SUGARBEET ROOT MAGGOT CONTROL BY USING SINGLE-, DUAL-, AND TRIPLE-COMPONENT INSECTICIDE REGIMES

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Introduction:

Severe infestations of the sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), occur on a frequent basis in central and northern portions of the Red River Valley (RRV) of North Dakota and Minnesota. Published research has demonstrated that this pest is capable of causing more than 45% yield losses in the absence of effective control measures (Boetel et al. 2010). High population levels of this pest typically require aggressive management programs to ensure adequate protection of the sugarbeet crop. Control programs in areas at high risk of economic loss from this pest usually consist of planting-time protection, in the form of a granular, liquid, or seed treatment insecticide, followed by an additive postemergence insecticide application (i.e., either a granular or sprayable liquid product) when the SBRM infestation warrants it. Broadcast applications of sprayable liquid insecticides, applied on an as-needed, rescue basis, are the most commonly used postemergence tools for SBRM control in the RRV. An advantage of postemergence sprays is that growers can use a “wait and see” approach, and make informed decisions on whether rescue insecticide treatments are needed based on current fly activity levels in their fields. This research was carried out to determine the most effective combinations of planting-time and postemergence liquid insecticide applications to optimize sugarbeet root maggot management methodology.

This project involved two experiments. The objectives of Study I were to: 1) compare Counter 20G granular insecticide with Poncho Beta seed treatment for at-plant SBRM control; 2) assess the efficacy of combining Poncho Beta with Counter 20G at planting time for a one-pass SBRM control system; 3) determine 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; 4) measure the performance of Counter 20G as a postemergence control option; and 5) determine if SBRM control can be maximized by employing a three-component (i.e., seed treatment insecticide + at-plant or postemergence granular insecticide + postemergence liquid spray) management program.

The objectives of Study II were to: 1) measure the impacts of Poncho Beta seed treatment and Counter 20G (at differing application rates) on root maggot control in dual-insecticide programs that include postemergence broadcast spray applications of Lorsban Advanced; and 2) assess the effect of application rate on performance of Lorsban Advanced as the postemergence component of dual-insecticide programs for sugarbeet root maggot control.

Materials and Methods:

Both of these experiments were conducted on a commercial sugarbeet field site near St. Thomas (Pembina County), ND during the 2019 growing season. Betaseed 8524 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 entries that included an insecticidal seed treatment in these trials. Study I was planted on 15 May, and Study II was planted on 14 May, 2019. 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. 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 alleys between replicates were maintained weed-free throughout the growing season by using tillage operations. Both experiments were arranged in a randomized complete block design with four replications of the treatments.

<u>Planting-time insecticide applications</u>: Counter 20G was applied in both trials 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: Postemergence insecticides in Study I consisted of two granular materials (i.e., Counter 20G and Thimet 20G) and one sprayable liquid insecticide product (i.e., Lorsban Advanced). Postemergence band-applied (Post B) granules were applied on 14 June (i.e., 3 days before peak SBRM fly activity). Banded placement of postemergence granules was achieved by using Kinze™ row banders that were attached to a tractor-mounted tool bar and adjusted to a height to deliver the insecticides in 4-inch bands. Similar to at-plant insecticide applications, postemergence granular output rates were also regulated by using a SmartBox™ system mounted on a tractor-drawn four-row toolbar. All postemergence granular applications were incorporated by 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 of each row unit. This system effectively stirred soil around the bases of sugarbeet seedlings and incorporated granules as the unit passed through each plot.

The postemergence spray applications of Lorsban Advanced in both Study I and Study II were broadcast-applied on 17 June (i.e., at peak SBRM fly activity). Sprays were applied from a tractor-mounted CO_2-propelled spray system equipped with an 11-ft boom that was calibrated to deliver a finished spray volume output of 10 GPA through TeeJet™ 11001VS nozzles.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed for these experiments on 29 July (Study I) and 31 July (Study II). Rating procedures consisted of randomly collecting ten sugarbeet roots (five from each of the outer two treated rows) per plot, hand-washing them in a bucket of water, and scoring each 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 18 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:

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 = 6.18 on the 0 to 9 scale of Campbell et al. [2000]) suggested that a moderately high infestation of SBRM larvae was present for the experiment. This level of pressure was slightly lower than expected, which was most likely due to the significant amount of rainfall (3.34") that occurred during the two-week period (i.e., June 7-21) that immediately surrounded peak SBRM fly activity in the field (see Appendix A at the end of the Entomology section of this publication). This likely contributed to substantial variability, in both insect pressure and yield, among plots and within replicates. As a result, there were relatively few significant differences between treatments.

