Project Proposal
Sugarbeet Research and Education Board of MN & ND
FY 2018-2019

Project Title: "Sugarbeet Insect Biology and Control"

Project Number/Description: (Project #8; continuation)

This project is a multi-faceted research program aimed at improving existing tools and developing new technology to monitor and control the major insect pests of sugarbeet in our region. Our overriding goal is to equip growers with key decision-making information to effectively manage these pests while maintaining profitability and minimizing negative impacts on the environment.

Project Leader:

Dr. Mark Boetel, Professor of Entomology
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Other Personnel Involved:

Allen Schroeder, Research Specialist, NDSU Entomology

Jacob Rikhus, Research Specialist, NDSU Entomology

Dr. Larry Campbell, Research Geneticist, USDA-ARS

Terry Lunde, Agriculturist, MinnDak Farmers Cooperative

Dr. Erik Wenninger, Associate Professor, University of Idaho

summer aides

Project Locations:

1. Trials on discovery and optimization of root maggot control tools will be conducted in **South St. Thomas Township,** an area that annually produces the Valley's highest infestations of the pest.

   A second, smaller set of root maggot control trials is proposed for a moderately infested location. The site is expected to be located in **Grand Forks County, ND** to save on travel costs.

2. Spensa® automated smart insect trap technology will be evaluated at 2 locations (**Pembina and Grand Forks counties in ND**, and at one location in **Minidoka County, ID**).

3. The sugarbeet root maggot fly monitoring network will involve 30 to 40 trapping sites **throughout the Red River Valley in MN and ND** (from Baker/Sabin, MN north to near the U.S./Canadian border) to identify hotspots and provide growers and crop advisors with near-real-time updates.

4. The springtail control site will be selected by conducting pre-season soil sampling in several fields to select a location. Sites to be sampled include one field near **Hillsboro, ND**, and samples will also be collected at **NDSU's Prosper Research farm**.

5. Efforts to support development of an insect pest ID mobile app will involve collecting multiple images of sugarbeet insect pests and look-alike non-pest insects. This work will be conducted throughout the Red River Valley production area.

Justification for Research:

The sugarbeet root maggot (SBRM) is the most damaging insect pest of beets in the region. This pest is capable of causing up to 45% yield losses in the absence of effective control (Boetel et al. 2010). Extremely high sugarbeet root maggot infestations have plagued RRV growers in recent years.

- **The highest SBRM infestations in nearly 20 years occurred in 2015 (Fig. 1).**
- **Aggressive scouting and management affected a 63% reduction in fly counts by 2017.**
- **SBREB funding enabled NDSU research and Extension work that led to effective control**
- **Continued research is needed to develop new monitoring and control tools for this serious pest.**

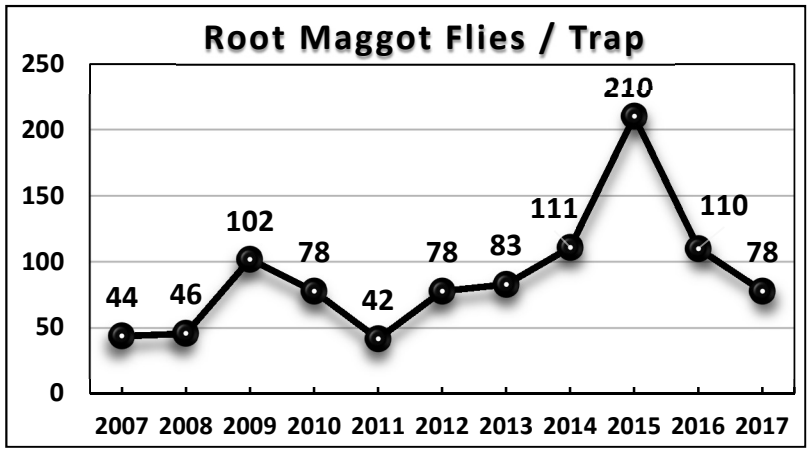

Figure 1. Average number of sugarbeet root maggot flies captured per sticky-stake trap by year, Red River Valley, 2007-2017.

CONTEXT STATEMENT: We conducted several labor- and time-intensive root maggot control tests near St. Thomas, ND in 2017. For the 2nd year in a row, severe weather compromised our research. A strong thunderstorm with damaging hail occurred on June 9 (during peak fly activity). It killed an estimated 40% of the population, but also likely washed off insecticides applied to several studies that day. Some studies had unusually low pressure, and the results of others lacked statistical differences. As such we request funding to repeat those experiments in 2018.

