OPTIMIZING APPLICATION TIMING AND RATES OF POSTEMERGENCE INSECTICIDE SPRAYS FOR SUGARBEET ROOT MAGGOT CONTROL

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is a perennial threat to the profitability of sugarbeet production in central and northern portions of the Red River Valley growing area of North Dakota and Minnesota. Adequate control of the frequently intense SBRM infestations that commonly occur in this area typically requires aggressive pest management practices. Pest management programs in areas at high risk of having damaging SBRM infestations usually consist of either a granular insecticide or an insecticidal seed treatment at planting, followed by an additive postemergence insecticide application. Broadcast applications of sprayable liquid insecticides, applied on an as-needed, rescue basis, are the most commonly used postemergence tools for root maggot control in the Red River Valley.

Effective for the 2010 growing season, federal label changes resulted in 10-day reapplication interval for all sprayable liquid chlorpyrifos insecticide products (e.g., Lorsban 4E, Lorsban Advanced, and all generic versions). The label revision lengthened the reapplication interval by three days and may have resulted in compromising the ability of sugarbeet growers to effectively manage the SBRM because significant fly activity peaks typically persist for less than 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 the 10-day reapplication restriction; 2) assess the impact of application rate on Lorsban Advanced performance; and 3) evaluate the 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 rural Pembina County, ND. Betaseed 89RR52 glyphosate-resistant seed was used for all treatments. Plots were planted on 9 May. 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.

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™ 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.

Postemergence insecticide applications. Additive postemergence insecticides used included Lorsban Advanced and Mustang Maxx. Treatment timings included seven, three, and two days pre-peak SBRM fly activity (i.e., 2, 6, and 7 June, respectively, and four and seven days after peak fly (i.e., 13 and 16 June, resp.). Sprays were delivered with a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ 110015VS nozzles and calibrated to deliver the broadcast sprays in a finished output volume of 10 GPA.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in this experiment on 1 and 2 August, 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 19 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, 2008), 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 of this trial averaged 7.2 on the 0 to 9 scale of Campbell et al. (2000), thus indicating that high SBRM pressure was present for the experiment (Table 1). All insecticide treatments, whether involving single at-plant applications, or at-plant/postemergence combinations, provided significant reductions in feeding injury when compared to the untreated check. General patterns indicated that the best protection from root maggot feeding injury was provided by entries that involved combining planting-time with aggressive postemergence control programs.

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, 2016

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 3 d Pre-peak Broadcast 7 d Post-peak Broadcast	7.5 lb 2 pts 2 pts	1.5 1.0 1.0	3.05 f
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 3 d Pre-peak Broadcast 7 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	3.33 ef
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	3.53 def
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 2 pts	1.5 1.0	3.95 c-f
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	4.10 b-f
Counter 20G + Mustang Maxx	B 2 d Pre-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	4.18 b-e
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	4.30 bcd
Counter 20G + Lorsban Advanced + Mustang Maxx	B 2 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 1 pt 4 fl oz	1.5 0.5 0.025	4.45 bcd
Counter 20G + Mustang Maxx + Lorsban Advanced	B 2 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 4 fl oz 1 pt	1.5 0.025 0.5	4.45 bcd
Counter 20G	B	8.9 lb	1.8	4.68 bc
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	4.73 bc
Counter 20G	B	7.5 lb	1.5	5.10 b
Check	---	---	---	7.20 a
LSD (0.05)				1.07

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = banded at planting

The best overall root protection was provided by the combination of Counter 20G at its moderate (7.5 lb product/ac) rate at planting plus two applications (3 days pre- and 7 days post-peak fly) of Lorsban Advanced at its high labeled rate of 2 pts/ac. Although this combination had numerically less root injury than all other treatments in the trial, the following entries were not significantly different from it: 1) Counter at 7.5 lb/ac + two 1-pt/ac applications of Lorsban Advanced at 3 days pre-peak and 7 days post-peak; 2) Counter at 7.5 lb/ac + two 2-pt/ac applications of Lorsban Advanced at 7 days pre-peak and 4 days post-peak; 3) Counter at 7.5 lb/ac + one postemergence application of Lorsban Advanced at its high labeled rate of 2 pts/ac at 3 days pre-peak; and 4) Counter at 7.5 lb/ac + one postemergence application of Lorsban Advanced at 1 pt/ac at 2 days pre-peak.

Application timing appeared to affect treatment performance in entries involving postemergence insecticide sprays in this trial. For example, in plots treated with a split (i.e., 1 pt/ac pre-peak + 1 pt/ac post-peak) application of Lorsban Advanced, applying the first postemergence application close to peak fly (i.e., 3 days pre-peak) and following 10 days later with the second application resulted in significantly better protection from SBRM feeding injury than when the first Lorsban spray was made earlier (i.e., 7 days pre-peak). A similar pattern was observed with split applications of Lorsban Advanced at 2 pts/ac each, where slightly better control occurred when the first of two 2-pt sprays of Lorsban was made near (i.e., 3 days before) peak fly rather than when the first spray was applied earlier; however, the difference was not statistically significant.

Rate-related differences were infrequent in this trial. For example, root maggot feeding injury in plots treated with a planting-time application of Counter 20G at the moderate (7.5 lb product/ac) rate was not statistically different from that in plots treated with Counter at its high labeled rate (8.9 lb/ac). Similarly, when a planting-time application of Counter at 7.5 lb product per acre was used as the base treatment, there was no significant difference between adding a single postemergence application of one or two pints of Lorsban Advanced.