All insecticide-protected plots in Study I sustained significantly lower levels of SBRM feeding injury than the untreated check, regardless of whether involving a seed treatment, a single at-plant granular insecticide application, or a multiple-application insecticide combination was used for SBRM control. General performance patterns demonstrated that single-component control programs are not sufficient to protect the crop from moderately high pressure such as that which existed for this trial.

The greatest root protection (i.e., lowest overall root injury) in Study I occurred in plots treated at planting with Counter 20G at its high (8.9 lb product/ac) rate plus a postemergence application of Thimet 20G at its high rate (7 lb product per acre). Other entries that provided excellent root protection (i.e., prevented SBRM feeding injury from exceeding 3.0 on the 0 to 9 scale) included the following:

1) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting) + Lorsban Advanced (1 pt/ac, peak fly);
2) Counter 20G (7.5 lb/ac, banded at planting) + Thimet (7 lb/ac, 3d before peak fly);
3) Counter banded at planting (8.9 lb/ac, banded at planting); and
4) Poncho Beta + Thimet 20G (7 lb/ac, 3d before peak fly) + Lorsban Advanced (1 pt/ac, peak fly).

Table 1. *Larval feeding injury* in an evaluation of sugarbeet root maggot control by combining planting-time insecticide granules or seed treatments with postemergence insecticides, St. Thomas, ND, 2019 (Study I)				
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Counter 20G + Thimet 20G	B 3 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	2.20 d
Poncho Beta + Counter 20G + Lorsban Advanced	Seed B Peak fly Broadcast	 8.9 lb 1 pt	68 g a.i./ unit seed 1.8 0.5	2.23 d
Counter 20G + Thimet 20G	B 3 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	2.23 d
Counter 20G	B	8.9 lb	1.8	2.60 cd
Poncho Beta + Thimet 20G + Lorsban Advanced	Seed 3 d Pre-peak Post B Peak fly Broadcast	 7 lb 1 pt	68 g a.i./ unit seed 1.4 0.5	2.73 cd
Poncho Beta + Counter 20G	Seed B	 8.9 lb	68 g a.i./ unit seed 1.8	3.05 cd
Poncho Beta + Counter 20G	Seed B	 5.25 lb	68 g a.i./ unit seed 1.05	3.20 cd
Poncho Beta + Thimet 20G	Seed 3 d Pre-peak Post B	 7 lb	68 g a.i./ unit seed 1.4	3.25 cd
Poncho Beta + Counter 20G	Seed 3 d Pre-peak Post B	 8.9 lb	68 g a.i./ unit seed 1.8	3.33 cd
Counter 20G	B	7.5 lb	1.5	3.63 bc
Poncho Beta	Seed		68 g a.i./ unit seed	3.70 bc
Poncho Beta + Counter 20G	Seed 3 d Pre-peak Post B	 5.25 lb	68 g a.i./ unit seed 1.05	4.50 b
Counter 20G	B	5.25 lb	1.05	4.68 b
Check	---	----	---	6.18 a
LSD (0.05)				1.161

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 B = 4-inch postemergence band; Seed = insecticidal seed treatment

Although there were relatively few significant differences among treatments in this trial with respect to SBRM feeding injury, positive application rate responses (i.e., higher rates performing numerically better than lower rates) were apparent when Counter was applied as a single-component treatment and when it was part of an integrated program. Additionally, applying Lorsban Advanced to establish a triple-component control program provided numerical improvements in root protection over corresponding single- and dual-component programs in this trial.

Yield data from Study I are presented in Table 2. All insecticide treatments in this experiment, except the single at-plant application of Counter 20G when applied at its lowest labeled rate (5.25 lb product/ac), resulted in statistically significant increases in recoverable sucrose yield when compared to the untreated check. As observed in the SBRM feeding injury data for Study I, trends suggested better performance with dual- and triple-component insecticide programs.

As observed in root injury rating results, the top-performing entry in Study I, with regard to recoverable sucrose yield and gross economic return, involved a planting-time application of Counter 20G at its high (8.9 lb product/ac) rate plus a postemergence application of Thimet 20G at its high rate (7 lb product per acre). That entry generated a gross revenue of $1,013/ac, which was $309/ac greater revenue than the untreated check plots and $77 more revenue than plots protected solely by the planting-time application of Counter at 8.9 lb/ac. The combination of Counter 20G at 8.9 lb/ac plus a postemergence application of Thimet 20G at 7.5 lb product per acre was statistically superior in relation to recoverable sucrose yield to the following treatments: 1) Poncho Beta + Counter 20G applied at postemergence at 5.25 lb/ac; 2) Poncho Beta + postemergence Thimet 20G at 7 lb/ac; 3) Poncho Beta alone; and 4) single applications of Counter at either its moderate (7.5-lb) or low (5.25-lb) labeled rate.

