Biology and Control of the Sugarbeet Root Maggot in the Red River Valley - 2002
2002 Sugarbeet Research and Extension Reports. Volume 33, Page 134-152

BIOLOGY AND CONTROL OF THE SUGARBEET ROOT MAGGOT IN THE RED RIVER VALLEY - 2002

Mark A. Boetel, Assistant Professor
Robert J. Dregseth, Research Specialist
Allen J. Schroeder, Research Specialist
Ayanava Majumdar, Graduate Research Assistant
Justin O. Knott, Graduate Research Assistant
Department of Entomology
North Dakota State University
Fargo, ND

Larry J. Smith, Superintendent
Northwest Research & Outreach Center
University of Minnesota
Crookston, MN

Acknowledgments:

A substantial portion of this research was funded by the Sugarbeet Research and Education Board of Minnesota and North Dakota. Their support is essential to this research program, and has played a major role in the successful development of strategies for forecasting, monitoring, and managing populations of the sugarbeet root maggot (SBRM). Support monies are utilized to defray labor, equipment, and travel expenses for conducting field and laboratory research. Additionally, this support assists us with carrying out field survey work. We are very grateful for the willingness of the following producers for providing us with portions of their sugarbeet fields for establishment of experimental test plots:

Brent & William Baldwin
Mike & Tom Borgen
Pete Carson
Jim Koester
Craig & Ray Steiger
Tom Strand
Mike & Robert Sweeney

Much appreciation is also due to the following producers for participating with us on strip trials, large-scale field studies, and/or allowing us to carry out commercial field surveys of sugarbeet root maggot feeding injury on their farms:

Pete Carson
C&R Ventures
Harlow & Jim Grove
Jim Howe
Jim Koester
Dave & Paul Mueller
Brad Narloch
Craig & Ray Steiger
Tim Thompson

Special thanks are extended to the American Crystal, Minn-Dak, and Southern Minnesota sugar cooperative agricultural staff for sharing sugarbeet insect survey information and providing timely knowledge regarding pest outbreaks and activity on an annual basis. We also acknowledge the efforts of Charlie Hotvedt and his staff at the American Crystal sugarbeet quality laboratory in East Grand Forks, MN, for processing harvest samples for quality assessments.

We also thank the seed and crop protection chemical companies for providing us with sugarbeet seed and test materials to conduct these research trials.

Finally, sincere gratitude is extended to the following summer aides and work study students for their valuable assistance with plot maintenance, sticky stake monitoring, collection of maggot larvae, soil sample processing, and digging and washing efforts associated with sugarbeet root maggot damage rating operations:

Cristy Evensvold
Shawn Frieler
Amy Moorhouse
Melisa Satterlund

Scott Hovde Tom Wiener
Lucas Knudsen Chad Zander

Sugarbeet Root Maggot Incidence & Severity during 2002

Many Red River Valley sugarbeet producers were able to initiate seedbed preparations slightly early in the spring of 2002 due to an early break from cold weather. However, cold temperatures resumed in mid- to late-May and tens of thousands of acres of early-planted sugarbeets required replanting due to stand losses from frost damage, rotting seed in cold moist soils, or seedling injury from wind abrasion and soil erosion. Additionally, the unseasonably cool temperatures that predominated following planting resulted in slow development of overwintered sugarbeet root maggot (SBRM) larvae and, subsequently, delayed fly emergence. Fly activity was monitored during 2002 in a cooperative effort between NDSU, UMN, and Minnesota Department of Agriculture personnel using sticky-stake traps. Initial detection of root maggot flies in current-year sugarbeet fields occurred near St. Thomas, ND, on 28 May, and peak fly activity in current-year beet fields occurred on 28 June at both St. Thomas sites (Fig. 1).

Fly activity was at relatively low levels throughout the season at Crookston, MN, with no major peaks being observed at that site. First fly, as well as peak activity occurred 10 to 14 days later than normal in most sugarbeet fields as a result of the extended periods of cool post-planting weather. Trap data indicated very low population levels in the southern and central areas of the Valley to moderate activity with patches of very high fly counts being recored in the northern portion. As has been the case for the past several years, the highest fly activity levels were recorded in Pembina and Walsh Counties of North Dakota.

Severe larval feeding injury resulted in killing many plants in occasional fields where root protection was insufficient due to either no insecticide being applied at reseeding or movement of soil insecticide granules away from rows by heavy post-planting rains. Frequent rainfalls throughout much of the growing season in most of the Valley made 2002 a difficult year to appropriately time postemergence rescue insecticide treatments. However, soil moisture was adequate in most maggot-infested fields for favorable levels of soil insecticide activation. Also, it appeared that the moist soil conditions caused most larvae to feed at fairly shallow soil depths (i.e., away from sugarbeet tap roots and near/within insecticide-treated zones). Therefore, in most cases, young beet plants were able to tolerate SBRM feeding injury, very few tap roots were severed, and insecticides performed adequately. A few cases of poor performance by planting-time and postemergence organophosphate insecticides were observed in northeastern ND.

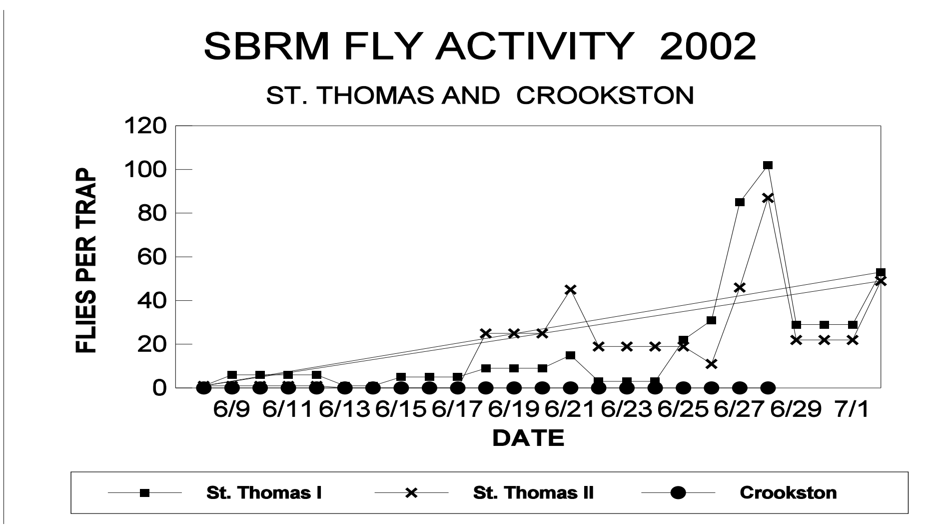

Fig. 1. Sugarbeet root maggot fly activity, St. Thomas (sites I and II), ND and Crookston, MN, 2002 (counts represent flies captured on sticky stakes on a per-trap per-day basis).

SBRM Population Forecast for the 2003 Growing Season

Although SBRM emergence was unusually late during 2002, historical records suggest that neither population level nor emergence timing should be impacted in 2003. The population forecast for the 2003 production season is presented in Figure 2. Sugarbeet root maggot populations are expected to be mostly low for southern and central portions of the Red River Valley in ND and MN. Also, infestations are likely to be relatively low on the Minnesota side of the Red River from Sabin north all the way to the U.S./Canadian border. Occasional areas of moderate pressure could occur in the central and northern areas of the Valley. Moderate to high infestations are anticipated in fields between the Grafton/Hoople vicinity in northeastern Walsh county and the Cavalier/Bathgate area in northern Pembina county of northeastern North Dakota. Naturally, moderate infestations can be expected to occur in the marginal areas between those where low and high populations are projected. Also, due to poor performance of soil- and foliar-applied insecticides in some northeastern ND fields, intermittent pockets with severe infestations are also likely to develop. Proximity of sugarbeets to previous-year beet fields, especially those where insecticide performance was unsatisfactory, can often increase the risk of damaging population levels. It should be clearly understood that **significant fly activity is likely for beets planted adjacently to previous-year beet fields that had moderate to high fly densities and/or substantial maggot feeding pressure.** Environmental conditions within the growing season can affect the precision of this forecast. Therefore, fly populations must be monitored for producers and pest managers to make that determination.

