AUGMENTING ROOT MAGGOT CONTROL BY COMBINING SEED TREATMENTS OR PLANTING-TIME GRANULAR INSECTICIDES WITH POSTEMERGENCE INSECTICIDES

Mark A. Boetel, Professor
Robert J. Dregseth and Allen J. Schroeder, Research Specialists

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

Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) is the most injurious insect pest of sugarbeet in the Red River Valley (RRV) growing area. For several decades, sugarbeet growers in the RRV have successfully managed this pest by applying planting-time granular insecticides and, in cases of high to severe infestations, adding a postemergence insecticide for additive protection.

Insecticidal seed treatments have been widely adopted in recent years by Valley growers for at-plant management of several soil-dwelling sugarbeet insect pests, including the SBRM. Seed treatment technology is attractive to growers as an insecticide option because no on-farm equipment calibration is required to achieve the desired application rate, no specialized application equipment is needed on the planter to deploy the insecticidal protection, and seed treatments allow for significant reductions in the amount of insecticide active ingredient applied to the environment. However, most research thus far suggests that insecticidal seed treatment materials do not provide sufficient SBRM control as stand-alone tools under moderately high to severe infestations of this pest.

Another new insect control option for sugarbeet producers is the recently registered 20% granular (i.e., 20G) formulation of terbufos (i.e., Counter) insecticide, which has replaced Counter 15G. This investigation was conducted in 2012 and involved two experiments. Study I was carried out to achieve the following: 1) determine if there are differences between the 15G and 20G formulations of Counter in controlling the sugarbeet root maggot; 2) compare conventional granular insecticides with Poncho Beta seed treatment for SBRM control; and 3) assess the impacts of additive postemergence applications of Thimet 20G to plots initially treated with either Counter 20G or Poncho Beta seed treatment.

Study II involved the following objectives: 1) compare Counter 20G and Poncho Beta insecticidal seed treatment with an experimental liquid insecticide (i.e., Stallion EC, a combination of zeta-cypermethrin [active ingredient in Mustang Max] and chlorpyrifos [active ingredient in Lorsban products]) for planting-time control of the SBRM; and 2) assess the efficacy of liquid insecticides (i.e., Lorsban Advanced and Stallion) applied as postemergence rescue treatments for additive SBRM control.

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 were applied to seed by a professional seed preparation company (Germains Seed Technology, Fargo, ND) for all seed treatment entries in both studies. Also, the same seed variety (SES VanderHave SV36917RR [glyphosate-resistant]) was used for all entries in both experiments. Both experiments were planted on 10 May 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 15G and 20G were 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. The planting-time application of Stallion EC was applied in 3-inch T-bands over open seed furrows by using a tractor-mounted CO_2-propelled spray system that was calibrated to deliver a finished spray volume of 5 GPA through TeeJet™ 8001E nozzles.

Postemergence insecticide applications. Postemergence insecticides used in Study I included Counter 20G and Thimet 20G. Postemergence banded granules (Post B) were applied on 1 June, which was 7 days before 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 application 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, all postemergence insecticides used were liquid materials (i.e., Lorsban Advanced and Stallion EC). Postemergence liquid applications were carried out on 7 June (i.e., about 1 day before the main peak in SBRM fly activity) using a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ AIXR 110015 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, 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 6 and 7 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 18 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. Sugarbeet root maggot feeding injury in the untreated check plots (mean = 7.83 on the 0 to 9 scale of Campbell et al. [2000]) indicated that a relatively high SBRM infestation was present for this study (Table 1). 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 (i.e., at-plant + postemergence insecticide) combination was used for SBRM control.

In comparing stand-alone insecticide entries (i.e., those with no postemergence insecticide applied) all conventional insecticide treatments of either Counter 15G or Counter 20G provided significantly greater levels of root protection than that of Poncho Beta. However, excellent root protection was achieved by combining Poncho Beta with an at-plant application of Counter at the low rate of 5.25 lb product/ac. Combining Poncho Beta with a postemergence banded application of Counter 20G also resulted in a significant improvement in root protection over that of using Poncho Beta as a stand-alone treatment.

