INTEGRATING INSECTICIDAL SEED TREATMENTS WITH CHEMICAL AND BIO-BASED INSECTICIDES FOR SUGARBEET ROOT MAGGOT CONTROL

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is the most serious insect pest of sugarbeet in the Red River Valley (RRV). Insecticides belonging to the same mode of action (acetylcholinesterase inhibition) have been used to control this insect for over three decades. Therefore, the potential for insecticide resistance development to these materials in root maggot populations is a major concern. This situation is further exacerbated by the fact that growers in extreme northeastern North Dakota need to make an additional one to two applications per year to avoid major economic loss from SBRM injury. A significant amount of effort during the past ten years has been placed on screening alternative insecticide chemistries for root maggot control; however, few materials have shown promise against this pest. The recent development of seed treatment insecticide materials has generated a substantial amount of grower interest. Seed treatment insecticides, if determined to be effective for managing important target pests such as the root maggot, would provide growers with viable new pesticide modes of action for insect control. This could help prolong the effectiveness of the currently registered materials. Seed treatments would also be attractive to the industry because of the following: 1) no on-farm calibration needed to achieve the appropriate field application rate; 2) no mixing required by grower (reduced likelihood of pesticide exposure); and 3) no specialized application equipment needed on planter.

This experiment was designed to achieve the following: 1) compare the efficacy of experimental seed treatments for root maggot control; and 2) test control programs consisting of seed treatments combined with conventional postemergence liquid insecticides.

Materials and Methods:

Three experiments were established on a field site near St. Thomas, ND and also at a second site near Minto, ND during the 2006 growing season. Seed treatment insecticides for Studies I and III were applied to seed by a custom seed-coating company (Germain's Technology Group, Inc., Fargo, ND). Treatment of seed for Study II was carried out by Syngenta Crop Protection (Greensboro, NC). Plots were planted using a 6-row John Deere 71 Flex planter set to plant at a depth of 1¼ inch and a rate of one seed every 4¾ inches of row. Plots were 6 rows (22-inch spacing) wide with the 4 centermost rows treated. The outer row on each side 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.

Counter 15G served as a planting-time granular insecticide standard in all three seed treatment experiments. Granules were either applied by using modified in-furrow (M) or spoon (S) placement. Modified in-furrow involved dropping granules down a tube over the row but directing them back away from the seed drop zone and immediately ahead of the rear press wheel. This allowed soil to begin covering seed before granules entered the furrow, thus avoiding direct insecticide/seed contact. Modified in-furrow placement resulted in delivery of a 2.5-inch band with the heaviest concentration of insecticide falling directly over the seed row. The “spoon” is a galvanized metal spoon-like apparatus with flanges on the outside edge to direct the granules in a miniature band over the row. A steel bolt (no. 10 size) was inserted at the center of the spoon near its tip with two metal hexagonal nuts attached to the bolt to deflect most insecticide granules laterally to fall immediately outside the edge of the furrow. Granular output rates used in these experiments were controlled by using planter-mounted Noble metering units.

Postemergence applications of Lorsban 4E were made using a tractor-mounted CO_2 spray system equipped with TeeJet 6501E nozzles. The system was calibrated to deliver a finished spray volume of 10 GPA. As with the planting-time treatments, the postemergence liquids were also applied to the inner four rows of each tractor pass, but three passes were made per plot for these treatments. This design was used to minimize the likelihood that flies affected by a foliar treatment in one plot would be able to successfully colonize a neighboring plot and vice versa. All evaluations in these plots were made within the central four-row tractor pass of each three-pass plot.

<u>Damage ratings</u>: Root maggot feeding injury was assessed in all tests 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 damage rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

<u>Harvest</u>: Treatment performance was also compared on the basis of sugarbeet yield parameters in all studies. Foliage was removed from plots immediately before harvest 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 12-16 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for analysis of sugar content and quality.

<u>Data analysis</u>: All data from damage rating and harvest samples were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 1999), and treatment means were separated using Fisher’s protected least significant difference (LSD) test at a 0.05 level of significance.