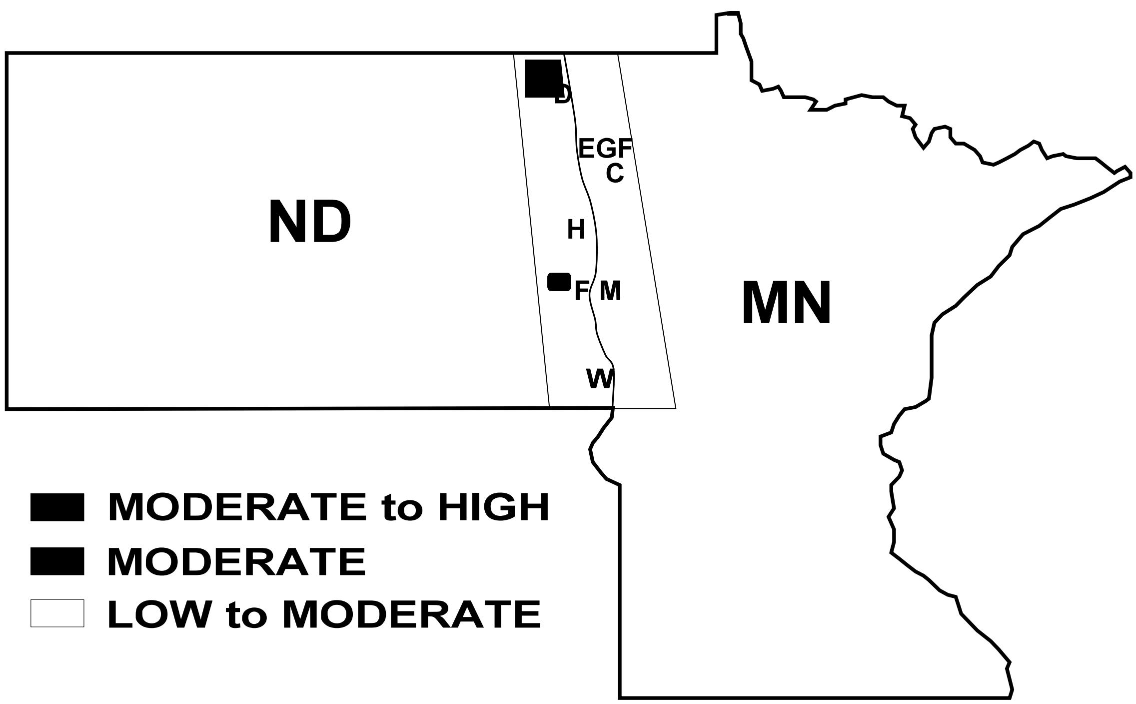

Fig. 2. Anticipated SBRM population levels for the 2003 growing season in the Red River Valley.

This forecast is general in nature, and will not always be precise on an individual-field basis. Growers in areas affected by the SBRM are encouraged to continue using planting-time insecticides. Fields should be carefully monitored from late May through June for significant increases in fly activity. High activity or an extended emergence period may warrant the need for additional control measures. Growers are encouraged to review research findings published in recent volumes of "Research and Extension Reports" to design effective management programs. NDSU extension will continue to inform growers on SBRM activity each spring via radio reports, DTN, and issues of the NDSU "Crop & Pest Report."

Sugarbeet Root Maggot Control Trials:

Research trials were conducted at St. Thomas, ND and Crookston, MN to evaluate the performance of chemical, cultural, and bioinsecticidal strategies for control of the sugarbeet root maggot. Typically, we typically establish trial sites in areas where high, as well as moderate or low populations are likely in years when variable SBRM infestation levels are expected throughout the Valley; however, since very low SBRM populations were expected during the 2002 growing season for most of the sugarbeet growing area beyond North Dakota's Walsh and Pembina Counties, we established two trial sites near St. Thomas (one on the William & Brent Baldwin farm, and the other on the Pete Carson farm). A third site was established on the University of Minnesota Northwest Research and Outreach Center near Crookston, MN.

Although emergence and peak fly activity occurred nearly two weeks behind normal in most growing areas, high fly numbers were recorded at both St. Thomas locations through early July. Soils remained somewhat dry and unseasonably cold during the first few weeks of the season, but gradually warmed up in June. Larval infestations ranged from moderate to severe in the trials at St. Thomas, whereas relatively low larval infestations developed at Crookston. Root maggot feeding pressure was so severe in many plots at the St. Thomas sites that sugarbeet tap roots were completely severed and, due to drought stress, many plants were unable to recover. Thus, significant plant stand and yield losses occurred, especially in plots immediately adjacent to the neighboring previous-year beet field. Relatively poor performance was recorded for many insecticide treatments in the St. Thomas trials. This may have resulted from heavy post-planting rains in June that could have caused movement of insecticide materials from the target zones leaving beets somewhat unprotected.

Damage Rating Scale:

The 0–9 damage rating scale was used for quantifying SBRM feeding injury. Criteria for respective points on the scale are as follows:

0 = no scars
1 = 1 to 4 small (pin head size) scars
2 = 5 to 10 small scars
3 = 3 large scars or scattered small scars
4 = few large scars and /of numerous small scars
5 = several large scars and/or heavy feeding on laterals
6 = up to 1/4 root scarred
7 = 1/4 to 1/2 of root blackened by scars
8 = 1/2 to 3/4 root blackened by scars
9 = more than 3/4 of root area blackened

Insecticide Application Methods used in Experiments:

All planting-time treatments were applied by using either standard or after-market insecticide delivery equipment mounted on a 6-row John Deere 71 Flex planter. Delivery of granular insecticide materials was regulated by using Noble metering units. ***Banded*** applications of granules were delivered in a 5-inch swath over the row using Gandy™ banders. ***Modified in-furrow*** placement consisted of dropping granules down a standard planter-equipped in-furrow tube over the row; however, granules were directed 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). The ***spoon*** application involved an in-furrow tube, however, a small galvanized steel device was attached to the terminal end of the tube. A no. 10 bolt with two nuts facing upward (inner face of spoon; near the tip) was used to laterally deflect the heavy central concentration of granules coming down the tube and, thus, reduce the likelihood of phytotoxicity to beet seedlings. The resulting application was a 3- to 4-inch swath with the heaviest concentration of granules being placed immediately adjacent to the seed furrow.

Planting-time applications of Mustang 1.5EW and F-0570 (Mustang) 0.8EW liquids were metered by using a Mustang/Raven™ liquid application system and were delivered at 5GPA spray volume using Teejet™ 6501E nozzles.

Banded placement involved delivery of a 3-inch swath 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 directly over the open seed furrow. Planting-time Vydate applications were also carried out using the Mustang/Raven™ Liquid Application System and were delivered in 15GPA of finished spray volume using Teejet™ 8004E nozzles in a 5-inch band. Postemergence granules were applied directly over the row in 4-inch bands through Kinze™ banders and output was regulated by using Noble metering units. Postemergence liquid treatments were applied in 7-inch bands by using a CO_2-powered cannister system that delivered a spray volume of 15 GPA through Teejet™ 8002E nozzles.

Placement Method Experiment:

This experiment was established at two sites near St. Thomas, ND (St. Thomas I, planted 14 May; and St. Thomas II, planted 17 May) to evaluate the impact of placement method on the efficacy of three registered soil insecticides applied at planting time. Treatments for this experiment included banded (B), modified in-furrow (M), and spoon (S) applications of Counter 15G, Lorsban 15G, and Temik 15G. All insecticides were applied at their respective high labeled rates.

The sugarbeet root maggot infestation was quite heavy for this experiment at the St. Thomas I (Baldwin) site, as was demonstrated by the severe root injury ratings (average of 7.0 on the 0–9 scale) that were recorded for the untreated control plots (Table 1). Generally, the insecticides performed quite poorly at this site. In fact, feeding injury for all insecticide treatments averaged 5.18 or greater. In comparing the insecticide treatments with regard to root protection, Lorsban 15G performed significantly ($P < 0.05$) better when applied modified in-furrow than when banded placement was used. That was the only detectable difference in insecticide performance relating to placement method at St. Thomas I. Although Temik 15G had performed exceptionally well in many of our trials during recent years, irrespective of placement method used, the product provided marginal to poor levels of root protection at the St. Thomas I site in 2002. For example, root injury recorded for plots treated with the banded application of Temik was not significantly different from that recorded in the untreated controls.
No significant impacts were observed in relation to gross sugarbeet yield, total recoverable sucrose, or percent sucrose for any treatment at St. Thomas I.

Table 1. Effect of insecticide placement method on control of sugarbeet root maggot larvae, St. Thomas (Site I), ND, 2002.

Treatment/ formulation	Rate lb (AI/ac)	Placement[a]	Recoverable sucrose (lb/ac)	Yield (T/ac)	Sucrose (%)	Damage rating (0-9)	Gross return ($/ac)
Counter 15G	1.8	M	4502 a	17.4 a	14.6 a	5.68 cd	321
Counter 15G	1.8	S	4611 a	17.6 a	14.7 a	5.95 bc	338
Counter 15G	1.8	B	4536 a	17.4 a	14.7 a	6.15 bc	329
Lorsban 15G	2	M	4498 a	17.0 a	14.9 a	5.18 d	335
Lorsban 15G	2	S	4368 a	16.4 a	15.0 a	5.83 bcd	330
Lorsban 15G	2	B	4550 a	17.6 a	14.7 a	5.90 bc	325
Temik 15G	2.1	M	4816 a	18.5 a	14.8 a	6.18 bc	349
Temik 15G	2.1	S	4924 a	18.5 a	15.0 a	6.23 bc	371
Temik 15G	2.1	B	4657 a	17.5 a	14.9 a	6.50 ab	349
Check	-	-	4075 a	15.3 a	15.0 a	7.00 a	307

Means within a column sharing the same letter are not significantly ($P > 0.05$) different (LSD).
[a]M = Modified-in-furrow; B = Band; S = Spoon

