ROOT MAGGOT CONTROL AND PLANT SAFETY OF INSECTICIDE, AZOXYSTROBIN FUNGICIDE, AND STARTER FERTILIZER COMBINATIONS IN SUGARBEET

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Introduction:

Combining crop management material (e.g., insecticide, fungicide, etc.) applications into one pass through the field, either at planting or after emergence of the crop, can be a significant cost-saving measure in most agricultural cropping systems. However, there is often uncertainty with regard to the impacts of such combinations on plant health or pest control efficacy.

Red River Valley sugarbeet producers often apply a planting-time insecticide to their crop for protection from losses associated with root-feeding insect pests, such as wireworms, springtails, white grubs, or the sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder). The latter is the most frequently problematic and most severe insect pest of sugarbeet in the growing region. Producers typically manage this pest through prophylactic insecticide application during sugarbeet planting, which consists of granular or sprayable liquid formulations, or insecticide-treated seed. In situations where high SBRM fly activity and associated larval feeding pressure are expected, most producers also supplement the at-plant insecticide with a postemergence-applied material, which can involve either granular or sprayable liquid formulations.

Fungicides are also frequently applied to manage soil-borne root diseases such as Rhizoctonia damping off, as well as Rhizoctonia crown and root rot, which are all caused by the pathogen *Rhizoctonia solani* Kühn. Similar to the insecticides used for SBRM management, fungicides targeting Rhizoctonia management in sugarbeet also can be delivered as planting-time and/or postemergence applications. Starter fertilizer applications are also commonly used by RRV sugarbeet producers. However, little is known about the crop safety of these combinations or if they either complement or impair product performance. If demonstrated to be safe for the crop and at least neutral in impact on control efficacy, consolidating product combinations into either tank-mixed combinations or concurrent (i.e., single-pass) applications would provide time savings and significant application-associated input costs.

This experiment was carried out to evaluate the impact of such 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. Several treatment combinations, based on the following application groupings, were evaluated:

1) Counter 20G insecticide, banded at planting with a concurrently applied (i.e., at same time through a separate delivery system) dribble-in-furrow application of 10-34-0 starter fertilizer;

2) Yuma 4E insecticide applied as a postemergence band in a tank mixture with Quadris (i.e., azoxystrobin) fungicide; and

3) Thimet 20G insecticide applied as a postemergence band with a concurrent application of Quadris (i.e., azoxystrobin) fungicide, also delivered in a band.

Materials and Methods:

This experiment was conducted during the 2020 and 2021 growing seasons in commercial sugarbeet field sites near St. Thomas in rural Pembina County, ND. Plots were planted on May 19 in 2020 and May 12 in 2021. Betaseed 8524 was used for all treatments in 2020, and Betaseed 8961 was used in 2021. Both varieties were glyphosate-resistant, regular pellet-sized seed. 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 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. The experiment was arranged in a randomized complete block design with four replications. Quadris was used as the postemergence fungicide, as it is the most common use of an azoxystrobin-based for postemergence root diseases in the Red River Valley growing area.

Planting-time insecticide applications. Planting-time applications of Counter 20G were applied by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy^{TM} row banders. Granular application rates were regulated by using planter-mounted SmartBox^{TM} computer-controlled insecticide delivery system that had been calibrated on the planter before all applications.

Planting-time liquid spray applications were delivered by using dribble in-furrow (DIF) placement. Dribble in-furrow applications were made by orienting a microtube (1/4" outside diam.) directly into the open seed furrow. Inline Teejet^{TM} No. 18 orifice plates were used to stabilize and restrict spray solution output from the microtubes for a delivery rate of 5 gallons per acre (GPA).

Postemergence insecticide applications. Additive postemergence insecticides applied in this trial included Yuma 4E (a generic chlorpyrifos formulation, similar to Lorsban 4E) and Thimet 20G. In 2020, treatment combinations that included postemergence applications of both Thimet or Yuma were applied on June 17, which was just one to two days before peak SBRM fly activity (i.e., "pre-peak"). That timing, is not recommended for applications of Thimet (recommended for 5-14 days pre-peak); however, an equipment failure and long periods of unfavorable weather prevented more timely applications of treatments that included it. In 2021, Thimet was applied on June 2 (7 days pre-peak) and Yuma was applied on June 3 (6 days pre-peak). The timing of Yuma applications in 2021 was also suboptimal for SBRM control, but similar weather conditions interfered with application timing.

