COMPARISON OF YUMA 4E AND MUSTANG MAXX® FOR POSTEMERGENCE SUGARBEET ROOT MAGGOT CONTROL

Mark A. Boetel, Professor
Jacob J. Rikhus, Research Specialist

Department of Entomology, North Dakota State University, Fargo, ND

Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), continues to be a major economic pest of sugarbeet in the Red River Valley (RRV) growing area of North Dakota and Minnesota. Unfortunately, SBRM populations in the production area have mostly trended upward and expanded in geographic distribution for much of the past decade. Successful SBRM management in areas affected by high to severe SBRM infestations typically requires aggressive insecticide-based control programs that usually consist of either a granular insecticide or an insecticidal seed treatment at planting, followed by an additive postemergence insecticide application when the localized infestation level warrants it. The most commonly used approach for postemergence root maggot control in the RRV is a broadcast application of a sprayable liquid insecticide product.

The most recent challenge to effective SBRM management in the RRV was the U.S. Environmental Protection Agency's revocation of all food crop tolerances for all chlorpyrifos-containing insecticide products in August of 2021. The loss of this insecticide active ingredient will likely be a major impediment to U.S. sugarbeet growers' ability to effectively manage the SBRM. In anticipation of the loss or restrictions on uses for this important insecticide, research was undertaken to evaluate Mustang Maxx as a pyrethroid insecticide alternative to chlorpyrifos for postemergence SBRM control.

Materials and Methods:

This experiment was conducted on a commercial sugarbeet field site near St. Thomas, ND during the 2020 and 2021 growing seasons. Glyphosate-resistant seed was used both years (i.e., Betaseed 8524 in 2020 and Betaseed 8961 in 2021). Plots were planted on 18 and 10 May in 2020 and 2021, respectively. 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. The experiment was arranged in a randomized complete block design with four replications of the treatments; however, environmental variability that impacted plots before harvest required exclusion of one replicate per year, thus resulting in three replications of yield data from each year.

<u>Planting-time insecticides</u>. All insecticide-treated plots received a planting-time application of Counter 20G at its maximum labeled rate of 8.9 lb product per acre. Counter 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 application output was regulated by using a planter-mounted SmartBox™ computer-controlled insecticide delivery system that had been calibrated on the planter before all applications.

<u>Postemergence insecticide applications</u>. Dual insecticide program treatments received additive postemergence applications of either Yuma 4E (active ingredient: chlorpyrifos) or Mustang Maxx (active ingredient: zetacypermethrin). Treatments that included postemergence applications involved both single and double postemergence spray applications of both products. Yuma was applied at either 1 or 2 pints of product per acre, and Mustang Maxx was applied at the maximum single-application rate of 4 fl oz per acre. Average postemergence insecticide timing compared included four days ahead of peak SBRM fly activity ("Pre-peak"), one day pre-peak, and five days after peak fly activity ("Post-peak"). Liquid insecticide solutions were delivered 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>Root injury ratings</u>. Sugarbeet root maggot feeding injury was assessed in this experiment on July 28 and

August 3 in 2020 and 2021, respectively. 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).

Harvest. Treatment performance was also compared on the basis of sugarbeet yield parameters. Plots were harvested on September 22 and 21, respectively, in 2020 and 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) 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. Initial analyses indicated that there were no significant treatment × year interactions for root injury ratings ($P = 0.0840$), recoverable sucrose yield ($P = 0.2023$), root yield ($P = 0.2917$), or percent sucrose content data ($P = 0.0718$). As such, two-year combined analyses were performed on all data from this experiment.

