APPLICATION RATE AND TIMING IMPACTS ON PERFORMANCE OF THIMET 20G FOR POSTEMERGENCE CONTROL OF THE SUGARBEET ROOT MAGGOT

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is a significant economic pest of sugarbeet in central and northern portions of the Red River Valley (RRV) growing area of Minnesota and North Dakota. Root maggot populations in this region have been at very high levels in recent years. Currently, only a small number of insecticide products labeled for use in sugarbeet have been shown to provide cost-effective SBRM control. Therefore, a major research goal has been to refine and optimize strategies for using postemergence insecticides to improve SBRM management for growers in areas affected by this pest. The key objective of this experiment was to assess the impacts of application timing and rate on the performance of Thimet 20G insecticide when applied as a postemergence rescue insecticide for SBRM control in the Red River Valley. A secondary objective was to compare moderate and high rates of Counter 20G (i.e., 7.5 and 8.9 lb product/acre, respectively) as planting-time components in dual-insecticide (i.e., planting-time + postemergence) programs for root maggot control.

Materials and Methods:

This study was carried out on two commercial field sites: one near St. Thomas in southern Pembina County, ND (Study I), and a second site near Thompson in Grand Forks County, ND. Plots were planted on 10 and 15 May, 2018 at St. Thomas and Thompson, respectively, using a 6-row Monosem NG Plus 7x7 planter set to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. The outer two rows of each plot served as buffers, and did not receive planting-time insecticide. Individual plots were 35 feet long, and 35-foot tilled alleys were maintained between replicates throughout the growing season. The experiment was arranged in a randomized complete block design with four replications of the treatments. Counter 20G was applied as a base planting-time insecticide for all plots that received insecticide protection, and it was applied at either the moderate (7.5 lb product/ac) or high (8.9 lb/ac) labeled rate. Band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders, was used for all Counter 20G applications. Granular output rates were regulated by using a planter-mounted SmartBox™ computer-controlled insecticide system that was calibrated on the planter before planting.

At the St. Thomas location, postemergence Thimet 20G granules were applied at either 13 or seven days before peak fly activity (i.e., 25 or 31 May, respectively), and rates of Thimet 20G included 4.9 and 7 lb product/ac. The same rates of Thimet were tested at Thompson, and they were applied on the same dates, which were 11 and 5 days before peak fly at Thompson. As with at-plant applications, granular output rates were regulated by using a SmartBox™ system mounted on a tractor-drawn four-row toolbar, and placement of insecticide in 4-inch bands was achieved by using Kinze™ row banders. Granules were incorporated by using two pairs of metal rotary tines that straddled each row. A set of tines was positioned ahead of each bander, and a second pair was mounted behind the granular drop zone. Lorsban Advanced, applied in a broadcast at 1 pt product/ac using TeeJet™ 110015VS nozzles, was also included in this experiment for comparative purposes. This application was made on 4 June at both locations, which was three days before the main peak in SBRM fly activity at St. Thomas, and one day pre-peak at Thompson.

Root injury ratings: Root maggot feeding injury assessments were carried out on 31 July (St. Thomas) and 2 August (Thompson) 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 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Performance was also compared using sugarbeet yield parameters derived by harvesting roots from all treatment plots. Plots at the St. Thomas location were harvested on 25 September, and the Thompson plots were harvested on 20 September. All foliage was removed from plots immediately before each respective harvest by using a commercial-grade mechanical defoliator. On the same day, all beets from the center two rows of each plot were extracted from soil by using a mechanical harvester, and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

Data analysis: All data from root injury ratings and yield/quality analyses were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2012). Treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

St. Thomas: Root maggot feeding injury results from the St. Thomas location of this trial are presented in Table 1. The SBRM infestation present for this experiment was considered severe, as was evidenced by the high average root maggot feeding injury rating of 7.95 (0 to 9 scale of Campbell et al. 2000) in the untreated check plots. All insecticide entries, including single planting-time applications, as well as treatments involving a planting-time insecticide plus either a postemergence application of Thimet 20G or Lorsban Advanced, provided significant reductions in SBRM feeding injury when compared to the untreated check plots.

