REGISTERED AND EXPERIMENTAL INSECTICIDES APPLIED AT PLANTING TIME AND POSTEMERGENCE FOR SUGARBEET ROOT MAGGOT CONTROL

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) is the most economically important insect pest of sugarbeet in the Red River Valley (RRV) growing area. Sugarbeet growers in the RRV have successfully managed this pest by prophylactically applying granular insecticides to at-risk fields during planting operations. High-risk fields, and those where unexpectedly high SBRM fly infestations occur, are also often treated with a postemergence insecticide to increase the likelihood of successful control.

Three seed treatment insecticides have received U.S. Environmental Protection Agency registration in the past 5 years. These materials have been widely adopted by RRV growers for at-plant management of several soil-dwelling sugarbeet insect pests, including the SBRM. Seed treatment technology is an attractive insecticide option for many growers because no on-farm equipment calibration is required to achieve the desired application rate, no specialized application equipment is needed, and seed treatments allow for significant reductions in the amount of insecticide active ingredient applied to the environment. Historically, insecticidal seed treatment materials have not performed as well as conventional granular insecticide formulations under high to severe SBRM pressure. However, recent research suggests that favorable levels of SBRM control can be achieved by combining seed treatments with postemergence insecticide applications. This project involved two field experiments with a common overriding goal of optimizing dual (planting-time + postemergence) control programs for effective management of the high to severe SBRM infestations that often develop in northern and central portions of the RRV.

Study I was carried out to achieve the following objectives in relation to SBRM control: 1) evaluate the efficacy of integrating Poncho Beta insecticidal seed treatment with postemergence-applied Thimet 20G insecticide; and 2) compare the performance of at-plant and postemergence applications of Counter 20 when used in combination with Poncho Beta seed treatment.

Study II was carried out with the following objectives: 1) assess the effectiveness of combining at-plant insecticidal protection (i.e., Counter 20G or Poncho Beta) with postemergence rescue sprays of the relatively new "Advanced" formulation of Lorsban liquid insecticide for SBRM control; and 2) evaluate two experimental liquid insecticides (i.e., F1 [a coded treatment designation] and Stallion) for efficacy against the SBRM.

Materials and Methods:

These experiments were carried out on a commercial sugarbeet field site near St. Thomas in rural Pembina County, ND. All insecticidal seed treatment materials for these studies were applied to seed by a professional seed preparation company (Germains Seed Technology, Fargo, ND). The same seed variety (i.e., SX Wrangler RR [glyphosate-resistant]) was used for all entries in both experiments. Study I was planted on 3 June, and Study II was planted on 6 June by using a six-row John Deere 71 Flex planter set to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row. 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 25-foot tilled alleys were maintained between replicates. The experiment was arranged in a randomized complete block design with four replications of the treatments. All of the planter's seed hoppers and associated seed delivery equipment (e.g., plates, rings, etc.) were completely disassembled, cleaned, and re-assembled after the application of each seed treatment entry to avoid cross-contamination of seed between treatment applications.

Planting-time insecticide applications. Counter 20G was applied by using band (B) placement, which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. Granular application rates were regulated by using planter-mounted Noble™ metering units that had been calibrated on the planter before all applications. In Study II, the planting-time application of the experimental insecticide F1 was applied with 10-34-0 starter fertilizer, which was diluted in water to a 40% fertilizer concentration, and delivered in 3-inch T-bands over open seed furrows by using a tractor-mounted electric diaphragm pump spray system that was calibrated to deliver a finished spray volume of 5 GPA through TeeJet™ 11001E nozzles.

Postemergence insecticide applications. Postemergence band (Post B) applications of the granular insecticides Counter 20G and Thimet 20G were applied on 19 June, which was during the main peak in SBRM fly activity. Banded placement of postemergence granules was achieved by using Kinze™ row banders attached to a tractor-mounted tool bar and adjusted to a height that resulted in the delivery of insecticides in 4-inch bands. As with at-plant applications, postemergence granular delivery rates were controlled by using planter-mounted Noble™ metering units; however, postemergence granules 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 of tines was mounted immediately behind the granular drop zone. This system effectively stirred soil around the bases of sugarbeet seedlings and incorporated granules into the upper ~0.5 inch of soil as the unit passed through each plot.

