EXPERIMENTAL SEED TREATMENTS AND LIQUID INSECTICIDES TO MANAGE THE SUGARBEET ROOT MAGGOT

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Introduction:

Insecticides belonging to two chemical classes (organophosphates and carbamates) have been used to protect Red River Valley sugarbeet fields from attack by the sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), for about 30 years. Both classes have the same mode of action in insects, and 2 to 3 applications per year are often needed in extreme northeastern North Dakota’s heavily infested areas to avoid major yield losses. Thus, SBRM populations in those portions of the production area have been subjected to a high level of selection pressure for the development of insecticide resistance. Limited insecticide options to manage the root maggot, in combination with the threat of insecticide resistance development, have provided a strong impetus for our research aimed at the discovery of new control tools.

This series of three experiments was designed to achieve the following: 1) evaluate the efficacy of experimental seed treatments for root maggot control; 2) test combinations of seed treatments with conventional postemergence liquid insecticides; 3) screen experimental liquid insecticides for efficacy in controlling root maggot larvae; and 4) assess the effects of placement method and 10-34-0 starter fertilizer on performance of MustangMax and Regent insecticides.

Materials and Methods:

These experiments were carried out in a commercial field site near St. Thomas, ND during the 2004 growing season. Crystal 822 variety seed was used for all three studies (including seed treatment insecticide entries), and plots were planted using a 6-row John Deere 71 Flex planter. Plots were 6 rows (22-inch spacing) wide with the 4 centermost rows treated, and the outer row on each side served as an untreated buffer. Seed spacing was one every 4 1/8 inches, and seeding depth was 1¼ inch. 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. Plots that received a postemergence liquid insecticide application were made three passes (18 rows) wide to minimize the amount of invasion by adult females from neighboring treatment plots; however, all evaluations were made on the inner 4 rows in the same manner as with the standard 4-row plots.

Planting-time granular insecticide treatments were either applied in a band (B) or by modified in-furrow (M) placement. Banded applications consisted of 5-inch swaths of granules that were achieved by using Gandy™ row banders. Modified in-furrow placement involved dropping granules down a tube over the row but directing them back away from the seed drop zone and in front of the rear press wheel. This allowed some soil to cover the seed before granules entered the furrow so as to avoid direct insecticide/seed contact. It is very important to ensure that no insecticide comes into contact with sugarbeet seed when using this placement method because some organophosphate insecticides can be very phytotoxic to sugarbeet seedlings. 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. Counter 15G served as a planting-time granular insecticide standard. It was used as both a stand-alone treatment and as part of other treatment regimes. Output rates of the granular materials used in these experiments were controlled by using planter-mounted Noble metering units.

Postemergence applications were made with 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 applications were also made to the inner four rows of each tractor pass, but three passes were made per plot for these treatments.

Damage ratings: 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).

Harvest: 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.

Data analysis: 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 materials and methods information for the three studies are respectively presented in the following three subsections of this report.

Study I:

This experiment was planted on May 7, 2004. Seed treatments in Study I included Poncho+Cyfluthrin (30+8 and 60+16 g ai/unit of seed), Poncho+Beta-cyfluthrin (60+8 g ai/unit seed), and Icon (25 and 50 g ai/unit seed). The same seed (Crystal 822) was used for all seed treatments and conventional insecticide entries in the experiment. The seed treatment was applied to seed by personnel at ASTEC, Inc. (Sheridan, WY). To avoid cross-contamination of seed from one plot to another, seed hoppers on the planter were completely disassembled and cleaned out before and after each seed treatment. Poncho was made available for our evaluations solely as a seed treatment combination with either Cyfluthrin or Beta-cyfluthrin (both pyrethroid insecticides) rather than alone because the manufacturer, Bayer CropScience, anticipated that one of those combinations will likely be how labeling is pursued for the U.S. market.

Lorsban 4E was applied as a postemergence treatment on June 21 (prior to peak fly) at a rate of 2 pt/acre in a 7-inch band over the row to provide additive control to the Poncho+Cyfluthrin and Poncho+Beta-cyfluthrin treatments. For comparative purposes, Lorsban 4E was also applied at the same rate to plots that had received Counter 15G (10 lb product/acre) and one set of plots that had no insecticide at planting. Damage ratings were carried out on August 17, and the plots were harvested on September 27.