Table 1. *Larval feeding injury* in an evaluation of Thimet 20G application timing and rate on sugarbeet root maggot control, St. Thomas, ND, 2018

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	4.95 e
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	7.5 lb 4.9 lb	1.5 1.0	5.33 de
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	5.43 de
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	5.80 cd
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	5.83 cd
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	7.5 lb 4.9 lb	1.5 1.0	6.08 c
Counter 20G + Lorsban Advanced	B 3 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	6.70 b
Counter 20G	B	8.9 lb	1.8	6.73 b
Counter 20G	B	7.5 lb	1.5	7.03 b
Check	-----	----	-----	7.95 a
LSD (0.05)				0.538

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch band; Post B = 4-inch postemergence band

General trends at St. Thomas indicated that later (7 days before peak fly activity) postemergence applications of Thimet 20G provided slightly better root protection than those applied earlier (13 days pre-peak). For example, the treatment combination of planting-time Counter 20G at its high (8.9 lb product/ac) rate, combined with a postemergence application of Thimet 20G at 7 lb product/ac at 7 days pre-peak, resulted in significantly lower SBRM feeding injury than the same treatment combination when the Thimet was applied earlier at 13 days pre-peak. Similarly, when both planting-time Counter and postemergence Thimet were applied at lower rates (7.5 and 4.9 lb product/ac, respectively), applying the Thimet at 7 days pre-peak performed significantly better at protecting roots from SBRM larval feeding injury than when it was applied 13 days before peak fly activity.

The postemergence application of Lorsban Advanced at 50% of its labeled maximum single application rate (1 pt product/ac) to plots that were initially treated at planting time with Counter 20 at 7.5 lb product/ac did not provide a significant improvement in root protection when compared to similar plots that had only received a planting-time Counter at the same (7.5-lb) rate. Although both of the single planting-time-only applications of Counter 20G provided significant reductions in root maggot feeding injury when compared to the untreated check plots, there was no statistical difference in performance between the 7.5- and 8.9-lb application rates. This was the case for treatments that involved both single, planting-time-only applications of Counter, as well as those involving planting-time Counter 20G and postemergence applications of Thimet. As such, this suggests that the higher rate of Counter 20G may not be necessary in dual-insecticide programs that include postemergence applications of Thimet 20G at its highest (7 lb product/ac) labeled rate, even under high SBRM pressure such as that which occurred at the St. Thomas location of this trial.

Yield data from St. Thomas are presented in Table 2. All insecticide-treated entries resulted in significant increases in recoverable sucrose yield, root tonnage, and percent sucrose when compared to the untreated check. There were no statistically significant differences between any of the dual (i.e., planting-time plus postemergence) insecticide entries in this trial. However, the only treatment combinations that resulted in significantly greater recoverable sucrose yield than the two single planting-time applications of Counter 20G included the following: 1) Counter 20G at its moderate (7.5 lb product/ac) rate plus a postemergence application of Thimet 20G at the high (7 lb/ac) rate at 7 days pre-peak; and 2) Counter 20G at 7.5 lb product/ac plus postemergence Thimet 20G at its low (4.9 lb/ac) labeled rate, which was also applied 7 days before peak fly activity. Similarly, the treatment combination of Counter 20G at 7.5 lb product per acre plus postemergence Thimet 20G at its high (7 lb/ac) rate at 7 days pre-peak was the only entry that significantly increased root yield over those of the single planting-time applications of Counter 20G. There were no significant differences in percent sucrose content between any of the insecticide-treated entries. As observed in previous years of testing these insecticide regimes, none of the yield parameters measured were impacted by Thimet 20G application rate or timing at St. Thomas in 2018.

Table 2. Impacts of Thimet 20G application timing and rate on *yield parameters* in an evaluation of sugarbeet root maggot control, St. Thomas, ND, 2018

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	8784 a	27.8 a	17.00 a	1124
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	7.5 lb 4.9 lb	1.5 1.0	8531 a	26.7 ab	17.13 a	1108
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	8233 ab	26.1 ab	16.93 a	1053
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	8187 ab	25.9 ab	17.03 a	1046
Counter 20G + Lorsban Advanced	B 3 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	8078 ab	25.6 ab	16.98 a	1031
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	7939 ab	24.8 ab	17.18 a	1031
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	7.5 lb 4.9 lb	1.5 1.0	7803 ab	24.9 ab	17.03 a	986
Counter 20G	B	7.5 lb	1.5	7297 b	24.4 b	16.30 a	867
Counter 20G	B	8.9 lb	1.8	7269 b	23.8 b	16.58 a	887
Check	-----	----	-----	4201 c	15.1 c	15.28 b	442
LSD (0.05)				1042.0	3.00	0.974	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = banded at planting; Post B = postemergence band