In Study II, the postemergence insecticides were all liquid formulations (i.e., Lorsban Advanced and Stallion EC). Postemergence sprays were applied on 20 June (i.e., about 1 day after the main peak in SBRM fly activity) using a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ 11001 VS 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 reduce the likelihood of flies exposed to a foliar liquid insecticide treatment in one plot moving into and colonizing a neighboring plot. However, only the central 11-ft pass received the liquid spray. All root maggot feeding injury and yield assessments were taken out of the center 4 rows of each plot.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in Studies I and II on 7 and 6 August, 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 plant) of Campbell et al. (2000).

Harvest: Treatment performance was also compared on the basis of sugarbeet yield parameters. Both studies were harvested on 23 September. Immediately before harvest, all foliage was removed from plots by using a commercial-grade mechanical defoliator. All beets from the center 2 rows of each plot were lifted 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 analyzed for sucrose content and quality.

Data analysis: All data from root injury ratings and harvest samples were subjected to analysis of variance using the general linear models 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. Despite very high root maggot fly activity in the immediate vicinity of these plots, root maggot feeding pressure in this test was only moderately high (as opposed to the very high to severe that typically occurs in this area). This was likely, in part, due to the unusually late date (3 June) on which this test was planted. That timing resulted in incomplete seedling emergence during the first five to seven days of SBRM fly activity. Thus, the seedlings that had not yet emerged were not available to female SBRM flies for depositing their eggs. This was partially supported by the moderate level of SBRM feeding injury sustained by plants in the untreated check plots (mean = 6.53 on the 0 to 9 scale of Campbell et al. [2000]) for Study I (Table 1).

All insecticide plots, except those that received Poncho Beta-treated seed as a stand-alone (i.e., no postemergence insecticide) treatment, had significantly lower levels of SBRM feeding injury than the untreated check. All stand-alone entries of Counter 20G provided significant reductions in feeding injury when compared to the check, and there were no significant differences in root protection among planting-time rates of Counter.

As observed in 2012, excellent root protection was achieved by combining Poncho Beta with a planting-time application of Counter 20G at its low labeled rate of 5.25 lb product/ac. Also reflective of our 2012 findings was that root protection in Poncho Beta plots was significantly improved by adding Counter 20G, irrespective of whether Counter was applied at planting time or postemergence.

Although results suggest that Thimet applications provided modest reductions in root maggot feeding injury, none of the differences between single (at-plant only) and dual (at-plant insecticide + postemergence Thimet) were statistically significant, regardless of whether Counter or Poncho Beta was used as the at-plant protection. This is the second consecutive year that postemergence Thimet applications did not provide significant reductions in SBRM feeding injury.

Table 1. *Larval feeding injury* in an assessment of at-plant insecticide granules, seed treatments, and postemergence granules for sugarbeet root maggot control, St. Thomas, ND, 2013

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb ai/ac)	Root injury (0-9)
Counter 20G + Thimet 20G	B Peak-fly Post B	7.5 lb 7 lb	1.5 1.4	2.53 d
Counter 20G + Thimet 20G	B Peak-fly Post B	8.9 lb 7 lb	1.8 1.4	2.80 cd
Counter 20G	B	8.9 lb	1.8	2.98 cd
Counter 20G	B	5.25 lb	1.05	3.30 cd
Counter 20G	B	7.5 lb	1.5	3.55 cd
Poncho Beta + Counter 20G	Seed Peak-fly Post B	5.25 lb	68 g a.i./ unit seed 1.05	3.75 c
Poncho Beta + Counter 20G	Seed B	5.25 lb	68 g a.i./ unit seed 1.05	3.85 c
Poncho Beta + Thimet 20G	Seed Peak-fly Post B	7 lb	68 g a.i./ unit seed 1.4	5.23 b
Poncho Beta	Seed		68 g a.i./ unit seed	5.58 ab
Check	---	----	---	6.53 a
LSD (0.05)				1.15

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

[a]B = at-plant band; Post B = postemergence band; Seed = insecticidal seed treatment

Patterns of performance with regard to yield parameters were somewhat similar to those observed in root maggot feeding injury assessments. The top-performing entry with regard to recoverable sucrose yield, root yield, and gross economic return was Counter 20G at its highest labeled rate (8.9 lb product/ac) combined with a postemergence application of Thimet 20G at its high labeled rate (7 lb/ac).