Study II:

The experiment was planted on May 5, 2004. Planting-time applications of liquid insecticides (MustangMAX 0.8EC and F-58038 2 lb/gal) were carried out using a planter-mounted Raven™ liquid application system equipped with 4 TeeJet 6501E nozzles. MustangMAX was applied at 4 fl oz of product/acre and F-58038 was applied at 6.4, 12.8 and 19.2 fl oz of product/acre. In-furrow applications involved turning the nozzles to orient the entire spray pattern directly into the furrow over the seed. One treatment of MustangMAX and three treatments of F-58038 (6.4, 12.8 and 19.2 fl oz product/ac) were also applied in a 3-inch T-band over the row. The finished spray volume for all planting-time liquid treatments was 5 GPA.

Postemergence liquid applications in Study II included Lorsban 4E and MustangMAX. Two applications of Lorsban 4E were applied over the top of the planting-time application of Counter 15G, and MustangMAX was applied up to 2 times after a planting-time application of MustangMAX. The first postemergence applications in this study were applied on June 21 (prior to peak fly) and the second postemergence application was made shortly after peak on July 1. Peak fly activity occurred on June 30, 2004. All liquid insecticide treatments were applied in 7-inch bands directly over the row. Damage ratings were done August 18, and the test was harvested on September 28.

<u>Study III</u>:

This experiment was planted on May 6, 2004. The study was designed to compare planting-time granules with one registered and one experimental planting-time liquid insecticide. Counter 15G treatments were applied at planting at the high label rate (11.9 lb product/acre) and at the moderate rate of 10.0 lb. Counter treatments were applied either by using modified in-furrow or band (5-inch swaths over the row) placement. These treatments served as standards for comparison with the liquid insecticides.

The two planting-time liquids evaluated in Study III were MustangMAX and Regent 4SC. **Regent was considered an experimental material in this study because it was not registered for commercial use in sugarbeet.** Mustang was applied both directly in-furrow and as a 3-inch T-band (banded directly over open furrow), whereas Regent was applied only as an in-furrow application. Liquid treatments were delivered through TeeJet 6501E nozzles at a finished spray volume of 5 GPA. Starter fertilizer (10-34-0) was used in some of these experiments as part of the finished spray mixture. MustangMax and Regent insecticides were diluted in water at a ratio of 60:1 (water:insecticide) prior to being mixed with the fertilizer to avoid the likelihood of clogging or other incompatibility issues. Nozzles were directed so that all of the concentrate was placed in-furrow. A fertilizer + water control was included to test for potential yield impacts that could occur independently of the expected root maggot feeding injury effects. A true untreated control was also included for comparative purposes. Damage ratings were done August 17, and the test was harvested on September 28.

Results and Discussion:

<u>Study I</u>:

Results for root injury ratings from Study I are presented in <u>Table 1</u>. Poncho+Beta-cyfluthrin and the high rate of Poncho+Cyfluthrin (60+16 g ai/unit seed) provided greater root protection than both rates of the Icon seed treatment; however, all seed treatments demonstrated insecticidal activity against the sugarbeet root maggot because they resulted in significant reductions in root injury when compared with the untreated check. There was no difference in root injury between the low (25 g) and high (50 g) rates of Icon.

Poncho, when combined with either Cyfluthrin or Beta-cyfluthrin, performed at levels similar to that of Counter 15G at a moderate application rate (10 lb product/acre). All Poncho-based seed treatments were enhanced by a postemergence application of Lorsban 4E before peak fly activity. The effect was demonstrated in both root protection and recoverable sucrose yield (<u>Table 2</u>). Also, the gross economic return provided by adding the Lorsban 4E ranged from about $150 to $350 per acre.

Root maggot feeding activity occurred exceptionally late during the 2004 growing season. Therefore, it was not anticipated that seed treatment insecticides would be able to provide such a sustained level of root protection as was demonstrated in this experiment. Icon and Poncho+Cyfluthrin seed treatment combinations appear to have good potential for providing protection from the root maggot, but may not serve as stand-alone treatments under the high maggot feeding pressure that commonly develops in northeastern North Dakota.

