83rd ANNUAL PACIFIC NORTHWEST INSECT MANAGEMENT CONFERENCE

RESEARCH REPORTS

JANUARY 8 & 9, 2024

Portland, OR

**These are research reports only, NOT management recommendations.

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AGENDA

83rd ANNUAL

PACIFIC NORTHWEST INSECT MANAGEMENT CONFERENCE

January 8 & 9, 2024

(*EACH PRESENTATION IS ALLOTTED 15 MINUTES*) MONDAY, JANUARY 8TH	
SIGN-IN	*10:30 Am*
CALL TO ORDER BUSINESS MEETING *(JUDGES FOR STUDENT COMPETITION; TUMBLEBUG COMMITTEE, RECOGNITION OF SPONSORS)*	11:00 Am
SECTION I (3 REPORTS)	11:15 Am
BREAK/LUNCH	12:00 Noon
SECTION I (2 REPORTS) SECTION II (0 REPORT) SECTION III (0 REPORT) SECTION IV (2 REPORTS)	1:30 Pm
BREAK	3:00 Pm
SECTION V (0 REPORTS) SECTION VI (1 REPORT) SECTION VII (2 REPORTS)	3:15 Pm
TUESDAY, JANUARY 9th	
CALL TO ORDER	9:00 Am
STUDENT PRESENTATIONS (8 REPORTS) BREAK	9:00 Am 11:00 Am
SECTION VIII (1 REPORT) SECTION IX (1 REPORT) FINAL BUSINESS MEETING ADJOURN	11:15 Am 11:30 Am 11:45 Am

SECTION I
Invasive Pests, Emerging Pests, and Hot Topics of Interest

COMPATIBILITY OF ENTOMOPATHOGENIC NEMATODES WITH CHEMICAL INSECTICIDES FOR THE CONTROL OF *DROSOPHILA SUZUKII*

Sérgio da C Dias[1], Andressa L de Brida[1], Maguintontz C Jean-Baptiste[1], Luís G Leite[2], Sergio M Ovruski[3], Jana C Lee[4], Flavio RM Garcia[1,4]

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Drosophila suzukii (Matsumura) (Diptera: Drosophilidae) is a pest that reduces the productivity of small fruits. Biological control with entomopathogenic nematodes (EPNs) and chemical insecticides suppress this pest, but the compatibility of the two approaches together requires further examination. The objective of this study was to evaluate the compatibility of *Steinernema brazilense* IBCBn 06, *S. carpocapsae* IBCBn 02, *Heterorhabditis amazonensis* IBCBn 24 and *H. bacteriophora* HB with ten chemical insecticides registered for managing *D. suzukii* pupae. The longevity of any adult flies that emerged post-treatment was also evaluated. Nematodes of the genus *Heterorhabditis* were most efficient, causing mortality greater than 80%. The insecticides spinetoram, malathion, abamectin, azadirachtin, and lambda-cyhalothrin reduced the viability (% of living infective juveniles) of *S. carpocapsae* IBCBn02. Incompatibility bioassays, spinetoram, phosmet, and acetamiprid were compatible with all the nematodes according to IOBC/WPRS Class 1, harmless (causing less than 30% mortality), and lambda-cyhalothrin reduced the infectivity of EPNs on *D. suzukii* pupae the most, by 20, 24 10 and 20% among *H. bacteriophora* HB, *H. amazonensis* IBCBn24, *S. carpocapsae* IBCBn02 and *S. brazilense* IBCBn06, respectively. The isolate *H. bacteriophora* HB caused 78.75% mortality of *D. suzukii* pupae when used alone, and 88.75% mortality when combined with spinetoram. Nevertheless, there was no change in the longevity of surviving adults (only 0.63 days). The number of IJs varied from 262.6 when the ENPs were used in isolation to 45-182 when mixed with an insecticide. In particular, novaluron drastically reduced the number of IJs when combined with the isolate *H. amazonensis* IBCBn 24 by 269.62 IJs and *H. bacteriophora* HB by 217.73. The insecticide novaluron did not increase pupal mortality or adult longevity when combined with EPNs, but it did not negatively affect the action of the EPNs. The combined use of the EPNs and compatible chemical insecticides were additive, except for novalurom, which negatively affected the EPNs.

Planned for submission to the Journal of Economic Entomology

EMERGING PESTS OF BERRIES WITH MORE THAN SIX LEGS

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Historically, mites and garden symphylans have not been a recognized pest of blueberry anywhere. In general conditions where blueberries are grown, cooler, wetter, more humid conditions, are not conducive to their development. Approximately seven years ago, spider mites and broad mites, were recognized as a problem on blueberries in Georgia and then later in other areas of the southeastern U.S. Additionally southern red mite was documented as a pest of blueberries in Florida. More recently the blueberry bud mite, *Acalitus vaccinia*, has also become a serious problem in Florida. Mite problems on blueberries in the southeast were quite severe and resulted in an effort to develop the first registrations for miticides on blueberries. In 2017, two-spotted spider mites (TSSM) were noticed causing damage for the first time on Washington blueberries in Whatcom County. In 2018, TSSM damaged blueberries fields were more common than in 2017. There are two possible reasons for the outbreak of TSSM in Washington blueberries. First, northwest Washington had unseasonably hot and dry conditions which could have created environmental conditions conducive for TSSM. Second, it appeared that many of the outbreaks were in fields that were managed for companies that also produce export quality fruit. These companies are required to manage spotted wing Drosophila intensively and there have very intensive control programs for the insect pest. It is possible that the TSSM outbreaks are a result of intensive SWD management programs. However, both theories are speculation as no one has ever studied mites on blueberries in the Pacific Northwest.

In Washington, TSSM moves from the weeds mid-season and attacks the new foliage for about six weeks. During this time they feed on the leaves and young shoots that will form the basis for the bush for the next few years. Late fruiting varieties such as Bluecrop, Bluejay, Elliot, Legacy and Liberty can have reduced sizing of fruit. All varieties will have compromised canopy from feed damage, so mite damage from one year impacts productivity of the following years due to reduced canopy. There is one product registered on blueberries that has efficacy against mites, fenpropathrin (Danitol, Valent), but since it is a pyrethroid, it is also thought to ultimately flare mites and make mites a worse problem. It is not considered to be a viable alternative for mite control. Recent work by Schreiber, Walters and Walsh has documented resistance to bifenzate in raspberry.

Garden symphylan Symphylans, *Scutigerella immaculata*, are small, cryptic myriapods without eyes and without pigment. The body is soft and 2 to 10 millimeters (0.079 to 0.39 in) long, divided into two body regions: head and trunk. Symphyla are rapid runners. They are primarily herbivores and detritus feeders living deep in the soil, under stones, in decaying wood, and in other moist places where they feed on the root hairs and rootlets and can sometimes cause crop failure. The garden centipede, *Scutigerella immaculate*, can be a serious pest of vegetable crops and tree seedlings, and occurs in greenhouses as well as agricultural situations. Symphylans have been reported as living up to four years, and molt throughout their lifetimes

While this pest has been known as a pest of blueberry, it has not been a pest of consequence in Washington until the planting of blueberries spread to areas not previously planted to the crop, particularly in cooler, wetter and/or heavier soils. Young plant roots that are fed on by the symphylans will either grow slowly, or become weakened, and succumb to other forms of pestilence.

The presentation will cover recent efforts to develop pest management tools for two-spotted spider mites in blueberry and raspberry and garden symphylan on blueberry.

STINK BUG IS AN EMERGING PEST OF POTATO

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Anecdotal grower information and photographic evidence from Dr. Andy Jensen indicated that stink bug was starting to appear on potato in the central Columbia Basin. In 2021 and 2022, stink bug was a significant pest of Clearwater potato on a single large potato farm east of Warden Washington. The grower applied insecticides to hundreds of acres of potatoes. Basic biological observation and a failed efficacy trial were carried out in 2022. In 2023, widespread economic damage from stink bug occurred in Grant and Walla Walla counties of Washington and Murrow County of Oregon. Thousands of acres were treated, most commonly pyrethroid insecticides, in July and August. The stink bug was identified as belonging to the genus *Chlorochroa* but it was not possible to identify to the pest to species. Curiously, insects from the same genus have recently started to become a pest of apples. In 2023, the first ever efficacy trial against stink bug in potatoes was completed.

Results and Discussion

No phytotoxicity was observed on potato by any treatment. Stink bug population was very uniform and consistent over the course of the trial Overall populations were moderately low. It would have been ideal to have a higher populations but locations with higher populations required immediate treatment by the grower. Only in a lower population situation were we allowed to conduct an efficacy trial before the field was treated commercially. The researchers went with the concept of half a loaf of bread is better than no loaf.

