SEED TREATMENT AND AT-PLANT GRANULAR INSECTICIDES COMBINED WITH POSTEMERGENCE CONTROL TOOLS TO MANAGE SUGARBEET ROOT MAGGOT

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) is the most important economic insect pest of sugarbeet in the Red River Valley (RRV) growing area. Previous field research has shown that this pest is capable of causing more than 45% yield losses in the absence of effective control measures (Boetel et al. 2010). Sugarbeet producers in the northern RRV annually face the threat to profitability that this pest poses. However, in recent years, the insect has expanded its range south and eastward, with damaging infestations occurring in Grand Forks and Traill counties of North Dakota, as well as Polk and Norman counties in Minnesota. Growers in areas at risk of high SBRM infestations typically begin control this pest by using planting-time insecticide protection, either in the form of a granular insecticide or an insecticidal seed treatment. Additive protection in moderate- to high-risk areas typically consists of either a banded application of a granular insecticide ahead of the anticipated peak in SBRM fly activity or a postemergence spray application timed close to peak fly. The postemergence spray strategy provides growers with a "wait and see" option to make informed decisions on whether rescue insecticide treatments are needed based on current SBRM fly activity data. Regardless of which strategy a grower prefers, it is critical that research continue toward determining the most effective combinations of planting-time and postemergence insecticides to optimize control of this important sugarbeet pest.

This study involved two experiments that were carried out during the 2015 growing season. The objective of Study I were to: 1) compare Counter 20G granular insecticide with Poncho Beta seed treatment for at-plant SBRM control; 2) determine the efficacy of combining Poncho Beta with Counter 20G at planting time for a one-pass protection system; 3) assess the impacts of additive postemergence applications of Thimet 20G to plots initially treated with either Counter 20G or Poncho Beta seed treatment for SBRM control; and 4) measure the performance of Counter 20G as a postemergence granular control option.

The objectives of Study II were to: 1) measure the impact of Lorsban Advanced liquid insecticide spray applications on plots initially treated at planting time with Poncho Beta seed treatment or Counter 20G for root maggot control; and 2) determine the most effective rate of Lorsban Advanced applied as a postemergence treatment for providing additive control.

Materials and Methods:

Both experiments were established on a commercial sugarbeet field site near St. Thomas in rural Pembina County, ND. The township in which the plots were located typically plays host to some of the most severe SBRM infestations in North America. Betaseed 89RR83 glyphosate-resistant seed was used for all entries in both experiments, and a professional seed preparation company (Germains Seed Technology, Fargo, ND) applied Poncho Beta insecticide to seed for all seed treatment entries in both experiments. Both experiments were planted on 27 May. All plots were planted using a 6-row Monosem NG Plus 4 7x7 planter set to plant 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" rows (i.e., rows one and six) on each side of the plot 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. To avoid cross-contamination of seed between treatment applications, planter seed hoppers and seed dispensation equipment were completely disassembled, cleaned, and re-assembled after the application of each treatment.

<u>Planting-time insecticide applications</u>. Counter 20G 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

rates were regulated by using a planter-mounted SmartBox™ computer-controlled insecticide delivery system that was calibrated on the planter immediately before all applications.

Postemergence insecticide applications (Studies I and II). Postemergence insecticides used in Study I consisted of two granular materials (i.e., Counter 20G and Thimet 20G) and one liquid spray product (i.e., Lorsban Advanced). Postemergence granules (Post B) were applied on 5 June, or about 7 days before the first main peak in SBRM fly activity. Band placement of postemergence granules was achieved by using Kinze™ row banders attached to a tractor-mounted tool bar and adjusted to a height needed to deliver the insecticides in 4-inch bands. As with at-plant applications, granular 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. All postemergence granular insecticides were incorporated using two pairs of rotary tines that straddled each row on the tool bar. A paired set of tines was positioned ahead of each bander, and a second pair was mounted behind the granular drop zone. This system effectively stirred soil around the bases of sugarbeet seedlings and incorporated granules as the unit passed through each plot.

