to repeating this study under similar, no-pest environments, the net impacts of the treatment combinations tested should also be evaluated under economically significant insect pest (e.g., sugarbeet root maggot or springtail) pressure and possibly also root disease pressure to more fully understand the crop safety and pest management capability of these treatment combinations.

Table 4. *Yield parameters* from an evaluation of postemergence-applied foliar insecticide-fungicide tank mixtures, Prosper, ND, 2025 (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	B	8.9 lb	1.8	8815.9 a	30.9 ab	15.68 a	968
Counter 20G Mustang Maxx	B 10-inch Post band	8.9 lb 4 fl oz	1.8 0.025	8767.3 ab	31.7 a	15.37 a	890
Counter 20G Mustang Maxx + Elatus	B 10-inch Post band	8.9 lb 4 fl oz 7.1 fl oz	1.8 0.025 0.2	8673.7 ab	31.3 ab	15.39 a	887
Counter 20G Mustang Maxx + Excalia	B 10-inch Post band	8.9 lb 4 fl oz 0.64 oz	1.8 0.025 0.01	8587.8 ab	31.5 a	15.34 a	844
Counter 20G Pilot 4E	B 10-inch Post band	8.9 lb 2 pts	1.8 1.0	8548.9 ab	31.4 a	15.20 a	832
Untreated	---	---	---	8453.3 ab	30.3 ab	15.58 a	877
Counter 20G Mustang Maxx + Quadris	B 10-inch Post band	8.9 lb 4 fl oz 10 fl oz	1.8 0.025 0.16	8373.4 ab	29.9 ab	15.64 a	880
Counter 20G Pilot 4E + Elatus	B 10-inch Post band	8.9 lb 2 pts 7.1 fl oz	1.8 1.0 0.2	8354.9 ab	29.8 ab	15.61 a	876
Counter 20G Pilot 4E + Excalia	B 10-inch Post band	8.9 lb 2 pts 0.64 oz	1.8 1.0 0.01	8082.0 b	29.2 b	15.43 a	824
Counter 20G Pilot 4E + Quadris	B 10-inch Post band	8.9 lb 2 pts 10 fl oz	1.8 1.0 0.16	7010.9 c	25.1 c	15.50 a	730
			LSD (0.05)	724.22	2.16	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 band = postemergence band.

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