This entry was statistically superior in recoverable sucrose yield to the single application of Counter at 8.9 lb product/ac, and adding the postemergence application of Thimet resulted in an increase in revenue of $194 over that of the single, at-plant Counter treatment. Similarly, the dual program comprised of Counter 20G at 7.5 lb/ac + postemergence Thimet provided $74/ac more revenue than the single-application program of Counter at 7.5 lb. However, the increase in recoverable sucrose from Thimet in this comparison was not statistically significant, nor was its impact on recoverable sucrose or root yield in plots initially treated with Poncho Beta.

Additive applications of Counter 20G (i.e., planting-time and postemergence) at the low labeled rate of 5.25 lb product/ac provided significant improvements in recoverable sucrose yield and root yield to plots that had been initially protected with Poncho Beta. However, there were no significant yield differences (i.e., recoverable sucrose or root tonnage) between the planting-time or postemergence addition of Counter.

The general lack of major benefits from postemergence applications of Thimet in Study I are somewhat reflective of performance by that product in 2012. Postapplication rainfall events and a short interval between Thimet application and peak SBRM fly activity were suggested as possible factors in the less-than-expected performance of Thimet in 2012. The relatively late timing of Thimet applications in relation to the timing of peak fly activity could also have impacted its performance in 2013, because SBRM fly activity was actually peaking at the time of the Thimet applications. This point is supported by our previous findings, which suggest that postemergence granules typically provide the best SBRM control if applied at least 5-7 seven days before peak fly activity occurs.

It should be noted that Counter 20G can only be applied once per year. Thus, if this product were applied at planting, it could not be applied to the same field at postemergence within the same cropping year. Additionally, it bears noting that using Counter 20G as a postemergence material will not always be a viable option for commercial sugarbeet production because it is labeled with a 110-day preharvest interval. Thus, if an application were made in early to mid-June for SBRM management, no treated portion of the field could be harvested until mid- to late-September at the earliest.

Table 2. ***Yield parameters*** **in an assessment of at-plant insecticide granules, seed treatments, and postemergence granules for sugarbeet root maggot control, St. Thomas, ND, 2013**

Treatment/ form.	Placement[a]	Rate (product/ac)	Rate (lb ai/ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 20G + Thimet 20G	B Peak-fly Post B	8.9 lb 7 lb	1.8 1.4	7558 a	25.4 a	16.08 a	791
Counter 20G + Thimet 20G	B Peak-fly Post B	7.5 lb 7 lb	1.5 1.4	7314 ab	25.2 a	15.75 a	734
Counter 20G	B	7.5 lb	1.5	6815 abc	24.0 a	15.43 a	660
Counter 20G	B	5.25 lb	1.05	6796 bc	24.7 a	15.15 a	625
Counter 20G	B	8.9 lb	1.8	6554 c	23.9 a	15.13 a	597
Poncho Beta + Counter 20G	Seed Peak-fly Post B	5.25 lb	68 g a.i./ unit seed 1.05	6331 c	23.9 a	14.63 a	537
Poncho Beta + Counter 20G	Seed B	5.25 lb	68 g a.i./ unit seed 1.05	6185 cd	23.4 ab	14.68 a	524
Poncho Beta + Thimet 20G	Seed Peak-fly Post B	7 lb	68 g a.i./ unit seed 1.4	6172 cd	21.8 bc	15.43 a	594
Poncho Beta	Seed		68 g a.i./ unit seed	5472 de	19.9 cd	15.15 a	502
Check	---	----	---	4877 e	18.4 d	14.63 a	417
LSD (0.05)				749	2.0	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 = at-plant band; Post B = postemergence band; Seed = insecticidal seed treatment

Study II. Root maggot feeding injury rating results from Study II appear in Table 3. The best root protection in this experiment was provided by the following treatments: 1) Counter banded at 7.5 lb product/ac + Lorsban Advanced postemergence broadcast at 2 pt product/ac; 2) Counter 20G banded at 7.5 lb/ac; 3) Counter 20G banded at 8.9 lb product/ac and 4) Counter banded at 7.5 lb + Lorsban Advanced postemergence broadcast at 1 pt/ac. These entries provided significantly superior root protection to all other entries in the experiment.