While the stink bug population in untreated plots maintained steady around 2 per plot (after 20 sweeps), all treatments showed significant reduction by 7 DAA (Table 1 column 3) with the lowest counts in Hero EC treated plots at 0.3 per plot, to the highest counts of 1.3 per plot in Assail 70WP treated plots.

This trend was maintained at 9 DAA, and for cumulative study total counts.

Overall, all treatments resulted significant (at P=0.05 LSD) reduction for total counts per plot (Graph 1) as compared to untreated check's 7 total counts (Table 1 column 6). Hero EC, Brigade 2EC, and Brigadier showed the best control with 1.3, 1.8, and 2 total counts per plot, respectively, around 76% efficacy compared to untreated. Most of the rest treatments resulted in 2.5 to 3.5 total counts, a range of 50% to 64% control efficacy. Assail 70WP appears to be the least efficient treatment with a total of 4.5 stink bug counts per plot, a 36% control efficacy, although this reduction is still statistically significant.

In summary, all the tested products showed good control of stink bug in this trial. The most effective treatments are: Hero EC, Brigade 2EC, Brigadier, Mustang Maxx, and Scorpion. Assail 70WP, Malathion, Rimon, Torac, and Cormoran showed relatively lower efficacy yet still strong enough to provide significant stink bug population reduction.

Table 1. Treatment effect on stink bug counts at different timings.

Rating Date			8/1/2023	8/4/2023	8/8/2023	8/10/2023	8/17/2023	
Rating Type			count	count	count	count	count	total count
Rating Unit/Min/Max			#, -, -	#, -, -	#, -, -	#, -, -	#, -, -	#, -, -
Sample Size			10 sweep	10 sweep	10 sweep	10 sweep	10 sweep	10 sweep
Collection Basis			1 plot	1 plot	1 plot	1 plot	1 plot	1 plot
Number of Subsamples			1	1	1	1	1	1
Crop Name			Potato	Potato	Potato	Potato	Potato	Potato
Pest Name			Stink bugs	Stink bugs	Stink bugs	Stink bugs	Stink bugs	Stink bugs
Days After First/Last Applic.			0, 0	3, 3	7, 7	9, 9	16, 16	
Trt No.	Treatment Name	Rate Rate Unit	Appl Code	1	2	3	4	5	6
1	Untreated			1.8a	1.8a	2.3a	2.3a	0.8a	7.0a
2	Hero EC	10.3fl oz/a	A	2.0a	0.0a	0.3d	0.8c	0.3a	1.3d
3	Scorpian	2.75fl oz/a	A	2.0a	0.5a	0.8bcd	1.3bc	0.3a	2.8bcd
4	Malathion F	1.25pt/a	A	2.0a	0.5a	1.0bc	1.3bc	0.5a	3.3bc
5	Dimethoate	1pt/a	A	2.0a	0.5a	1.0bc	1.3bc	0.3a	3.0bcd
6	Assail 70wp	3.4oz/a	A	2.0a	1.3a	1.3b	1.5b	0.5a	4.5b
7	Rimon	12fl oz/a	A	2.0a	0.8a	1.0bc	1.3bc	0.3a	3.3bc
8	Brigade 2EC	6.4fl oz/a	A	2.0a	0.0a	0.5cd	1.0bc	0.3a	1.8cd
9	Brigadier	6.14fl oz/a	A	2.0a	0.0a	0.5cd	1.0bc	0.5a	2.0cd
10	Torac	21fl oz/a	A	2.0a	0.8a	1.0bc	1.3bc	0.5a	3.5bc
11	Cormoran	12fl oz/a	A	2.0a	0.5a	1.0bc	1.3bc	0.5a	3.3bc
12	Mustang Maxx	4fl oz/a	A	2.0a	0.3a	0.8bcd	1.0bc	0.5a	2.5cd
LSD P=.05				0.21	1.06	0.71	0.59	0.66	1.96
Standard Deviation				0.14	0.74	0.49	0.41	0.46	1.37
CV				7.29	130.76	52.59	32.66	110.54	43.11
Levene's F^				0.758	0.641	0.659	0.327	0.402	1.09
Levene's Prob(F)				0.678	0.782	0.766	0.974	0.946	0.396
Replicate F				1.000	1.168	2.371	3.000	5.500	2.146
Replicate Prob(F)				0.4051	0.3367	0.0882	0.0445	0.0035	0.1131
Treatment F				1.000	2.027	4.138	3.273	0.500	4.740
Treatment Prob(F)				0.4671	0.0578	0.0007	0.0041	0.8894	0.0002

*STUDENT

Section I: Invasive Pests, Emerging Pests, and Hot Topics of Interest

Multi-year effects of erythritol solutions, an experimental treatment for Spotted-wing drosophila, on treated plants

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Spotted-wing drosophila (*Drosophila suzukii*) is a vinegar fly and an invasive pest of small and stone fruits, especially caneberries, cherries, and blueberries in the PNW. Its ability to oviposit in ripe and ripening fruit has resulted in significant economic damages to growers since its arrival on the West Coast in 2008. Erythritol is a naturally occurring sugar alcohol that has been shown to increase mortality at a dose-dependent rate in both *D. suzukii* adults and larvae when ingested. In the field, erythritol solutions are filtered and sprayed onto target plants as the fruits begin to blush. Non-target species such as honeybees and yellow jackets do not appear to be negatively affected by erythritol exposure, and fruit quality is not impacted by the erythritol treatments, making erythritol a candidate for wider testing. Previously, erythritol solutions have been observed to damage plants, causing desiccation and spotting on 1-17% of treated leaves inconsistent with mold, diseases, or other insect damage. Therefore, our objectives to were to compare visible damage and impact on plant function by applying various 1.5M erythritol solution combined with the attractive phagostimulants sucrose and sucralose, as well as a water-only control. In year one, the parameters of chlorophyll fluorescence, stomatal conductance, osmotic potential, and visual leaf damage were assessed by treating greenhouse blueberries, field cherries, field blueberries, and wild Himalayan blackberries with erythritol solutions. In year two, the multi-year effects of erythritol solutions were assessed with the same parameters in field cherries and field blueberries by re-treating year one plots. In addition, the individual effects of erythritol, sucrose, and sucralose solutions on plant function were assessed. Differences will be quantified by comparison amongst treatment groups.

Automated, image-based monitoring of spotted-wing drosophila using deep learning

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The invasive spotted-wing drosophila (SWD; *Drosophila suzukii*) costs the cherry and berry industry $718 M annually when unmanaged. Researchers have developed many traps and lures for monitoring SWD that rely on manual monitoring, but this is cumbersome and provides limited temporal resolution. While SWD can be present and abundant in berry crop landscapes, it also coexists with other species of *Drosophila* that do not cause crop damage, therefore accurate identification of flies, particularly females, is essential for management decisions. An automated trapping grid would provide growers with real-time decision aids, showing daily, seasonal and environmental patterns in pest activity. Monitoring female SWD will enable us to track: 1) early season activity since few males overwinter, 2) the response to insecticides as females are more resilient, and 3) reproductive trends by targeting gravid females with specific lures. We aim to develop an automated trap that can discriminate between SWD and other fly species in the field, and distinguish between SWD males and females.

We have developed a low-cost, computerized camera trap to study SWD dispersal (Fig. 1). A Raspberry Pi camera points down at a mesh trap filled with a white wine + apple cider vinegar lure (Fig 1A-B); flies walk on a fabric surface before entering one of a series of funnels. This imaging approach advantageously provides a standard, dorsal view of the flies at fixed position from the camera – exposing key anatomical features that should allow for species and sex discrimination. Images of male and female SWD (Fig. 1D,E) show a clear view of spotted wings and enlarged ovipositor in contrast to the *D. melanogaster* female (Fig. 1F). Our overall approach is to train a computer vision model with annotated image data that can identify and discriminate SWD males and females from other drosophilids through deep learning.

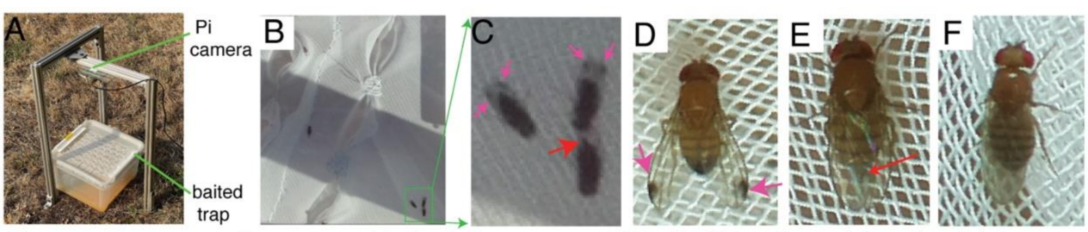

Figure 1. Camera trap images provide basis for automated ID of SWD males and females. (A) Computerized camera trap used to study SWD dispersal. (B) Trap surface image with original camera (Pi V2). Green box expanded in panel C. (C) Expanded view of two male SWD (spotted wings, pink arrows) and one female SWD (enlarged ovipositor, red arrow). (D) Male SWD image obtained with Pi HQ camera. (E) Female SWD (ovipositor,red arrow). (G) Female *D. melanogaster* lacks enlarged ovipositor.

