IMPACT OF INSECTICIDE SPRAY RATES, TIMING, AND PRODUCT ROTATIONS FOR POSTEMERGENCE ROOT MAGGOT CONTROL

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Introduction:

Severe infestations of the sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), frequently develop in central and northern portions of the Red River Valley (RRV) growing area of North Dakota and Minnesota. Sugarbeet root maggot populations in this production area have been mostly trending upward during much of the past decade. As such, this pest is an ongoing, and even growing threat to farm profitability for many producers growing sugarbeet within its range. This intense insect pressure typically requires aggressive pest management programs to ensure adequate protection of the sugarbeet crop. Pest management programs in areas at high risk for damaging SBRM infestations usually consist of either a granular insecticide or an insecticidal seed treatment at planting, followed by an additive postemergence insecticide application when the 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.

Current U.S. Environmental Protection Agency labeling for all sprayable liquid insecticide products containing the active ingredient chlorpyrifos (e.g., Lorsban 4E, Lorsban Advanced, and all generic versions) includes a 10-day reapplication interval. This requires a 10-day period between successive applications of any sprayable liquid insecticide formulation that includes chlorpyrifos. The restriction, which began in 2010, lengthened the reapplication interval by three days. It has been thought that this restriction could impair growers' ability to effectively manage the SBRM with chlorpyrifos-based products, because high fly activity periods usually only persist for about seven days. In an effort to address this potential problem, research was undertaken to achieve the following objectives regarding postemergence SBRM management: 1) determine the most effective timing schemes for repeated applications of Lorsban Advanced sprays that adhere to its 10-day reapplication restriction; 2) assess the impact of application rate on Lorsban Advanced performance; and 3) evaluate Mustang Maxx as a single postemergence tool and as rotated with Lorsban Advanced applications for postemergence SBRM control.

Materials and Methods:

This experiment was conducted on a commercial sugarbeet field site near St. Thomas in southern Pembina County, ND. Betaseed 89RR52 glyphosate-resistant seed was used for all treatments. Plots were planted on 10 May, 2018. 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. No insecticide was applied to the outer "guard" rows (i.e., rows one and six) of each plot, as those rows served as untreated buffers. 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.

<u>Planting-time insecticide applications</u>. 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™ row banders. Granular application rates were regulated by using planter-mounted SmartBox™ computer-controlled insecticide delivery system that had been calibrated on the planter before all applications.

<u>Postemergence insecticide applications.</u> Additive postemergence insecticides used included Lorsban Advanced and Mustang Maxx. Treatments that included postemergence applications involved both single and double postemergence spray applications at varying rates. Treatment timings compared included seven and three days ahead of ("Pre-peak") SBRM fly activity (i.e., 31 May and 4 June, respectively, and one, four, and eight days after peak ("Post-peak") fly activity (i.e., 8, 12, and 15 June, resp.). Liquid insecticide solutions were delivered with a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ 110015VS nozzles calibrated to deliver

applications in a finished output volume of 10 GPA.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in this experiment on 31 July by 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 24 September. 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), and treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

Sugarbeet root maggot feeding injury ratings in the untreated check plots averaged 7.93 on the 0 to 9 scale of Campbell et al. (2000) (Table 1), suggesting that a high SBRM infestation was present for the experiment. All insecticide treatments, including single-, dual-, and triple-insecticide application programs, resulted in significant reductions in SBRM feeding injury when compared to that sustained in the untreated check plots. Additionally, all treatments that included at least one postemergence insecticide spray resulted in significant increases in root protection when compared with similar plots that solely received the same amount of Counter at planting time.

Overall, the root injury rating results from this trial showed that applying the high rate (2 pts product/ac) of Lorsban Advanced was consistently superior to using the 1-pt rate of Lorsban under the high and sustained SBRM pressure that was present for this trial. Excellent SBRM control was achieved by applying Lorsban Advanced at the 2-pt rate at two widely separated (7 days pre-peak + 8 days post-peak; or 7 days pre-peak + 4 days post-peak) spray intervals, despite a moderate rate (7.5 lb product/ac) of Counter 20G being used at planting time. Results also demonstrated that, when the lower (1 pt/ac) rate of Lorsban Advanced was used for two postemergence applications, better control could be achieved by making the applications at the wider (7 days pre- and 8 days post-peak) interval than when made at a closer (7 days pre- and 4 days post-peak) spray interval.