Severe larval infestations also developed at St. Thomas II (Carson), as was evidenced by the average damage rating of 7.28 in the untreated check plots (Table 2). Marginal control was provided by Counter 15G treatments at this study site, and somewhat poor root protection levels resulted from Lorsban 15G applications. However, Temik 15G performed considerably better at this location. Placement played a role in root protection provided by Counter 15G at this site, with significantly less root feeding injury being sustained in plots treated with modified in-furrow and spoon applications than banded treatments. Also, with respect to root protection, Lorsban 15G applied via the spoon method performed better than when banded. Our damage rating data suggest that Temik performance is not influenced by placement method. This suggestion is further supported by findings from our yield assessments . Specifically, that percent sucrose, gross sugarbeet yield, and total recoverable sucrose parameters were not significantly different among the three placement methods for Temik. However, modified in-furrow and banded applications of Temik were the only treatments in the entire experiment that yielded statistically more sugarbeet tonnage and total recoverable sucrose than the untreated check plots. Recoverable sucrose yield in banded Lorsban 15G plots was statistically greater than in those that received the modified in-furrow treatment. However, placement did not have a major impact on yield of Counter 15G. It should be noted that chlorpyrifos-containing products (e.g., Lorsban 15G and Nufos 15G) can cause major plant injury to sugarbeet plants if the spoon technique is used without the no. 10 nut/bolt modification because too heavy of an insecticide concentration will be placed adjacent to (or in contact with) beet seedlings. Producers that choose to use the spoon method to apply one of these products at planting time are strongly advised to modify it properly with the nut/bolt set to avoid these problems. Also, it bears noting that **modified in-furrow placement of Lorsban 15G was used in this study for comparative purposes, and is not recommended for use by growers in commercial sugarbeet production due to its potential for causing plant injury.**

Table 2. Effect of insecticide placement method on control of sugarbeet root maggot larvae, St. Thomas (Site II), 2002.

Treatment/ formulation	Rate lb (AI/ac)	Placement[a]	Recoverable sucrose (lb/ac)	Yield (T/ac)	Sucrose (%)	Damage rating (0-9)	Gross return ($/ac)
Counter 15G	1.8	M	5869 bc	22.7 b-d	14.6 a	4.53 de	417
Counter 15G	1.8	S	6367 ab	23.3 b-d	15.3 a	4.83 d	502
Counter 15G	1.8	B	6263 ab	23.6 b-d	14.9 a	6.03 bc	470
Lorsban 15G	2	M	5194 c	20.1 d	14.6 a	6.30 bc	-369
Lorsban 15G	2	S	5627 bc	21.1 cd	15.0 a	5.85 c	424
Lorsban 15G	2	B	6122 ab	23.4 b-d	15.0 a	6.93 ab	448
Temik 15G	2.1	M	7028 a	26.0 ab	15.2 a	3.03 f	544
Temik 15G	2.1	S	6489 ab	24.5 ab	15.1 a	2.85 f	485
Temik 15G	2.1	B	6879 a	27.0 a	14.7 a	3.60 ef	475
Check	-	-	5684 bc	21.8 cd	14.6 a	7.28 a	411

Means within a column sharing the same letter are not significantly ($P > 0.05$) different (LSD).
[a]M = Modified-in-furrow; B = Band; S = Spoon

Registered Soil Insecticides and Application Rates Test:

This experiment was established at two sites (Site I on the Baldwin farm and Site II on the Carson farm) near St. Thomas in northeastern North Dakota and at one location near Crookston in western Minnesota to evaluate the performance of registered insecticides at high, standard, and low labeled rates in the Red River Valley for control of the sugarbeet root maggot. Planting dates for this trial were 15 May at the St. Thomas Site I, and 17 May at the St. Thomas II and Crookston locations.

Untreated control plots at St. Thomas I had an average damage rating of 6.43 on the 0 to 9 scale (Table 3). Thus, a moderately high sugarbeet root maggot infestation was present for the experiment. Rate responses were seldom manifested in performance of the various insecticides used in this trial. For example, no significant differences were detected in root injury levels, raw sugarbeet tonnage, or total recoverable sucrose yield among 1.0, 1.5, and 2.0 lb (AI)/ac application rates of Lorsban 15G. Also, the only detectable rate impact relating to root feeding injury occurred with modified in-furrow applications of Counter 20CR, where increasing the treatment rate from 0.9 lb to 1.5 lb (AI)/ac resulted in significantly less damage. Also, significant impacts of application rate on yield were limited to the following: 1) increasing the rate of banding Counter 15G from 1.05 to 1.8 lb (AI)/ac; and 2) increasing the rate of Counter 15G applied modified in-furrow from 1.5 to 1.8 lb. Both of these rate increases resulted in significant improvements in sugarbeet root yield and total recoverable sucrose. Generally poor levels of root protection were observed with several insecticide treatments. Treatments that failed to provide significant protection of sugarbeet roots (i.e., root injury was not significantly lower than untreated check) included banded treatments of Counter 15G at 0.9, 1.05, 1.5, and 1.8 lb (AI)/ac, Lorsban 15G banded at the 1.5 lb rate, and both treatments of Mustang (3" T-band and in-furrow). Placement and formulation were more influential than application rate in this experimental site. For instance, treatment with Counter 15G using modified in-furrow placement was statistically superior in root protection as compared to banded placement at both 1.5 lb and 1.8 lb (AI)/ac application rates. Also, modified in-furrow placement resulted in significantly lower average damage ratings than banding when Counter 20CR was applied at the 1.5 lb rate. However, although trends toward increased sugarbeet tonnage and total recoverable sucrose yield with modified in-furrow treatment were correspondent with reduced SBRM feeding injury, none of those differences were statistically significant. In regard to formulation impact, Counter 20CR performed significantly better than the 15G form in providing protection from SBRM feeding injury when both were applied in a band at the 1.8 lb rate. However, that disparity was not reflected in sugarbeet yield or quality parameters measured. Relatively poor performance was recorded for both treatments of Mustang 1.5EW at this study site. The moderately high SBRM infestation that developed was apparently too severe for this product to provide adequate control because damage ratings, sugarbeet tonnage, and total recoverable sucrose yield means recorded for both the 3" T-band and the in-furrow treatment were not significantly different from the untreated check.

Table 3. Comparison of registered soil insecticide rates and formulations for managing sugarbeet root maggot larvae, St. Thomas (Site I), ND, 2002.

Treatment/ formulation	Rate lb (AI/ac)	Placement[a]	Recoverable sucrose (lb/ac)	Yield (T/ac)	Sucrose (%)	Damage rating (0-9)	Gross return ($/ac)
Counter 15G	0.9	B	4151 c-f	14.4 d-g	15.8 a	6.05 a-d	357
Counter 15G	1.05	B	3859 f	13.6 g	15.5 a	6.33 ab	-322
Counter 15G	1.5	B	4167 c-f	13.9 fg	16.2 a	6.13 abc	376
Counter 15G	1.8	B	4537 a-e	15.6 a-f	15.8 a	6.25 ab	394
Counter 15G	0.9	M	4579 a-d	15.9 a-e	15.7 a	5.30 de	391
Counter 15G	1.5	M	4388 b-f	15.1 b-g	15.8 a	4.88 ef	378
Counter 15G	1.8	M	5031 a	17.4 a	15.7 a	5.08 ef	432
Counter 20CR	1.5	B	4312 b-f	15.2 b-g	15.6 a	5.45 cde	361
Counter 20CR	1.8	B	4632 abc	16.2 a-d	15.6 a	5.00 ef	391
Counter 20CR	0.9	M	4761 ab	16.3 abc	15.9 a	5.25 ef	415
Counter 20CR	1.5	M	4584 a-d	16.2 a-d	15.5 a	3.93 g	382
Counter 20CR	1.8	M	4863 ab	16.5 ab	16.1 a	4.53 fg	431
Lorsban 15G	1	B	4349 b-f	15.3 b-g	15.5 a	5.63 b-e	363
Lorsban 15G	1.5	B	4168 c-f	14.5 c-g	15.7 a	6.05 a-d	357
Lorsban 15G	2	B	4414 b-f	15.4 b-g	15.6 a	5.35 de	375
Mustang 1.5 EW	0.05	3" TB	3994 ef	14.3 d-g	15.4 a	6.13 abc	-324
Mustang 1.5 EW	0.05	IF	4044 def	14.1 efg	15.6 a	6.38 ab	343
Check	-	-	3885 f	13.6 g	15.5 a	6.43 a	327

Means within a column sharing the same letter are not significantly ($P > 0.05$) different (LSD).
[a]M = Modified-in-furrow; B = Band; TB = 3" Band over open seed furrow; IF = directly in-furrow