An unusual pattern observed in this study in 2012 was that postemergence applications of Thimet 20G were generally ineffective in providing statistically significant increases in root protection when Thimet-containing dualapplication entries were compared with stand-alone entries. The only exception to this was that plots protected at planting time with Poncho Beta and at postemergence with Thimet 20G had significantly lower levels of root maggot feeding injury than those solely protected by Poncho Beta. The combination entry of Counter 20G applied at planting time at the high (8.9 lb product/ac) rate, combined with a postemergence banded application of Thimet 20G at its high labeled rate of 7 lb product/ac also performed well in preventing root maggot feeding injury.

Although not significant, the 15G formulation of Counter tended to provide slightly better levels of root protection than the 20G formulation when the same rate (either 1.5 or 1.8 lb) of active ingredient was applied per acre. Both formulations, when applied at the highest labeled application rate of active ingredient per acre, provided good protection from SBRM feeding injury, even if they were applied as stand-alone (i.e., without a postemergence insecticide) treatments.

Table 1. *Larval feeding injury ratings* from evaluation of planting-time granules, seed treatments, and postemergence granules for sugarbeet root maggot control (Study I), St. Thomas, ND, 2012

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 15G	B	11.9 lb	1.8	3.65 f
Counter 15G	B	10 lb	1.5	3.73 f
Poncho Beta + Counter 20G	Seed B	 5.25 lb	68 g a.i./ unit seed 1.05	3.85 ef
Counter 20G + Thimet 20G	B 7 d pre-peak Post B	8.9 lb 7 lb	1.8 1.4	4.05 ef
Counter 20G	B	8.9 lb	1.8	4.18 def
Counter 20G	B	7.5 lb	1.5	4.23 def
Counter 20G	B	5.25 lb	1.05	4.43 def
Counter 20G + Thimet 20G	B 7 d pre-peak Post B	7.5 lb 7 lb	1.5 1.4	4.68 cde
Poncho Beta + Counter 20G	Seed 7 d pre-peak Post B	 5.25 lb	68 g a.i./ unit seed 1.05	5.00 cd
Poncho Beta + Thimet 20G	Seed 7 d pre-peak Post B	 7 lb	68 g a.i./ unit seed 1.4	5.30 c
Poncho Beta	Seed		68 g a.i./ unit seed	6.28 b
Check	---	----	---	7.83 a
LSD (0.05)				0.85

Means within a column sharing a letter are not significantly ($P = 0.05$) different from each other (Fisher's Protected LSD).
[a]B = at-plant band; Post B = postemergence band; Seed = insecticidal seed treatment

Yield results from Study I are presented in Table 2. 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 the stand-alone entry of Counter 20G, applied at its highest labeled rate (8.9 lb product/ac). Other entries that resulted in statistically significant increases in sucrose yields above the untreated check in Study I included the following: 1) Counter 20G at 5.25 lb/ac; 2) Counter 15G at 10 lb/ac; 3) Counter 20G (8.9 lb/ac) at planting + Thimet 20G (7 lb/ac) postemergence; 4) Poncho Beta + Counter 20G (5.25 lb/ac) planting-time banded; and 5) Counter 20G (7.5 lb/ac) planting-time banded. The only entries that resulted in statistically significant increases in root tonnage when compared to that in the untreated check plots were Counter 20G banded at 8.9 and 5.25 lb/ac, and Counter 15G applied in a band at 10 lb product/ac.

With regard to gross revenue comparisons, all chemical treatments in Study I, irrespective of whether a seed treatment, at-plant granule, or postemergence granule was used, provided major economic benefits when compared to the revenue generated from the untreated check. Economic benefits from insecticide-protected plots ranged from $139/ac for Poncho Beta (the lowest-yielding chemically treated plots) to $612 per acre for plots treated with the high (8.9 lb product/ac) rate of Counter 20G.

As observed in root maggot feeding injury assessments, the yield data also suggested a general lack of benefit from postemergence applications of Thimet 20G applications in Study I. The reason for this is unclear, but it is at least possible that postapplication weather conditions, which were characterized by frequent rainfalls (>1.5" total within first 2 weeks after treatment) and several days of warm (80°F) weather, could have caused excessive volatilization (vaporization loss) of the active ingredient in Thimet 20G. However, volatilization impacts were not measured in this study.

Another, possibly more likely, explanation for the relative ineffectiveness of Thimet in this study could be that the 7-day interval between postemergence applications and the subsequent peak in fly activity did not allow sufficient time for the active ingredient in Thimet to be activated and released from its granular carrier. However, this study was not designed to address the impacts of application timing on postemergence granular insecticides.