Justification (cont'd):

Sugarbeet Root Maggot Control Discovery and Optimization. A relatively small number of chemical pesticides are currently registered by the U.S. Environmental Protection Agency (EPA) for root maggot management. In 2016, the EPA proposed a complete ban on all uses of chlorpyrifos, the most commonly used foliar insecticide for postemergence control of the root maggot in the Red River Valley (Lueck et al. 2016). Although a final decision has not been made on this, it is critical that we develop new alternative insecticidal approaches for postemergence root maggot control. Our research has shown that **at-plant insecticide protection**, regardless of whether it is in the form of a granular, sprayable liquid, or a seed treatment, **cannot provide acceptable root maggot control** under the severe infestation levels that annually plague growers in the central and northern RRV.

Another concern is that, with so few root maggot control options, RRV sugarbeet producers have had to rely heavily on the same insecticide mode of action (i.e., acetylcholinesterase [ACHE] inhibition) to manage this pest for 40+ years. In areas affected by severe SBRM infestations, it is common for fields to receive two to three applications of these materials each growing season to achieve satisfactory control. This long-term pattern of repeated use of ACHE-inhibiting insecticides has exerted intense selection pressure on RRV root maggot populations for the development of insecticide resistance. Research is critically needed to develop alternative strategies for root maggot management to ensure the long-term sustainability and profitability of sugarbeet production for growers affected by this pest.

Spensa® Technologies smart, automated insect monitoring/mapping technology. The goal of this proposed work is not to identify a better trap, but rather to determine if counts from these traps can be positively correlated with those from conventional sticky stake traps. If so, this technology could vastly increase our capability to broadly monitor root maggot fly populations throughout the growing area. It could also greatly increase the site-specific precision of our root maggot mapping and forecasting activities. It is conceivable that, if this technology is demonstrated to provide effective numerous individual growers may be able to deploy traps in their own fields to monitor fly activity on their individual farms. Growers could also volunteer to provide their data to NDSU for additional observations to use in the annual root maggot population forecast.

Root Maggot Fly Count Network. Major increases in root maggot populations during the mid-2000s prompted NDSU to expand the root maggot fly monitoring network from about 10 to 12 fields annually to over 35 fields per year beginning in 2007. The program has since been enhanced to include near-real-time online posting and GPS mapping of fly counts to provide growers and crop advisors with area-specific and timely information on fly activity and emerging hot spots. This information has been very well received by growers, and it has been viewed as a critical component to management decision-making in areas affected by this pest. As such, we suggest that this activity be continued.

Springtail control tools. Springtails can also be a major pest problem for Red River Valley sugarbeet growers. These pests are most problematic in fields with heavy-textured, high-organic matter soils (Boetel et al. 2001). Previous research suggests that springtails are capable of causing gross revenue losses of nearly $500 per acre if not properly controlled (Boetel et al. 2007). Additional research is needed to identify alternative tools for springtail control because neonicotinoid seed treatment insecticides are under increasing scrutiny regarding toxicity to pollinators such as honey bees. Additional information on springtail biology is also needed to develop effective tools to manage them.

Insect pest ID mobile app. We were recently contacted by software engineers from Myriad Mobile, a mobile device application design company, to consider collaborating with them on developing a mobile app for insect pest identification. We envision that, if successfully developed, this app would be a welcome diagnostic tool for growers, sugar cooperative agriculturists, crop scouts, and university Extension personnel.

The ***research*** portion of this proposal involves multiple insecticide performance trials on important insect pests in our region. Much of this work is aimed at optimizing the use of registered tools (granular insecticides, seed treatment, postemergence sprays, etc.) for insect management. The advances we hope to make are significant improvements on existing pest management tools to make them more effective or more economically sound. Additional work involves screening new, unregistered experimental insecticides and alternative control techniques for managing insect pests. All proposed research is designed to improve the overall sugarbeet industry in MN and ND by equipping growers with unbiased, research-based knowledge for effective control of major insect pests.

