INTEGRATED CONTROL OF SUGARBEET ROOT MAGGOT BY USING RESISTANT GERMPLASM, AN INSECT PATHOGEN, AND AN INSECTICIDAL SEED TREATMENT

Mark A. Boetel[1], Professor
Stephan T. Jaronski[2], Research Insect Pathologist
Larry G. Campbell[3], Research Geneticist
Jacob J. Rikhus[1], Research Associate
Allen J. Schroeder[1], Research Specialist

[1]Department of Entomology, North Dakota State University, Fargo, ND
[2]USDA-ARS, Northern Plains Agricultural Research Laboratory, Sidney, MT
[3]USDA-ARS, Northern Crop Science Laboratory, Fargo, ND

Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is the most severe insect pest of sugarbeet in the Red River Valley (RRV). For more than four decades, many RRV sugarbeet growers have relied on granular and sprayable liquid insecticides belonging to the organophosphate and carbamate chemical classes for SBRM control. Unfortunately, both of these classes employ the same mode of action (i.e., acetylcholinesterase inhibition) for insect control. Although other control tools, including neonicotinoid seed treatment insecticides (e.g., Cruiser 5FS, NipsIt Inside, and Poncho Beta) and a pyrethroid sprayable liquid (MustangMaxx) have been labeled for use in sugarbeet in recent years, none of these alternatives have proven as efficacious as the conventional organophosphates and carbamate products.

Growers in areas frequently plagued by high to severe SBRM infestations typically need to apply additive postemergence insecticide treatments to achieve good control of this pest. Unfortunately, those applications also have mostly involved additional use of organophosphate insecticides, which continues to exert increased selection pressure on SBRM populations for the potential development of insecticide resistance to these materials. This concern has been the impetus for an ongoing pursuit of discovering effective alternatives for root maggot control.

This investigation was carried out during the 2014 growing season to evaluate the following for SBRM management in the Red River Valley growing area: 1) a granular formulation of the fungal insect pathogen, *Metarhizium anisopliae* (Metschnikoff) Sorokin; 2) an experimental SBRM-resistant sugarbeet variety; 3) Poncho Beta insecticidal seed treatment; and 4) integrated programs comprised of various combinations of these alternative control tools.

Materials and Methods:

This research was carried out at a commercial grower field site near St. Thomas (Pembina County), ND during the 2104 growing season. The experiment was planted on 4 June, 2014 by using a 6-row John Deere™ 71 Flex planter. The planter was adjusted to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Betaseed 89RR83, a glyphosate-resistant sugarbeet seed variety, was used as the susceptible commercial cultivar, and an unnumbered SBRM-resistant variety, developed by co-author L.G.C. (USDA-ARS, NCSL, Fargo, ND) was the only maggot-resistant material used in the trial. Each plot was 6 rows (22-inch spacing) wide with the 4 centermost rows treated. The outer "guard" row on each side of the plot served as an untreated buffer. Each plot was 35 feet long, and 25-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.

Poncho Beta was used for all insecticidal seed treatment entries, and it was applied to seed by a custom seed-coating company (Germains Seed Technology, Fargo, ND). To avoid cross-contamination of seed between treatment applications, planter seed hoppers and seed dispensation equipment were completely disassembled, cleaned, and re-assembled after the application of each treatment.

Counter 20G was included in the trial as a planting-time granular insecticide standard at both moderate (7.5 lb) and high (8.9 lb product/ac) rates for comparison with the alternative integrated control entries. All granular treatments were applied by using band (B) placement, which consisted of a 5-inch swath of granules applied to each row through Gandy™ row banders. Granular output rates were regulated by using planter-mounted Noble™ metering units that were calibrated on the planter before planting.

Root injury ratings: Root maggot feeding injury was assessed in all plots on 6 August. Ratings consisted of 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: Treatment performance was also compared on the basis of sugarbeet yield parameters. Plots were harvested on 24 September. Immediately before harvest, the foliage was removed from all treatment plots by using a commercial-grade mechanical defoliator. After defoliation, all beets from the center two rows of each plot were extracted from soil 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 harvest samples were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2008). Treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

Results from this trial indicated that a relatively high SBRM infestation was present, as injury ratings in the untreated ("Susceptible") check plots averaged 7.68 on the zero to nine scale of Campbell et al. (2000) (Table 1). Counter 20G, applied at its highest labeled rate (8.9 lb product/ac) resulted in the greatest level of root protection from SBRM feeding injury in this trial. This entry reduced SBRM feeding injury over that in the susceptible check by 4.95 on the 0 to 9 scale, and was statistically superior to all treatments, except the moderate (7.5 lb/ac) rate of Counter 20G. The best alternative, integrated control program in this experiment with respect to root protection consisted of a combination of SBRM-resistant germplasm, combined with Poncho Beta seed treatment, and the MA1200 fungal bioinsecticide. This entry was not statistically outperformed by the moderate (7.5-lb) rate of the chemical standard, Counter 20G, but it provided significantly better root protection than Poncho Beta alone, Poncho Beta+MA1200, MA1200 alone, and the susceptible check. The only entries in this trial that failed to provide significant levels of root protection when compared to the check included the following: Poncho Beta+MA1200 and MA1200 alone.