It should be noted that Counter insecticide (both 15G and 20G formulations) can only be applied once per year. Thus, if either of these products were applied at planting, they could not be applied to the same field at postemergence. Additionally, it bears noting that using a Counter product as a postemergence material will not always be a viable option for commercial sugarbeet production because both 15G and 20G formulations are 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* from evaluation of planting-time granules, seed treatments, and postemergence granules for sugarbeet root maggot control (Study I), St. Thomas, ND, 2012

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	B	8.9 lb	1.8	7637 a	22.4 a	18.23 a	1338
Counter 20G	B	5.25 lb	1.05	6826 ab	20.5 ab	17.88 a	1174
Counter 15G	B	10 lb	1.5	6805 ab	19.6 ab	18.55 a	1211
Counter 20G + Thimet 20G	B 7 d pre-peak Post B	8.9 lb 7 lb	1.8 1.4	6462 abc	18.9 abc	18.35 a	1137
Poncho Beta + Counter 20G	Seed B	 5.25 lb	68 g a.i./ unit seed 1.05	6355 abc	18.9 abc	18.00 a	1102
Counter 20G	B	7.5 lb	1.5	6315 abc	18.6 abc	18.15 a	1104
Poncho Beta + Counter 20G	Seed 7 d pre-peak Post B	 5.25 lb	68 g a.i./ unit seed 1.05	6043 bcd	18.0 bc	18.00 a	1045
Counter 20G + Thimet 20G	B 7 d pre-peak Post B	7.5 lb 7 lb	1.5 1.4	5690 bcd	16.4 bc	18.45 a	1011
Counter 15G	B	11.9 lb	1.8	5663 bcd	16.6 bc	18.13 a	991
Poncho Beta + Thimet 20G	Seed 7 d pre-peak Post B	 7 lb	68 g a.i./ unit seed 1.4	5100 cd	14.9 c	18.28 a	895
Poncho Beta	Seed		68 g a.i./ unit seed	5025 cd	15.0 c	17.95 a	865
Check	---	----	---	4582 d	14.9 c	16.83 a	726
LSD (0.05)				1515	4.3	NS	

Means within a column sharing a letter are not significantly ($P = 0.05$) different from each other (Fisher's Protected LSD).
[a]B = at-plant band; Post B = postemergence band; Seed = insecticidal seed treatment

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

The following entries in Study II failed to provide significant levels of root protection when compared to the untreated check: 1) Poncho Beta + Lorsban Advanced (2 pt product/ac); 2) Stallion EC, applied at planting time in a 3" T-band; 3) Poncho Beta + Lorsban Advanced (1 pt/ac); 4) Poncho Beta; and 5) Stallion EC, applied postemergence (without an at-plant insecticide) at 11.75 fl oz/ac.

Overall, the trends in this study indicated that the protection provided by planting-time granular insecticide applications was generally better than that provided by Poncho Beta seed treatment and the liquid insecticide, Stallion EC. Additionally, no significant benefits with respect to increases in root protection were observed when postemergence applications of Lorsban Advanced or the experimental insecticide (i.e., Stallion EC) were added to planting-time applications of Counter 20G or Poncho Beta seed treatment. One potential reason for this was that the spray applications were made only 1 day before the main peak in SBRM fly activity. Thus, a substantial amount of

SBRM eggs could have already been deposited at the bases of sugarbeet seedlings by the time spray applications were carried out. It should also be noted that this site had the highest recorded levels of fly activity in the entire Red River Valley during 2012, and moderately high activity persisted for nearly three weeks after the initial peak. This likely resulted in very high SBRM larval infestations in these plots.

Table 3. *Larval feeding injury ratings* from evaluation of planting-time granules, liquids, seed treatments, and postemergence liquid insecticides for sugarbeet root maggot control (Study II), St. Thomas, ND, 2012

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G	B	8.9 lb	1.8	4.63 d
Counter 20G	B	7.5 lb	1.5	5.50 d
Counter 20G + Lorsban Advanced	B 1 d pre-peak Broadcast	7.5 lb 2 pts	1.5 1.0	5.58 cd
Counter 20G + Lorsban Advanced	B 1 d pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	5.68 bcd
Poncho Beta + Lorsban Advanced	Seed 1 d pre-peak roadcast	 2 pts	68 g a.i./ unit seed 1.0	6.60 abc
Stallion EC	3" TB	11.75 fl oz		6.73 ab
Poncho Beta + Lorsban Advanced	Seed 1 d pre-peak Broadcast	 1 pt	68 g a.i./ unit seed 0.5	6.80 a
Poncho Beta	Seed		68 g a.i./ unit seed	6.88 a
Check	---	----	---	7.38 a
Stallion EC	1 d pre-peak Broadcast	11.75 fl oz		7.45 a
LSD (0.05)				1.05