All insecticide treatments provided exceptional increases in gross revenue at the St. Thomas location of this trial. For example, even when insecticide protection was limited to a single planting-time application of Counter 20G, gross revenue was increased by between $425 and $445 when compared to the revenue recorded for the untreated check. The treatment combination of planting-time Counter 20G at 7.5 lb product per acre plus a

postemergence broadcast application of Lorsban Advanced at 1 pt product per acre generated a gross revenue increase of $589 over the untreated check and an additional $164 in revenue compared to similar plots that received the planting-time-only application of Counter at 7.5 lb/ac. The highest overall gross revenue in this trial at St. Thomas was recorded for plots treated at planting with Counter 20G at 7.5 lb/ac and at 7 days pre-peak with Thimet 20G at its high (7 lb product/ac) rate. This combination generated $1,124/ac in gross revenue, which was an increase of $682/ac above that of the untreated check, and $257 above the single planting-time application of Counter at 7.5 lb/ac. Applying this treatment later (i.e., 7 days pre-peak) resulted in a revenue increase of $93/ac when compared to the revenue achieved from similar plots that received the Thimet earlier (i.e., 13 days before peak fly). Similarly, when lower rates of both Counter (7.5 lb/ac) and Thimet (4.9 lb/ac) were used, applying the postemergence Thimet at 7 days pre-peak increased gross revenue by $122/ac when compared to applying the Thimet in the same Counter/Thimet rate regime, but at 13 days before peak fly.

Thompson: Root injury rating results from the Thompson, ND location of this trial are provided in Table 3. Sugarbeet root maggot feeding pressure at this location was considered moderate, as indicated by the average SBRM feeding injury rating of 5.6 on the 0 to 9 scale of Campbell et al. (2000) that was recorded for roots from the untreated check plots. However, general trends in both root rating and yield data corresponded closely with those observed at the St. Thomas location.

At Thompson, all of the insecticide entries in this trial provided significant reductions in SBRM feeding injury when compared to the untreated check. Plots that received postemergence Thimet applications that were made closer to (i.e., 5 days before) peak activity had numerically lower levels of SBRM feeding injury than those treated earlier (11 days pre-peak) with postemergence Thimet; however, there were no significant differences in root protection as related to Thimet application timing, irrespective of the rate of planting-time Counter or postemergence Thimet being used. The postemergence application of Lorsban Advanced at its moderate (1 pt product/ac) rate to plots initially treated with Counter 20G at 7.5 lb/ac was the only postemergence insecticide application that did not provide a significant improvement in root protection when compared to similar plots that had only received the single planting-time application of Counter 20G at the same rate. Also, in comparing postemergence SBRM tools overall, plots that received Thimet had significantly less SBRM feeding injury than those treated at postemergence with Lorsban Advanced, irrespective of Thimet application timing or rate.

Table 3. *Larval feeding injury* in an evaluation of Thimet 20G application timing and rate on sugarbeet root maggot control, Thompson, ND, 2018

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	1.95 c
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	7.5 lb 4.9 lb	1.5 1.0	1.98 c
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	2.35 c
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	2.45 c
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	2.53 c
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	7.5 lb 4.9 lb	1.5 1.0	2.58 c
Counter 20G + Lorsban Advanced	B 3 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	3.43 b
Counter 20G	B	8.9 lb	1.8	3.65 b
Counter 20G	B	7.5 lb	1.5	3.78 b
Check	-----	----	-----	5.60 a
LSD (0.05)				0.718

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch band; Post B = 4-inch postemergence band

Yield data from the Thompson location appear in Table 4. Trends in yield results corresponded closely with root injury rating data, and also supported our findings for both root rating and yield data from St. Thomas. For example, later applications of postemergence Thimet 20G at Thompson tended to provide slightly greater sucrose yields and root tonnage than earlier applications in plots that received the same amount of planting-time Counter. All dual-insecticide combinations that involved a later (i.e., 5 days before peak fly vs. 11 days pre-peak) postemergence application of Thimet 20G resulted in significant increases in recoverable sucrose yield when compared to the untreated check plots. The only dual-insecticide combination involving an earlier (i.e., 11 days pre-peak) postemergence application of Thimet that provided a significant increase in recoverable sucrose yield when compared to the untreated check was when both planting-time Counter and postemergence Thimet were applied at high rates (i.e., 8.9 and 7 lb product/ac, respectively).