To collect image data for model training, we set up the camera inside a clear wind tunnel (Fig. 2). We then released flies of one of the following categories: 1) SWD females (summer and winter morphs), 2) SWD males (summer and winter morphs), 3) *D. melanogaster* females, and 4) *D. melanogaster* males. We recorded continuously as the flies flew around the tunnel and eventually landed and walked around on the lure. To facilitate image annotation, we only released inside the tunnel one category of flies, and did not mix sexes or species for each individual recording session.

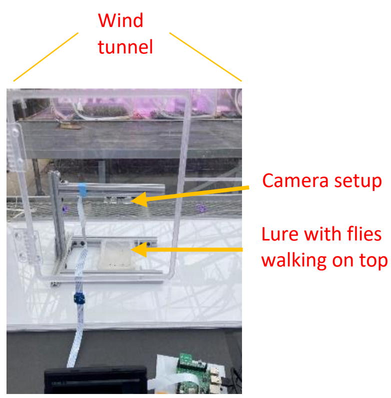

Figure 2. Camera setup used inside wind tunnel to record images of flies for model training.

Our approach to training the model involves sequential steps of refining object detection (to find flies), and object classification (to discriminate fly species and sex). We are fine-tuning a pretrained computer vision model for real-time object detection (YOLOv8; Redmon et al). After recording flies in the wind tunnel, we then converted these videos into thousands of still images and fed them to a previously trained model for object detection, which draws bounding boxes around flies (Fig. 3). After evaluating the object detection model, we found that sometimes the model failed to detect flies, or detected objects that were not flies (e.g., debris on the trap). Because of this, we manually sorted correct images, and used them to re-train the model and improve its fly detection capabilities. We then applied multi-object classification by training the model with the following classes (categories): 1) SWD females (summer and winter morphs), 2) SWD males (summer and winter morphs), 3) *D. melanogaster* females, and 4) *D. melanogaster* males. We are currently working on implementing and evaluating the object classifier that will enable the computer vision model to distinguish among all these categories.

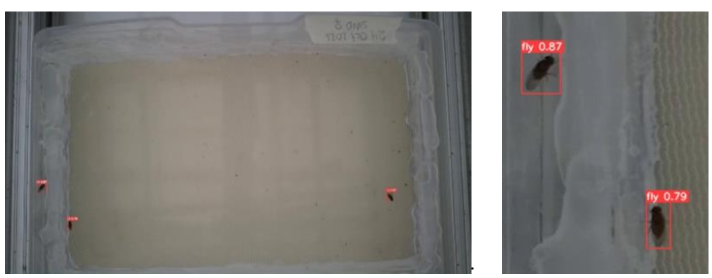

Figure 3. Object detection model draws bounding boxes around flies

This effort to automated monitoring of female SWD should enable growers to target management when and where exposure is greatest, and check resulting efficacy. This approach can potentially generalize to other insects and image-based agricultural questions.

Section I: Invasive Pests, Emerging Pests, and Hot Topics of Interest

*STUDENT: I want to be included in the student competition

Dispersive distance of DayGlo powder marked Euscelidius variegates (Hemiptera: Cicadellidae) in Oregon sweet cherry orchards

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Mark-release-recapture (MRR) experiments were conducted on Euscelidius variegates, the key cherry X-disease vector in The Dalles, Oregon, to evaluate their movement and dispersal in managed cherry orchards.

Adult leafhoppers were captured from cherry orchards using reversed leaf blowers, returned to the lab, sorted from bycatch, returned to the field, and marked with fluorescent powder, and released at multiple distances from a central sticky trap in two orchard sites (Figure 1). The marking method did not significantly affect the survival rate of E. variegates.

The overall release-recapture rate, based on six MRR experiments within a 4-meter range, was 1.25%. The highest recapture rate was observed at 1 meter away from the central trap, followed by a sharp decline in subsequent distances (Figure 2). The estimated maximum dispersal distance of the marked population was determined to be between 6 and 11 meters (Figure 3). Possible effects of drive roe ground cover are discussed. This research provides valuable insights into the movement patterns of E. variegates, and aids in the development of effective strategies for disease management and future IPM programs in Oregon cherry orchards.

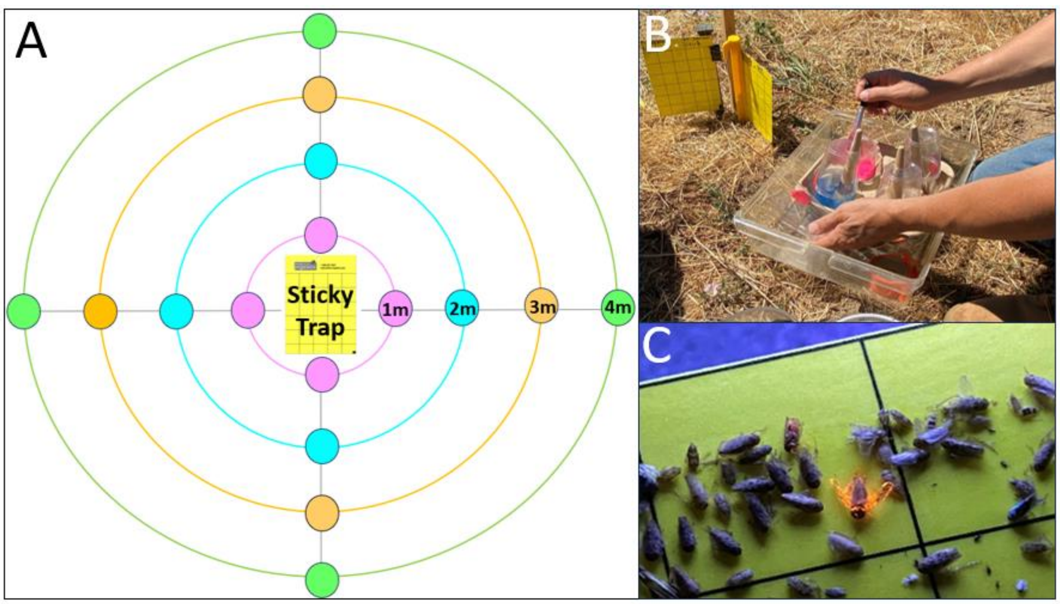


Figure 1. Yellow sticky trap with the arrangement of the marked leafhopper with their corresponding Day-Glo powder color and distance (A). Process of on-site leafhopper marking (B). Identification of marked leafhopper under ultraviolet light (C).

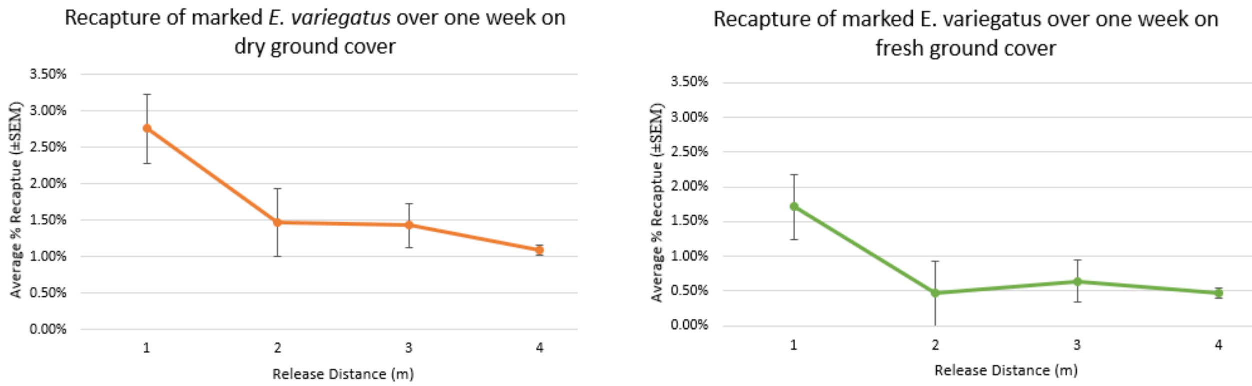
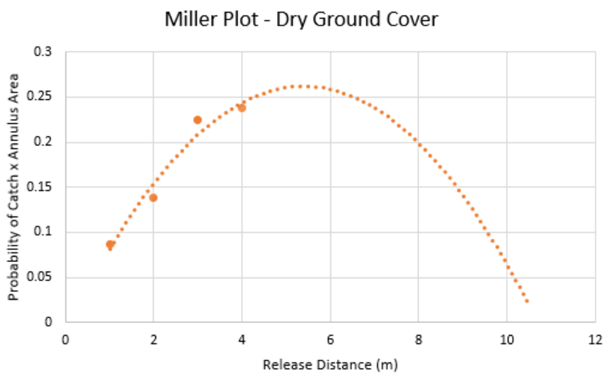