In Study II, all postemergence insecticide treatments involved Lorsban Advanced spray applications. Sprays were applied on 10 June (i.e., about 2 days before peak SBRM fly activity) using a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ 110015VS nozzles. The system was calibrated to deliver a finished spray volume of 10 GPA as a broadcast application. Plots assigned to receive postemergence broadcasts of liquid insecticides were three tractor passes (i.e., 33 ft rather than the standard 11-ft width) wide to minimize the likelihood of flies exposed to a foliar liquid insecticide treatment in one plot emigrating from it and colonizing a neighboring plot. However, all root maggot feeding injury ratings and harvest samples were taken out of the inner four rows of each plot.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in both studies between 27 and 28 July, respectively, 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 for both studies were harvested on 30 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:

Study I. Sugarbeet root maggot feeding injury rating results for Study I are presented in Table 1. The level of root injury that occurred in the untreated check plots (mean = 7.5 on the 0 to 9 scale of Campbell et al. [2000]) suggested that a relatively high SBRM infestation was present for this study. All insecticide-protected plots had significantly lower levels of root maggot feeding injury than the untreated check, irrespective of whether a seed treatment, single at-plant granular application, or dual-treated combination was used for SBRM control. Also, all entries that included an additive insecticide application provided significant improvements in root protection from SBRM feeding injury over Poncho Beta alone and the single, at-plant applications of Counter 20G. There were no statistical differences in SBRM feeding injury between any of the dual insecticide treatments, irrespective of whether they consisted of Poncho Beta seed treatment plus at-plant Counter 20G, Poncho Beta plus postemergence Counter applications, or conventional granular programs consisting of Counter applied at planting-time combined with Thimet at postemergence.

Table 1. ***Larval feeding injury*** **in an evaluation of planting-time insecticide granules, seed treatments, and postemergence granules for sugarbeet root maggot control, St. Thomas, ND, 2015**				
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Poncho Beta + Counter 20G	Seed 7 d Pre-peak Post B	 5.25 lb	68 g a.i./ unit seed 1.05	3.28 c
Poncho Beta + Counter 20G	Seed 7 d Pre-peak Post B	 8.9 lb	68 g a.i./ unit seed 1.8	3.48 c
Poncho Beta + Counter 20G	Seed B	 8.9 lb	68 g a.i./ unit seed 1.8	3.68 c
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	3.95 c
Poncho Beta + Counter 20G	Seed B	 5.25 lb	68 g a.i./ unit seed 1.05	3.98 c
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	3.98 c
Poncho Beta + Thimet 20G	Seed 7 d Pre-peak Post B	 7 lb	68 g a.i./ unit seed 1.4	3.98 c
Poncho Beta	Seed		68 g a.i./ unit seed	5.15 b
Counter 20G	B	8.9 lb	1.8	5.43 b
Counter 20G	B	7.5 lb	1.5	5.53 b
Counter 20G	B	5.25 lb	1.05	5.53 b
Check	---	----	---	7.50 a
LSD (0.05)				1.02

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; Post B = postemergence band; Seed = insecticidal seed treatment

Yield data from Study I are shown in Table 2. Treatment performance in relation to yield parameters mostly followed similar patterns to those observed in root maggot feeding injury data for this trial. All insecticide treatments, irrespective of whether consisting of single at-plant protection (i.e., Counter 20G or Poncho Beta) provided statistically significant increases in both recoverable sucrose yield and root tonnage. The top-performing entries in with regard to recoverable sucrose and root yield were two dual treatments consisting of Counter 20G at planting time, combined with a postemergence application of Thimet 20G. Although these treatments were not statistically different from each other with regard to sucrose yield, root tonnage, or percent sucrose, the program

Table 2. ***Yield parameters*** **from an evaluation of planting-time insecticide granules, seed treatments, and postemergence granules for sugarbeet root maggot control, St. Thomas, ND, 2015**							
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 + Thimet 20G	B 7 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	8392 a	30.1 a	15.18 a	903
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	7912 ab	30.1 a	14.45 a	766
Poncho Beta + Counter 20G	Seed B	 8.9 lb	68 g a.i./ unit seed 1.8	7685 abc	28.8 abc	14.65 a	767
Poncho Beta + Counter 20G	Seed 7 d Pre-peak Post B	 8.9 lb	68 g a.i./ unit seed 1.8	7615 abc	28.7 abc	14.63 a	753
Poncho Beta + Thimet 20G	Seed 7 d Pre-peak Post B	 7 lb	68 g a.i./ unit seed 1.4	7525 abc	27.3 bcd	15.00 a	793
Poncho Beta + Counter 20G	Seed 7 d Pre-peak Post B	 5.25 lb	68 g a.i./ unit seed 1.05	7418 abcd	28.1 abcd	14.53 a	728
Poncho Beta + Counter 20G	Seed B	 5.25 lb	68 g a.i./ unit seed 1.05	7342 bcd	29.1 ab	14.05 a	655
Counter 20G	B	8.9 lb	1.8	7335 bcd	27.8 bcd	14.48 a	719
Counter 20G	B	7.5 lb	1.5	6767 cde	26.6 cd	14.13 a	617
Poncho Beta	Seed		68 g a.i./ unit seed	6460 de	26.6 cd	13.58 a	532
Counter 20G	B	5.25 lb	1.05	6265 e	25.8 d	13.63 a	515
Check	---	----	---	4675 f	19.2 e	13.58 a	388
LSD (0.05)				1047	2.3	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 = banded at planting; Post B = postemergence band; Seed = insecticidal seed treatment

consisting of Counter and Thimet, applied at their maximum labeled application rates, generated the highest gross economic return in this experiment ($903). That revenue was $515 above that generated from untreated check plots, and it was the only entry that yielded significantly more recoverable sucrose yield than the single at-plant entries of either Counter 20G or Poncho Beta seed treatment.