The ***Extension/Outreach*** benefits to producers from this program largely involve the delivery of new pest control knowledge through winter grower seminar presentations, fact sheets, newsletter articles, radio interviews, and summer field day tours. Other Extension delivery includes updates to the *Sugarbeet Production Guide* and the *ND Insect Management Guide*, as well as articles in the annual "*Research and Extension Reports*" publication. One key example of a major Extension arm of this project is our annual project on in-season modeling, survey, and mapping of sugarbeet root maggot populations. This also helps generate the ***root maggot forecast map*** for the subsequent year.

In summary, most of this proposal involves insect pest management research because the profitability of many Minnesota and North Dakota sugarbeet growers is annually at risk of economic loss due insect pest damage. In addition to the SBRM, other important insect pest threats include wireworms, springtails, *Lygus* bugs, cutworms, white grubs, and root aphids. Economic impacts of insect pests can include input costs associated with replanting, yield and revenue losses, control costs, and storage losses. Some pests occur sporadically and are difficult to predict. This unpredictability has resulted in a lack of solid data regarding control of some pests. Therefore, it is important to aggressively pursue research on controlling sporadic pests when outbreaks occur.

Objectives:

1. ***Sugarbeet root maggot control discovery & optimization***

   a) Evaluate Movento®, a newly registered foliar insecticide, as a root maggot control tool

      i. Investigate how Movento® can be integrated into current root maggot control programs

      ii. Assess impact of Movento® application timing (i.e., peak fly vs. 1 & 2 weeks pre-peak)

      iii. Combine Movento® with other postemergence sprays (e.g., Lorsban Advanced)

   b) Screen experimental materials and commercially available products that are not currently labeled for use in sugarbeet.

      i. Veratran D (a botanical insecticide containing Sabadilla alkaloids)

      ii. Ecozin Plus 1.2%ME (azadirachtin, an insect antifeedant and growth disruptor)

      iii. Vydate C-LV (a promising carbamate insecticide)

      iv. Evergreen Crop Protection 60-6EC (a pyrethroid insecticide plus a synergist)

      v. Warrior II with Zeon technology (microencapsulated pyrethroid formulated with a protectant to extend residual activity and provide controlled active ingredient release over time)

      vi. Captiva (an insect repellent)

      vii. *Vectobac / Aquabac G* (*contains Bacillus thuringiensis* var. *israelensis* [*Bti*], a bacterial insect pathogen with specific activity against larvae of fly species)

   c) Improve conventional insecticide programs in response to recent label changes (*10-day mandatory interval between Lorsban spray applications*)

      i. Test Lorsban Advanced spray rates and timings (varied 10-day pre- and post-peak)

      ii. Assess the efficacy of rotating other registered post sprays (e.g., Mustang, Asana) with Lorsban Advanced to allow for shorter spray intervals (closer to peak fly)

      iii. Evaluate intensive, 3-tiered programs (granular or seed treatment insecticide at planting + a postemergence granule + a single peak-fly liquid insecticide spray)

   d) Optimize at-plant insecticide rates to: 1) minimize phytotoxicity to sugarbeet seedlings; and 2) achieve sufficient protection from sugarbeet root maggot injury (in combination with post-applied insecticides).

   e) Determine the most effective postemergence programs to use when an insecticidal seed treatment is used at planting, and evaluate dual at-plant combinations of a seed treatment and a granular insecticide at planting time.

   f) Collaborate with Dr. Larry Campbell (USDA/ARS) to assess the World *Beta* germplasm collection for host plant resistance to maggot feeding and use in future sugarbeet breeding

2. **Spensa® Technologies smart, automated insect monitoring/mapping technology**
   - **a)** Compare experimental “smart” trapping technology with conventional sticky stakes
   - **b)** Test two Spensa® traps: 1) Sentinel camera trap; and 2) the Z-trap
   - **c)** Assist manufacturer with developing species-specific classifier to generate accurate counts
   - **d)** Evaluate Spensa® Technologies hardware (accuracy of insect identification)
   - **e)** Assess the associated software (mapping, data management, etc.)