Figure 2. Recapture rate over four release distances of marked E.variegatus over one week in cherry orchard with dry and fresh ground cover conditions



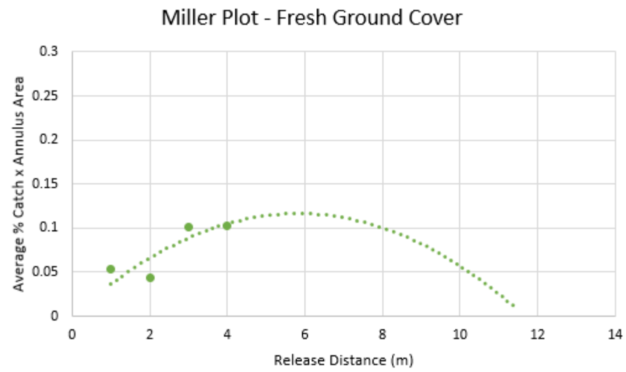


Figure 3. The miller plot showed the estimated maximum dispersal distance and density of the marked E.variegatus population in cherry orchard with dry and fresh ground cover conditions (Miller et al., 2015; Adams et al., 2017).

Reference:

Miller, J.R., Adams, C.G., Weston, P.A., Schenker, J.H., 2015. Trapping of small organisms moving randomly: principles and applications to pest monitoring and management. Springer.

Adams, C.G., Schenker, J.H., McGhee, P.S., Gut, L.J., Brunner, J.F., Miller, J.R., 2017. Maximizing Information Yield From Pheromone-Baited Monitoring Traps: Estimating Plume Reach, Trapping Radius, and Absolute Density of *Cydia pomonella* (Lepidoptera: Tortricidae) in Michigan Apple. J. Econ. Entomol. tow258. https://doi.org/10.1093/jee/tow258

Madagascar Hissing Roaches: Feeding and Behavioral Information of a Popular Insect Used in Extension Programs

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Madagascar Hissing Cockroaches have become a popular insect for K-12 extension work. They seem scary at first, with their loud hissing and armored appearance, but they are quite docile in nature, lacking the ability to fly or bite. Seeing people hold these daunting creatures without being harmed can help kids overcome their fears of insects. However, research indicates that cockroaches can have different personalities[1]. Does this finding extend to Madagascar Hissing Cockroaches? Thus, our study examined the feeding preferences of Madagascar Hissing Cockroaches, as well as interactive behaviors between males, females, and nymphs.

For this experiment, adult roaches were acquired from several sources (e.g., PetCo and Amazon). Individuals were randomly assigned into two different 15.5”x7”x9” plastic containers with ventilated lids. Each container had about an inch of soil on the bottom and several pieces of a cut-up egg carton as hides. They were fed every other day with lettuce, and they were given a solid water supplement (Zilla Cricket Drink). In addition, they were misted every day. The temperature was kept at 21^{o}C; however, a heat source was added during the colder months. Roaches reproduced under controlled conditions, and the first nymph batch emerged within a month. When the nymphs approached the 4th instar, five random females, five random males, and five nymphs were selected for the experiments. Two experiments were conducted using the software EthoVision by Noldus, using a plastic tub as an arena.

The feeding experiment focused on feeding preferences, which included the choice between lettuce, dog food, and banana, placed on different sections of the arena. Before the food experiment, roaches were introduced to each food source. Twenty-four hours before the experiment, all food was taken away. During the experiment, they were placed into the arena one at a time and monitored for time spent at each food source.

The behavior experiment tested different roach pairing responses. Treatments included male versus male, male versus female, male versus nymph, female versus female, female versus nymph, and nymph versus nymph. Before the pairing experiment, each roach was assigned a number and then placed in a covered petri dish overnight. When the experiment began, a random number generator was used to assign pairings, and each pair was monitored for time touching, huddling behavior, fighting behavior, and mating behavior.

The results indicate that there are significant differences in feeding preferences and behaviors between male, female, and nymph roaches. The results also suggest that there may be differences in the ways that Madagascar Hissing Roaches interact with each other based on age and gender.

1. Stanley, C. R., Mettke-Hofmann, C., & Preziosi, R. F. (2017). Personality in the cockroach Diploptera punctata: Evidence for stability across developmental stages despite age effects on boldness. *PLOS ONE*, *12*(5), e0176564. https://doi.org/10.1371/journal.pone.0176564

RECEPTOR INTERFERENCE

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The annual economic losses to agriculture by the hundreds of major arthropod pests are estimated to exceed $100 billion in the U.S. alone. If economic impacts on human health, the environment, and other non-target arthropods are included, losses will be even more. Invasive species have more impact because there are usually no or fewer competitors and natural enemies in the new ecosystem. The discovery of new insecticides to improve pest management is a long iterative process with high risk and low chances of success.

For decades, insect neuropeptides (NPs) and their G protein-coupled receptors (GPCRs), have been offered as biological targets for the development of new insecticides, because they are involved in many key biological processes in insects. A key roadblock to success has been how expensive chemistries can be efficiently screened for identifying active compounds.

New genomic and proteomic tools have advanced and facilitated the development of new approaches to insecticide discovery. We developed a novel GPCR-based screening technology that uses millions of short peptides generated by bacteriophages, and a method using an insect Sf9 cell expression system. The novel short peptides, as agonists or antagonist, could interfere with the target GPCR-ligand functions. This new mechanism is called 'receptor interference' (Receptor-i). The Receptor-i method offers several advantages, such as 1) the insect cell-based screening system rapidly leads to target-specific GPCR agonists or antagonists; 2) the delivery of bioactive peptides to target pests can be flexible, such as topical, ingested, and plant-incorporated; 3) a variety of GPCR targets are available, thus minimizing the development of potential insecticide resistance. The first proof-of-concept technology can be applied to all other GPCRs for invertebrate pests.

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SECTION II
Bees and Pollinators

DETECTION OF AN EXOTIC MASON BEE IN NORTH AMERICA

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In spring 2023, a citizen scientist made an iNaturalist accession in North Vancouver, BC of the European Orchard Bee, *Osmia cornuta* (Latreille), marking the first record of this species in a wild North American population. This confirmed *O. cornuta* record suggests the potential that the species will more broadly establish in North America - a possibility which we examine in this study. Understanding the range and establishment of *O. cornuta* (and other non-native mason bees) is important for protecting the abundance and habitat of native species. Indeed, the rapid North American range expansion of two non-native *Osmia* species – *O. cornifrons* and *O. taurus* has been linked to a decline in populations of the native *O. lignaria*.

To investigate the possible broader establishment of *O. cornuta*, we examined cocoons at Canada's largest beekeeping operation on Vancouver Island, <200 km from the coordinates of the iNaturalist accession. At this location we found a cache of suspected *O. cornuta* cocoons that we distinguished visually by size, color, and texture. We imaged all cocoons individually, then dissected, identified and sexed the adult bees, finding that 30 of the suspected Vancouver Island specimens were indeed *O. cornuta*.

A primary dispersal vector of mason bees is the commercial shipment of their cocoons for deployment in agricultural systems. This commercial shipment has led to the intermingling, and inadvertent shipment of *Osmia* species that have similar-looking cocoons. Because of this issue, we wanted to understand how *O. cornuta* cocoons physically compared with the *O. lignaria* and *O. cornifrons* cocoons. Using an automated image analysis pipeline we extracted several characteristics from cocoon images to determine how distinguishable these cocoons are from visual cues alone. Our results suggest that *O. cornuta* cocoons will be difficult to discriminate from native and naturalized species, posing challenges for commercial distributors interested in preventing the spread of non-native *Osmia*.

To investigate the invasiveness potential of *O. cornuta*, we evaluated the bee's habitat suitability across North America. To do this, we extracted a broad set of climate and vegetation measures for areas where *O. cornuta* is established (primarily in Europe) and used these to predict potentially suitable habitats for *O. cornuta* in North America. We find that areas of the Pacific Northwest and the eastern U.S. are likely suitable habitats for *O. cornuta*, raising the possibility for its rapid expansion in the coming years. Future research will focus both on the ecological effects of *O. cornuta* on other mason bees and plant communities as well as developing methods to control its inadvertent commercial spread.