Specific information on materials and methods for the three studies are respectively

presented below.

Study I: This experiment was planted with on May 9, 2006 at St. Thomas and May 18 at Minto using Beta 1305R seed treated with Tachigaren fungicide at 20 g ai/unit (100,000 seeds). Insecticidal seed treatments, applied to seed by Germain's Technology Group (Fargo, ND.), included Poncho+Beta-cyfluthrin (30+4 and 60+8 g ai/unit of seed, respectively), Poncho 600 (60 g ai/unit), and Cruiser 5FS (60 g ai/unit). A granular formulation of the insect-pathogenic fungus *Metarhizium anisopliae* (strain F52), combined with the low (30+4 g ai/ unit) rate of Poncho+Beta-cyfluthrin, was also included in this trial. Experimental granules for this treatment were developed at the USDA-ARS National Center for Agricultural Utilization Research (Peoria, IL). To avoid cross-contamination of seed between treatment applications, planter seed hoppers were completely disassembled, cleaned, and re-assembled after each seed treatment.

Although Poncho 600 was included in this trial, it should be pointed out that it was used solely as a comparative treatment with Poncho-based combinations that included Beta-cyfluthrin. At the time of this writing, the manufacturer of Poncho (Bayer Crop Science, Research Triangle Park, NC) awaits USEPA processing of their application for full Section 3 registration of Poncho+Beta-cyfluthrin for insect control in sugarbeet.

Treatments in this experiment also included most of the above-mentioned materials with an additive postemergence application of Lorsban 4E, which was applied on June 6 in a 7-inch bands over the row. Sugarbeet root maggot feeding injury was assessed in the plots August 1, and plots were harvested on September 20.

Study II: This experiment was planted using Hilleshög 2417Rz seed on May 9 and May 17 at St. Thomas and Minto, ND, respectively. The focus of the study was on the performance of Cruiser 5FS seed treatment insecticide at a range of application rates. Seed treatments used in this experiment included Cruiser 5FS (20, 40, 60, and 80 g ai/unit [100,000 seeds]) and Poncho 600 (60 g ai/unit). Counter 15G, applied at 11.9 lb product/ac by using modified in-furrow (M) placement was applied as a stand-alone planting-time treatment and in combination with Cruiser seed treatment at the high (80 g ai/ unit) application rate. Root maggot feeding injury assessments were conducted August 1, and this trial was harvested on September 20.

Study III: This experiment was planted on May 9 and May 17, 2006 at St. Thomas and Minto, ND, respectively. This seed treatment experiment compared the efficacy of the following seed treatment insecticides against wireworms in sugarbeet: V-10170 (at rates of 60 and 75 g ai/unit seed), V-10170 + Danitol (at 60+7.5 and 60+15 g ai/unit seed, respectively), Cruiser 5FS (at 60 g ai/unit), Poncho 600 (at 60 g ai/unit seed). Counter 15G, applied at 10 and 11.9 lb product/ac by using modified in-furrow (MIF) placement, and at 10 lb/ac via spoon (S) placement. Root injury ratings were conducted on August 1, and the plots were harvested September 20.

Results and Discussion:

The seedbed at Minto remained very dry after planting, and resulted in delayed and erratic seedling emergence. The poorly developed plants that emerged were not very attractive for egg laying by female root maggot flies, and resulting larval damage to roots was very light and inconsistent at the site. Therefore, the Minto data for Studies I, II, and III are not included in this report.

Study I: Results from root injury assessments for Study I at St. Thomas are presented in Table 1. The sugarbeet root maggot infestation in this test was moderately high. Roots in the untreated control plots had an average root injury rating of 6.58 (0 to 9 scale). Counter 15G, the registered insecticide material in this trial, provided very good levels of root protection when applied at 10 lb product/ac. Its performance did not appear to be affected by placement because no statistical difference was detectable between the spoon and modified in-furrow treatments.

