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EXPERIMENTAL SEED TREATMENTS AND LIQUID INSECTICIDES FOR CONTROL OF THE SUGARBEET ROOT MAGGOT

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Introduction:

The sugarbeet root maggot, *Tetanops myopaeformis* (Röder), is a serious insect pest of sugarbeet in the Red River Valley of Minnesota and North Dakota. Root maggots cause injury to the plant by rasping the surface of the developing sugarbeet root with oral hooks. Heavy infestations of this insect are capable of severing main taproots of the plants and can be sufficient to kill plants, especially under drought stress. Therefore, the pest is capable of causing major stand reductions. Campbell et al. (1998) estimated that the root maggot is capable of causing yield losses of up to 42% if control measures are not taken, and Blickenstaff et al. (1981) reported yield losses of up to 100% in heavily infested, localized areas.

The removal of most chlorinated hydrocarbon insecticides in the 1970s forced growers to begin using organophosphate and carbamate insecticides to protect their sugarbeet fields from attack by the root maggot. Organophosphates and carbamates are two different insecticide classes, but they have the same mode of action in insects. Materials having this same mode of action, acetylcholinesterase inhibition, have been used to control the sugarbeet root maggot for about 30 years with 2 to 3 applications per year being needed in heavily infested areas. Thus, sugarbeet root maggot populations in the Red River Valley growing area have been subjected to an enormous amount of selection pressure for insecticide resistance development. Limited insecticide options to manage the root maggot, coupled with the looming threat of insecticide resistance development, have provided a strong impetus for research on new chemical control tools. This study was carried out to achieve the following: 1) evaluate the efficacy of experimental seed treatments and liquid insecticides for planting-time root maggot control; 2) determine the impact of timing and application rate on performance of postemergence liquid insecticides; and 3) assess the effects of 10-34-0 starter fertilizer on insecticide effectiveness and sugarbeet yield variables.

Materials and Methods:

A site near St. Thomas, ND was chosen for series of three experiments involving the following experimental insecticides for sugarbeet root maggot control:

1) Vydate C-LV applied at planting-time and postemergence;
2) Regent 4SC and Mustang 0.8EC with and without 10-34-0 starter fertilizer; and
3) Poncho, Gaucho, and Spinosad seed treatments, and SpinTor 2SC as a postemergence material

Planting dates ranged from May 13 to 15, 2003. All three experiments were arranged in a randomized complete block design with four replications. Tilled plant-free alleys (25 ft width) were established between replicates. Plots treated with planting-time granules were 6 rows wide by 35 ft long. Postemergence liquid treatments were aimed at killing adult root maggot flies, in addition to achieving control of larvae in the soil. Therefore, plots treated with post liquids were 18 rows wide with all 18 rows being sprayed to limit invasion and egg laying by female root maggot flies from neighboring treatment plots. All evaluations of control and yield were made from the inner four rows of each plot. Planting-time granules were applied using planter-mounted Noble metering units.

A planter-mounted Raven™ liquid application system was used to apply all planting-time liquid insecticides. Planting-time treatments of Vydate C-LV were delivered in 5-inch T-bands over the row at 15GPA of finished spray volume using Teejet™ 8002E nozzles. Water-based treatments of Mustang 0.8EC and Regent 4SC were applied in 3-inch T-bands at an output volume of 5GPA using Teejet™ 6501E nozzles. The thickness and higher viscosity (resistance to flow) of 10-34-0 required the use of Teejet™ 11001 nozzles to maintain the 3-inch band width when the fertilizer-based mixtures were applied. T-banded applications were directed over the open seed furrow in front of the rear press wheel of the planter, and in-furrow placement was achieved by orienting the nozzle lengthwise and directly into the open seed furrow. Water for planting-time Vydate treatments was buffered to pH 6.0 before applications to maximize persistence of the material into the maggot feeding period.