The mean damage rating (7.83 on 0 to 9 scale) recorded for untreated control plots at St. Thomas II indicated that the SBRM infestation was even more severe than recorded for St. Thomas I (Table 4). Accordingly, poor performance was recorded for several treatments. For example, average root injury ratings for the following treatments were not significantly different ($P > 0.05$) from the untreated check plots: Counter 15G banded at 1.8 lb, Lorsban 15G banded at 1.0 and 1.5 lb, and Mustang 1.5EW applied at 0.05 lb (AI)/ac via banded and in-furrow placement. Harvest data further supported those findings, with the following treatments failing to achieve significant improvements in total recoverable sucrose yield: Counter 15G only at the low (0.9 lb) rate, Lorsban 15G at 1.0 and 1.5 lb rates, and both T-banded and in-furrow treatments of Mustang 1.5EW at 0.05 lb (AI)/ac. Similar to our results at St. Thomas I, application rate did not provide major impacts on insecticide efficacy at St. Thomas II. In the rate range tested for Counter 15G, application rate had no demonstrable impact on performance of banded applications of the insecticide at this site. However, root injury in plots treated with the high (1.8 lb [AI]/ac) application rate of Counter 15G using modified in-furrow placement, was statistically lower than that recorded in plots treated at low and medium (0.9 and 1.5 lb, respectively) rates. Similar to our findings with the 15G formulation of Counter, there was not a rate response with Counter 20CR when it was placed in a band. Significantly better performance was recorded for the 1.5 lb rate of Counter 20CR than for the low (0.9 lb) rate when applied modified in-furrow; however, unexplainably, the 1.5 lb rate also produced root injury ratings that were significantly lower than the high (1.8 lb) treatment of Counter 20CR. Lorsban 15G performed similarly to Counter 15G at this site with no significant differences in root injury being detected between 1.0, 1.5, and 2.0 lb (AI)/ac application rates. However, root injury sustained in sugarbeet plots treated at the two lower rates (1.0 and 1.5 lb) of Lorsban 15G were not significantly different from that recorded for the untreated controls. Correspondingly, those failures carried through to yield with both low and medium rates of Lorsban 15G failing to produce significant improvements in sugarbeet root tonnage and recoverable sucrose levels compared to untreated check plots. Albeit, applying the high (2.0 lb [AI]/ac) rate of Lorsban 15G resulted in significantly ($P < 0.05$) lower root injury and an increase of 1,151 lb of recoverable sucrose yield per acre at this site. As observed at St. Thomas I, insecticide placement had generally more measurable impacts on efficacy than application rate. For example, when Counter 15G was placed modified in-furrow at either 0.9 or 1.8 lb rates, sugarbeet roots had significantly less root maggot feeding injury than when it was banded at those same application rates. Similarly, Counter 20CR provided statistically better root protection using modified in-furrow placement than banded at either 1.5 lb or 1.8 lb rates. Although not statistically significant, it also bears noting that plots treated with Counter 20CR at 1.8 lb (AI)/ac yielded an average of 761 lb more recoverable sucrose when receiving the insecticide via modified in-furrow as compared to the same rate in a banded application. As observed at St. Thomas I, Mustang 1.5EW provided relatively poor SBRM control, with average root injury ratings, sugarbeet root yields, and total recoverable sucrose levels being not significantly different from that recorded for the untreated check plots, irrespective of placement technique used.

Table 4. Comparison of registered soil insecticide rates and formulations for managing sugarbeet root maggot larvae, St. Thomas (Site II), ND, 2002.

Treatment/ formulation	Rate lb (AI/ac)	Placement[a]	Recoverable sucrose (lb/ac)	Yield (T/ac)	Sucrose (%)	Damage rating (0-9)	Gross return ($/ac)
Counter 15G	0.9	B	4476 c-f	15.6 b-d	15.8 a	6.93 cde	382
Counter 15G	1.05	B	5099 a-d	18.2 abc	15.5 a	6.93 cde	420
Counter 15G	1.5	B	5006 a-d	17.8 abc	15.4 a	6.90 c-f	412
Counter 15G	1.8	B	5631 ab	19.4 ab	15.8 a	7.30 a-d	485
Counter 15G	0.9	M	5064 a-d	17.3 abc	15.9 a	6.38 fg	442
Counter 15G	1.5	M	4969 a-d	16.6 b-d	16.1 a	6.65 ef	447
Counter 15G	1.8	M	5230 a-d	18.1 abc	15.8 a	5.55 h	450
Counter 20CR	1.5	B	4994 a-d	17.4 abc	15.8 a	6.80 def	426
Counter 20CR	1.8	B	5139 a-d	17.9 abc	15.7 a	6.90 c-f	437
Counter 20CR	0.9	M	5314 a-d	18.5 abc	15.8 a	6.90 c-f	452
Counter 20CR	1.5	M	5390 abc	18.8 abc	15.8 a	6.10 g	457
Counter 20CR	1.8	M	5900 a	20.8 a	15.6 a	6.73 ef	493
Lorsban 15G	1	B	4435 c-f	15.8 b-d	15.4 a	7.60 ab	365

Table 4. Comparison of registered soil insecticide rates and formulations for managing sugarbeet root maggot larvae, St. Thomas (Site II), ND, 2002.

Treatment/ formulation	Rate lb (AI/ac)	Placement[a]	Recoverable sucrose (lb/ac)	Yield (T/ac)	Sucrose (%)	Damage rating (0-9)	Gross return ($/ac)
Lorsban 15G	1.5	B	4249 def	15.2 cd	15.4 a	7.58 ab	346
Lorsban 15G	2	B	4724 b-e	16.4 b-d	15.8 a	7.15 b-e	404
Mustang 1.5 EW	0.05	3" TB	4399 c-f	15.7 b-d	15.5 a	7.35 abc	361
Mustang 1.5 EW	0.05	IF	3798 ef	13.0 d	15.9 a	7.58 ab	331
Check	-	-	3573 f	13.2 d	14.9 a	7.83 a	276

Means within a column sharing the same letter are not significantly ($P > 0.05$) different (LSD).
[a]M = Modified-in-furrow; B = Band; TB = 3" Band over open seed furrow; IF = directly in-furrow

The Crookston site had very light SBRM pressure with a mean damage rating of 3.23 (0–9 scale) being recorded for beets collected from untreated check plots (Table 5). Basically, all insecticide treatments provided significant ($P < 0.05$) reductions in root maggot feeding injury. However, due to the relatively low population level at this site, no statistical differences in root injury were detectable among insecticide compounds, rates, placement, or formulations. Although occasional differences in raw sugarbeet tonnage yield were observed among treatments, none of those disparities were formulation-, rate-, or placement-related. Insecticide treatments that performed well with respect to raw sugarbeet yield were Counter 15G banded at low and standard rates (0.9 and 1.5 lb, respectively), Mustang 1.5EW at 0.05 lb applied modified in-furrow either with or without starter (10-34-0) fertilizer. These findings could be misleading because the overall top-yielding treatment in raw sugarbeet tonnage (21.7 tons per acre) was the starter fertilizer control (no insecticide), which was significantly higher than the raw yield mean for the untreated check. That same fertilizer-only treatment also produced the second highest recoverable sucrose yield per acre, although that value was not significantly greater than all remaining treatments. Albeit, very little emphasis should be placed on findings relating to yield parameters from this study location.

Table 5. Comparison of application rates and placement methods of registered insecticides for managing sugarbeet root maggot larvae, Crookston, MN, 2002.

Treatment/ formulation	Rate lb (AI/ac)	Placement[a]	Recoverable sucrose (lb/ac)	Yield (T/ac)	Sucrose (%)	Damage rating (0-9)
Counter 15G	0.09	B	5907 a	20.1 abc	15.9 a	2.35 b
Counter 15G	1.05	B	5851 a	19.8 bcd	15.9 a	2.33 b
Counter 15G	1.5	B	5864 a	20.1 abc	15.8 a	2.35 b
Counter 15G	1.8	B	5833 a	19.9 bcd	15.8 a	2.05 b
Counter 15G	1.5	M	5847 a	20.0 bcd	15.9 a	2.28 b
Counter 15G	1.8	M	5654 a	19.9 bcd	15.4 a	2.05 b
Counter 20CR	1.5	B	5783 a	20.0 bcd	15.7 a	2.13 b
Counter 20CR	1.8	B	5805 a	19.9 bcd	15.8 a	2.30 b
Counter 20CR	1.5	M	5662 a	18.7 cd	16.4 a	1.98 b
Counter 20CR	1.8	M	5547 a	18.8 cd	15.9 a	2.15 b
Lorsban 15G	1	B	5828 a	20.0 bcd	15.9 a	2.45 b
Lorsban 15G	1.5	B	5762 a	20.0 bcd	15.6 a	2.00 b
Lorsban 15G	2	B	6082 a	19.8 bcd	16.5 a	2.45 b
Mustang 1.5 EW	0.05	IF	6053 a	20.1 abc	16.3 a	2.28 b
Mustang 1.5 EW	0.05	TB	5742 a	19.3 cd	16.0 a	2.08 b

Table 5. Comparison of application rates and placement methods of registered insecticides for managing sugarbeet root maggot larvae, Crookston, MN, 2002.