Table 1. *Larval feeding injury* in an assessment of integrating biocontrol fungus granules, host plant resistance, and an insecticidal seed treatment for sugarbeet root maggot control, St. Thomas, ND, 2014

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G	B	8.9 lb	1.8	2.73 f
Counter 20G	B	7.5 lb	1.5	2.85 ef
Resistant line + Poncho Beta + MA1200	--- Seed B	20 lb	68 g a.i./ unit seed	4.15 de
Resistant line + Poncho Beta	--- Seed		68 g a.i./ unit seed	4.58 d
Resistant line + MA1200	--- B	20 lb		4.88 cd
Resistant line	---	---	---	5.23 bcd
Poncho Beta	Seed		68 g a.i./ unit seed	6.10 bc
Poncho Beta + MA1200	Seed B	20 lb	68 g a.i./ unit seed	6.30 ab
MA1200	B	20 lb		6.48 ab
Susceptible (check)	---	---	---	7.68 a
LSD (0.05)				1.40

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; Seed = insecticidal seed treatment

Yield results from this trial on integrated programs for SBRM control are presented in Table 2. Sucrose yields and root yield values closely corresponded to root injury rating results. For example, there was no significant difference in performance between the moderate (7.5 lb product/ac) and high labeled rate (8.9 lb) of Counter 20G with regard to recoverable sucrose, root tonnage, or percent sucrose. Also reflective of root injury data was that the three-way integrated control program consisting of the SBRM-resistant line, Poncho Beta, and MA1200 was not significantly outperformed in root tonnage yield by the 7.5-lb application of Counter 20G. Additionally, combining the resistant line with Poncho Beta (i.e., without MA1200) resulted in recoverable sucrose and root yields, as well as a sucrose percentage that was not significantly different from those of Counter at 7.5 lb per acre.

Table 2. *Yield parameters* in an assessment of integrating biocontrol fungus granules, host plant resistance, and an insecticidal seed treatment for sugarbeet root maggot control, St. Thomas, ND, 2014

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	B	8.9 lb	1.8	6460 a	24.7 a	14.48 bc	510
Counter 20G	--- B	7.5 lb	1.5	5984 ab	22.5 ab	14.53 bc	487
Resistant line + Poncho Beta	--- Seed		68 g a.i./ unit seed	5095 bc	19.7 bc	14.48 bc	390
Resistant line + Poncho Beta + MA1200	--- Seed B	20 lb	68 g a.i./ unit seed ---	4831 cd	19.4 bc	13.98 cd	335
Resistant line	---	---	---	4710 cd	16.8 cd	15.43 a	426
Poncho Beta + MA1200	Seed B	20 lb	68 g a.i./ unit seed ---	4600 cd	18.4 cd	13.93 cd	324
Poncho Beta	--- Seed		68 g a.i./ unit seed	4526 cd	17.6 cd	14.28 cd	344
Resistant line + MA1200	--- B	20 lb	---	4508 cd	16.4 cd	15.08 ab	392
MA1200	B	20 lb	---	4341 cd	17.1 cd	13.98 cd	318
Susceptible (check)	---	---	---	3918 d	16.0 d	13.65 d	259
LSD (0.05)				1008	3.4	0.68	

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; Seed = insecticidal seed treatment

Alternative control programs, consisting of either single, or combined management tools, resulted in gross revenue benefits that ranged from $59/ac for the stand-alone application of MA1200 to $131/ac for the integrated program consisting of the resistant line plus Poncho Beta seed treatment. However, the conventional chemical insecticide entries, consisting of single planting-time applications of Counter 20G, generated revenue benefits of $228 to $251/ac, depending on the rate applied. Irrespective of these differences in potential revenue between alternative and conventional control programs, these results suggest that sugarbeet production might be sustainable if conventional organophosphate insecticides were, at some point in the future, removed from federal registration; however, this is not a certainty, as the input costs of these alternative control tools is not yet known.

It should be noted that wet seedbed conditions persisted during early spring of 2014, and this prevented plot planting until 4 June, which was only 19 days before peak SBRM fly activity in the area. This, combined with higher-than-average fly activity that persisted for several weeks at this site, probably diminished the overall performance of all control programs tested in this trial. This could be especially true for the alternative programs that included the application of live fungus conidia (i.e., the resting stage of fungi). A longer interval between fungus-treated granule applications and the SBRM larval feeding period could have potentially allowed for increased fungal sporulation and, consequently, more likelihood of larval contact with active spores, which could have led to more infection and SBRM larval mortality. As such, this research should be repeated by pursuing a more typical (i.e., late-April to early May) planting date to more accurately and realistically test the pest management potential of these various integrated control strategies.

References Cited:

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