Counter 15G and Lorsban 15G were used as registered standards for comparative purposes in these experiments. It should be noted that the standard (10 lb product/ac) rate of Counter and Lorsban was used rather than the maximum labeled rates (11.9 and 13.4 lb, respectively). Banded insecticide granules were delivered in 5-inch swaths over the row using Gandy™ banders. Modified in-furrow placement consisted of dropping granules down a standard in-furrow tube over the row with output directed backward near the rear press wheel so some soil would cover the seed before the insecticide reached the row. This placement method resulted in a 2- to 3-inch band with the heaviest insecticide concentrations being placed immediately over the row (it is critical that the insecticide does not come in contact with the seed when using this application technique).

Root damage ratings were carried out on August 5 and 6. Ten beets per plot (five from each of the outer two treated rows) were dug, hand-washed, and rated for sugarbeet root maggot feeding injury in accordance with the 0 to 9 scale (0 = no damage; 9 = 75% of root surface having feeding scars) of Campbell et al. (2000). Performance was also evaluated based on sugarbeet yield. Immediately before harvesting, foliage was removed from plots using a commercial-grade mechanical defoliator and all beets from the center 2 rows of each plot were lifted using a mechanical harvester. Total harvested beets were weighed in the field using a digital scale. A representative subsample of 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. 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 the Fisher protected least significant difference (LSD) test at a 0.05 level of significance.

Results:

Test 1. Root injury in the untreated check plots (average of 6.53 on 0 to 9 scale) indicated the presence of a moderately high root maggot infestation for the Vydate test (Table 1). All insecticide treatments in this experiment provided significant levels of root protection when injury was compared with the untreated control. Vydate performed extremely well in this trial. The 5" T-band application of Vydate was not statistically outperformed by the standard application rate (10 lb product/ac) of Counter 15G; however, the postemergence spray applications of Vydate were even more impressive. Vydate treatments that exceeded the Counter standard in root protection included the single postemergence application of 4.24 pt product/ac 2wk before peak fly, the split application of 2.12 pt pre-peak and at peak fly, and the combination of a 5" T-band of Vydate at 2.12 pt followed by a pre-peak fly postemergence treatment at the same rate. It is important to point out the fact that several of these treatments had no planting-time insecticide application (refer to "Timing" heading in Table 1). This further underscores the fact that good control was provided by these entries. Comparable levels of root protection to that of Counter 15G were also achieved with the following postemergence Vydate treatments: 2.12 pt applied 2 wk pre-peak + 1.06 pt at peak fly; dual (pre-peak + peak) applications of 1.06 pt, dual applications of 0.53 pt; however, reducing the rates did result in less root protection.

Table 1. Evaluation of Vydate experimental insecticide applied at planting and postemergence to protect sugarbeet from sugarbeet root maggot *feeding injury*, St. Thomas, ND, 2003

Treatment/form.	Placement	Timing	Rate (product/ac)	Rate (lb ai/ac)	Root injury (0-9)
--- Vydate C-LV	-- 7" Post Band	-- 2 wk pre-peak	-- 4.24 pt	-- 2.0	3.15 e
--- Vydate C-LV + Vydate C-LV	-- 7" Post Band 7" Post Band	-- 2 wk pre-peak Peak fly	-- 2.12 pt 2.12 pt	-- 1.0 1.0	3.45 e
Vydate C-LV + Vydate C-LV	3" TB 7" Post Band	Planting 2 wk pre-peak	2.12 pt 2.12 pt	1.0 1.0	3.75 de
--- Vydate C-LV	-- 7" Post Band	-- Peak fly	-- 4.24 pt	-- 2.0	4.13 d
Vydate C-LV	3" TB	Planting	4.24 pt	2.0	4.33 cd
--- Vydate C-LV + Vydate C-LV	-- 7" Post Band 7" Post Band	-- 2 wk pre-peak Peak fly	-- 2.12 pt 1.06 pt	-- 1.0 0.50	4.33 cd
--- Vydate C-LV + Vydate C-LV	-- 7" Post Band 7" Post Band	-- 2 wk pre-peak Peak fly	-- 1.06 pt 1.06 pt	-- 0.50 0.50	4.80 bc
Counter 15G	M	Planting	10 lb	1.5	4.88 bc
--- Vydate C-LV + Vydate C-LV	-- 7" Post Band 7" Post Band	-- 2 wk pre-peak Peak fly	-- 0.53 pt 0.53 pt	-- 0.25 0.25	5.43 b
Check	-----	-----	-----	-----	6.53 a
LSD (0.05)					0.67