Although all insecticide regimes tested provided major benefits regarding recoverable sucrose yield and root tonnage, none of the entries resulted in a significant impact on percent sucrose content, suggesting that root injury caused by the SBRM is less related to quality parameters and more associated with impacting the plant's ability to develop root mass. Overall, the findings from this trial demonstrate that effective SBRM control from dual (i.e., planting-time plus postemergence) insecticide programs generated revenue benefits ranging from $267 to $515 per acre when compared to the untreated checks, whereas single at-plant programs (i.e., Counter or Poncho Beta) only provided benefits of between $127 and $331 per acre. Although the benefits provided by single-application programs are sizable, and clearly generate revenue that exceeds associated input costs, the practice of applying an additive insecticide, either at planting-time or postemergence results in substantially more yield and revenue. These findings also underscore the importance of the SBRM as a serious economic pest of sugarbeet.

It should be noted that Counter insecticide can only be applied once per year. Therefore, if it is applied at planting, it cannot be applied to the same field at postemergence. It also bears noting that the Counter 20G label has been revised to include a 90-day preharvest interval (i.e., PHI, the number of days that must elapse after application before a crop can be harvested) for sugarbeet. This makes Counter 20G a much more feasible product as a postemergence option for sugarbeet root maggot control, as it previously was labeled with a 110-day PHI. The new, 90-day PHI should work well for SBRM management in the Red River Valley, because postemergence granule applications are typically most effective if made in late-May to early-June. However, growers must comply with this new PHI if choosing to use Counter 20G for postemergence SBRM control.

Study II. Results from root maggot larval feeding injury assessments for Study II appear in Table 3. As observed in Study I, relatively high SBRM larval feeding pressure occurred in Study II, as was evidenced by the high average root injury rating recorded for the untreated check (7.45 on the 0 to 9 scale). Also, all insecticide entries provided significant reductions in feeding injury when compared with the untreated check plots.

Table 3. *Larval feeding injury* in an evaluation of planting-time insecticide granules, seed treatments, and postemergence liquid sprays for sugarbeet root maggot control, St. Thomas, ND, 2015

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Poncho Beta + Lorsban Advanced	Seed 2 d Pre-peak Broadcast	 2 pts	68 g a.i./ unit seed 1.0	3.88 d
Poncho Beta	Seed		68 g a.i./ unit seed	4.33 cd
Poncho Beta + Lorsban Advanced	Seed 2 d Pre-peak Broadcast	 1 pt	68 g a.i./ unit seed 0.5	4.38 cd
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	4.80 bcd
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	8.9 lb 1 pt	1.8 0.5	4.85 bcd
Counter 20G	B	8.9 lb	1.8	5.03 bc
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	5.40 bc
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 2 pts	1.5 1.0	5.50 b
Counter 20G	B	7.5 lb	1.5	5.50 b
Check	---	----	---	7.45 a
LSD (0.05)				1.08

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; Seed = insecticidal seed treatment

The following treatments provided the best root protection in this trial: 1) Poncho Beta + Lorsban Advanced applied postemergence as a broadcast at 2 pts of product/ac; 2) Poncho Beta alone; 3) Poncho Beta + Lorsban Advanced as a postemergence broadcast at 1 pt/ac; 4) Counter banded at 8.9 lb product/ac + Lorsban Advanced postemergence at 2 pts/ac; and 5) Counter banded at 8.9 lb product/ac + Lorsban Advanced at 1 pt/ac. The top three of these entries resulted in significantly better root protection than the stand-alone application of Counter 20G at its mid-range rate of 7.5 lb product/ac.

Overall, the SBRM feeding injury results from this study indicated that the root protection provided by Poncho Beta insecticidal seed treatment was generally better than that provided by Counter 20G. This has not been observed in previous trials. As such, this experiment should be repeated in the future to determine if this is a newly established phenomenon.

No significant increases in root protection were observed when postemergence applications of Lorsban Advanced were added to planting-time applications of Counter 20G or Poncho Beta seed treatment. This is also an uncommon finding, although similar patterns were observed in trials conducted in 2014. It could have been a result of the unusually high and extended period of SBRM fly activity, which also resulted in a high SBRM larval infestation in these plots. The long period of fly activity also made it difficult to effectively time the postemergence Lorsban sprays for effective SBRM control in this experiment.