3. ***Sugarbeet root maggot fly monitoring network, mapping, and population forecast***
   - **a)** Conduct extensive surveys (30-45 sites) of root maggot fly activity to provide producers with frequent (3 times/week) real-time updates on outbreak locations throughout Red River Valley
   - **b)** Post fly counts and maps on NDSU website (same-day reports for near-real-time reporting)
   - **c)** Use NDSU developmental model to predict timing of peak sugarbeet root maggot fly activity and update growers on proper timing of postemergence insecticide treatments
   - **d)** Communicate breaking information to sugar cooperatives for timely alerts to growers
   - **e)** Combine fly count and damage rating data to develop root maggot forecast

4. ***Springtail control tools***
   - **a)** Screen experimental seed treatment insecticides
   - **b)** Evaluate performance of registered seed treatment and granular insecticides (varied rates)

5. **Insect pest ID mobile app**
   - **a)** Collect digital imagery of common sugarbeet insect pests from multiple angles and under varied light/background conditions
   - **b)** Collect similar imagery of look-alike, non-pest insect species
   - **c)** Consult with Myriad Mobile personnel on development of a user-friendly insect ID app
   - **d)** Test and provide feedback on the app

Materials and Methods: Most of the proposed work will be carried out by Dr. Boetel and research specialists Allen Schroeder and Jacob Rikhus. Summer aides will be hired for the summer to assist with insect monitoring, stand counts, hand-weeding, plant thinning, plot maintenance, and data entry.

1. ***Sugarbeet root maggot control*:**

   Multiple control tools (e.g., repellents, biorational insecticides, conventional registered and experimental granular, liquid, and seed treatment insecticides, etc.) will be compared for root maggot control efficacy. Granular and liquid insecticides will be applied using conventional equipment. Seed treatments will be applied by Germain's Seed Technology (Fargo, ND).

   Special emphasis in this objective will be made on optimizing the effectiveness of postemergence insecticides to augment the moderate control provided by seed treatment materials. **This is especially critical, given that there is now a federal label requirement for a 10-day interval between successive applications of all chlorpyrifos-based (Lorsban and generic) liquid sprays.** As such, our proposed research involves integrating other liquid sprays (Asana, Mustang, Warrior II, etc.) to use in alternation with chlorpyrifos-based products like Lorsban.

   Other research will be conducted to screen wild sugarbeet relatives from the USDA-ARS *Beta* germplasm collection for resistance to root maggot feeding injury. This will involve evaluating about 30 accessions we receive from the National Plant Germplasm Coordinating Committee.

   All experiments under this objective will be established using conventional equipment for seedbed preparation, planting, insecticide applications, and harvest. Each trial will be replicated a minimum of four times. Insecticide performance will be assessed by rating ten roots (5 from each of the two outer rows) according to the 0 to 9 rating scale (Campbell et al. 2000). In mid- to late-September, 2 rows of each plot will be harvested to compare root yield, recoverable sucrose, percent sucrose, and estimated gross revenue.

2. **Spensa® Technologies smart, automated insect monitoring/mapping technology:**

   Twelve traps (4 Sentinel [camera-based] traps & 8 Z-trap sensor-based traps) would be deployed along the edge of a sugarbeet field in Pembina County. Four experimental traps of each type would be paired with and compared side-by-side with the currently used sticky-stake traps in a replicated, randomized complete block design. The remaining four Z-traps would be baited with a root maggot pheromone, developed by Dr. Erik Wenninger in collaboration with Dr. Boetel and others (Wenninger et al. 2017), to attract root maggot flies into the traps.

   The Spensa® software collects count and location data, and communicates the information via cellular communications technology. The camera trap is trained to "visually" recognize the target insect, and records the number of target insects enter the trap. The Z-trap employs hardware similar to that of a "bug zapper". The fly is attracted by the pheromone and enters the trap, and when it makes contact, an electrical current is evaluated by the software in the unit. Calibration is based on the impedance value of the target species.

   Before traps are deployed, software of both types will be calibrated to develop a root maggot fly-specific classifier (artificial intelligence/learning technology) to ensure that they count only sugarbeet root maggot flies and can distinguish them from other fly species common to sugarbeet fields (stable flies, house flies, etc.).

3. ***Sugarbeet root maggot fly surveys, online mapping, and population forecasts*:**

   The NDAWN (North Dakota Agricultural Weather Network) system will be used in combination with the NDSU root maggot model for site-specific forecasting of peak fly activity. Sticky stakes (Blickenstaff and Peckenpaugh 1976) will be used to monitor fly activity levels in several (30-40) grower fields throughout the entire Red River Valley growing region.