Table 4. Impacts of Thimet 20G application timing and rate on *yield parameters* in an evaluation of sugarbeet root maggot control, Thompson, ND, 2018

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	7.5 lb 4.9 lb	1.5 1.0	12,136 a	38.9 a	16.95 a	1528
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	11,054 b	36.6 ab	16.65 a	1331
Counter 20G + Thimet 20G	B 7 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	10,880 b	34.7 b-e	17.20 a	1379
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	10,726 b	35.7 bcd	16.55 a	1281
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	10,518 bc	36.3 abc	16.03 a	1189
Counter 20G + Thimet 20G	B 13 d Pre-peak Post B	7.5 lb 4.9 lb	1.5 1.0	10,458 bc	35.3 bcd	16.28 a	1224
Counter 20G + Lorsban Advanced	B 3 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	10,322 bc	33.4 cde	16.90 a	1283
Counter 20G	B	8.9 lb	1.8	10,206 bc	34.4 b-e	16.50 a	1199
Counter 20G	B	7.5 lb	1.5	10,099 bc	33.1 de	16.70 a	1232
Check	-----	----	-----	9,571 c	32.1 e	16.38 a	1130
LSD (0.05)				999.8	3.17	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch band; Post B = 4-inch postemergence band

The highest recoverable sucrose yield in this trial at Thompson was achieved with the dual-insecticide combination comprised of planting-time Counter 20G at 7.5 lb/ac plus 4.9 lb/ac of Thimet 20G postemergence at 5 days before peak SBRM fly activity. This combination was the only dual-insecticide combination that resulted in significantly greater recoverable sucrose yield than either of the planting-time-only Counter treatments. It also generated more root yield than all treatments, except the following: 1) planting-time Counter at 7.5 lb/ac plus a postemergence application of Thimet at 7 lb/ac at 5 days pre-peak; and 2) planting-time Counter at the high (8.9 lb/ac) rate plus postemergence Thimet applied at 7 lb/ac at 11 days pre-peak. There were no significant differences in percent sucrose content between any of the treatments in this study at Thompson, including comparisons between the best-performing insecticide combinations and the untreated check.

Despite relatively few significant differences among treatments in relation to yield in this study at the Thompson location, most insecticide programs in the experiment provided substantial revenue benefits when compared to the untreated check. The highest gross revenue of $1,528/ac was recorded for the treatment that included Counter 20G at planting time using its moderate rate (7.5 lb/ac) plus a postemergence application of Thimet 20G at its lower (4.9 lb/ac) rate at 5 days before peak fly activity. This combination generated $304 more revenue than when the same rates of Counter and Thimet were used, but the Thimet was applied earlier (i.e., 11 days pre-peak). In general, revenue increases from applying Thimet later (i.e., 5 days vs. 11 days pre-peak) in this trial ranged from $50 to the aforementioned $304/ac. Thus, even under the moderate SBRM pressure that existed at the

Thompson location, dual-insecticide pest management programs clearly paid for themselves in additional gross revenue.

The single planting-time insecticide treatments at Thompson also provided cost-effective control and strong revenue increases above the untreated check that ranged from $69 to 102/ac for the 8.9- and 7.5-lb/ac rates of Counter 20G, respectively. The trend of slightly less revenue with the higher planting-time rate of Counter was observed with both planting-time-only as well as dual-insecticide programs involving later-applied postemergence Thimet at this location. This could suggest that using a moderate rate of Counter 20G at planting and combining it with a postemergence application of Thimet at either 4.9 or 7 lb/ac about one week before peak SBRM fly activity could optimize performance. More research may be needed to better understand this approach to sugarbeet root maggot control.

As observed in previous years of testing, the results of this experiment showed that combining at-plant Counter 20G with postemergence applications of Thimet 20G provides effective control of the sugarbeet root maggot. Although general trends suggested slightly better control and yield/revenue benefits when Thimet 20G was applied later (i.e., 5 to 7 days before peak fly activity), statistically significant differences related to Thimet application timing and rate were rare among the two study locations. This supports previous testing on similar dual-insecticide treatment regimes, and suggests that growers have a relatively wide (i.e., 1- to 2-week) window of flexibility in relation to when the Thimet must be applied to achieve effective SBRM control. The additional economic returns from postemergence insecticide applications in this experiment provide ample justification for the use of these materials to provide additive control of the sugarbeet root maggot, even under moderate sugarbeet root maggot pressure such as that which occurred at the Thompson location. As such, effective SBRM management programs, such as those comprised of the dual-insecticide tactics tested in this experiment, will be essential to ensuring the profitability of sugarbeet production in areas affected by moderate to high infestations of this pest.

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