SECTION III
Environmental Toxicology and Regulatory Issues

SECTION IV
Field Crop Pests

Section IV
Field Crop Pests (includes cereals and vegetables)

THE DECADES LONG SAGA OF REPLACING DI-SYSTON FOR CONTROL OF EUROPEAN ASPARAGUS APHD

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The European asparagus aphid, *Brachycornella asparagi*, is an obligatory feed of asparagus. Whilst feeding it injects a liquid that is highly toxic to the plant that if accumulated in high enough levels will kill the plant. This invasive species was introduced into Washington in the 1980s. The insect was exceedingly difficult to manage as there was no tolerance for the insect making biocontrol not an option. Most common insecticides such as neonicotinoids were not effective in its control due at least in part to the plant having essentially no foliage to uptake the product. WSU's Dr. Wyatt Cone helped develop disulfoton (Di-Syston), a highly effective systemic organophosphate insecticide, for control of the pest. Di-Syston was so effective and other products were comparatively ineffective, no other means of control were developed for control of the pest. As a result, Washington and any other grower in the U.S. facing this pest relied exclusively on this insecticides. In a typical year, Washington growers applied 1 to 2 applications of Di-Syston to every acre of asparagus.

In 1993, concerned with the overreliance on Di-Syston, Washington asparagus growers charged a newly minted Washington State University Assistant Professor of Entomology with finding alternative insecticides for control of European asparagus aphid. Over a period of ten years, with support from the Washington Asparagus Commission, Washington Commission on Integrated Pest Management and the IR-4 Project, an effective use pattern for lamba cyhalothrin, Warrior II, was developed. Use of the product was made available via the Section 18 process and during this period, the use of Di-Syston was cancelled. Concerned with only having a single product for control of aphids, growers directed an effort to find alternative methods of controlling the pest. Further complicating the process was the emergence of a fledgling organic asparagus industry in Washington. Research, against supported by the WAC and the WCIPM developed organic controls for the aphid. Management programs depended on tank mixes, high rates of applications and repeated applications of azadiractin (Aza-Direct) and pyrethrins (Pyganic). Additionally, loss of chlorpyrifos (Lorsban) on asparagus further disrupted efforts to control mixed assemblages of aphids and asparagus beetles

EPA would not permit new registrations of pyrethroids and as a result access to Warrior via the Section 18 process was disallowed after ten years. This presentation will focus on subsequent attempts to develop organic and conventional means to control European asparagus aphid and asparagus beetle.

*Student Competition

Section IV: Field Crop Pests

Integrating Host Plant Resistance for Corn Earworm Management in Hemp

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The reintroduction of hemp (*Cannabis sativa* L.) to the United States presents a formidable economic challenge in the form of infestations of corn earworm, *Helicoverpa zea* (Boddie) pest. The corn earworm pest is a major hindrance, particularly to floral hemp production systems, when pest larvae feed on the hemp flower buds. Their feedings cause extensive bud tunneling and lesions that eventually result in flower bud rot, thereby impacting flower and cannabinoid yield loss. Currently, Oregon hemp growers rely heavily on biological insecticides to manage corn earworms, and only a few insecticides are permitted for hemp use nationwide. Also, the current insecticide-based control methods do not provide full protection. Thus, it is important to establish additional integrated pest management tools, including host plant resistance. Three types of host plant resistance, antixenosis, antibiosis and tolerance, are known to influence the development and selection of resistant crop varieties. With consideration to host plant resistance types, we are evaluating various hemp germplasms for the possible roles of flower morphology, trichome structure, and flower chemical content (cannabinoid and terpene profiles) in relation to host plant resistance and/or host selection preferences in corn earworm.

Acknowledgments: This research project is supported by funding from USDA NIFA CPPM Applied Research and Development Program and USDA ARS Non-Assistance Cooperative Agreement.

Exploring Biological Control Methods in Corn Earworm Management Practices

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Corn earworm, *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae), is a serious pest in floral hemp production systems in Oregon. The pest larvae feed on flower buds causing wounds that allow environmental pathogen entry into bud tissue or affect nutrient transport to flower parts, and result in flower rot. This damage eventually affects flower cannabinoid and yield levels. Biological insecticides are currently being used for corn earworm management, but they do not provide full coverage and are costly as well. Hence, there is an urgent need to establish alternative pest management methods including biological control parasitoid agents that complement current insecticide-based control. The *Microplitis croceipes* (Hymenoptera: Braconidae) is a corn earworm-specific endoparasitoid and known to provide natural larval control in many economically important crops. However, there is limited information on *M. croceipes* ability to control corn earworm in hemp. In this project, we are exploring how parasitoids target corn earworms at varying larval life stages to cause elevated mortality.

Acknowledgments: This research project is supported by funding from USDA NIFA CPPM Applied Research and Development Program, USDA Western SARE, and USDA ARS Non-Assistance Cooperative Agreement.

Immunity related genes as biological targets in the gray garden slug *Deroceras reticulatum* infected with nematodes for the slug management

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Pest slugs are highly pestiferous and threaten global sustainable agriculture. Among them, the gray garden slug (*Deroceras reticulatum*), is a common terrestrial slug native to Europe with global distribution including North America, stands out as the predominant species and is commonly considered the most severe pest of vegetables and field crops. Slugs are commonly controlled by chemical bait pellets containing metaldehyde. In the past methiocarb was used, yet it is toxic to beneficial invertebrates and other nontarget organisms. In this study, we describe RNA-seq expression profiling of *D. reticulatum* whole body response to nematodes infection. *De novo* transcriptome was generated from the whole body of the slug-control and slug-nematode. Comparison of gene expression levels between slug-control vs slug-nematode revealed that a total of 517 unigenes were upregulated while 342 unigenes were downregulated and 175 downregulated. To further investigate the biological functions of different expression genes (DEGs), gene ontology (GO) and functional enrichment analysis were performed to map all the DEGs to terms in the GO, eukaryotic Ortholog Groups of proteins (KOG) and Kyoto Encyclopedia of Genes and Genomes Pathway (KEGG) database.

Among these DEGs, many genes and related pathways involved in immunity were identified in slug-control vs slug-nematode. These included genes mainly belonged to the Toll, Imd, JNK, scavenger receptors (SCRs), C-type lectins (CTLs), immunoglobulin-like domains and JAK/STAT63 signaling pathways. To confirm the gene expression patterns identified by the RNA-seq data, the transcript levels of 18 immune related DEGs were examined by quantitative real-time PCR (qRT-PCR). The results showed that the DEGs obtained from the *De novo* transcriptome sequencing data were in accordance with the gene expression profiles from RNA-Seq data. Our finding provides insights into the immune response of *D. reticulatum* underling the infection of nematodes which is valuable to understand how nematode affects the immune system of *D. reticulatum* and provide to identify biological targets using pathogenic nematodes for the development of new control methods for pest slugs in the field.

SECTION V
Potato Pests

SECTION VI
Small Fruit, Tree fruits and Nuts

*Student Competition

Section VI: Pests of Wine Grapes, Orchards

Optimizing Current Pheromone-Based Tools for Monitoring and Controlling Mealybugs in Vineyards

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Abstract

Grape mealybug (*Pseudococcus maritimus*) is a well-established pest of Oregon vineyards. Monitoring of the flying male adults is an important tool in timing control measures. The commercially available pheromone lures significantly improve the pest detection in vineyards. Optimizing these lures can help wine grape growers to adopt stronger monitoring practices and aid in timely effective pesticide applications. Another, wine grape pest, vine mealybug (*Psedococcus ficus*) is a recently detected invasive species with a quarantine status in Jackson County OR. Mating disruption is an effective vine mealybug control strategy in California but has not been tested under Oregon conditions. Our studies have two-fold objectives: 1) evaluating the efficacy of newly formulated lures compared to current standards for male adult grape mealybug detection 2) evaluating the volatilization rates of three commercially available vine mealybugs pheromone dispensers under Oregon conditions. Our grape mealybugs data show that the new lures detect significantly more males. For vine mealybugs mating disruption dispensers, we found a single product with highly uniform volatilization rates indicating a steady release of pheromones over time. The other products had greater variability in their volatilization rates. Implications and possible causes of this variability as well as future works are discussed.