Lorsban Advanced postemergence sprays were generally ineffective in providing benefits in root protection over that of single, planting-time-only treatments in this experiment. However, the experimental insecticide referred to in this report as "F1" provided a significant reduction in SBRM feeding injury when compared to the untreated check. Poncho Beta also provided significant reductions in feeding injury in this experiment.

The following entries failed to provide significant levels of root protection when compared to the untreated check in Study II: 1) Lorsban Advanced at 2 pt product/ac postemergence (no at-plant insecticide); and 2) Stallion EC, applied postemergence at 11.75 fl oz/ac (no at-plant insecticide).

Yield results for Study II are presented in Table 4. The highest recoverable sucrose yields in this study were recorded in entries that included a planting-time application of Counter 20G. Dual application plots that received Counter 20G at planting time, and either the 1- or 2-pt/ac postemergence application of Lorsban Advanced, produced the highest recoverable sucrose yields in the experiment; however, it should be noted that yield from those entries was not significantly different from either of the planting-time-only Counter treatments. Similarly, there was no significant benefit from postemergence Lorsban Advanced in plots that had been planted with Poncho Beta-treated seed.

Table 3. ***Larval feeding injury*** **in an evaluation insecticidal seed treatments, granules, planting-time liquids, and postemergence liquid sprays for sugarbeet root maggot control, St. Thomas, ND, 2013**				
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Counter 20G + Lorsban Advanced	B 1 d post-peak Broadcast	7.5 lb 2 pts	1.5 1.0	2.70 e
Counter 20G	B	7.5 lb	1.5	2.90 e
Counter 20G	B	8.9 lb	1.8	3.10 e
Counter 20G + Lorsban Advanced	B 1 d post-peak Broadcast	7.5 lb 1 pt	1.5 0.5	3.67 e
Poncho Beta	Seed		68 g a.i./ unit seed	5.03 d
Poncho Beta + Lorsban Advanced	Seed 1 d post-peak Broadcast	 1 pt	68 g a.i./ unit seed 0.5	5.17 cd
Poncho Beta + Lorsban Advanced	Seed 1 d post-peak Broadcast	 2 pts	68 g a.i./ unit seed 1.0	5.63 bcd
Liquid-F1 + 10-34-0 starter fert.	3" TB	17 fl oz 5 gpa		5.70 bcd
Lorsban Advanced	1 d post-peak Broadcast	2 pts	1.0	6.23 abc
10-34-0 check	3" TB	5 gpa		6.50 ab
Stallion	1 d post-peak Broadcast	11.75 fl oz		6.63 ab
Check	---	----	---	7.10 a
LSD (0.05)				1.15

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

[a]B = Band; Seed = insecticidal seed treatment; TB = T-band over open seed furrow;

One encouraging finding from this study was that plots treated at planting time with F1, the experimental insecticide, produced recoverable sucrose yields that were not significantly different from planting-time applications of Counter 20G at its moderate (7.5 lb product/ac) or highest (8.9 lb) labeled application rate. It should be noted that the intermediate yields produced by F1-treated plots, although similar to those from Counter-treated plots, were also not statistically different from the untreated check. Continued evaluations of this product should be pursued in the future. Other insecticides that did not result in statistically significant increases in recoverable sucrose or root tonnage when compared to the untreated check included Poncho Beta, Lorsban Advanced, and Stallion.