Cruiser seed treatment, which was applied at 60 g ai/unit of seed, also provided fairly good protection of roots from SBRM feeding injury. In fact, Cruiser was not outperformed by the single planting-time treatment of Counter 15G, applied modified in-furrow, or the dual-insecticide program that consisted of Counter 15G at planting plus a postemergence application of Lorsban 4E. Cruiser also provided statistically better root protection than Poncho 600 at 60 g and Poncho+Beta-cyfluthrin at 60+8 g ai/unit of seed. The only entry in the experiment that performed better than Cruiser was a spoon-applied treatment of Counter 15G at the 10-lb rate.

The high (60+8 g) rate of Poncho+Beta-cyfluthrin did not differ significantly from the untreated check with respect to protection from root maggot feeding injury; however, adding a postemergence foliar application of Lorsban 4E improved root protection to the extent that feeding injury in the dual-application treatment was statistically lower than in the check. Poncho-based seed treatment entries in this experiment generally resulted in marginal levels of root maggot control. This differed from our findings from previous years. One possible factor that could have contributed to this was the low rainfall that occurred in 2006. Typically, several inches of rainfall are received in most Red River Valley locations during the month of June. In 2006, only 0.64 inch of rain fell on these plots during June. The reason for these surprising findings remains unresolved.

Foliar applications of Lorsban 4E did not provide significant improvements in root maggot control to seed treatment entries or to Counter. This result is atypical compared to what has been observed in similar experiments during the past several years. The general lack of additive control from Lorsban 4E was probably influenced by application timing and weather factors. Peak fly activity occurred exceptionally early (June 2), yet our postemergence foliar treatments of Lorsban 4E were not applied until June 6. Thus, much of the root maggot fly activity for the season had taken place before the applications were made. The dry weather also probably had an impact on the performance of Lorsban. Rainfall can aid with incorporating liquid insecticides like Lorsban into the soil, thus, resulting in larval control in addition to killing the adult flies. It is unlikely that the low and infrequent rains during 2006 would have aided with incorporation of the Lorsban.

These findings support our contention in previous reports that, although Poncho-based seed treatment combinations appear to have good potential for providing some protection from root maggot feeding injury, they may not serve as stand-alone treatments under the high maggot feeding pressure that commonly develops in northeastern North Dakota. These results also underscore the importance for growers to pay close attention to NDSU's forecast and updates regarding peak fly activity timing each year, and to maintain a keen awareness of fly numbers in their individual fields.

Yield parameters in this trial were probably affected more by the heavy wireworm infestation that developed in these plots and caused high plant stand losses in several treatments. Therefore, the yield data associated with these treatments are presented in another article in this report entitled “Wireworm Management in Sugarbeet using Experimental Seed Treatment Insecticides”.

Table 1. *Feeding injury* in evaluation of experimental seed treatments for sugarbeet root maggot control, St. Thomas, ND, 2006

Treatment/form	Placement[a]	Rate (product/ac)	Rate (ai/ac)	Root injury (0-9)
Counter 15G	S	10 lb	1.5 lb	2.15 f
Counter 15G + Lorsban 4E	M 7” Post B	10 lb 2 pts	1.5 lb 1.0 lb	2.98 ef
Counter 15G	M	10 lb	1.5 lb	3.43 def
Cruiser	Seed		60 g ai/ unit seed	4.00 cde
Poncho+Beta-Cyfluthrin Lorsban 4E	Seed 7” Post B	2 pts	60+8 g ai/ unit seed 1.0 lb	4.68 bcd
Poncho+Beta-Cyfluthrin	Seed		30+4 g ai/ unit seed	4.95 bc
Poncho+Beta-Cyfluthrin *Metarhizium* Granule	Seed IF		30+4 g ai/ unit seed 2X	5.13 abc
Poncho+Beta-Cyfluthrin Lorsban 4E	Seed 7” Post B	2 pts	30+4 g ai/ unit seed 1.0 lb	5.23 abc
Poncho 600 + Lorsban 4E	Seed 7” Post B	2 pts	60 g ai/ unit seed 1.0 lb	5.38 abc
Poncho+Beta-Cyfluthrin	Seed		60+8 g ai/ unit seed	5.73 ab
Poncho 600	Seed		60 g ai/ unit seed	5.93 ab
Check	---	----	---	6.58 a
LSD (0.05)				1.45