Another interesting finding was related to both application timing and rate. There was no significant difference in SBRM feeding injury between 1- and 2-pt split applications of Lorsban Advanced when the first spray was made near peak fly as described above (i.e., 3 days pre-peak); however, when the first spray was applied earlier, the split application of two 2-pt sprays resulted in significantly lower SBRM feeding injury than when the splits were applied at the 1-pt rate. This provides further evidence that applying the first of two postemergence sprays at or near peak fly activity may be more effective than applying it one week ahead of peak fly.

Postemergence applications of Mustang Maxx did not appear to provide major benefits with regard to protection from SBRM feeding injury. For example, in plots that were initially treated with an at-plant application of Counter 20G at its moderate (7.5 lb product/ac) rate, there was no significant difference in SBRM feeding injury between treatments that received Mustang Maxx at its full labeled rate and those that only received the at-plant application of Counter.

Yield results and associated gross economic returns from this trial are presented in Table 2. All dual- and triple-insecticide application programs in this experiment significantly increased recoverable sucrose and root yield when compared to the untreated check. There were no significant differences among dual- and triple-component programs in relation to recoverable sucrose yield or root tonnage. The following postemergence sprays in dual-insecticide programs did not provide significant increases in recoverable sucrose or yield over that of the single planting-time treatment of Counter at 7.5 lb/ac: 1) Mustang Maxx at 4 fl oz/ac; and 2) Lorsban Advanced at its low (1 pt product/ac). In comparing entries that included the same at-plant rate of Counter 20G, Mustang Maxx did not impart a significant impact on the yield parameters measured; however, it bears noting that the two triple-component programs that involved postemergence applications of Mustang produced the 2nd- and 3rd-highest recoverable sucrose and the top two highest root yields in the experiment.

The only insecticide treatment that failed to generate a significantly greater recoverable sucrose yield than the untreated check was the planting-time-only treatment of Counter 20G at its moderate (i.e., 7.5 lb product/ac) rate. Also, neither of the single planting-time treatments (i.e., 7.5 and 8.9 lb/ac) of Counter 20G produced significant increases in root yield when compared to the untreated check plots.

The best overall treatment with regard to sucrose yield and gross economic return was the triple-component program of the moderate (7.5 lb product/ac) rate of Counter 20G at planting, combined with two split applications of Lorsban Advanced at its high (2 pts/ac) rate at three days before peak fly and seven days after peak. This treatment produced 281 lb more recoverable sucrose and generated $55/ac more gross revenue than plots treated with the same insecticides and rates, but in which the first Lorsban application was applied earlier (i.e., seven days pre-peak). Although the differences in recoverable sucrose and root yield were not statistically significant between these two programs, this pattern corresponded closely with that in the root injury rating assessments.

Table 2. *Yield parameters* from an assessment of postemergence insecticide spray timing, rate, and frequency impacts on sugarbeet root maggot control, St. Thomas, ND, 2016							
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 + Lorsban Advanced	B 3 d Pre-peak Broadcast 7 d Post-peak Broadcast	7.5 lb 2 pts 2 pts	1.5 1.0 1.0	8105 a	28.5 abc	15.35 a	818
Counter 20G + Lorsban Advanced + Mustang Maxx	B 2 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 1 pt 4 fl oz	1.5 0.5 0.025	7988 a	30.5 a	14.43 bcd	689
Counter 20G + Mustang Maxx + Lorsban Advanced	B 2 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 4 fl oz 1 pt	1.5 0.025 0.5	7926 a	28.9 ab	14.95 abc	750
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	7911 a	28.3 abc	15.10 ab	775
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	7824 a	28.1 abc	15.15 ab	763
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 3 d Pre-peak Broadcast 7 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	7541 a	28.0 abc	14.80 a-d	689
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	7147 ab	27.5 abc	14.10 cde	608
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 2 pts	1.5 1.0	7063 ab	27.6 abc	14.20 cde	580
Counter 20G + Mustang Maxx	B 2 d Pre-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	6717 abc	25.2 abc	14.48 bcd	602
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	6649 abc	25.4 abc	14.48 bcd	575
Counter 20G	B	8.9 lb	1.8	5478 bc	21.6 bcd	13.95 de	439
Counter 20G	B	7.5 lb	1.5	4925 cd	20.5 cd	13.40 e	346
Check	---	---	---	3447 d	14.1 d	13.43 e	255
LSD (0.05				1939.7	8.23	0.858	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = banded at planting

In plots initially treated with the lower (7.5 lb/ac) rate of Counter 20G at planting, the addition of a postemergence insecticide generated between $256 and $472/ac in additional revenue over those that did not receive a postemergence insecticide. Similarly, adding a postemergence insecticide spray of Lorsban Advanced at 2 pts/ac to plots that received initial at-plant protection by applying Counter at its high labeled rate (8.9 lb/ac), generated $336 in additional gross economic return per acre. It also should be noted that the top-yielding entry (i.e., Counter 20G at 7.5 lb/ac at planting + two postemergence applications of Lorsban Advanced at 2 pts/ac each, applied at 3 days pre-peak and seven days post-peak) increased recoverable sucrose yield by over 4,600 lb and root yield by 14.4 tons/ac, and also improved gross economic return by $563/ac when compared to the untreated check. Given that the Lorsban Advanced label now mandates a 10-day re-application interval for this material, these findings suggest that it should be applied at or within two to three days of SBRM peak fly activity, even if it is anticipated that more than one application will be needed.

Most of the SBRM control programs evaluated in this experiment provided effective SBRM control that translated to major yield benefits, and there were no significant recoverable sucrose or root yield differences among the top-performing ten treatments. 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 to use in areas where damaging SBRM populations occur. Overall, the findings from this experiment provide strong evidence regarding the significance of the sugarbeet root maggot as a serious economic pest of sugarbeet, and also underscore the importance of effective pest management strategies in areas affected by it.

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