Introduction

Due to the cryptic nature of mealybugs, monitoring with visual surveys can be costly and inaccurate. For this reason, highly specific lures utilizing sex pheromones have been successfully used to actively trap this pest for the past decade. However, these lures are an additional cost that growers may not be willing to pay. This cost barrier can hamper regional control and research efforts. Thus, a more cost-effective lure is highly desirable to enhance regional monitoring practices. We conducted field trials of two optimized lures vs the current grower's standard in grape mealybug infested southern Oregon vineyard. In addition to being a tool for monitoring, sex pheromones can also be used to disrupt mating. Dispensers which emit sex pheromones at low concentrations across an entire vineyard or wine growing region inhibit males from successfully locating a female, and thus effectively reduce the population. This tactic has been a powerful tool in controlling vine mealybug in California. Vine mealybug has recently been detected in Jackson County OR. Data on how these dispensers behave under Oregon's climate are thus needed to inform potential management options. As an initial study we used gravimetrics to determine the volatilization rates of three commercially available pheromone dispensers.

Materials and Methods

Lure trials:
In late July 2023 we placed out seven delta traps baited with either the current grower standard lure or one of two newly developed lure formulations from Pacific Biocontrol for a total of 21 traps in a vineyard located at Jackson County. All traps were placed in the same row in a random block design. Traps were placed 200 feet apart, and the number of male grape mealybugs was recorded weekly until early September. Data was analyzed using a repeated measure analysis.

Pheromone dispenser trials:
In mid-June 2021, 100 each of three commercially available were placed along the top wire (approx.1.5 m high) and bottom wire (approx. 0.5 m high) of blueberry rows at the Lewis brown experimental farm in Corvallis OR. High placement provided significantly more sun exposure while low placement was shaded under the plant canopy. Temperature, relative humidty, and solar intensity were measured hourly using Hobo datalogger. Initial weights were taken from 5 of each dispenser and 5 more were randomly sampled each week for 15 weeks.

Results & Discussions

The two optimized formulations, 111 and 112,from pacific biocontrol both detected more males at every sampling time then the current grower's standard. Formulation 111 detected the most males (Fig.1). We observed a single peak in male flights among all lures mid-August However, the formulation 111 detected 4 times more males during this peak then the current growers standard.

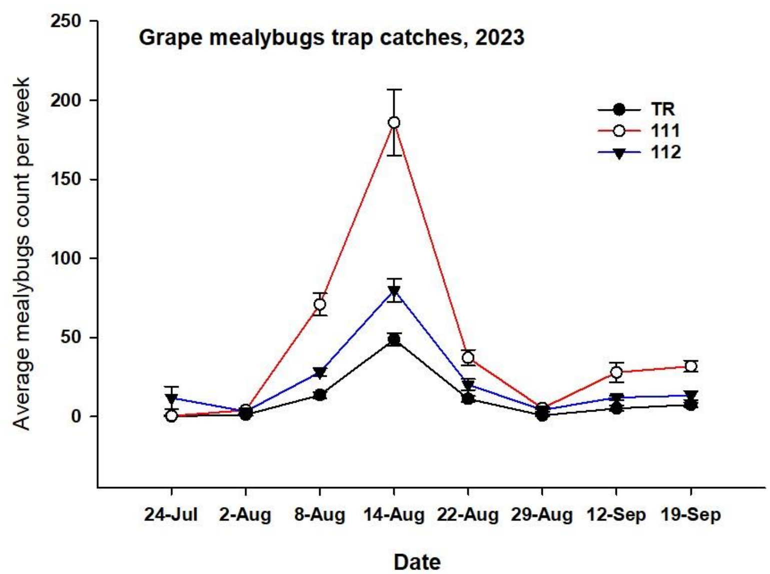

Figure 1 Average number of adult male grape mealybugs detected per lure type

Both Type #1 and Type #2 displayed high variability in average weights per week (Fig. 2). This is possible due to these formulations being more reactive to environmental conditions or the dispensers themselves having less consistent dosing. Type #3 shows more consistent release. Dispensers located in the shade had lower overall release compared to dispensers placed in direct sun.

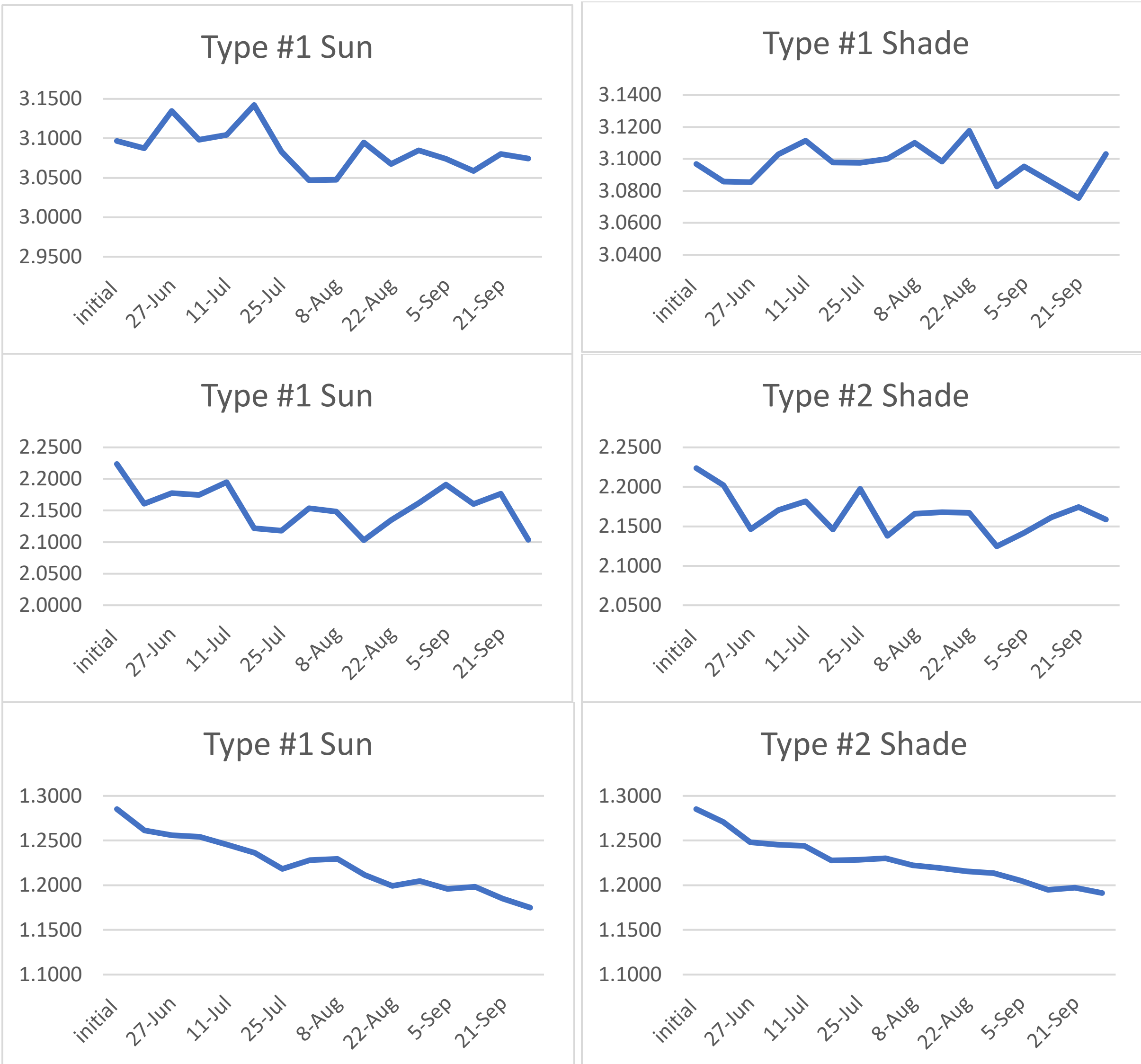

Fig. 2 Average weekly weights of dispensers placed in sun or shade

Conclusions & Future Work

Newly optimized lure formulations show potential to be a highly effective tool for growers. We plan on using this tool to help determine the associated cost to growers from grape mealybugs in Oregon.

Following up our gravimetric study we plan to monitor vine mealybug in the field and create phenological models to inform growers on the optimal time to place out dispensers for mating disruption. We also plan on evaluating any changes in efficacy related to shade or sun placement in effort to reduce the recommend rates for these products.