Treatment/ formulation	Rate lb (AI/ac)	Placement[a]	Recoverable sucrose (lb/ac)	Yield (T/ac)	Sucrose (%)	Damage rating (0-9)
Mustang 1.5EW +	0.05	IF				
10-34-0 fertilizer		-	6512 a	21.5 ab	16.3 a	2.15 b
10-34-0 fertilizer		IF	6488 a	21.7 a	16.1 a	3.28 a
Check	-	-	5564 a	18.4 d	16.4 a	3.23 a

Means within a column sharing the same letter are not significantly (*P* > 0.05) different (LSD).
[a]M = Modified-in-furrow; B = Band; TB = Band over open seed furrow; IF = In-furrow

Planting-time and Postemergence Granular and Liquid Insecticide Combinations:

This experiment was established on 14 May, 2002 at St. Thomas, ND to determine the relative efficacy of standard and low labeled application rates of registered insecticides at planting-time followed by postemergence rescue treatments. An underlying goal was to assess whether it is better to simply apply a high rate of their preferred soil insecticide at planting time or to apply a low rate of a soil insecticide at planting, and then add postemergence if needed based on fly activity in their fields.

Planting-time granules were applied using methods described previously and Kinze™ banders were used to apply postemergence granules in 4-inch bands on 17 June (11 days before peak fly activity). Postemergence granular delivery was regulated using Noble metering units on a tractor-mounted toolbar. Insecticide incorporation into the soil is critical to these applications because it helps protect the product from losses due to photodegradation, heat extremes, and runoff. An incorporation device was mounted on each row-unit on the tool bar, and each was equipped with two sets of rotary tines: (1) a set placed ahead of the insecticide bander for breaking up the soil surface adjacent to beet seedlings immediately before granule drop; and (2) one set behind the bander for granule incorporation. However, due to moist soil conditions at the time of postemergence applications, the front set of rotary tines was collecting mud clods in test runs we performed before treatment applications were made. Therefore, the front rotary tine wheels were removed and only rear incorporators were used for these treatments. Postemergence liquid insecticide treatments were applied with the same tool bar. Application of the single Lorsban 4E treatment, as well as the first installment of a dual postemergence treatment of 4E took place on 20 June (eight days before peak fly activity). The second application of Lorsban 4E in the dual treatment was carried out on 27 June, which corresponded closely with peak fly activity for the site (28 June).

Our first postemergence granular applications were followed within 24 hours by a 0.47-inch rain shower, which should have been sufficient for insecticide activation. The first application of postemergence liquids was also followed by a rainfall event two days later (22 June), which added 1.32 inches of precipitation. This most likely washed most of the insecticide material off plants and onto the surrounding soil. Also, the rain would likely have assisted with further incorporation of the insecticide into the target zone and may have enhanced larval control by those treatments. No further measurable rainfall was received in the plot area until 16 July. Therefore, the second application of the postemergence Lorsban 4E treatment would not have had the favorable conditions for incorporation and larval activity as the earlier single treatment, and any impact on efficacy would have been in the form of adult control. Our fly activity data for the site (Fig. 1) does indicate that there were still relatively large numbers of flies present when this application was made.

The mean damage rating recorded for untreated control plots in this test was 6.83 on the 0-9 scale (Table 6), which indicated the presence of a relatively high sugarbeet root maggot infestation level. The only insecticide treatments that did not provide significantly lower levels of SBRM feeding injury than that recorded for untreated check plots were the single (planting-time only) application of Counter 15G at 1.5 lb and the dual treatment of Counter 15G at a reduced (0.9 lb [AI]/ac) rate combined with a postemergence application of Thimet 20G at 1.4 lb. It should be noted that all insecticide treatments were applied using band placement, irrespective of whether applied at planting or postemergence. In general, banded applications did not perform as well as modified in-furrow treatments in our registered rate trial at the St. Thomas I and II sites (Tables 3-4). Thus, our findings may have been different in this trial had we included that modified in-furrow placement method in some treatments. However, dual (planting-time plus postemergence) treatments performed very well in this trial. For example, the top treatments in relation to root protection were (1) Counter 15G at the low (0.9 lb [AI]/ac) labeled rate + 2 postemergence applications of Lorsban 4E at 1.0 lb, (2) Counter 15G at 1.5lb + a single 1-lb postemergence application of Lorsban 4E, (3) Counter 15G at 0.9 lb + Lorsban 15G at 1.5 lb, (4) and Counter 15G at 0.9 lb + two postemergence applications of Lorsban 4E at 0.5 lb. The top overall treatment in this trial, in relation to both root protection and yield parameters measured, was the dual treatment of Lorsban 15G applied at planting time at 1.0 lb (AI)/ac followed by a postemergence rescue application of Counter 15G at 1.5 lb/ac. That encouraging finding repeats what we observed with the same Lorsban-followed-by Counter treatment in 2001, and suggests that Counter 15G, although usually emphasized as a planting-time treatment, should not be overlooked as a postemergence treatment. Also, it indicates that Lorsban 15G can serve as an effective planting-time option in a dual (planting-time + postemergence) insecticide program, although great care should be taken in choosing a planting-time insecticide. Lorsban 15G, because it cannot be applied modified in-furrow will not likely give acceptable control of early-season sub-soil pests such as wireworms. Additionally, Counter 15G, 20CR, and Lorsban 15G, can only be used once per season on any given field.

Interestingly, we observed no significant differences in yield or root protection in comparing the lower dual treatment of Counter 15G (0.9 lb) at planting + Thimet 20G (1.0 lb) applied postemergence versus the high combination of Counter at 1.5 lb + Thimet applied at 1.4 lb postemergence. Also, increasing postemergence rate of Thimet 20G from 1.0 to 1.4 lb (AI)/ac when following a reduced (0.9 lb [AI/ac]) planting-time application of Counter 15G did not improve performance in relation to damage ratings, raw sugarbeet yield, or total recoverable sucrose. Other notable findings from this study involved postemergence applications of Lorsban 4E in combination with a reduced reduced (0.9 lb) rate of Counter 15G at planting time. For instance, splitting the Lorsban 4E postemergence treatment into two 0.5-lb applications did not improve level of root protection, beet tonnage, or sucrose yield when compared to a single l-lb application. However, a rate response was evident in that significantly ($P < 0.05$) better root protection was achieved when the high rate of 1.0 lb (AI)/ac was used for the double postemergence treatments of Lorsban 4E that followed Counter 15G in comparison to when they were applied at 0.5 lb each.

Significant improvements in root protection, as well as yield parameters, were also achieved with both postemergence-applied Lorsban 4E regimes (split applications of 0.5 lb [AI]/ac each, and a single application of 1 lb) that followed the planting-time-application of Counter 15G at the standard rate of 1.5 lb (AI)/ac. Also, both split postemergence applications (1 or 2 lb total active ingredient per season) and the single treatment of 1.0 lb (AI)/ac in combination with Counter 15G at the standard rate were statistically superior in relation to root damage ratings, sugarbeet root tonnage, and recoverable sucrose yield, when comparing them to planting-time-only treatment with Counter 15G at either the standard (1.5 lb [AI]/ac) or the high (1.8 lb) rate.

Similar to our 2001 data, these results suggest that a postemergence rescue insecticide application can augment SBRM control considerably. Favorable results are likely to be achieved by applying Counter 15G or Lorsban 15G at the standard (1.5 lb [AI]/ac) rate at planting time and, if fly activity levels warrant, following with one of the postemergence treatments used successfully in this experiment. Additionally, it is critical for growers to understand that prolonged periods of unfavorable weather can delay and even preclude efforts to apply postemergence treatments at an effective time in relation to the root maggot life cycle. Therefore, until further research is conducted, growers should be very cautious when choosing whether (or by how much) to reduce their planting-time insecticide application rate.

Table 6. Comparison of granular and liquid insecticides applied at planting-time and postemergence for controlling sugarbeet root maggot larvae, St. Thomas, ND, 2002.

Treatment/ formulation	Rate lb (AI/ac)			Recoverable sucrose	Yield	Sucrose	Damage rating	Gross return
	Planting-time	Postemergence[a]	Placement[b]	(lb/ac)	(T/ac)	(%)	(0-9)	($/ac)
Counter 15G	1.5	---	B	3834 d-g	13.6 ghi	15.4 a	6.38 ab	317
Counter 15G	1.8	---	B	4067 c-f	14.4 d-h	15.5 a	5.88 bcd	338
Counter 15G + Lorsban 15G	0.9 ---	--- 1.0	B B	4452 bcd	15.9 b-e	15.3 a	5.40 c-f	364
Counter 15G + Lorsban 15G	0.9 ---	--- 1.5	B B	4441 b-e	15.4 b-g	15.7 a	4.85 efg	379
Counter 15G + Thimet 20G	0.9 ---	--- 1.0	B B	3799 fg	13.5 ghi	15.3 a	5.85 bcd	312
Counter 15G + Thimet 20G	0.9 ---	--- 1.4	B B	3794 fg	13.1 hi	15.7 a	6.15 abc	326
Counter 15G + Thimet 20G	1.5 ---	--- 1.4	B B	4146 b-f	14.3 e-h	15.8 a	5.65 b-e	359
Counter 15G + Lorsban 4E + Lorsban 4E	0.9 --- ---	--- 0.5 0.5	B B B	4366 b-f	15.0 c-h	15.8 a	5.35 c-f	381
Counter 15G + Lorsban 4E	0.9 ---	--- 1.0	B B	4594 abc	15.9 b-f	15.7 a	5.35 c-f	396
Counter 15G + Lorsban 4E + Lorsban 4E	0.9 --- ---	--- 1.0 1.0	B B B	4768 ab	16.8 abc	15.6 a	4.18 g	400
Counter 15G + Lorsban 4E + Lorsban 4E	1.5 --- ---	--- 0.5 0.5	B B B	4706 ab	17.1 ab	15.1 a	5.00 d-g	375
Counter 15G + Lorsban 4E	1.5 ---	--- 1.0	B B	4694 ab	16.4 a-d	15.6 a	4.70 fg	397
Counter 20CR + Thimet 20G	1.5 ---	--- 1.4	B B	3926 def	13.8 fgh	15.6 a	5.48 c-f	330
Lorsban 15G	1.5	---	B	4348 b-f	15.6 b-g	15.3 a	5.23 def	354
Lorsban 15G	2	---	B	3819 efg	13.5 ghi	15.5 a	5.38 c-f	318
Lorsban 15G + Counter 15G	1.0 ---	--- 0.9	B B	4651 abc	16.3 a-e	15.6 a	5.18 def	392

Table 6. Comparison of granular and liquid insecticides applied at planting-time and postemergence for controlling sugarbeet root maggot larvae, St. Thomas, ND, 2002.