Within-field variability resulted in no significant differences among treatments for this study; however, trends corresponded well with root damage ratings (Table 2). For example, the two treatments that averaged the highest recoverable sucrose yield per acre were the split application of Vydate at 2.12 pt pre-peak + 2.12 pt at peak fly activity and the single pre-peak application of the full (4.24 pt) rate. Those treatments also resulted in average gross economic returns of $958 and $934 ($174 and 150 above the check plots, respectively).

Table 2. *Yield parameters* from plots treated with Vydate experimental insecticide at planting and postemergence to protect sugarbeet from sugarbeet root maggot, St. Thomas, ND, 2003								
Treatment/form.	**Placement**	**Timing**	**Rate (product/ac)**	**Rate (lb ai/ac)**	**Recoverable sucrose (lb/ac)**	**Root yield (T/ac)**	**Sucrose (%)**	**Gross return ($/ac)**
--- Vydate C-LV + Vydate C-LV	-- 7" Post Band 7" Post Band	-- 2 wk pre-peak Peak fly	-- 2.12 pt 2.12 pt	-- 1.0 1.0	7495 a	21.2 a	18.78 a	958
Vydate C-LV	-- 7" Post Band	-- 2 wk pre-peak	-- 4.24 pt	-- 2.0	7322 a	20.8 a	18.65 a	934
--- Vydate C-LV + Vydate C-LV	-- 7" Post Band 7" Post Band	-- 2 wk pre-peak Peak fly	-- 1.06 pt 1.06 pt	-- 0.50 0.50	6949 a	20.2 a	18.28 a	871
Vydate C-LV	3" TB	Planting	4.24 pt	2.0	6949 a	20.3 a	18.35 a	868
Vydate C-LV + Vydate C-LV	3" TB 7" Post Band	Planting 2 wk pre-peak	2.12 pt 2.12 pt	1.0 1.0	6558 a	19.0 a	18.40 a	826
Counter 15G	M	Planting	10 lb	10	6473 a	18.8 a	18.33 a	811
Check	-----	-----	-----	-----	6282 a	18.4 a	18.33 a	784
--- Vydate C-LV	-- 7" Post Band	-- Peak fly	4.24 pt	2.0	6153 a	18.0 a	18.35 a	767
--- Vydate C-LV + Vydate C-LV	-- 7" Post Band 7" Post Band	-- 2 wk pre-peak Peak fly	-- 2.12 pt 1.06 pt	-- 1.0 0.50	6079 a	17.5 a	18.55 a	769
--- Vydate C-LV + Vydate C-LV	-- 7" Post Band 7" Post Band	-- 2 wk pre-peak Peak fly	-- 0.53 pt 0.53 pt	-- 0.25 0.25	5550 a	16.5 a	17.88 a	683
LSD (0.05)					NS	NS	NS	

Test 2. Results of screening the experimental seed treatments were also encouraging. Root maggot feeding pressure was slightly lower in this trial as was evidenced by the root damage mean of 5.5 in the untreated check plots (Table 3). Counter 15G, applied at the standard (medium) rate of 10 lb product/ac resulted in significantly lower levels of root injury than all other treatments in this study. The Poncho seed treatment, when applied at the high (45 g/ai unit of seed) also provided a significant reduction in root damage when compared with the check. Both low and high rates of Poncho gave comparable levels of root protection to Lorsban 15G at 10 lb/ac and the high rate was not statistically better than the lower rate (22.5 g/unit of seed). No other treatments provided significant decreases in root maggot feeding injury. Spinosad seed treatment and the SpinTor 2SC showed no activity against root maggot larvae in this study. In fact, root injury in those plots was numerically higher than in the control plots.