Results and Discussion:

Sugarbeet root maggot feeding injury ratings in the untreated check plots averaged 6.92 on the 0 to 9 scale of Campbell et al. (2000) (Table 1), suggesting that relatively high SBRM infestations were present for the both years of the experiment. All insecticide treatment combinations, including single-, dual-, and triple-insecticide component programs, resulted in significant reductions in sugarbeet root maggot feeding injury when compared to that sustained in the untreated check plots. Plots treated with Counter 20G at its highest labeled rate (8.9 lb product/ac), followed by two postemergence broadcast sprays of Yuma 4E (either 1 or 2 pts product/ac) resulted in the lowest overall root injury ratings in the experiment. However, plots protected by similar treatment combinations involving the same rate of Counter at planting, followed by either a single application of Yuma 4E at its maximum single-application rate (2 pts/ac) or a dual application of Mustang Maxx, were not significantly outperformed by those that received two applications (1 or 2 pts/ac) of Yuma. The two top-performing treatments that included dual postemergence applications of Yuma 4E did, however, perform significantly greater than those that received only a single postemergence insecticide application, irrespective of whether it was Mustang Maxx or Yuma 4E.

Table 1. *Larval feeding injury* in an assessment of Yuma 4E® and Mustang Maxx® for postemergence sugarbeet root maggot control, St. Thomas, ND, 2020-2021

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Yuma 4E + Yuma 4E	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	8.9 lb 1 pt 1 pt	1.8 0.5 0.5	2.92 d
Counter 20G + Yuma 4E + Yuma 4E	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	8.9 lb 2 pts 2 pts	1.8 1.0 1.0	3.05 d
Counter 20G + Yuma 4E	B 1 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	3.72 cd
Counter 20G + Mustang Maxx + Mustang Maxx	B 1 d Pre-peak Broadcast 2 d Post-peak Broadcast	8.9 lb 4 fl oz 4 fl oz	1.8 0.025 0.025	3.88 bcd
Counter 20G + Mustang Maxx	B 1 d Pre-peak Broadcast	8.9 lb 4 fl oz	1.8 0.025	4.16 bc
Counter 20G + Yuma 4E	B 3 d Pre-peak Broadcast	8.9 lb 1 pt	1.8 0.5	4.25 bc
Counter 20G	B	8.9 lb	1.8	4.81 b
Check	---	---	---	6.92 a
LSD (0.05)				1.010

Means within a column sharing a letter are not significantly ($P = 0.05$) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch band; Post Broad = postemergence broadcast

Yield and associated gross economic return (i.e., excluding application and product costs) results from this trial are presented in Table 2. All treatments that included at least one postemergence insecticide spray provided significant increases in both recoverable sucrose yield and root tonnage. The single planting-time treatment consisting of Counter 20G at 8.9 lb/ac was the only treatment in the entire trial that did not provide a significant increase in recoverable sucrose or sugarbeet root yield. As observed with root injury rating data, excellent sucrose and root yields resulted from treatment combinations that included two postemergence applications of Yuma 4E (i.e., either 1 or 2 pts product/ac). Plots treated with those combinations produced significantly more root tonnage than all other treatments in the trial, and significantly greater recoverable sucrose yield per acre than all treatments, except the combination of Counter 20G plus a single application of Yuma at 2 pts/ac. Unfortunately, although trends suggested some numerical increases in sucrose and root tonnage from single postemergence application of Yuma 4E at the lower, 1-pt rate and both the single and double applications of Mustang Maxx none of those additive treatments resulted in a significant increase in either recoverable sucrose yield or root tonnage.

Table 2. *Yield parameters* from an assessment of Yuma 4E® and Mustang Maxx® for postemergence sugarbeet root maggot control, St. Thomas, ND, 2020-2021