Treatment/ formulation	Rate lb (AI/ac)		Placement[b]	Recoverable sucrose	Yield	Sucrose	Damage rating	Gross return
	Planting-time	Postemergence[a]		(lb/ac)	(T/ac)	(%)	(0-9)	($/ac)
Lorsban 15G + Counter 15G	1.0 ---	--- 1.5	B B	5178 a	18.2 a	15.6 a	4.90 efg	435
Check	---	---	---	3221 g	11.6 i	15.1 a	6.83 a	259

Means within a column sharing the same letter are not significantly ($P > 0.05$) different (LSD).

[a]Postemergence granules applied 17 June; Postemergence liquids applied 20 & 27 June. Peak fly = 28 June, 2002

[b]B = Band

Experimental Planting-time Soil Insecticides:

Following the ban of most chlorinated hydrocarbon insecticides in the 1970s, growers were forced to begin using organophosphate and carbamate insecticides in their insect control programs. Both of those insecticide classes have the same mode of action in insects, and representatives from both classes have been used to protect the sugarbeet crop from losses due to sugarbeet root maggot feeding injury for nearly 30 years. Temik 15G, a carbamate product, was used extensively throughout the Red River Valley until widespread root maggot control failures began occurring in the mid- to late-1980s. The performance problems escalated to such levels that most sugarbeet growers ceased use of the product, and have, for the past two decades, been relying heavily on organophosphate insecticides such as Counter 15G and 20CR, Lorsban (15G and 4E formulations), and Thimet 15G. Dyfonate, also belonging to the organophosphate class, was used to some extent by sugarbeet producers in the region prior to the manufacturer's voluntary removal the product from registration. Thus, sugarbeet root maggot population in the Red River Valley growing area have been under tremendous selection pressure for the potential development of insecticide resistance. Although resistance to organophosphate insecticides was not detected in a screening study conducted by Armstrong et al. (1997), the potential remains. Coupled with this is the fact that alternative insecticide chemistries have not been shown to be particularly efficacious against SBRM larvae in the soil. Since an extremely limited number of soil insecticide options are currently available to Red River Valley sugarbeet producers for managing this insect we have made it a research priority to actively screen new products that may have potential for controlling this most serious economic insect pest of sugarbeet.

This experiment was conducted at St. Thomas, ND and planting took place on 16 May. Experimental insecticide materials used in this trial included Vydate L and clothianidin. Additional treatments considered to be experimental because their application timing or use rate was not labeled included the following: (1) Temik 15G applied postemergence-only; (2) Counter 15G + Temik 15G blended at 1.0 (combined active ingredient) per acre; and (3) Counter 15G + Temik 15G blended at a total of 1.5 lb (total AI)/ac. Vydate was applied as three application timings (planting time, 2-leaf postemergence, and 4-leaf postemergence). Gaucho and clothianidin seed treatments were used in this trial at rates of 45 and 25 grams (AI)/unit of seed).

All Vydate treatments were delivered at 15GPA of finished spray volume using Teejet™ 8004E nozzles with output being metered by using a Mustang/Raven™ Liquid Application system. Water used to prepare all Vydate-containing treatments was buffered to pH 6.0 prior to mixing. The planting-time treatment of Vydate was applied in a 5-inch band over the open furrow in front of the rear press wheel of the planter. Counter 15G was applied at 1.5 lb (AI)/ac, and served as a registered standard for comparative purposes in the experiment. All granular treatments were applied by using the modified in-furrow placement method described in the "Insecticide Application Methods used in Experiments" section of our report.

The mean damage rating of 7.05 recorded for untreated control plots in this study suggested that we had an excellent SBRM infestation in the location we chose for carrying out this test (Table 7). The best-performing treatments with regard to root protection included the following (listed in descending order of efficacy): Gaucho seed treatment at 45 g (AI)/unit of seed, the registered standard (Counter 15G at 1.5 lb [AI]/ac), clothianidin seed treatment at 45 g (AI)/unit of seed, and Vydate L applied postemergence at the 2-leaf sugarbeet growth stage. None of those treatments were significantly ($P < 0.05$) outperformed by the Counter standard when comparisons were made according to either raw sugarbeet tonnage or total recoverable sucrose yield. The two insecticidal seed treatments performed at similar levels with respect to root protection and recoverable sucrose yield. However, raw tonnage was significantly greater (17.8 versus 15.2 tons per acre) when the clothianidin treatment was used. That disparity translated to an average 587-lb advantage in total recoverable sucrose yield for clothianidin plots, although the difference was not significant. Vydate performance was remarkably affected by treatment timing. Specifically, root injury was significantly reduced, and a statistical increase (1,191 lb/ac) was observed when the 2-leaf postemergence treatment was used instead of the planting-time application. Also, plots treated with the 2-leaf postemergence application of Vydate produced significantly higher raw sugarbeet tonnage and recoverable sucrose yield than the 4-leaf treatment. These findings regarding postemergence Vydate are surprising given the fact that no planting-time insecticide was applied for SBRM control or for protection against soil-borne secondary insect pests. Since yield effects were slightly more consistent than root protection, great care should be taken in interpreting these results. It does, however, suggest the remote possibility that a slight growth regulator effect could be contributing to yield increases. This has occasionally been observed with other carbamate insecticides. The overall findings of this study are reason for some optimism regarding chemical control of the sugarbeet root maggot. Notwithstanding, it should be remembered that these are findings based on a single year of research. We plan to continue with this research indefinitely.

Table 7. Evaluation of experimental insecticides for controlling sugarbeet root maggot larvae, St. Thomas, ND, 2002.

Treatment/ formulation	Rate lb (AI/ac)		Placement[a]	Recoverable sucrose	Yield	Sucrose	Damage rating	Gross return
	Planting-time	Post-emergence		(lb/ac)	(T/ac)	(%)	(0-9)	($/ac)
Counter 15G	1.5	---	M	4346 abc	16.1 ab	15.0 a	4.03 e	337
Counter 15G +	Blend	---	M					
Temik 15G	1.0	---	M	4198 abc	15.2 b-d	15.1 a	5.93 bc	337
Counter 15G +	Blend	---	M					
Temik 15G	1.5	---	M	4595 ab	17.1 ab	14.9 a	5.23 cd	353
Vydate L	2	---	B	3862 bc	14.0 cd	15.2 a	6.80 ab	308
Vydate L	---	2.0 2 leaf	B	4926 a	14.4 ab	15.5 a	4.95 cde	409
Vydate L	---	2.0 4 leaf	B	3735 c	13.5 d	15.3 a	5.73 bc	301
Temik 15G	---	1	B	4320 abc	15.6 a-d	15.3 a	5.78 bc	349
Gaucho	45g ai/unit	---	Seed	4204 abc	15.2 b-d	15.2 a	3.95 e	339
Clothianidin	25g ai/unit	---	Seed	4791 a	17.8 a	14.9 a	4.63 de	369
Check	-	-	-	3635 c	13.3 d	15.1 a	7.05 a	287

Means within a column sharing the same letter are not significantly ($P > 0.05$) different (LSD).
Postemergence liquids applied 20 & 27 June. Peak Fly = 28 June, 2002
[a] M = Modified-in-furrow; B = Band; Seed = film-coated insecticide treatment on bare seed

Reference Cited

Armstrong, J. S., R. B. Carlson, A. Schroeder, and R. J. Dregseth. 1998. Testing sugarbeet root maggots for insecticide resistance in the Red River Valley, 1997. 1997 Sugarbeet Research and Extension Reports. 28: 242-244.