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD).
[a]B = at-plant band; Post B = postemergence band; Seed = insecticidal seed treatment

Yield results for Study II are presented in Table 4. Contrary to the results from root maggot feeding injury ratings, the yield comparisons provided very encouraging results. The better-performing entries in this study mostly involved planting-time insecticidal protection, either in the form of the granular material, Counter 20G, or Poncho Beta seed treatment, combined with a postemergence broadcast application of Lorsban Advanced. When Poncho Beta was used as the at-plant insecticidal protection, the high (2 pt product/ac) rate of Lorsban Advanced was necessary to result in significant increases in sucrose yield, root tonnage, and percent sucrose when compared to the untreated check plots. Plots protected with this treatment combination also produced significantly greater yields and percent sucrose than those treated with the combination of Poncho Beta plus postemergence Lorsban Advanced at the lower, 1 pt/ac rate. Excellent sucrose yields were produced in plots that were initially treated at planting time with Counter 20G, and subsequently treated with a postemergence broadcast application of Lorsban Advanced, irrespective of whether the Lorsban spray was applied at the 1- or 2-pt rate.

Calculations of estimated gross revenue in Study II indicated that major benefits in economic return are achievable when effective SBRM control strategies are carried out, even in the presence of relatively high infestations. The highest gross economic return values were recorded for dual-treatment (at-plant + postemergence spray) entries such as Counter 20G banded at 7.5 lb + Lorsban Advanced at 2 pt, Poncho Beta + Lorsban Advanced at 2 pt, and Counter 20G banded at 7.5 lb + Lorsban Advanced at 1 pt, which generated revenue benefits of $535, $338, and $357/ac, respectively, when compared to the untreated check plots. Single (i.e., at-plant-only) entries in this experiment that also resulted in positive economic returns relative to the untreated checks included Counter 20G at 8.9 lb product/ac, Counter 20G at 7.5 lb/ac, Stallion applied at planting-time in a 3-inch T-band, and Poncho Beta seed treatment, which generated respective revenue benefits of $281, $267, $135, and $87/ac. These levels of economic return would have easily justified the input costs associated purchasing and applying these insecticides.

The revenue benefits from insecticidal protection observed in this research clearly demonstrate the importance of the sugarbeet root maggot as an economic pest, and underscore the value of effectively controlling it.

Table 4. *Yield parameters* from evaluation of planting-time granules, liquids, seed treatments, and postemergence liquid insecticides for sugarbeet root maggot control (Study II), St. Thomas, ND, 2012							
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 pre-peak Broadcast	7.5 lb 2 pts	1.5 1.0	7435 a	22.4 a	17.83 ab	1271
Poncho Beta + Lorsban Advanced	Seed 1 d pre-peak Broadcast	2 pts	68 g a.i./ unit seed 1.0	6264 ab	18.8 ab	17.90 ab	1074
Counter 20G + Lorsban Advanced	B 1 d pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	6247 ab	18.4 abc	18.20 a	1093
Counter 20G	B	8.9 lb	1.8	6083 abc	18.8 ab	17.43 abcd	1017
Counter 20G	B	7.5 lb	1.5	5997 abc	18.5 ab	17.53 abc	1003
Stallion	3" TB	11.75 fl oz		5418 bcd	17.4 bcd	16.93 bcde	871
Poncho Beta	Seed		68 g a.i./ unit seed	4990 bcde	15.6 bcd	17.33 abcd	823
Check	---	----	---	4733 cde	15.7 bcd	16.63 cde	736
Poncho Beta + Lorsban Advanced	Seed 1 d pre-peak Broadcast	1 pt	68 g a.i./ unit seed 0.5	4304 de	14.3 cd	16.35 de	664
Stallion	1 d pre-peak Broadcast	11.75 fl oz		3888 e	13.5 d	15.98 e	574
LSD (0.05)				1446	4.1	1.09	

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

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