Postemergence iquid insecticide solutions were delivered with a tractor-mounted CO_2-propelled spray system equipped with TeeJet^{TM} XR 110015VS nozzles, and the system was calibrated to deliver a finished output volume of 10 GPA. Postemergence granular output rates were regulated by using a SmartBox^{TM} system mounted on a tractor-drawn four-row toolbar, and placement of insecticide in 4-inch bands was achieved by using Kinze^{TM} row banders. Granules were incorporated by using two pairs of metal rotary tines that straddled each row. A set of tines was positioned ahead of each bander, and a second pair was mounted behind the granular drop zone.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in this experiment on July 27 in 2020, and on August 3 in 2021. 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. Plots were harvested on September 23 in 2020 and on September 21 in 2021. 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). Treatment means were compared by using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance. Initial analyses indicated that there were no significant treatment × year interactions for root injury ratings (P = 0. 4507), recoverable sucrose yield (P = 0. 2609, or root yield (P = 0. 1619). Therefore, two-year combined analyses were performed on all data from this experiment.

Results and Discussion:

Sugarbeet root maggot feeding injury results from this two-year trial are shown in Table 1. This data should be interpreted with the aforementioned fact that an equipment failure and unfavorable weather conditions prevented the applications of Yuma 4E and Thimet 20G at preplanned timings in relation to peak SBRM fly activity. As such, the performance levels of treatments including those products could have been negatively affected.

The average SBRM feeding injury sustained in the true untreated check and the fertilizer-only check plots (8.19 and 7.58, respectively, on the 0 to 9 scale of Campbell et al. [2000]) indicated the presence of severe larval infestations for both years of the experiment. 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.

The lowest level of SBRM feeding injury (i.e., the highest level of root protection) was observed in plots that received the combination of a planting-time application of Counter 20G at its moderate labeled rate (7.5 lb product/ac) plus a tank-mixed postemergence combination of Yuma 4E (2 pts/ac) plus Quadris fungicide; however, that entry was not statistically superior to any of the dual (i.e., planting-time plus postemergence) insecticide entries in the trial. Root protection from SBRM feeding injury was not significantly impaired by applying starter fertilizer at the same time as banded applications of Counter 20G at planting time. In fact, numerically (i.e., not statistically) lower levels of SBRM feeding injury were recorded in Counter 20G-treated plots when starter fertilizer was included than when the fertilizer was not used. There also were no significant reductions in SBRM control when Quadris was applied concurrently with Thimet 20G or when it was tank mixed with Yuma 4E, irrespective of the rate at which the insecticides were applied.

Table 1. *Larval feeding injury* from an evaluation of concurrently applied and tank-mixed combinations of azoxystrobin fungicide with sugarbeet root maggot-targeted insecticides, St. Thomas, ND, 2020-2021

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Yuma 4E + Quadris	B 10” Post B, 1 d Pre-peak	8.9 lb 2 pt 10 fl oz	1.8 1.0 0.17	3.62 f
Counter 20G + Thimet 20G + Quadris	B 4” Post B, 1 d Pre-peak 10” Post B, 1 d Pre-peak	8.9 lb 7 lb 10 fl oz	1.8 1.4 0.17	4.07 ef
Counter 20G + Yuma 4E + Quadris	B 10” Post B, 1 d Pre-peak	8.9 lb 1 pt 10 fl oz	1.8 0.5 0.17	4.26 def
Counter 20G + Thimet 20G	B 4” Post B, 1 d Pre-peak	8.9 lb 7 lb	1.8 1.4	4.28 def
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	4.76 cde
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	4.99 bcd
Counter 20G	B	8.9 lb	1.8	5.42 bc
Counter 20G	B	7.5 lb	1.5	5.54 b
Fertilizer check	DIF	5 GPA		7.58 a
Untreated check	-----	----	-----	8.19 a
LSD (0.05)				0.771

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 liquid formulations); DIF = dribble in-furrow

Yield data from this experiment are presented in Table 2. Overall performance patterns indicated that treatment combinations including dual (planting-time plus postemergence) insecticide applications provided greater recoverable sucrose and root yields, and higher gross economic returns than the insecticide treatments that did not include a postemergence insecticide.