The following entries in Study I provided excellent gross economic returns, and were not statistically outperformed in relation to sucrose yield by the aforementioned top-performing treatment (Counter 20G at planting [8.9 lb/ac] + Thimet 20G [3d before peak fly, 7 lb/ac]):

1) Poncho Beta + Thimet 20G (7 lb/ac, 3d before peak fly) + Lorsban Advanced (1 pt/ac, peak fly);
2) Counter 20G (7.5 lb/ac, banded at planting) + Thimet (7 lb/ac, 3d before peak fly);
3) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting) + Lorsban Advanced (1 pt/ac, peak fly);
4) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting);
5) Poncho Beta + postemergence Counter 20G (8.9 lb/ac, 3d before peak fly);
6) Counter 20G (8.9 lb/ac, banded at planting); and
7) Poncho Beta + Counter 20G (5.25 lb/ac, banded at planting).

Although numerically lower than the gross economic return generated by the aforementioned top-yielding treatment, these control programs still generated between $130 and $283/ac more gross revenue than that recorded for the untreated check plots. These revenue increases would have easily paid for the product and application costs associated with their use, and also would have provided excellent net returns in revenue per acre for a producer.

Table 2. ***Yield parameters*** **from an evaluation of sugarbeet root maggot control by combining planting-time insecticide granules or seed treatments with postemergence insecticides, St. Thomas, ND, 2019 (Study I)**

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 3 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	9915 a	33.3 a	16.53 a	1,013
Poncho Beta + Thimet 20G + Lorsban Advanced	Seed 3 d Pre-peak Post B Peak fly Broadcast	 7 lb 1 pt	68 g a.i./ unit seed 1.4 0.5	9573 ab	32.0 abc	16.60 a	987
Counter 20G + Thimet 20G	B 3 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	9556 abc	33.8 a	15.75 ab	880
Poncho Beta + Counter 20G + Lorsban Advanced	Seed B Peak fly Broadcast	 8.9 lb 1 pt	68 g a.i./ unit seed 1.8 0.5	9468 abc	32.6 ab	16.10 ab	922
Poncho Beta + Counter 20G	Seed B	 8.9 lb	68 g a.i./ unit seed 1.8	9352 a-d	32.5 ab	16.03 ab	894
Poncho Beta + Counter 20G	Seed 3 d Pre-peak Post B	 8.9 lb	68 g a.i./ unit seed 1.8	9222 a-d	30.4 bcd	16.83 a	977
Counter 20G	B	8.9 lb	1.8	9131 a-d	30.6 bc	16.48 a	936
Poncho Beta + Counter 20G	Seed B	 5.25 lb	68 g a.i./ unit seed 1.05	9055 a-d	32.0 abc	15.83 ab	834
Poncho Beta + Counter 20G	Seed 3 d Pre-peak Post B	 5.25 lb	68 g a.i./ unit seed 1.05	8895 bcd	30.1 cd	16.40 ab	897
Counter 20G	B	7.5 lb	1.5	8748 b-e	32.0 abc	15.33 bc	745
Poncho Beta + Thimet 20G	Seed 3 d Pre-peak Post B	 7 lb	68 g a.i./ unit seed 1.4	8654 cde	30.7 bc	15.78 ab	789
Poncho Beta	Seed		68 g a.i./ unit seed	8461 de	28.3 d	16.65 a	871
Counter 20G	B	5.25 lb	1.05	7965 ef	30.6 bc	14.58 c	591
Check	---	----	---	7192 f	24.7 e	16.25 ab	704
LSD (0.05)				912.6	2.22	1.105	

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 B = 4-inch postemergence band; Seed = insecticidal seed treatment

In comparing dual- and triple-component SBRM control programs, the addition of Lorsban Advanced (1 pt/ac) to plots initially planted with Poncho Beta-treated seed and treated at postemergence with Thimet 20G at 7 lb product per acre resulted in a significant increase in recoverable sucrose yield (i.e., by 919 lb/ac) and $198 in additional revenue when compared to the similar entry that lacked the additional Lorsban application. However, when the initial protection involved Poncho Beta-treated seed combined with a planting-time application of Counter 20G at its high labeled rate (8.9 lb/ac), the addition of a peak-fly application of Lorsban Advanced did not result in a significant increase in recoverable sucrose yield or root tonnage, and it only generated $28 in additional revenue.