Field Performance of Registered and Experimental Formulations of Zeta-cypermethrin (Mustang) Insecticide:

This experiment was established in a commercial sugarbeet field near St. Thomas on 15 May, 2002 to assess the impacts of formulation, application rate, placement, and tankmixing with 10-34-0 starter fertilizer on the performance of zeta-cypermethrin products under extremely heavy SBRM populations. Two formulations of zeta-cypermethrin were evaluated: F-0570 0.8 EW and Mustang 1.5EW. Liquid insecticide treatments, in addition to 10-34-0 fertilizer controls, were applied using the Mustang/Raven^{TM} application system equipped with Teejet 6501E nozzles that were appropriately oriented to either apply the products in 3-inch bands or directly in-furrow, at a finished spray volume rate of 5 GPA. Postemergence treatments were applied using a CO_2-powered cannister spray system which was calibrated to deliver a finished spray volume of 15 GPA in 7-inch bands via Teejet 8002E nozzles. Premixing of Mustang and F-0570 treatments (to avoid compatibility problems) was carried out in accordance with the manufacturer's protocol for a 60:1 (water:insecticide) dilution, and Unite^{TM} compatibility agent was used in the mixture at the labeled 3 pt/100 gal rate. Insecticide, starter fertilizer, Unite, and water were all stored in a heated area until immediately before mixing operations to avoid cold temperature-related tankmix coagulation problems that were being experienced at the time by sugarbeet growers. Consequently, we believe our tankmixed fertilizer/insecticide treatments went on well because no precipitate or coagulation was apparent as we periodically checked the tank during the applications. However, we stopped between treatments for an unrelated adjustment, and the down-time was sufficient for a cool-down and some precipitate formed in the tankmix. Warm water allowed for a fairly quick cleanup of the coagulated material, and we successfully carried out our application of the remaining treatments using warm-water mixes with no further complications.

The presence of a moderately high SBRM infestation for this experiment was evidenced by a root injury mean of 6.4 on the 0 to 9 scale for our untreated control plots (Table 8). The industry standard treatment of Counter 15G applied at 1.5 lb (AI)/ac provided root protection that was statistically superior to all insecticide entries except the dual treatment of F-0570 applied in a 3-inch T-band plus a postemergence application of Lorsban 4E. Unfortunately, these two treatments were the only ones to provide root protection levels that were significantly different from the fertilizer-only controls and the true untreated check. Although trends were apparent in slightly increased control when F-0570 was applied via 3-inch T-band and frequent numerical decreases in efficacy when the product was tankmixed with 10-34-0 starter fertilizer, none of those differences were significant. Additionally, no rate responses in root protection were detected. Due to the relative lack of efficacy provided by the zeta-cypermethrin in relation to root protection, treatment impacts on yield parameters should be interpreted with considerable caution. The only fertilizer/insecticide-related difference observed in this experiment involved F-0570 0.8EW applied at 0.025 lb (AI)/ac in a 3-inch T-band. Significantly more raw sugarbeet tonnage and total recoverable sucrose yield were obtained with this insecticide application when the 10-34-0 starter fertilizer was omitted. However, consistent with data from our root injury ratings, no major impacts on efficacy were observed in relation to placement, application rate, or formulation of zeta-cypermethrin.

Generally, quite poor performance was observed with labeled (Mustang 1.5EW) and experimental formulations (F-0570) of zeta-cypermethrin in this experiment under the relatively high SBRM population level that existed in the plots. Although nonsignificant, efficacy could have been slightly compromised due to binding of insecticide active ingredient to extremely soil particles during planting-time applications; however, neither product provided adequate SBRM control, irrespective of whether it was mixed with starter fertilizer. These results, combined with findings from the past two years, suggest that the current formulations of zeta-cypermethrin may not be effective products for SBRM control. The manufacturer of this material, FMC Corporation, has since developed a cold weather formulation of this active ingredient. Therfore, further testing may be required to fully evaluate its potential as a planting-time treatment. Also, with very few chemical tools available, use of this product may have a better fit in areas of low to moderate SBRM infestations, and against secondary soil pests such as cutworms or wireworms. We continue to recommend that producers avoid reliance on Mustang as a planting-time treatment for sugarbeet root maggot control in areas of the Valley where high population levels are expected. This is also in accordance with the label for this product which suggests only *suppression* under light to moderate SBRM population levels.

Table 8. Performance evaluation of zeta-cypermethrin (Mustang) insecticide treatments and registered postemergence applications for managing sugarbeet root maggot larvae, St. Thomas, ND, 2002.

Treatment/ formulation	Rate lb (AI/ac)		Placement[a]	Recoverable sucrose	Yield	Sucrose	Damage rating	Gross return
	Planting-time	Postemergence		(lb/ac)	(T/ac)	(%)	(0-9)	($/ac)
F-0570 0.8EW	0.025	---	3" TB	3918 a-d	14.1 a-d	15.3 a	6.28 bc	316
F-0570 0.8EW	0.05	---	3" TB	4065 abc	14.9 abc	15.1 a	6.38 bc	321
F-0570 0.8EW	0.075	---	3" TB	4144 abc	15.6 ab	14.7 a	6.30 bc	312
F-0570 0.8EW	0.025	---	M-tube	3124 b-e	11.9 b-e	14.6 a	6.88 abc	228
F-0570 0.8EW	0.05	---	M-tube	3731 a-d	13.6 a-d	15.1 a	6.78 abc	295
F-0570 0.8EW +	0.025	---	3" TB					
10-34-0 fertilizer	---	---	---	2300 e	8.9 e	14.3 a	6.88 abc	-165
F-0570 0.8EW +	0.025	---	M-tube					
10-34-0 fertilizer	---	---	---	2987 cde	12.1 b-e	14.1 a	7.35 a	-195
Mustang 1.5EW +	0.05	---	3" TB					
10-34-0 fertilizer	---	---	---	3005 b-e	11.4 cde	14.6 a	7.28 a	-221
Mustang 1.5EW +	0.05	---	M-tube					
10-34-0 fertilizer	---	---	---	3547 b-d	13.7 a-d	14.5 a	6.75 abc	254
F-0570 0.8EW +	0.025	---	3" TB					
F-0570 0.8EW	---	0.025	B	3669 b-d	13.7 a-d	14.9 a	6.30 bc	278
F-0570 0.8EW +	0.025	---	3" TB					
Asana XL 0.66EC	---	0.05	B	3675 b-d	13.7 a-d	14.7 a	6.08 c	280
F-0570 0.8EW +	0.025	---	B					
Lorsban 4E	---	1.0	B	4879 a	17.3 a	15.5 a	4.75 d	404
Counter 15G	1.5	---	M	4151 ab	15.7 ab	14.7 a	4.30 d	309
Check	---	---	---	3167 b-e	12.4 b-e	14.4 a	6.43 bc	221
10-34-0 fertilizer	---	---	3" TB	3623 b-d	13.6 a-d	14.7 a	6.68 abc	273
10-34-0 fertilizer	---	---	M-tube	2810 de	10.8 de	14.4 a	6.98 ab	-204

Means within a column sharing the same letter are not significantly ($P > 0.05$) different (LSD).

[a]M = Modified-in-furrow; B = Band; TB = 3" Band over open seed furrow; M-Tube = Microtube, directly in-furrow

Postemergence liquids applied 20 June. Peak Fly = 28 June.

Impact of Planting/Application Date on Soil Insecticide Efficacy:

This experiment was initiated in 2001 and repeated in 2002 to determine the impact of planting/insecticide application date on performance of registered soil insecticides in controlling the sugarbeet root maggot. A major objective was also to determine the reason for extremely variable levels of performance at SBRM control by registered soil insecticides in the Red River Valley. The experiment was established in a commercial sugarbeet field near St. Thomas, ND. Treatments were arranged in a split-plot design (four replicates) with planting date serving as the main plot effect and insecticide as the sub-plot. Planting dates included 14 May, 28 May, and 4 June, whereas, insecticide treatments consisted of 15G formulations of the following products applied at the same rate (1.5 lb [AI]/ac,): Counter, Lorsban, and Temik. Also, all insecticide/planting date treatments were compared with an untreated check.

Results of this experiment are presented in Table 9. The average damage ratings of 6.83, 6.30, and 5.98 recorded for the early-, mid-, and late-planted untreated control plots, respectively, indicated that a relatively high SBRM infestation level had developed in the plots. Overall, our findings closely corresponded with those from 2001. Within the three application dates, all insecticide treatments resulted in significantly lower root injury than that recorded for the untreated check plots. Also similar, but even more consistent than our 2001 findings, was the fact that all three insecticides performed significantly better when applied at the middle and late planting dates; however, no difference was detected between the middle and late applications irrespective of insecticide used. Interestingly, although root injury levels were consistently lower in mid- and late-planted treatments for all insecticides, total recoverable sucrose yield was lower with the latter treatments. Much of these findings, especially regarding yield, correspond well with observations from previous years with higher yields being achieved in earlier-planted beets. However, it is interesting that neither yield nor damage rating was significantly impacted by planting date in the untreated controls of our study. This finding is also correspondent with our results from 2001. Results of our investigation suggest that reduced postapplication persistence of these insecticide materials may be a major factor behind a reduced control among planting/application dates.

Table 9. Impact of planting/application date on performance of registered planting-time soil insecticide treatments for management of sugarbeet root maggot larvae, St. Thomas, ND, 2002.