Table 3. Performance of experimental seed treatments and liquid (soil and foliar) insecticides in preventing sugarbeet root maggot *feeding injury*, St. Thomas, ND, 2003				
Treatment/form.	**Placement**	**Rate (lb product/ac)**	**Rate (lb ai/ac)**	**Root injury (0-9)**
Counter 15G	M	10	1.5	3.85 e
Poncho	SEED	45 g ai/unit	n/a	4.63 d
Lorsban 15G	B	10	1.5	4.78 cd
Poncho	SEED	22.5 g ai/unit	n/a	5.08 bcd
Gaucho	SEED	45 g ai/unit	n/a	5.43 bc
Check		---	---	5.50 bc
Spinosad	SEED	22.5 g ai/unit	n/a	5.53 ab
--- SpinTor 2SC	--- 7" Post B	--- 6 oz	--- 0.094	5.60 ab
Spinosad + SpinTor 2SC	SEED 7" Post B	22.5 g ai/unit + 6 oz	n/a 0.094	5.80 ab
Spinosad seed	SEED	45 g ai/unit	n/a	6.25 a
LSD (0.05)				0.73

Recoverable sucrose and sugarbeet root yield were numerically higher for Counter 15G than for any other treatment in this test although neither of these yield parameters were significantly impacted by the treatments (Table 4). Gaucho- and SpinTor-treated plots yielded disproportionately more recoverable sucrose in relation to their poor performance in root protection. This appears to be a product of higher percent sucrose content and is probably not related to protection from root maggot feeding injury.

Table 4. *Yield parameters* from plots treated with experimental seed treatments and liquid (soil and foliar) insecticides to control sugarbeet root maggot larvae, St. Thomas, ND, 2003							
Treatment/form.	**Placement**	**Rate (lb product/ac)**	**Rate (lb ai/ac)**	**Recoverable sucrose (lb/ac)**	**Root yield (T/ac)**	**Sucrose (%)**	**Gross return ($/ac)**
Counter 15G	M	10	1.5	6736 a	22.2 a	16.73 abc	755
--- SpinTor 2SC	7" Post B	6 oz	--- 0.094	6185 a	19.6 a	17.20 a	721
Poncho	SEED	45 g ai/unit	n/a	6148 a	19.9 a	16.93 ab	701
Lorsban 15G	B	10	1.5	6085 a	19.5 a	17.03 ab	699
Gaucho	SEED	45 g ai/unit	n/a	5985 a	19.0 a	17.20 a	696
Spinosad +	SEED	22.5 g ai/unit + 6	n/a	5864 a	19.6 a	16.45 bc	646

SpinTor 2SC	7" Post B	oz	0.094				
Poncho	SEED	22.5 g ai/unit	n/a	5858 a	19.2 a	16.75 abc	661
Spinosad	SEED	22.5 g ai/unit	n/a	5628 a	19.0 a	16.28 c	613
Check		---		5420 a	18.4 a	16.25 c	590
Spinosad seed		45 g ai/unit	n/a	5200 a	17.5 a	16.43 bc	571
LSD (0.05)				NS	NS	0.64	

Test 3. Evaluations of planting-time liquid insecticides were somewhat discouraging. Relatively poor levels of control were recorded for both Regent 4SC and Mustang 0.8EC (Table 5). Effectiveness of these materials was not significantly impacted by rate, placement, or applying with 10-34-0 starter fertilizer. Counter 15G (10 lb product/ac) was the only treatment that resulted a significant reduction in root feeding injury in this test. Clearly, neither material is likely to provide acceptable levels of root maggot control.