Predictors of cherry susceptibility to attack by *Drosophila suzukii*

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Following its introduction and establishment in the US in 2008, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) quickly became a major pest of numerous soft fruit crops including blueberries, caneberries and cherries. Control is achievable with insecticide sprays, but application timing can be a challenge. This pest also has many alternative hosts and is active year-round, so trap captures do not always equate to crop damage. Cherry growers in the Willamette Valley have expressed dissatisfaction with current recommendations for timing sprays that target this pest. It is recommended that sprays are applied just ahead of fruit becoming susceptible to attack, but this can vary widely between cultivars. The purpose of this 3-year study was to look at the risk of *D. suzukii* attack as a function of fruit physiology and susceptibility in both blush and dark cherry varieties. Beginning in early spring 2021 we collected cherries from 5 different varieties of blush and dark cherries and evaluated their color, firmness, brix, field infestation as well as susceptibility to infestation when exposed to lab-raised *D. suzukii*. We also deployed dataloggers in the field to track temperature and humidity. A FirmTech was used to evaluate fruit firmness, and we found that this followed a well-defined pattern that can be modeled with high confidence (Fig. 1). Individual varieties showed distinct trajectories in softening, indicating that risk of *D. suzukii* attack differed by variety. There was a large difference between 2021 and 2022 data. The cooler 2022 season delayed fruit maturation by approximately 3 weeks, showing that optimal spray timing can be affected greatly by environmental conditions. Natural infestations occurred in 2021 and 2022 at the beginning of June, with infestation rate being much higher in 2022 compared with 2021 (Fig. 2). We did not find any natural infestation in fruit that were collected in 2023 despite being unsprayed, and numerous *D. suzukii* were captured on baited sticky traps. We found that fruit exposed to female *D. suzukii* in the lab had much higher infestation rates compared with naturally occurring attacks (Fig. 3). The role of color as a potential predictor for infestation is discussed.

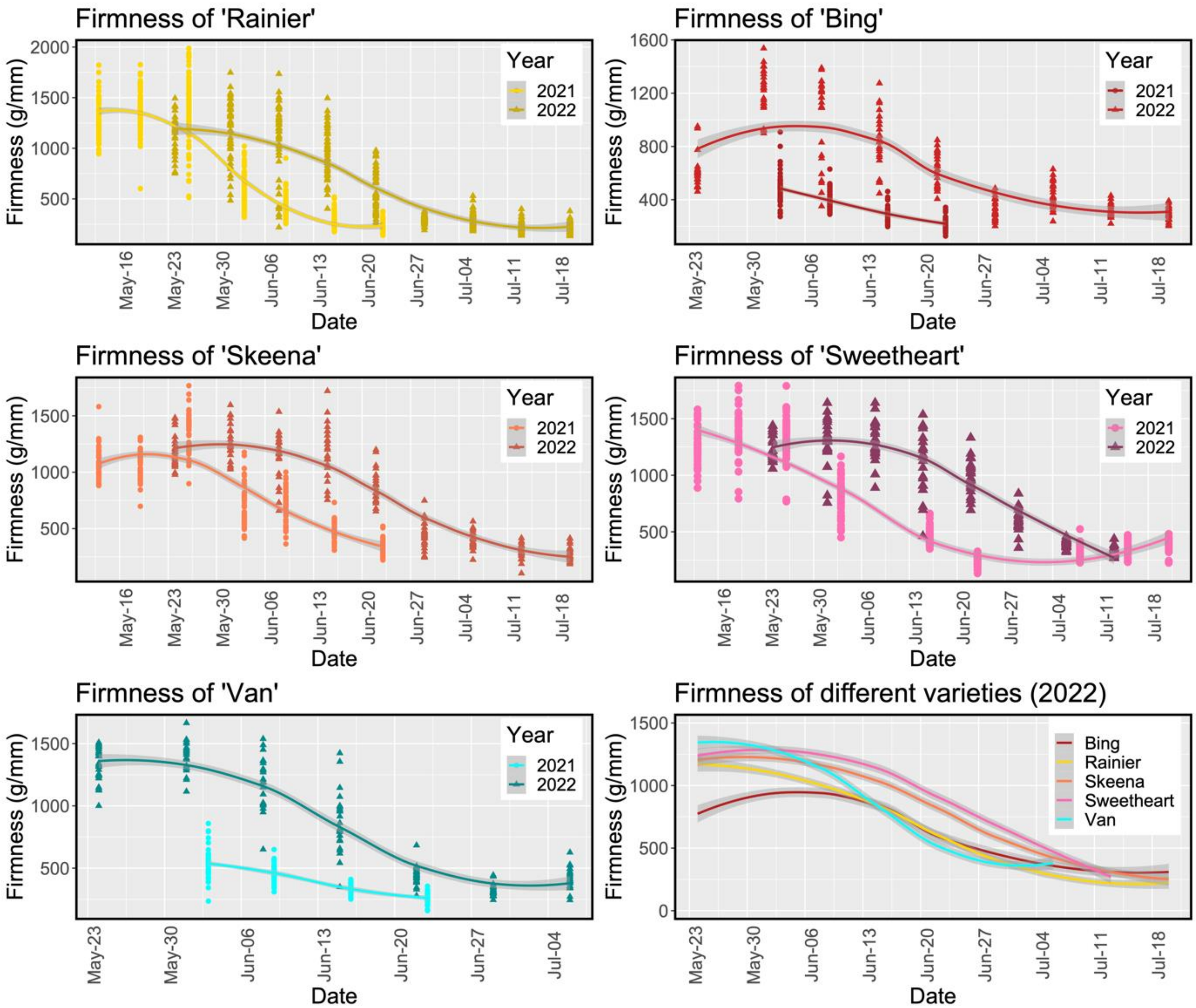

Figure 1. Firmness of all varieties in 2021 and 2022 according to FirmTech readings. Firmness followed a well-defined pattern that can be modeled with high confidence. Cherry firmness in 2022 was very different from the prior year with cooler temperatures delaying fruit maturation be approximately 3 weeks.

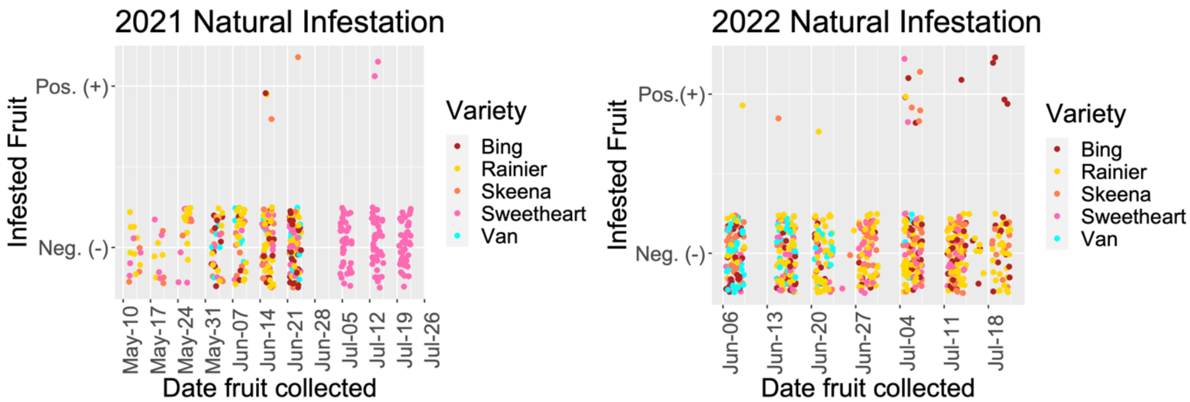

Figure 2. Natural infestations of all varieties in 2021 and 2022. Wild detections occur as fruit matures and softens.

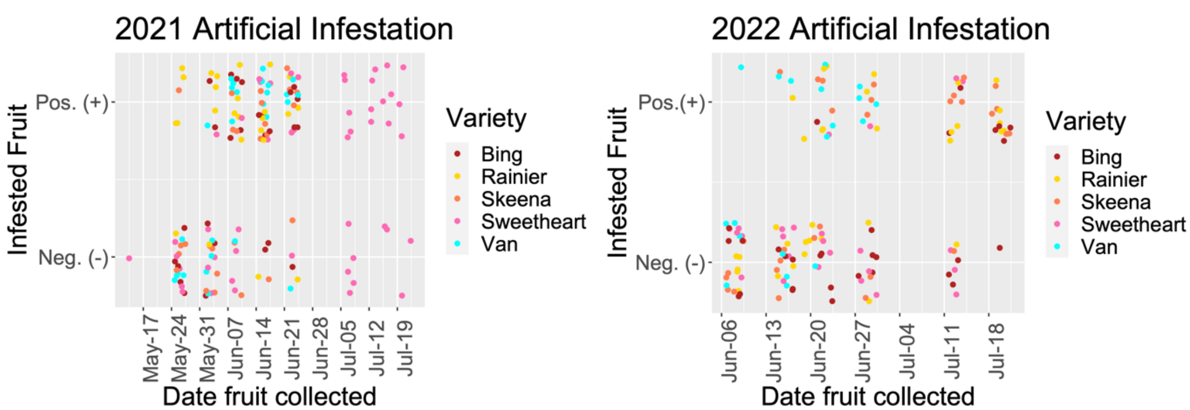

Figure 3. Artificial infestation of all varieties in 2021 and 2022. Fruit were collected from the field and exposed to lab-raised *D. suzukii* for 24 hours. Data indicate more fruit were susceptible to attack than suggested by naturally infested data.