Planting Date	Treatment/ formulation	Rate lb (AI/ac)	Placement[a]	Recoverable sucrose (lb/ac)	Yield (T/ac)	Sucrose (%)	Damage rating (0-9)	Gross return ($/ac)
Early (14 May)	Counter 15G	1.5	B	3860 ab	15.0 a	14.6 c	6.85 a	271
Early (14 May)	Lorsban 15G	1.5	B	3907 a	14.4 ab	15.2 a	7.00 a	304
Early (14 May)	Temik 15G	1.5	B	4090 a	15.0 a	15.3 a	6.48 abc	323
Early (14 May)	Check	-	-	3404 bc	13.1 bc	14.8 abc	6.83 ab	246
Mid (28 May)	Counter 15G	1.5	B	3157 cd	12.3 cd	14.5 c	5.78 cde	223
Mid (28 May)	Lorsban 15G	1.5	B	3069 cd	12.0 cd	14.5 c	5.50 de	216
Mid (28 May)	Temik 15G	1.5	B	2996 cd	11.7 cde	14.5 c	5.63 cde	209
Mid (28 May)	Check	-	-	2451 e	9.7 f	14.2 c	6.30 a-d	165
Late (4 June)	Counter 15G	1.5	B	2841 de	11.2 def	14.3 c	5.53 de	194
Late (4 June)	Lorsban 15G	1.5	B	3101 cd	12.3 cd	14.3 c	5.25 e	209
Late (4 June)	Temik 15G	1.5	B	2734 de	10.7 def	14.5 c	5.23 e	191
Late (4 June)	Check	-	-	2515 e	10.0 ef	14.3 c	5.98 b-e	168

Means within a column sharing the same letter are not significantly ($P > 0.05$) different (LSD).
[a]B = Band

Location:	**St. Thomas, ND, Pembina County**- William and Brent Baldwin Farm (St.Thomas I)	
Sugarbeet Variety:	Van der Have 66140 and Beta 6600	
Plot Size:	Six 35-ft long rows, 4 Center rows treated	
Experimental Design:	Randomized complete block, 4 replicates	
Soil Name:	Loam	
% OM, pH:	3.6% OM, 7.9% pH	
Previous Crop:	Wheat - 2001	
Soil Preparation:	Field cultivator worked once	
Herbicide:	Betamix (0.5 pt/A) + Upbeet (1/8 oz/A) + Stinger (1.3 fl oz/A) + Select (2 fl oz/A) + MSO (1.5% v/v), June 5, 2002 Betamix (0.5 pt/A) + Upbeet (1/8 oz/A) + Stinger (1.3 fl oz/A) + Select (2 fl oz/A) + MSO (1.5% v/v), June 14, 2002 Betamix (0.5 pt/A) + Upbeet (1/8 oz/A) + Stinger (1.3 fl oz/A) + Select (2 fl oz/A) + MSO (1.5% v/v), June 24, 2002	
Fungicide:	Eminent (13 oz/ac) on August 9, 2002; Super Tin (5 oz/ac) on August 23, 2002	
Insecticide:	Noble applicators, granules 5" band (B), modified in furrow (M), spoon (S), 3" band over open seed furrow (TB), microtube directly in-furrow(M-tube); post granules, 4" band; Postemergence liquids, 7" band	
Planting Depth:	1.25"	
Planting Date:	May 14, 2002	Planting Date (early), Placement, Planting-time vs Post granule studies, Postemergence Foliar
	May 15, 2002	Registered, FMC experiments
	May 16, 2002	Experimentals
	May 28, 2002	Planting Date (mid)
	June 04, 2002	Planting Date (late)
Post Treatments:	June 17, 2002	Post Granules; Planting-time vs Post
	June 20, 2002	Lorsban 4E; Planting-time vs Post granules Lorsban 4E, Asana, & Mustang; FMC Vydate: Experimentals
	June 27, 2002	Lorsban 4E; Planting-time vs Post granules Vydate; Experimentals
Rainfall:	May 22, 2002	0.12"
	May 28, 2002	0.13"
	May 29, 2002	0.11"
	May 31, 2002	0.02"
	Total/May	**0.38"**
	June 09, 2002	1.16"
	June 10, 2002	1.23"
	June 12, 2002	0.29"
	June 18, 2002	0.47"
	June 22, 2002	1.32"
	June 23, 2002	0.10"
	June 24, 2002	0.69"
	Total/June	**5.26"**
	July 04, 2002	0.33"
	July 05, 2002	0.12"
	July 09, 2002	0.17"
	July 10, 2002	0.30"
	July 20, 2002	0.52"
	July 30, 2002	0.16"
	July 31, 2002	0.12"
	Total/July	**1.72"**
	Total/August	**5.40"**
	Total/September	**1.30"**
Damage Ratings:	July 29, 30, 30, 31, and August 12, 2002	

Harvest:	September 30 and October 1, 2002
Harvest Sample:	2 center rows x 35' long - 70' total

Location:	**St. Thomas, ND, Pembina County -** Pete Carson Farm (St.Thomas II)	
Sugarbeet Variety:	Van der Have 66140 and Beta 6600	
Plot Size:	Six 35-ft long rows, 4 Center rows treated	
Experimental Design:	Randomized complete block, 4 replicates	
Soil Name:	Silt Loam	
Previous Crop:	Wheat - 2001	
Soil Preparation:	Field cultivator worked twice	
Herbicide:	Betamix (0.5 pt/A) + Upbeet (1/8 oz/A) + Stinger (1.3 fl oz/A) + Select (2 fl oz/A) + MSO (1.5% v/v), June 5, 2002	
	Betamix (0.5 pt/A) + Upbeet (1/8 oz/A) + Stinger (1.3 fl oz/A) + Select (2 fl oz/A) + MSO (1.5% v/v), June 14, 2002	
	Betamix (0.5 pt/A) + Upbeet (1/8 oz/A) + Stinger (1.3 fl oz/A) + Select (2 fl oz/A) + MSO (1.5% v/v), June 24, 2002	
Fungicide:	Eminent (13 oz/ac), August 9, 2002	
	Super Tin (5 oz/ac), August 23, 2002	
Insecticide:	Noble applicators, granules 5" band (B), modified in furrow (M), spoon (S),	
Planting Depth:	1.25"	
Planting Date:	May 17, 2002	Registered, Placement studies
Rainfall:	May 22, 2002	0.12"
	May 28, 2002	0.13"
	May 29, 2002	0.11"
	May 31, 2002	0.02"
	Total/May	**0.38"**
	June 09, 2002	1.16"
	June 10, 2002	1.23"
	June 12, 2002	0.29"
	June 18, 2002	0.45"
	June 22, 2002	1.32"
	June 23, 2002	0.10"
	June 24, 2002	0.69"
	Total/June	**5.24"**
	July 04, 2002	0.38"
	July 05, 2002	0.12"
	July 09, 2002	0.17"
	July 10, 2002	0.30"
	July 20, 2002	0.52"
	July 30, 2002	0.16"
	July 31, 2002	0.12"
	Total/July	**1.77"**
	Total/August	**4.36"**
	Total/September	**2.32"**

Damage Ratings:	July 30 and August 13, 2002
Harvest:	September 30, 2002
Harvest Sample:	2 center rows x 35' long - 70' total

Location:	**Crookston, MN, Polk County**	
Sugarbeet Variety:	Beta 2088	
Plot Size:	Six 35-ft long rows, 4 center rows treated	
Experimental Design:	Randomized complete block, 4 replicates	
Soil Name:	Wheatville Loam	
Previous Crop:	Wheat - 2001	
Soil Preparation:	Alloway Seedbedder	
Herbicide:	Betamix (0.5 pt/A) + Upbeet (1/8 oz/A) + Stinger (1.4 fl oz/A) + Select (2 fl oz/A) + Scoil (1 3/4 pt/A), June 17, 2002	
	Betamix (0.5 pt/A) + Upbeet (1/8 oz/A) + Stinger (1.3 fl oz/A) + Select (2 fl oz/A) + Scoil (1 3/4 pt/A), June 21, 2002	
Fungicide:	Super Tin (5 oz/ac), August 2, 2002	
	Eminent (13 oz/ac), August 17, 2002	
Insecticide:	Noble applicators, granules banded (B) 5" band, modified in-furrow (M), band over open seed furrow (TB)	
Planting Depth:	1 1/2"	
Planting Date:	May 17, 2002	Registered Experiment
Rainfall:	May 22, 2002	0.02"
	May 23, 2002	0.07"
	May 29, 2002	0.05"
	Total/May	**0.14"**
	June 09, 2002	3.52"
	June 10, 2002	0.08"
	June 11, 2002	0.03"
	June 13, 2002	0.40"
	June 18, 2002	0.60"
	June 19, 2002	0.22"
	June 22, 2002	1.10"
	June 24, 2002	0.35"
	June 25, 2002	0.25"
	Total/June	**6.55"**
	July 04, 2002	0.18"
	July 07, 2002	0.45"
	July 09, 2002	1.22"
	July 10, 2002	1.10"
	July 17, 2002	0.67"
	July 24, 2002	0.01"
	July 27, 2002	0.05"
	July 31, 2002	0.22"
	Total/July	**3.90"**
	Total/August	**9.20"**
	Total/September	**1.36"**
Damage Ratings:	July 30, 2002	
Harvest:	September 24, 2002	
Harvest Sample:	2 center rows x 35' long - 70' total	