Dual-component insecticide programs in Study I that were comprised of Poncho Beta and Counter 20G tended to perform better when Counter was applied at its high labeled rate (8.9 lb product/ac), which resulted in gross economic returns increases by between $23 and $106/ac. Trends also suggested that those programs performed better than when Poncho Beta was used in combination with a single postemergence application of Thimet 20G. However, it should be noted that none of the additional granular applications to plots planted with Poncho Beta-treated seed resulted in statistically significant sucrose yield or root tonnage increases in comparison to those protected by Poncho Beta alone. This could have resulted from the large amount of variability among plots that occurred from irregular spots in the field and overland flooding that occurred due to heavy mid-June rains.

It should be noted that Counter insecticide can only be applied once per year. Therefore, if Counter 20G is applied at planting, it cannot be applied postemergence to the same field. It also bears noting that Counter 20G is now labeled with 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 a much more feasible product as a postemergence option for sugarbeet root maggot control than it had been in the past, as it previously was labeled with a 110-day PHI. The 90-day PHI should work well for Red River Valley growers choosing to use Counter 20G for SBRM management. Postemergence granule applications for SBRM control in the area are typically most effective if made in late-May to early-June. If this product were to be applied to a field on June 1, the 90-day PHI would expire before September 1, which is typically the earliest that pre-pile sugarbeet harvest operations begin in the Valley.

Study II. This experiment involved evaluations of dual-insecticide programs, comprised of either Counter 20G or Poncho Beta for the planting-time component and Lorsban Advanced, applied at either 1 or 2 pts of product per acre, as the postemergence component, for SBRM control. Results from evaluations of sugarbeet root maggot larval feeding injury in Study II indicated that a moderate level of SBRM larval feeding pressure occurred in this trial. This is supported by the moderate level of root maggot feeding injury (i.e., 5.5 rating on the 0 to 9 scale) recorded for the untreated check plots (Table 3).

All insecticide-treated entries provided significant reductions in SBRM feeding injury when compared to the untreated check. The treatment combination of Counter 20G at planting, plus a postemergence application of Lorsban Advanced at its high (2 pts product/ac) rate, was most effective at preventing SBRM larval feeding injury. This combination resulted in significantly lower feeding injury than the combination of Poncho Beta plus Lorsban Advanced at 2 pts/ac, as well as the single-component program that consisted of just Poncho Beta-treated seed.

Table 3. *Larval feeding injury* in an evaluation of sugarbeet root maggot control by combining planting-time insecticide granules or seed treatments with postemergence liquid sprays, St. Thomas, ND, 2019 (Study II)

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	8.9 lb 2 pts	1.8 1.0	1.75 c
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	8.9 lb 1 pts	1.8 0.5	2.03 c
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	7.5 lb 1 pt	1.5 0.5	2.23 bc
Counter 20G	B	8.9 lb	1.8	2.33 bc
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	7.5 lb 2 pts	1.5 1.0	2.35 bc
Counter 20G	B	7.5 lb	1.5	2.40 bc
Poncho Beta + Lorsban Advanced	Seed Peak fly Broadcast	1 pt	68 g a.i./ unit seed 0.5	2.75 bc
Poncho Beta + Lorsban Advanced	Seed Peak fly Broadcast	2 pts	68 g a.i./ unit seed 1.0	3.23 b
Poncho Beta	Seed		68 g a.i./ unit seed	3.28 b
Check	---	----	---	5.50 a
LSD (0.05)				1.096

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; Seed = insecticidal seed treatment

Most other dual-insecticide (i.e., seed treatment or granular insecticide at planting plus a postemergence application of Lorsban Advanced at peak SBRM fly activity) programs performed well at protecting roots from SBRM feeding injury. Overall performance patterns suggested two things: 1) the high labeled rate of Counter 20G (8.9 lb product/ac) provided numerically (i.e., not statistically) better root protection than the moderate (7.5 lb/ac); and 2) Counter tended to provide slightly better root protection than Poncho Beta in both single- and dual-insecticide programs. For example, the top six treatments (i.e., lowest SBRM feeding injury) all involved Counter 20G for the planting-time component, including those involving stand-alone planting-time applications of Counter. However, it should be noted that significant differences associated with these trends were rare in Study II.

Yield results for Study II are presented in Table 4. All insecticide programs, irrespective of whether involving a single planting-time product (i.e., seed treatment or granular insecticide), or a combination treatment, provided significant increases in both recoverable sucrose yield and root tonnage in this trial. However, although treatment performance patterns somewhat corresponded with those observed in the root maggot feeding injury rating results, there were no significant differences in recoverable sucrose yield among insecticide-protected treatments. This was probably a result of the major variability among plots within replicates that was prevalent at this location in 2019.