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 + Yuma 4E + Yuma 4E	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	8.9 lb 2 pts 2 pts	1.8 1.0 1.0	9,244 a	29.2 a	17.0 a	1,395
Counter 20G + Yuma 4E + Yuma 4E	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	8.9 lb 1 pt 1 pt	1.8 0.5 0.5	8,938 a	27.9 ab	17.1 a	1,364
Counter 20G + Yuma 4E	B 1 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	8,261 ab	25.6 bc	17.2 a	1,269
Counter 20G + Mustang Maxx + Mustang Maxx	B 1 d Pre-peak Broadcast 2 d Post-peak Broadcast	8.9 lb 4 fl oz 4 fl oz	1.8 0.025 0.025	7,679 bc	23.6 cd	17.2 a	1,194
Counter 20G + Mustang Maxx	B 1 d Pre-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	7,592 bc	23.4 cd	17.1 a	1,176
Counter 20G + Yuma 4E	B 3 d Pre-peak Broadcast	8.9 lb 1 pt	1.8 0.5	7,548 bc	24.0 cd	16.8 a	1,132
Counter 20G	B	8.9 lb	1.8	6,797 cd	21.4 de	16.8 a	1,029
Check	---	---	---	6,084 d	19.4 e	16.3 a	901
LSD (0.05)				1,070.6	3.04	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch band; Post Broad. = postemergence broadcast

Although there were no significant differences among the top three treatments with regard to recoverable sucrose per acre or root yield, economic return results suggest that, under the high SBRM pressure that developed for both years of this study, substantial increases in gross revenue can be achieved through effective postemergence insecticide approaches. Even the lowest-yielding planting-time/postemergence treatment combination, consisting of Counter 20G at planting plus one application of Yuma 4E at 1 pt/ac, generated $103/ac in increased revenue when compared to Counter alone. Another interesting finding was that, when a total of two pints of Yuma 4E was used, splitting the total product amount applied into two separate applications of one pt each resulted in a revenue increase of $95 over the single, two-pint application.

The best-performing treatment, in considering protection from SBRM feeding injury, recoverable sucrose yield, root tonnage, and resulting gross revenue, was the combination of planting-time Counter 20G at its high labeled rate (8.9 lb/ac) plus two 2-pt/ac applications of Yuma 4E, one at 5 days SBRM fly activity and the second one at 5 days post-peak. This combination generated $946/ac more gross revenue than the untreated check, and at least $31/ac more greater revenue than any other insecticide treatment combination tested in this experiment. Also supportive of aggressive approaches to SBRM management was the finding that the top-performing program in this trial (Counter at planting followed by two 2-pt/ac applications of Yuma 4E) increased gross economic return over the Counter-only treatment by $366/ac.

The top-yielding, aggressive approach also generated $201/ac greater gross revenue than a similar treatment combination comprised of Counter at planting plus two applications of Mustang Maxx at its maximum labeled rate (4 fl oz/ac). This suggests that dual broadcast applications of a chlorpyrifos-containing sprayable liquid (e.g., Lorsban 4E, Yuma 4E, etc.), probably provide superior postemergence SBRM management to those involving dual applications of a pyrethroid-based insecticide such as Mustang Maxx. It should be noted, however, that single and dual postemergence broadcasts of Mustang Maxx provided respective revenue benefits of $147 and $165/ac when compared to the single, Counter 20G-based control programs.

Given that chlorpyrifos tolerances in sugarbeet have been revoked, it is highly likely that U.S. sugarbeet producers will face serious challenges with regard to SBRM management in the future. Producers in affected areas, such as much of the RRV sugarbeet growing area, who perennially experience the threat of economically damaging SBRM infestations, should strongly consider using a pyrethroid insecticide in lieu of the regulatory loss of chlorpyrifos-based products as sprayable liquid insecticide options. Another viable, although expensive, option would be to invest in equipment for applying postemergence applications of a granular organophosphate insecticide product. Results further suggest that even two applications of a pyrethroid insecticide may still be insufficient in maximizing yield and associated revenue under high SBRM infestation pressure. Another general conclusion that can be drawn is that the root protection, yield, and revenue benefits from additive postemergence insecticides demonstrate that they are cost-effective tools that easily pay for themselves in areas where moderately high to severe SBRM populations occur.

Acknowledgments:

The authors thank Wayne and Austin Lessard, and Darryl Collette for allowing us to conduct this research on their farms. Appreciation is also extended to the Sugarbeet Research and Education Board of Minnesota and North Dakota for providing partial funding to support this project. We also thank 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. Gratitude is 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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