Table 1. ***Root injury*** **in test of experimental seed treatments for sugarbeet root maggot control, St. Thomas, ND, 2004.**				
Treatment/form.	**Placement**	**Rate (product/ac)**	**Rate (ai/ac)**	**Root injury (0-9)**
Poncho+Beta-cyfluthrin Lorsban 4E	Seed 7" Band	 2 pts	60+8 g ai/ unit seed 1 lb	2.63 f
Counter 15G Lorsban 4E	M 7" Band	10 lb 2 pts	1.5 lb 1 lb	2.78 f
Poncho+Cyfluthrin Lorsban 4E	Seed 7" Band	 2 pts	60+16 g ai/ unit seed 1 lb	2.80 f
Poncho+Cyfluthrin Lorsban 4E	Seed 7" Band	 2 pts	30+8 g ai/ unit seed 1 lb	3.18 ef
Untreated Lorsban 4E	---- 7" Band	----- 2 pts	---- 1 lb	3.70 e
Poncho+Cyfluthrin	Seed		60+16 g ai/ unit seed	4.90 d
Poncho+Beta-cyfluthrin	Seed		60+8 g ai/ unit seed	5.40 cd
Counter 15G	M	10 lb	1.5 lb	5.50 cd
Poncho+Cyfluthrin	Seed		30+8 g ai/ unit seed	5.85 bc
Icon 6.2 TS	Seed		50 g ai/ unit seed	6.25 b
Icon 6.2 TS	Seed		25 g ai/ unit seed	6.45 b
Check	---	----	---	7.48 a
LSD (0.05)				0.75

Table 2. ***Yield parameters*** **from plots treated with experimental seed treatments for sugarbeet root maggot control, St. Thomas, ND, 2004.**							
Treatment/form.	**Placement**	**Rate (product/ac)**	**Rate (ai/ac)**	**Recoverable sucrose (lb/ac)**	**Root yield (T/ac)**	**Sucrose (%)**	**Gross return ($/ac)**
Poncho+Beta-cyfluthrin Lorsban 4E	Seed 7" Band	 2 pts	60+8 g ai/ unit seed 1 lb	5720 a	19.2 a	15.97 a-e	619
Poncho+Cyfluthrin Lorsban 4E	Seed 7" Band	 2 pts	30+8 g ai/ unit seed 1 lb	5595 a	18.0 ab	16.57 a	632
Poncho+Cyfluthrin Lorsban 4E	Seed 7" Band	 2 pts	60+16 g ai/ unit seed 1 lb	4961 ab	16.4 abc	16.20 abc	547
Counter 15G Lorsban 4E	M 7" Band	10 lb 2 pts	1.5 1 lb	4939 abc	16.0 abc	16.40 ab	553
Untreated Lorsban 4E	---- 7" Band	----- 2 pts	---- 1 lb	4053 bcd	13.4 cd	16.13 a-d	447
Icon 6.2 TS	Seed		25 g ai/ unit seed	3783 bcd	13.6 bcd	15.03 ef	379
Poncho+Cyfluthrin	Seed		60+16 g ai/ unit seed	3697 bcd	12.4 cd	15.80 a-e	399
Poncho+Beta-cyfluthrin	Seed		60+8 g ai/ unit seed	3595 bcd	12.7 cd	15.17 def	367
Counter 15G	M	10 lb	1.5 lb	3490 cd	12.2 cd	15.47 b-f	362
Check	---	----	---	3411 d	12.2 cd	15.13 ef	342
Icon 6.2 TS	Seed		50 g ai/ unit seed	2856 d	10.3 d	14.80 f	284
Poncho+Cyfluthrin	Seed		30+8 g ai/ unit seed	2699 d	9.4 d	15.37 c-f	280
LSD (0.05)				1461	4.6	0.97	

Study II:

Root injury and yield data for this study are presented in Tables 3 and 4, respectively. The root maggot infestation in this test was extremely high and, as mentioned previously, feeding activity occurred unseasonably late. Also, SBRM infestations persisted for an unusually long period of time. Mustang and the experimental material F-58038 (both liquid and granular formulations) provided reductions in sugarbeet root maggot feeding injury; however, the only treatment to cause a significant improvement in recoverable sucrose and root tonnage over that of the untreated check was the intensive conventional regime of Counter 15G (10 lb product/acre) followed by two 1-pt applications of Lorsban 4E at postemergence. Much of the control provided by postemergence liquid insecticides is from killing adult SBRM flies. Our past observations have shown that larvicidal activity also can be achieved with Lorsban 4E if rain is received within a 2-3 days of the application. Generally, treatments involving either Mustang or F-58038 were overwhelmed by the high larval infestations that developed, and did not provide acceptable levels of root protection or a yield benefit.