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

[a]S = Spoon; M = Modified in-furrow; B = Band; Seed = insecticidal seed treatment; IF = Directly into seed furrow

Study II: Root injury assessments for this study are presented in Table 2. The average root injury rating of 5.75 (0 to 9 scale) in the untreated check plots indicated a moderate root maggot infestation was present during this study. Excellent protection from root maggot feeding injury was achieved by the combined treatment of Cruiser at the high (80 g ai/unit of seed) rate plus a planting-time application of Counter 15G at 11.9 lb product/ac. Similar performance was observed by the stand-alone application of 11.9 lb of Counter. The 60- and 80-g rates of Cruiser, when used as stand-alone control programs, provided significant reductions in root maggot feeding injury when compared with the untreated check. Treatments that failed to adequately protect roots from maggot damage included Cruiser 5FS, applied at either 20 or 40 g ai/unit, and Poncho 600 at 60 g; however, it should be noted that Bayer Crop Science (Research Triangle Park, NC), manufacturer of Poncho, does not intend to market the single-active-ingredient product (Poncho 600) for root maggot control. Rather, the company anticipates future USEPA registration of Poncho+Beta-cyfluthrin for this purpose.

Table 2. *Feeding injury* in plots treated with experimental seed treatments to control sugarbeet root maggot larvae, St. Thomas, ND, 2006

Treatment/form	Placement[a]	Rate (product/ac)	Rate (lb ai/ac)	Root injury (0-9)
Cruiser 5FS + Counter 15G	Seed M	 11.9 lb	80 g ai/ unit seed 1.8 lb	3.40 c
Counter 15G	M	11.9 lb	1.8 lb	3.48 c
Cruiser 5FS	Seed		80 g ai/ unit seed	4.38 bc
Cruiser 5FS	Seed		60 g ai/ unit seed	4.45 bc
Poncho 600	Seed		60 g ai/ unit seed	4.95 ab
Cruiser 5FS	Seed		40 g ai/ unit seed	5.08 ab
Check	---	----		5.75 a
Cruiser 5FS	Seed		20 g ai/ unit seed	5.80 a
LSD (0.05)				1.21

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

[a]**Seed = insecticidal seed treatment; M = Modified in-furrow**

Yield data for this experiment appear in Table 3. No significant yield differences were detected among treatments, irrespective of yield parameter measured; however, yield trends generally followed the patterns of the root maggot feeding injury comparisons. The insecticide-based treatments (i.e., seed treatments and conventional granular insecticide entries) produced numerically higher sucrose yields than the untreated check. The highest recoverable sucrose yield average was observed in plots treated with Cruiser 5FS at 80 g ai/unit of seed combined with an at-plant application of Counter 15G at its highest labeled rate (11.9 lb product/ac).

Table 3. *Yield parameters* from plots treated with experimental seed treatments to control sugarbeet root maggot larvae, St. Thomas, ND, 2006

Treatment/form	Placement[a]	Rate (product/ac)	Rate (lb ai/ac)	Recoverable sucrose (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Cruiser 5FS + Counter 15G	Seed M	11.9 lb	80 g ai/ unit seed 1.8 lb	8483 a	29.1 a	16.10 a	914
Counter 15G	M	11.9 lb	1.8 lb	7875 a	27.4 a	15.88 a	833
Cruiser 5FS	Seed		40 g ai/ unit seed	7837 a	27.8 a	15.73 a	808
Cruiser 5FS	Seed		80 g ai/ unit seed	7819 a	27.2 a	15.90 a	831
Cruiser 5FS	Seed		20 g ai/ unit seed	7689 a	26.6 a	16.05 a	823
Poncho 600	Seed		60 g ai/ unit seed	7539 a	26.8 a	15.73 a	776
Cruiser 5FS	Seed		60 g ai/ unit seed	7201 a	25.2 a	15.85 a	756
Check	---	----	---	6959 a	25.6 a	15.25 a	681
LSD (0.05)				NS	NS	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD).
[a]Seed = insecticidal seed treatment; M = Modified in-furrow