   Data will be posted on the NDSU Entomology website 3 times per week to give growers and crop advisors near-real-time updates on outbreaks and control recommendations. Updates will be communicated via the *North Dakota Crop & Pest Report* and *Sugarbeet Radio*. Breaking information may also be communicated via "text alerts" through agricultural staff from the affected sugar cooperatives. Follow-up surveys of root injury at each fly monitoring site will be overlaid with mapping data to generate next year's root maggot risk forecast.

4. ***Springtail control research*:**

   Pre-season soil sampling will be used to determine the best location(s) for success of these experiments aimed at evaluating tools for springtail control. Plots will be established using conventional equipment for seedbed preparation, planting, and insecticide applications. At-plant granular and liquid insecticides, and insecticidal seed treatments, will be compared for springtail control efficacy. Insecticide performance will be assessed by conducting stand counts on at least three dates, and assessing treatment impacts on root and sucrose yield, quality, and revenue.

5. ***Insect pest ID app*:**

   This would involve artificial intelligence gathered through machine vision and processed through machine learning. Digital imagery would be used to develop algorithms for the learning process. The app would be developed to employ a mobile device camera to scan an insect in the field and give the user a positive ID on the insect.

Time Line of Anticipated Accomplishments:

This proposed research involves field experiments to evaluate new technologies, treatment combinations, and other experimental concepts. Many of these studies are multi-year in design to provide reliable information on tools and strategies for monitoring and managing important insect pests of sugarbeet.

Preliminary preparations for the proposed research, including seed treating, plot planning, and procurement of research materials (e.g., pesticides, seed, safety equipment, sticky stakes & adhesive, flags, etc.) will be done in February/March. Calibration of granular insecticide rates and assembly/maintenance of field equipment will take place in March/April. Soil sampling and sample processing for springtails will be done in April to early May. Plots will be planted in early May. Harvest of all plots is anticipated to take place in mid-to late-September.

Annual monitoring of SBRM populations will begin in late-May and continue throughout the flight activity period, which usually ends in the first week of July. The information generated by this activity is critical to assist growers, agriculturalists, crop advisors, and extension personnel with up-to-date information on the need for and timing of postemergence insecticide applications. It also assists with making important control recommendations, and provides important information to formulate the root maggot forecast for the next year. As mentioned above, follow-up "ground-truthing", which involves rating all fly-monitoring fields for SBRM feeding damage, will be carried out in August and September.

Collection of imagery for the insect identification mobile app would be conducted throughout the growing season. Some imagery can be collected in the field while carrying out other research described in this proposal. Additional trips will be made to other locations as needed.

Field performance of insect (i.e., root maggot and springtail) control tools will be made available for viewing by the R&E Board and area producers through research and demonstration plot tours during the growing season. Results will also be presented to Research & Education Board members, growers, sugar cooperative agriculturists, extension/research personnel, and agricultural industry representatives at the annual "Sugarbeet Research Reporting Session" in January. Findings will also be published in the "Sugarbeet Research and Extension Reports" publication. Consistent findings will be incorporated into recommendations presented in the annual Sugarbeet Grower Seminars, and our key findings will be incorporated into Extension documents such as the "Sugarbeet Production Guide."

References Cited:

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Wenninger, E. J., S. Y. Emmert, K. Tindall, H. Ding, M. A. Boetel, D. Rajabaskar, and S. D. Eigenbrode. 2017. Aggregation behavior and a putative aggregation pheromone in sugar beet root maggot flies (Diptera: Ulidiidae). Journal of Insect Science. 17(1), 29: 1–9.

Itemized Budget:

Budget category	Subproject					
	1	2	3	4	5	
	Root Maggot Control Optimization & New Tools	Smart Technology for Insect Monitoring	Root Maggot Monitoring & Prediction	Springtail & Wireworm Control	Insect ID Mobile App	Category subtotals
Labor	18,750	2,000	10,500	3,000	1,000	35,250
Fringe benefits	1,875	200	1,050	300	100	3,525
Equipment (over $250)		3,300				3,300
Supplies	1,500	250	500	300		2,550
Travel (vehicle use, per diem, lodging, etc.)	15,500	1,000	10,500	1,000	700	28,700
Leases	14,000			2,000		16,000
Other (equipment maint./repair)	400			75		475
Subproject totals	$52,025	$6,750	$22,550	$6,675	$1,800	
					Total Funding Request:	**$89,800**