Another positive finding was that Mustang Maxx provided comparable postemergence SBRM control to that of the 1-pt rate of Lorsban Advanced. Mustang also appeared to be an effective rotation partner product with Lorsban Advanced in plots that received applications of these insecticides spaced 4 days apart, and there was no significant impact on root protection by applying either Mustang or Lorsban first in the rotation. The following treatments provided the best protection from SBRM feeding injury in this trial:

1) planting-time Counter 20G at 7.5 lb/ac + two 2-pt/ac postemergence applications of Lorsban Advanced at 7 days pre-peak and 8 days post-peak;
2) planting-time Counter 20G at 7.5 lb/ac + two 2-pt/ac postemergence applications of Lorsban Advanced at 7 days pre-peak and 4 days post-peak; and
3) planting-time Counter 20G at 7.5 lb/ac + two 1-pt/ac postemergence applications of Lorsban Advanced at 7 days pre-peak and 8 days post-peak.

Good root protection from SBRM larval feeding injury was also achieved with the following treatments:

1) planting-time Counter 20G at 7.5 lb/ac + 1 pt/ac of Lorsban Advanced at 3 days pre-peak + 4 fl oz/ac of Mustang Maxx at 1 day post-peak;
2) planting-time Counter 20G at 7.5 lb/ac + 4 fl oz/ac of Mustang Maxx at 3 days pre-peak+ 1 pt/ac of Lorsban Advanced at 1 day post-peak;
3) planting-time Counter 20G at 8.9 lb/ac + a single 2-pt/ac postemergence application of Lorsban Advanced at 3 days pre-peak;
4) planting-time Counter 20G at 7.5 lb/ac + two 1-pt/ac postemergence applications of Lorsban Advanced at 3 days pre-peak and 8 days post-peak; and
5) planting-time Counter 20G at 7.5 lb/ac + 4 fl oz/ac of Mustang Maxx at 3 days pre-peak.

Table 1. ***Larval feeding injury*** **in an assessment of postemergence insecticide spray timing, rate, and frequency impacts on sugarbeet root maggot control, St. Thomas, ND, 2018**				
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 7 d Pre-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 2 pts 2 pts	1.5 1.0 1.0	3.10 h
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 7 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 2 pts 2 pts	1.5 1.0 1.0	3.15 h
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 7 d Pre-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	3.73 gh
Counter 20G + Lorsban Advanced + Mustang Maxx	B 3 d Pre-peak Broadcast 1 d Post-peak Broadcast	7.5 lb 1 pt 4 fl oz	1.5 0.5 0.025	3.88 fg
Counter 20G + Mustang Maxx + Lorsban Advanced	B 3 d Pre-peak Broadcast 1 d Post-peak Broadcast	7.5 lb 4 fl oz 1 pt	1.5 0.025 0.5	3.90 fg
Counter 20G + Lorsban Advanced	B 3 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	4.13 efg
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 3 d Pre-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	4.28 efg
Counter 20G + Mustang Maxx	B 3 d Pre-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	4.35 d-g
Counter 20G + Lorsban Advanced	B 3 d Pre-peak Broadcast	7.5 lb 2 pts	1.5 1.0	4.53 c-f
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 7 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	4.60 cde
Counter 20G + Lorsban Advanced	B 3 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	5.03 cd
Counter 20G	B	8.9 lb	1.8	5.08 c
Counter 20G	B	7.5 lb	1.5	6.13 b
Check	---	---	---	7.93 a
LSD (0.05)				0.689

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 results and associated gross economic returns 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. Single planting-time applications of Counter 20G (i.e., both 7.5- and 8.9-lb rates) were the only treatments in the entire trial that did not provide significant increases in recoverable sucrose and sugarbeet root yield. As observed with root injury rating data, excellent sucrose and root yields resulted from treatment combinations that included at least one postemergence application of Lorsban Advanced at its high labeled rate (2 pts product/ac). The best overall treatments in this trial with regard to recoverable sucrose yield included the following:

1) planting-time Counter at 8.9 lb/ac + a single 2-pt/ac postemergence application of Lorsban Advanced at 3 days pre-peak;
2) planting-time Counter 20G at 7.5 lb/ac + two 2-pt/ac postemergence applications of Lorsban Advanced at 7 days pre-peak and 4 days post-peak;
3) planting-time Counter at 7.5 lb/ac + two 2-pt/ac postemergence applications of Lorsban Advanced at 7 days pre-peak and 8 days post-peak; and
4) planting-time Counter at 7.5 lb/ac + a single 1-pt/ac postemergence application of Lorsban Advanced at 3 days pre-peak;
5) planting-time Counter at 7.5 lb/ac + two 1-pt/ac postemergence applications of Lorsban Advanced at 7 days pre-peak and 4 days post-peak; and
6) planting-time Counter at 7.5 lb/ac + 4 fl oz/ac of Mustang Maxx applied postemergence at 3 days pre-peak + 1 pt/ac of Lorsban Advanced at 1 day post-peak.