Table 4. ***Yield parameters*** **from an evaluation of sugarbeet root maggot control by combining planting-time insecticide granules or seed treatments with postemergence liquid sprays, St. Thomas, ND, 2019 (Study II)**

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 Peak fly Broadcast	7.5 lb 1 pt	1.5 0.5	9876 a	33.9 ab	16.15 a	965
Counter 20G	B	8.9 lb	1.8	9846 a	34.8 a	15.73 a	904
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	8.9 lb 2 pts	1.8 1.0	9689 a	33.7 abc	16.05 a	924
Counter 20G	B	7.5 lb	1.5	9642 a	32.1 abc	16.65 a	1002
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	8.9 lb 1 pts	1.8 0.5	9431 a	33.0 abc	15.85 a	888
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	7.5 lb 2 pts	1.5 1.0	9318 a	33.0 abc	15.73 a	852
Poncho Beta	Seed		68 g a.i./ unit seed	9171 a	32.0 bc	15.88 a	866
Poncho Beta + Lorsban Advanced	Seed Peak fly Broadcast	2 pts	68 g a.i./ unit seed 1.0	9112 a	31.0 c	16.28 a	906
Poncho Beta + Lorsban Advanced	Seed Peak fly Broadcast	1 pt	68 g a.i./ unit seed 0.5	9027 a	31.5 bc	16.00 a	855
Check	---	----	---	7634 b	27.6 d	15.38 a	669
LSD (0.05)				1192.2	2.79	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; Seed = insecticidal seed treatment

Dual-insecticide (i.e., planting-time plus postemergence) programs tended to provide numerically improved levels of recoverable sucrose yield and root tonnage over single-component programs, but the differences were not statistically significant. Despite a relative lack in significant differences among insecticide treatments, the top-performing treatments with regard to recoverable sucrose yield and root tonnage in Study II included the following:

1) Counter 20G (7.5 lb product/ac, at-plant band) + postemergence Lorsban Advanced (1 pt/ac, peak fly)
2) Counter 20G (8.9 lb/ac, banded at planting)
3) Counter 20G (8.9 lb/ac, banded at planting) + Lorsban Advanced (2 pts/ac, peak fly);
4) Counter 20G (7.5 lb/ac, banded at planting)
5) Counter 20G (8.9 lb/ac, banded at planting) + Lorsban Advanced (1 pt/ac, peak fly); and
6) Counter 20G (7.5 lb product/ac, banded at planting) + Lorsban Advanced (2 pst/ac, peak fly).

Although significant yield differences among insecticide treatments were lacking in Study II, it is worth considering the relative gross economic returns provided by various insecticide regimes tested. The aforementioned top-performing treatments generated gross revenue increases of at least $183/ac in comparison to the check, and the increased revenue from the combination of Counter 20G plus a postemergence application of Lorsban Advanced (1 pt product/ac) increased gross revenue by $333/ac. Similarly, the combination of Poncho Beta-treated seed plus Lorsban Advanced at its high (2 pts/ac) rate generated a gross revenue increase of $237/ac over that of the check.

Despite a substantial amount of unplanned variability among plots in these trials, the results of both Studies I and II indicate that effective root maggot control can result in significant yield and revenue increases that would easily justify the cost of control. Our findings also demonstrate that the additional insecticide in dual- and triple-component insecticide programs is likely to be highly beneficial in protecting the crop from major destruction and generating excellent gross return values for the producer. These results also illustrate the economic significance of the root maggot as a major pest of sugarbeet in the Red River Valley. As such, effective management of the sugarbeet root maggot feeding injury is essential to maximizing economic returns in areas affected by this pest.

References Cited:

Boetel, M.A., R. J. Dregseth, and A. J. Schroeder. 2010. Economic benefits of insecticide applications for root maggot control in replanted sugarbeet. J. Sugar Beet Res. 47: 35-49.

Boetel, M. A., R. J. Dregseth, A. J. Schroeder, and C. D. Doetkott. 2006. Conventional and alternative placement of soil insecticides to control sugarbeet root maggot (Diptera: Ulidiidae) larvae. J. Sugar Beet Res. 43: 47–63.

Campbell, L. G., J. D. Eide, L. J. Smith, and G. A. Smith. 2000. Control of the sugarbeet root maggot with the fungus *Metarhizium anisopliae*. J. Sugar Beet Res. 37: 57–69.

SAS Institute. 2012. The SAS System for Windows. Version 9.4. SAS Institute Inc., 2002-2012. Cary, NC.

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