Table 5. ***Root feeding injury*** **in plots treated with experimental liquids and registered granular soil insecticides at planting time to control sugarbeet root maggot larvae, St. Thomas, ND, 2003**

Treatment/form.	Placement	Rate (lb product/ac)	Rate (lb ai/ac)	Root injury (0-9)
Counter 15G	M	10	1.5	3.83 e
Lorsban 15G	B	10	1.5	4.78 d
Check	-	---	---	4.78 d
Counter 15G	B	10	1.5	4.90 cd
Mustang + 10-34-0 fert	3" TB	4 oz + 5 GPA	0.025	5.10 bcd
Mustang 0.8EC	3" TB	4 oz	0.025	5.25 bcd
Mustang + 10-34-0 fert	IF	4 oz + 5 GPA	0.025	5.38 abcd
Mustang 0.8EC	IF	4 oz	0.025	5.45 abcd
Regent 4SC	IF	4.16 oz	0.13	5.55 abc
Regent + 10-34-0 fert.	IF	2.08 oz + 5 GPA	0.65	5.73 ab
Regent + 10-34-0 fert.	IF	4.16 oz + 5 GPA	0.13	6.00 a
Regent 4SC	IF	2.08 oz	0.065	6.03 a
LSD (0.05)				0.71

Yields from this test (Table 6) were quite good given the extensive root scarring that was observed during damage rating; however, no significant differences were detected between treatments. Although significant differences were not detectable, the conventional treatments of Counter 15G at 10 lb of product per acre using modified in-furrow and banded placement achieved the highest recoverable sucrose yields in the study. Gross economic returns from those treatments were \$88 and \$78 per acre more than that from the untreated check plots.

Table 6. ***Yield parameters*** **from plots treated with experimental liquids and registered granular soil insecticides at planting time to control sugarbeet root maggot larvae, St. Thomas, ND, 2003**

Treatment/form.	Placement	Rate (lb product/ac)	Rate (lb ai/ac)	Recoverable sucrose (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return (\$/ac)
Counter 15G	M	10	1.5	8189 a	24.7 a	17.83 a	994
Counter 15G	B	10	1.5	8038 a	24.0 a	17.98 a	984
Mustang + 10-34-0 fert	IF	4 oz+ 5 GPA	0.025	7920 a	25.8 a	16.88 a	895
Check	-	---	---	7920 a	25.5 a	16.90 a	906
Mustang 0.8EC	IF	4 oz	0.025	7756 a	24.7 a	17.08 a	897
Regent + 10-34-0 fert.	IF	2.08 oz+ 5 GPA	0.065	7579 a	24.1 a	17.28 a	878
Mustang 0.8EC	3" TB	4 oz	0.025	7488 a	24.5 a	16.85 a	846
Lorsban 15G	B	10	1.5	7470 a	23.8 a	17.23 a	864
Regent 4SC	IF	2.08 oz	0.065	7382 a	23.9 a	16.95 a	841
Regent 4SC	IF	4.16 oz	0.13	7307 a	23.2 a	17.43 a	823
Mustang + 10-34-0 fert	3" TB	4 oz+ 5 GPA	0.025	7239 a	22.6 a	17.43 a	853
Regent + 10-34-0 fert.	IF	4.16 oz+ 5 GPA	0.13	7216 a	22.8 a	17.08 a	828
LSD (0.05)				NS	NS	NS	

Discussion:

Vydate provides excellent root maggot control when applied at either planting-time or post-emergence. This supports our findings from 2002. Poncho seed treatment also appears to have potential as a root maggot control material. Mustang, Regent, and spinosad (both as a seed treatment and as SpinTor 2SC) did not provide sufficient protection from root maggot feeding injury. Future research on Vydate is anticipated to include applications with 10-34-0 starter fertilizer at planting-time, delivery in lower spray volumes (3 to 5GPA), and crop safety and effectiveness of postemergence treatments when tank-mixed with micro-rate herbicide combinations. Additional research will focus on evaluations of this promising seed treatment at more rates and on pelleted and minimum build-up seed. The true test of many of these materials will come under more dry soil conditions that can often amplify the impacts of root maggot feeding injury.

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