The treatment combination comprised of Counter 20G at its high labeled rate (8.9 lb product/ac) plus a postemergence tank mixture of Yuma 4E (high labeled rate of 2 pts product/ac) and Quadris fungicide at its recommended rate (10 fl oz product/ac) produced greatest recoverable sucrose yield, root tonnage, and gross revenue in this trial. Reducing the rate of Yuma 4E to 1 pint per acre resulted in plots producing comparable sucrose and root yields, but gross economic return was $44 higher when the Yuma component was applied at its full 2-pt labeled rate.

Table 2. Impacts of concurrently applied and tank-mixed combinations of azoxystrobin fungicide and sugarbeet root maggot-targeted insecticides on *yield parameters*, St. Thomas, ND, 2020-2021

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Gross return ($/ac)
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	8.9 lb 2 pt 10 fl oz	1.8 1.0 0.17	8,409 a	29.0 a	1,140
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	8.9 lb 1 pt 10 fl oz	1.8 0.5 0.17	7,800 ab	26.1 b	1,096
Counter 20G + Thimet 20G + Quadris	B 4" Post B, 1 d Pre-peak 10" Post B, 1 d Pre-peak	8.9 lb 7 lb 10 fl oz	1.8 1.4 0.17	7,584 ab	24.9 b	1,092
Counter 20G + Thimet 20G	B 4" Post B, 1 d Pre-peak	8.9 lb 7 lb	1.8 1.4	7,455 b	24.7 b	1,065
Counter 20G	B	8.9 lb	1.8	6,241 c	21.1 c	866
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	6,203 c	21.2 c	850
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	6,175 c	20.8 c	861
Counter 20G	B	7.5 lb	1.5	5,642 c	19.4 c	766
Fertilizer check	DIF	5 GPA		4,493 d	15.7 d	600
Check	-----	----	-----	4,058 d	14.9 d	499
LSD (0.05)				909.3	4.10	

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 liquid formulations); DIF = dribble in-furrow

In plots that received the planting-time combination of a banded application of Counter 20G at 7.5 lb product per acre plus a concurrently applied (i.e., dribbled in-furrow) application of 10-34-0 starter fertilizer, the inclusion of the fertilizer resulted in numerical, but not statistically significant, increases in both recoverable sucrose yield and root tonnage per acre. However, when Counter was applied at its high labeled rate (8.9 lb product/ac), numerical, non-significant reductions in recoverable sucrose yield, root tonnage, and gross revenue were observed when 10-34-0 starter fertilizer was applied in furrow ahead of the insecticide bands at planting time.

The overall findings of this experiment suggest that applying 10-34-0 starter fertilizer dribble-in-furrow concurrently with a planting-time application of Counter 20G is a feasible approach to fertility and pest management that is unlikely to result in negative impacts on sugarbeet root maggot control or sugarbeet yield parameters. Similarly, combining azoxystrobin-based fungicide applications with SBRM-targeted insecticide applications, through either tank mixing (i.e., Yuma 4E + Quadris) or by using concurrent delivery systems (i.e., Quadris banded concurrently, but delivered ahead of the deposition Thimet granules), is not likely to result in reduced root maggot control or negative impacts on sugarbeet yield or quality.

It should be noted that this trial was conducted in environments in which high SBRM feeding pressure developed. The net impacts of the treatment combinations on plant health under lower SBRM pressure, or in its absence need to be studied under both pest-free and SBRM-infested scenarios to more fully characterize the safety and SBRM control efficacy of these treatment combinations.

Acknowledgments:

Appreciation is extended to Wayne and Austin Lessard, and Darryl Collette for allowing us to conduct this research on their farms. The authors also thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for providing partial funding to support this project. We also appreciate the contributions of Carter Blackwell, Zane Miller, Brett Skarda, Claire Stoltenow, Kenan Stoltenow, Gannon Rockstad, Karter Wasberg, and Victor Yang for assistance with plot maintenance, stand counting, root sample collection, and data entry. Thanks are also extended to 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 ND02398.

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