<u>Study III</u>: The average level of root maggot feeding injury in the untreated check plots in Seed Treatment Study III was 6.2 (Table 4). Thus, the maggot infestation in this study was considered moderately high. Counter 15G, the registered standard in the experiment, tended to perform the best. Spoon-applied treatments of Counter, at either 10 or 11.9 lb product/ac, provided significantly better protection from root maggot feeding injury than all seed treatment entries; however, all seed treatment insecticides resulted in statistically lower root maggot feeding injury than the untreated check. Few differences were observed among seed treatments with respect to root maggot damage. Cruiser 5S, applied to seed at 60 g ai/unit, performed significantly better than the 60- and 75-g ai/unit rates of the V-10170 seed treatment. No statistical differences were detected between rates of V-10170. Poncho 600 seed treatment, applied at 60 g ai/unit, provided a comparable level of protection from root maggot feeding injury to that of Cruiser (also at 60 g/unit) in this experiment.

Table 4. *Feeding injury* in plots treated with experimental seed treatments to control sugarbeet root maggot larvae, St. Thomas, ND, 2006

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb ai/ac)	Root injury (0-9)
Counter 15G	S	11.9 lb	1.8 lb	1.85 f
Counter 15G	S	10 lb	1.5 lb	2.15 ef
Counter 15G	M	10 lb	1.5 lb	3.15 de
Cruiser	Seed		60 g ai/ unit seed	3.38 cd
V-10170+Danitol	Seed		60+7.5 g ai/ unit seed	3.98 bcd
Poncho 600	Seed		60 g ai/ unit seed	4.28 bc
V-10170+Danitol	Seed		60+15 g ai/ unit seed	4.70 b
V-10170	Seed		75 g ai/ unit seed	4.70 b
V-10170	Seed		60 g ai/ unit seed	4.75 b
Check	---	----	---	6.20 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]S = Spoon; M = Modified in-furrow; Seed = insecticidal seed treatment

All Counter 15G treatments were effective at protecting sugarbeet root yield and recoverable sucrose in this study, irrespective of rate or placement (Table 5). Other treatments that provided in significant improvements in root and sucrose yield over that of the untreated check in this study included the seed treatment combination of V-10170+Danitol (60+ 7.5 g ai/unit of seed) and the single seed treatment of V-10170 at 60 g ai/unit. No consistent patterns in yield parameters were detected between seed treatment rates or combinations. This study should be carried out again to determine the repeatability of these findings.

Table 5. *Yield parameters* from plots treated with experimental seed treatments to control sugarbeet root maggot larvae, St. Thomas, ND, 2006

Treatment/form	Placement[a]	Rate (product/ ac)	Rate (lb ai/ac)	Recoverable sucrose (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 15G	M	10 lb	1.5 lb	9605 a	33.1 ab	16.30 a	1031
Counter 15G	S	10 lb	1.5 lb	9400 a	34.3 a	15.60 a	932
Counter 15G	S	11.9 lb	1.8 lb	9377 a	32.9 abc	16.00 a	982
V-10170+Danitol	Seed		60+7.5 g ai/ unit seed	9315 ab	32.8 a-d	16.03 a	971
V-10170	Seed		60 g ai/ unit seed	9104 abc	32.4 a-d	15.87 a	936
Cruiser	Seed		60 g ai/ unit seed	8797 a-d	31.2 b-e	15.90 a	907
V-10170	Seed		75 g ai/ unit seed	8534 bcd	30.8 cde	15.70 a	862
Poncho 600	Seed		60 g ai/ unit seed	8290 cd	30.6 de	15.47 a	809
V-10170+Danitol	Seed		60+15 g ai/ unit seed	8268 d	30.1 e	15.63 a	823
Check	---	----	---	8246 d	29.9 e	15.67 a	824
LSD (0.05)				819	2.2	NS	

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

[a]S = Spoon; M = Modified in-furrow; Seed = insecticidal seed treatment

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