Yield results for Study II (Table 4) corresponded closely to the root maggot feeding injury data. All insecticide entries in Study II provided significant increases in recoverable sucrose and root yield when compared to the untreated check plots. There were very few significant differences among treatments. The top-performing entry in this study with regard to both recoverable sucrose and root yield included the following: 1) Counter 20G applied at planting at its highest labeled (8.9 lb product/ac), combined with a postemergence broadcast application of Lorsban Advanced at its maximum labeled (2 pts/ac); and 2) Poncho Beta seed treatment combined with a postemergence application of Lorsban Advanced (also at the maximum rate of 2 pts/ac). Although these two entries did not produce statistically superior sucrose yields or root tonnage from that of the other dual-insecticide programs tested, they generated gross revenue increases of up to $157 above the other programs. Another dual-insecticide program that performed well in Study II involved Poncho Beta for at-plant protection, combined with a postemergence application of Lorsban Advanced at 1 pt/ac. This entry was not statistically different in recoverable sucrose or root tonnage from the top-yielding entries, and it generated the second-highest revenue in the experiment.

Table 4. *Yield parameters* from an evaluation of planting-time insecticide granules, seed treatments, and postemergence liquid sprays for sugarbeet root maggot control, St. Thomas, ND, 2015

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 2 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	7433 a	29.0 a	14.20 ab	687
Poncho Beta + Lorsban Advanced	Seed 2 d Pre-peak Broadcast	2 pts	68 g a.i./ unit seed 1.0	7275 ab	28.8 a	13.98 ab	654
Poncho Beta	Seed		68 g a.i./ unit seed	7125 ab	26.8 ab	14.63 a	707
Poncho Beta + Lorsban Advanced	Seed 2 d Pre-peak Broadcast	1 pt	68 g a.i./ unit seed 0.5	6855 ab	25.6 ab	14.63 a	688
Counter 20G	B	8.9 lb	1.8	6645 ab	26.0 ab	14.18 ab	610
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	8.9 lb 1 pt	1.8 0.5	6608 ab	25.6 ab	14.33 ab	621
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	6431 ab	25.1 ab	14.08 ab	593
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 2 pts	1.5 1.0	6328 ab	25.8 ab	13.70 bc	530
Counter 20G	B	7.5 lb	1.5	6079 b	23.7 b	14.15 ab	561
Check	---	----	---	3762 c	16.5 c	12.98 c	264
LSD (0.05				1354	4.6	0.75	

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; Seed = insecticidal seed treatment

An unusual finding in Study II was that Poncho Beta as a stand-alone (i.e., without postemergence protection) treatment generated the highest gross economic return ($707/ac) in Study II. This finding has never been observed in previous testing. One or more of the following factors could have contributed to this finding: 1) Poncho-only plots incurred lower SBRM infestations than other plots; 2) roots from Poncho plots were of exceptionally high quality (e.g., low tare, high sucrose content, etc.); and/or 3) a sampling error. Regardless of what may have led to this result, the trial should be repeated to determine the validity of these findings.

General patterns observed in results from Study II indicated that insecticide protection, either in the form of a single at-plant granular or seed treatment insecticide, or as a dual-insecticide program, provide significant levels of root protection from SBRM feeding injury and major yield and revenue benefits. Insecticide-protected plots, overall, generated gross revenue increases that ranged from $297 to $443/ac when compared to untreated control plots. Thus, effective SBRM management is essential in areas that are at risk of high SBRM infestations.

The results of Study II also suggest that, although postemergence applications of Lorsban Advanced appeared to provide additive SBRM control and revenue increases when compared to single at-plant control tools, they did not lead to significant reductions in larval feeding injury or yield benefits, irrespective of Lorsban Advanced application rate. The consistent lack of significant yield impacts from Lorsban Advanced applications in 2015 reflect the results of a similar trial conducted in 2014, and could be related to application timing and its relationship to the prolonged period of relatively high SBRM fly activity. Historically, high levels of SBRM activity have persisted for about 10 to 12 days. In this trial, all Lorsban Advanced sprays were applied at two days before the initial, main peak in fly activity. However, relatively high levels of fly activity persisted for about 21 days. If SBRM populations continue to exhibit these unusually long fly activity periods, adequate control of the pest may require either multiple applications of a product like Lorsban Advanced, separate applications of more than one sprayable liquid insecticide material, or deployment of a postemergence granular insecticide under high SBRM infestation levels that are common in the central and northern Valley.

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