Table 3. R*oot injury* in sugarbeet treated with Mustang, F-58038, or registered insecticides for sugarbeet root maggot control, St. Thomas, ND, 2004.				
Treatment/form.	**Placement**	**Rate (product/ac)**	**Rate (lb ai/ac)**	**Root injury (0-9)**
Counter 15G + Lorsban 4E + Lorsban 4E	B 7" Post B 7" Post B	10 lb 1 pt 1 pt	1.5 0.5 0.5	2.98 f
Counter 15G	M	11.9 lb	1.8	4.40 e
F-58038 2 lb/gal liquid	3" TB	12.8 fl oz	0.20	5.73 d
F-58038 1.15G	M	17.4 lb	0.20	5.80 cd
F-58038 2 lb/gal liquid	3" TB	19.2 fl oz	0.30	5.80 cd
F-58038 2 lb/gal liquid	IF	19.2 fl oz	0.30	5.93 bcd
Mustang 0.8EC	IF	4 fl oz	0.025	6.05 bcd
Counter 15G	M	10 lb	1.5	6.08 bcd
F-58038 1.15G	M	8.8 lb	0.10	6.10 bcd
Mustang 0.8EC + Mustang 0.8EC + Mustang 0.8EC	IF 7" Post B 7" Post B	4 fl oz 4 fl oz 4 fl oz	0.025 0.025 0.025	6.13 bcd
F-58038 2 lb/gal liquid	IF	6.4 fl oz	0.10	6.25 bcd
Mustang 0.8EC	3" TB	4 fl oz	0.025	6.70 bc
F-58038 2 lb/gal liquid	3" TB	6.4 fl oz	0.10	6.75 b
Check	----	----	----	7.68 a
LSD (0.05)				0.91

Table 4. *Yield parameters* from sugarbeet treated with Mustang, F-58038, or registered insecticides for sugarbeet root maggot control, St. Thomas, ND, 2004.							
Treatment/form.	**Placement**	**Rate (product/ac)**	**Rate (lb ai/ac)**	**Recoverable sucrose (lb/ac)**	**Root yield (T/ac)**	**Sucrose (%)**	**Gross return ($/ac)**
Counter 15G + Lorsban 4E + Lorsban 4E	B 7" Post B 7" Post B	10 lb 1 pt 1 pt	1.5 0.5 0.5	4725 a	16.9 a	15.25 abc	477
Counter 15G	M	11.9 lb	1.8	4460 ab	15.4 ab	15.55 a	469
Check	----	----	----	3880 bc	13.2 bc	15.70 a	413
F-58038 2 lb/gal liquid	3" TB	12.8 fl oz	0.20	3727 cd	12.7 c	15.75 a	397
Counter 15G	M	10 lb	1.5	3601 cd	13.1 bc	15.05 abc	356
F-58038 2 lb/gal liquid	IF	6.4 fl oz	0.10	3544 cd	12.5 c	15.25 abc	362
Mustang 0.8EC	IF	4 fl oz	0.025	3432 cd	12.2 c	15.23 abc	348
F-58038 2 lb/gal liquid	IF	19.2 fl oz	0.30	3371 cd	12.0 c	15.18 abc	341
Mustang 0.8EC	3" TB	4 fl oz	0.025	3332 cd	12.7 c	14.50 c	310
F-58038 1.15G	M	8.8 lb	0.10	3332 cd	11.4 c	15.65 a	352
Mustang 0.8EC + Mustang 0.8EC + Mustang 0.8EC	IF 7" Post B 7" Post B	4 fl oz 4 fl oz 4 fl oz	0.025 0.025 0.025	3323 cd	11.6 c	15.40 ab	344
F-58038 2 lb/gal liquid	3" TB	6.4 fl oz	0.10	3200 cd	12.0 c	14.50 c	302
F-58038 1.15G	M	17.4 lb	0.20	3177 d	11.8 c	14.70 bc	307
F-58038 2 lb/gal liquid	3" TB	6.4 fl oz	0.10	3167 d	10.9 c	15.55 a	332
LSD (0.05)				692	2.4	0.81	

Study III:

As evidenced by the root injury rating of 7.3 on the 0 to 9 scale for the untreated check plots (Table 5), root maggot feeding pressure in this study was very high. The only treatments that provided significant reductions in root injury were Counter 15G applied modified in-furrow at both 5.9 and 11.9 lb product/acre, the banded application of Counter at 10 lb, and Regent 4SC at the high (4.16 fl oz/acre) rate when tankmixed with 10-34-0 starter fertilizer. Trends suggested that both Mustang and Regent may provide slightly better root protection when mixed with the 10-34-0 starter fertilizer, although the harvest results indicated that the benefit would not likely translate to a major yield advantage (Table 6). In fact, in comparing 10-34-0 alone with the untreated control, the former did not cause a statistical yield increase. Significant improvements in both recoverable sucrose and sugarbeet root yield were observed when comparing the following treatments with the untreated check: Counter 15G modified in-furrow at 5.9, 10, and 11.9 lb, Counter at 11.9 lb banded, MustangMax T-banded at 4 fl oz/acre, Regent at 2.08 fl oz/acre + 10-34-0. Regent alone at the 3.2 fl oz rate also resulted in a significant increase in sucrose yield over that of the untreated check. Although not statistically significant, the yield data indicated that T-banding Mustang may be more effective for root maggot control than placing the material directly in the seed furrow.