There were no significant different differences among these top six treatments with regard to recoverable sucrose yield. The highest root tonnage yield was achieved by applying Counter 20G at 8.9 lb/ac, and following that with one postemergence application of Lorsban Advanced at 2 pts/ac. However, the best overall 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 7.5 lb/ac plus two 2-pt/ac applications of Lorsban Advanced, one at 7 days pre-peak and the second one at 4 days after peak SBRM fly activity. This combination generated $476/ac more gross revenue than the untreated check plots, and $29/ac more greater revenue than any other insecticide treatment combination tested in this experiment.

Table 2. ***Yield parameters*** **from an assessment of postemergence insecticide spray timing, rate, and frequency impacts on sugarbeet root maggot control, St. Thomas, ND, 2018 (5)**

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 + Lorsban Advanced	B 3 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	8886 a	28.5 a	16.80 a	1118
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 7 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 2 pts 2 pts	1.5 1.0 1.0	8783 a	26.7 ab	17.55 a	1182
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 7 d Pre-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 2 pts 2 pts	1.5 1.0 1.0	8529 a	25.8 bc	17.60 a	1153
Counter 20G + Lorsban Advanced	B 3 d Pre-peak Broadcast	7.5 lb 2 pts	1.5 1.0	8192 ab	25.7 bc	17.10 a	1059
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 7 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	8166 ab	25.6 bc	17.03 a	1058
Counter 20G + Mustang Maxx + Lorsban Advanced	B 3 d Pre-peak Broadcast 1 d Post-peak Broadcast	7.5 lb 4 fl oz 1 pt	1.5 0.025 0.5	8114 abc	26.4 ab	16.55 a	998
Counter 20G + Lorsban Advanced + Mustang Maxx	B 3 d Pre-peak Broadcast 1 d Post-peak Broadcast	7.5 lb 1 pt 4 fl oz	1.5 0.5 0.025	7583 bcd	24.4 bcd	16.78 a	952
Counter 20G + Mustang Maxx	B 3 d Pre-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	7352 dc	23.5 cd	16.90 a	931
Counter 20G + Lorsban Advanced	B 3 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	7248 d	23.8 cd	16.53 a	881
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 7 d Pre-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 1.0 1.0	7234 d	23.5 cd	16.65 a	894
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 3 d Pre-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	7087 de	22.1 de	17.15 a	924
Counter 20G	B	8.9 lb	1.8	6386 ef	20.8 ef	16.60 a	785
Counter 20G	B	7.5 lb	1.5	6030 f	19.6 f	16.68 a	745
Check	---	---	---	5889 f	19.6 f	16.43 a	706
LSD (0.05)				801.6	2.35	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

One major positive finding in this study was that spreading out two postemergence applications of Lorsban Advanced to between 11- and 15-day intervals (i.e., 7 days pre- + 4- or 8-days post-peak) did not appear to compromise control, as long as the high rate (2 pts/ac) of Lorsban was used for both applications. However, when Lorsban Advanced was applied at the lower (1 pt/ac) rate, the 11-day (7 days pre- and 4 days post-peak) reapplication interval was statistically superior to the wider (15-day; i.e., 7 days pre-peak and 8 days post-peak) re-spray interval. Applying the successive 1-pt applications of Lorsban Advanced at the 11-day interval increased recoverable sucrose by 932 lb/ac and root yield by 2.1 tons/ac, and also generated $164/ac more in gross economic return than when the same rate of Lorsban Advanced was applied at a 15-day re-spray interval. Another interesting finding was that, in treatments that involved two postemergence applications of the lower (1 pt/ac) rate of Lorsban Advanced at an 11-day respray interval, recoverable sucrose and root yield were significantly increased (by 1,079 lb and 3.5 tons/ac, respectively) when the Lorsban applications were made at 7 days pre-peak and 4 days post-peak, as opposed to applying them at 3 days pre-peak and 8 days after peak fly. This may have resulted from the sustained period of high fly activity surrounding the main peak in fly activity. As such, these comparisons should probably be tested further.

Postemergence applications of Mustang Maxx (4 oz product/ac) appeared to provide similar yield benefits to those of the lower (1 pt product/ac) rate of Lorsban Advanced, and adding Mustang Maxx in the postemergence spray rotation provided significant increases in both recoverable sucrose (866 lb/ac) and root yield (2.6 tons/ac) if the Mustang was applied first in the rotation. This contradicts findings from those observed in 2017; however, it should also be noted that there was no significant difference in either sucrose yield or root tonnage in comparing the two treatments that involved either Mustang Maxx followed by Lorsban Advanced or the reverse-order rotation of these two products. Therefore, more research on this rotation scheme may also be needed.

Overall, most of the SBRM control programs evaluated in this experiment provided effective SBRM control that translated to major yield and revenue benefits. 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.

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