The highest gross economic return values recorded in Study II were from plots that received the dual-application entries of Counter 20G banded at 7.5 lb + Lorsban Advanced at 2 pt and Counter 20G banded at 7.5 lb + Lorsban Advanced at 1 pt. Applying the higher (2-pt) rate of Lorsban Advanced generated $829/ac in gross economic return, which was a $332 increase in revenue over that of the untreated check plots. Also, plots treated with the 2-pt rate of Lorsban generated $25/ac more gross return than those treated with the 1-pt rate.

Although Lorsban Advanced did not result in statistically significant yield increases in this experiment, it did produce economic return increases that growers may consider practically significant. For example, the low (1-pt) and high (2-pt) rates of Lorsban Advanced, when applied to plots that had initially been treated with Counter at 7.5 lb product/ac, generated gross return increases of $101 to $126/ac. There were no apparent economic benefits from Lorsban Advanced in Poncho Beta-treated plots in this experiment. The general lack of major benefits from Lorsban sprays in this study could have been a result of application timing. Although these applications were planned to be applied between two and four days before peak SBRM fly activity, they could not be applied until one day post-peak. Thus, a substantial amount of mating and egg laying by SBRM adults likely took place before the Lorsban could be applied. This aspect of SBRM management should be researched further, especially given that growers using insecticidal seed treatments in high-risk SBRM areas must rely on materials like Lorsban Advanced to augment the partial control provided by seed treatments.

Quality parameters also appeared to be impacted by root maggot feeding injury and control measures in this experiment. For example, the highest percent sucrose concentration occurred in plots that had been treated with the dual-application treatments comprised of Counter 20G at planting + Lorsban Advanced at postemergence (both rates). Relatively high sucrose concentrations were also recorded for plots treated with single, planting-time-only applications of Counter, Poncho Beta, and F1.

The results of this experiment underscore the economic importance of the sugarbeet root maggot as an insect pest, even under just moderately high infestation levels. Its economic significance was illustrated in this experiment by the fact that the best-performing entries resulted in gross economic return values that were between $307 and $332 greater than that generated by the untreated check plots. As such, growers in areas where the root maggot looms as an ongoing threat should carefully design effective programs to manage it, and thus, prevent the occurrence of major economic loss.

Table 4. *Yield parameters* in an evaluation insecticidal seed treatments, granules, planting-time liquids, and postemergence liquid sprays for sugarbeet root maggot control, St. Thomas, ND, 2013

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 1 d post-peak Broadcast	7.5 lb 2 pts	1.5 1.0	7745 a	25.6 a	16.23 a	829
Counter 20G + Lorsban Advanced	B 1 d post-peak Broadcast	7.5 lb 1 pt	1.5 0.5	7476 a	24.6 abc	16.30 a	804
Counter 20G	B	8.9 lb	1.8	7197 ab	25.0 ab	15.57 abc	712
Counter 20G	B	7.5 lb	1.5	7154 ab	25.0 ab	15.60 abc	703
Liquid-F1 + 10-34-0 starter fert.	3” TB	17 fl oz 5 gpa		6321 bc	21.9 bcd	15.70 ab	632
Check	---	----	---	5707 cd	21.3 cd	14.70 c	497
Poncho Beta + Lorsban Advanced	Seed 1 d post-peak Broadcast	 1 pt	68 g a.i./ unit seed 0.5	5560 cde	20.1 de	15.13 bc	513
10-34-0 check	3” TB	5 gpa		5529 cde	20.7 d	14.80 bc	478
Poncho Beta	Seed		68 g a.i./ unit seed	5279 cde	18.7 de	15.47 abc	509
Poncho Beta + Lorsban Advanced	Seed 1 d post-peak Broadcast	 2 pts	68 g a.i./ unit seed 1.0	5242 de	19.0 de	15.07 bc	483
Stallion	1 d post-peak Broadcast	11.75 fl oz		5150 de	18.9 de	15.03 bc	463
Lorsban Advanced	1 d post-peak Broadcast	2 pts	1.0	4652 e	16.8 e	15.20 bc	432
LSD (0.05				1048	3.5	0.94	

Means within a column sharing a letter are not significantly (*P* = 0.05) different from each other (Fisher’s Protected LSD test).
[a]B = band; Seed = insecticidal seed treatment; TB = T-band over open seed furrow

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