These findings suggest that neither Mustang nor Regent should be used as a stand-alone material for root maggot control. Further testing is needed to determine if these insecticides will perform better in a program that includes an additive postemergence treatment such as Lorsban 4E or Vydate C-LV.

Table 5. *Root feeding injury* in sugarbeet treated with Counter, Regent, or MustangMax to control sugarbeet root maggot larvae, St. Thomas, ND, 2004.

Treatment/form.	Placement	Rate (product/ac)	Rate (lb ai/ac)	Root injury (0-9)
Counter 15G	M	11.9 lb	1.8	5.60 d
Counter 15G	B	10 lb	1.5	6.03 cd
Counter 15G	M	5.9 lb	0.9	6.13 cd
Regent 4SC + 10-34-0 fert.	IF	4.16 fl oz		6.53 bc
Regent 4SC	IF	2.08 fl oz		6.57 abc
MustangMAX 0.8EC	IF	4 fl oz	0.025	6.60 abc
MustangMax + 10-34-0 fert	IF	4 fl oz	0.025	6.60 abc
Regent 4SC	IF	3.20 fl oz		6.60 abc
Regent 4SC + 10-34-0 fert.	IF	2.08 fl oz		6.60 abc
Counter 15G	M	10 lb	1.5	6.67 abc
Counter 15G	B	11.9 lb	1.8	6.77 abc
MustangMAX 0.8EC	3” TB	4 fl oz	0.025	6.90 ab
Regent 4SC	IF	4.16 fl oz		6.97 ab
Regent 4SC	IF	1.25 fl oz		6.97 ab
10-34-0 fert.	IF	----	----	7.17 ab
Check	--	----	----	7.30 a
LSD (0.05)				0.74

Table 6. ***Yield parameters*** **from sugarbeet treated with Counter, Regent, or MustangMax to control sugarbeet root maggot larvae, St. Thomas, ND, 2004.**							
Treatment/form.	**Placement**	**Rate (product/ac)**	**Rate (lb ai/ac)**	**Recoverable sucrose (lb/ac)**	**Root yield (T/ac)**	**Sucrose (%)**	**Gross return ($/ac)**
Counter 15G	M	11.9 lb	1.8	4466 a	15.0 a	15.90 a	483
Counter 15G	M	10 lb	1.5	4144 ab	14.4 ab	15.47 abc	432
MustangMAX 0.8EC	3" TB	4 fl oz	0.025	3958 abc	14.0 ab	15.17 a-d	404
Counter 15G	B	11.9 lb	1.8	3875 abc	13.1 a-d	15.73 ab	416
Counter 15G	M	5.9 lb	0.9	3832 abc	13.7 abc	15.13 a-d	388
Regent 4SC + 10-34-0 fert.	IF	2.08 fl oz		3817 abc	13.5 abc	15.13 a-d	388
Regent 4SC	IF	3.20 fl oz		3700 a-d	12.5 a-e	15.77 a	397
Regent 4SC	IF	2.08 fl oz		3633 a-e	12.9 a-e	15.10 a-e	369
Counter 15G	B	10 lb	1.5	3522 b-e	12.6 a-e	15.03 a-e	356
MustangMax + 10-34-0 fert	IF	4 fl oz	0.025	3387 b-e	12.2 a-e	14.87 b-e	338
Regent 4SC + 10-34-0 fert.	IF	4.16 fl oz		3357 b-e	12.4 a-e	14.63 cde	326
Regent 4SC	IF	1.25 fl oz		3113 cde	11.6 b-e	14.57 de	298
Mustang 0.8EC	IF	4 fl oz	0.025	3067 cde	11.0 cde	14.87 b-e	308
Regent 4SC	IF	4.16 fl oz		2804 de	10.4 de	14.60 cde	269
10-34-0 fert.	IF	----	----	2707 e	10.2 e	14.23 e	256
Check	--	----	----	2696 e	10.2 e	14.50 de	254
LSD (0.05)				943	2.9	0.90	

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