SECTION VII
Pests of Turf and Ornamentals

SUPPLEMENTING RHODODENDRONS WITH SILICON FOR INSECT CONTROL

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The azalea lace bug (ALB), *Stephanitis pyrioides* (Scott) (Hemiptera: Tingidae) is a pest of azaleas and rhododendrons (*Rhododendron* spp.) where feeding causes leaf stippling. Supplementing with elemental silicon has led to tissue uptake and enhanced defense in other plants. Whether supplementation would be effective on rhododendrons and ALB was unknown. Thus, our first objective was to test uptake in rhododendrons. Potted plants were supplemented for 4 or 8 wk with calcium silicate and calcium carbonate (calcium only) via foliar or soil application. In both trial years, rhododendrons did not take up extra silicon or calcium in leaves compared to controls. Our second objective tested whether supplementation improved resistance to ALB, which can also occur through topical effects. Results were mixed in four choice and two no-choice trials. In choice tests caging detached leaves or whole plants, there was a reduction in frass deposition, oviposition and sometimes adults on plants supplemented with calcium silicate or calcium carbonate compared to controls. In an open choice greenhouse test, there were no differences. In no-choice tests, there were no differences or oviposition was higher on foliar/soil silicon-treated plants than the control in one trial. Since rhododendron aphids (*Illinoia lambersi*) appeared in the greenhouse, our third objective compared their natural colonization on previously supplemented rhododendrons. Infestation of new leaf rosettes or random leaves was lower on plants sprayed with foliar silicon or calcium applied via soil in two trials.

Planning for submission to J Economic Entomology

Evaluation of endophyte-mediated resistance response of commercially available perennial ryegrass and tall fescue cultivars to winter cutworm, *Noctua pronuba* (L.) (Lepidoptera: Noctuidae)

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Exploring *Epichloë* endophytes is an exciting frontier for insect pest management in cool-season turfgrass systems in Oregon. The symbiotic relationship between grass and endophytes has garnered recognition for its economic impact on insect anti-herbivory. Oregon is internationally renowned as the primary producer of cool-season forage and turf grass seed, accounting for an impressive 70% of the global supply. This sector, Oregon's fifth-largest agricultural commodity valued at $458 million, engages over 1,500 growers, as per the USDA National Agricultural Statistics Service's 2020 report. By capitalizing on endophyte-mediated anti-herbivory properties in grasses, the grass industry in Oregon has the potential to significantly reduce dependence on pesticides in global turf, pasture, and cover crop applications. In this study, we evaluated endophyte-mediated resistance in commercial cultivars of perennial ryegrass (*Lolium perenne*) and tall fescue (*Schedonorus phoenix* (Scop.) Holub) against an economic insect pest *Noctua pronuba* (L.) (Lepidoptera: Noctuidae), or winter cutworm. The research objectives were to quantify *Epichloë* endophyte infection of 51 perennial ryegrass cultivars, and examine a mycotoxin genotype of *Epichloë* associated with each cultivar. Moreover, the plant resistance response was measured by conducting two experiments to determine the effects of endophyte infection on the survival and the fitness of five *N. pronuba* larvae released in bioassay arena containing five plants over a 14-day period. The second/third instar *N. pronuba* were subject to feed on two grass species (tall fescue, perennial ryegrass), with two levels of endophyte infection (high, low), and two fungicide treatments (no fungicide, fungicide for fungal endophyte eradication) The experiment was replicated 4-5 times in two separate trials. Data was collected on insect mortality, larval weight, feeding damage in terms of aboveground grass biomass and green area after 14 days of insect release. After the completion of feeding experiment, individual plant endophyte infection status was quantified using a high throughput multiplex PCR method. Preliminary analyses suggested that *N. pronuba* mortality was found to be influenced by the variability in endophytic infection within the tall fescue cultivars. Information generated in this study could guide future research efforts on the identification and development of promising cultivar-endophyte combinations for producing vigorous plant stands with greater tolerance and resistance to insect predation.

SECTION VIII
New & Current Product Development

Identification of agonists and antagonists using *in vitro* and *in vivo* bioassays for the Western flower thrips

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Microscopic in size but devastating in impact, western flower thrips (WFT), *Frankliniella occidentalis* (Thysanoptera: Thripidae) (Pergande), is a polyphagous west US native with a broad host range that has persistently plagued the global nursery industry due to its fast generation time, cryptic size, high rate of transport, and ability to transmit devastating plant viruses. Frequent high-volume use of broad-spectrum synthetic pesticides often culminates in reports of insecticide resistance. The need for alternate control measures, such as bioactive molecules, is a prominent point of discussion in nursery settings impacted by WFT.

Insect neuropeptides (NPs) and G protein-coupled receptors (GPCRs) are often proposed biological targets for next-generation pesticides. NPs are synthesized in neurosecretory cells and are released to the target tissues for various biological processes. Within target tissues, they bind to a corresponding GPCR, which will transduce their signal to initiate biological functions. GPCRs, known as seven transmembrane proteins composed of extracellular complex, couple with G proteins associated with signal transduction inside cells. They are involved in many essential biological processes during insect life stages. In this study, our biological target is a NP and its GPCR, which is relatively consistently expressed for a variety of biological processes, such as water regulation, anti-diuresis, and desiccation across all life stages of WFT.

The relationship between a GPCR and a NP can be thought of like a lock and key model. When this lock-and-key relationship is disrupted to inhibit the specific physiological function, it impacts the survival of the thrips. One means of disruption is to gum up the lock with a different bioactive peptide, which prevents the key from fitting inside. While a key is known as an “agonist,” the disrupting “gum” is known as an “antagonist.” To correctly identify bioactive peptides as antagonists, cell-based *in vitro* screens, live injection assays, and live feeding assays must be performed. Here, we present the progress we have made in developing a method to distinguish between agonists and antagonists for a GPCR of WFT. *In vitro* screens were implemented by functionally expressing the GPCR in the commercially available *Spodoptera frugiperda* 9 (Sf9) insect cell line. Sf9 is user-friendly and provides for a more accurate representation of insect biochemical physiology compared to mammalian cells, which are more commonly implemented in insecticide mechanism-of-action studies, by nature of wider familiarity. Considering the additional factor of our GPCR of interest using calcium as a second messenger, and the specific kit we use to measure calcium mobilization as a proxy for GPCR activation, there are currently no antagonist-screening methods developed yet for this particular combination. However, once fully developed, it will allow for a user friendly, high-throughput method to identify the mechanism of action of bioactive peptides.

PLINAZOLIN® technology: A New Broad-Spectrum IRAC Group 30 Insecticide

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PLINAZOLIN® technology is a new active ingredient coming soon from Syngenta. The active ingredient, isocycloseram, is a new insecticide that will offer a novel mode of action formulated to act against a broad spectrum of agricultural pests including mites, thrips, true bugs, beetles, certain lepidopteran pests as well as other insect pests. Isocycloseram, which is an Insecticide Resistance Action Committee (IRAC) Group 30, acts by contact and ingestion and has no known cross resistance to other insecticides. Isocycloseram was submitted to the U.S. EPA and Canada's PMRA in 2021 (joint submission), it received a reduced risk status for U.S. registration in cotton and soybeans. It was concurrently submitted to the state of California and was granted an expedited review. State registrations are anticipated to follow federal registration.

SECTION IX
Extension & Consulting:
Updates and Notes from the Field

COOPERATIVE MONITORING OF WESTERN CORN ROOTWORM

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Western corn rootworm (Coleoptera: Chysomelidae *Diabrotica virgifera virgifera* LeConte), is a major pest of both field corn and sweet corn. Adult beetles feed on foliage, pollen and silk, and developing kernels. If populations are high enough, feeding by adults can interfere with yield, but a bigger and more common problem is larval feeding. Rootworm larvae feed directly on corn roots, which leads to reduced vigor and poor stand establishment, and, if root damage is extensive, complete crop loss. Lodging is also very common and makes harvest operations difficult.

The geographic range of this pest has been expanding towards western North America. It was detected in Colorado in 1909 and is now considered a sporadic but important pest in eastern Oregon, Washington, and Idaho. A cooperative, preliminary survey of western Oregon was conducted by OSU and ODA in 2018. We found over 8,000 *D. virgifera* beetles. In 2023, we requested participation in the Corn Rootworm IPM working group, and this report summarizes those results.

We monitored six sites in the Willamette Valley (5 sweet corn, 1 silage) from 6-Jul to 7-Sept, 2023 using yellow sticky trap transects. We found 122 adult beetles, but counts never exceeded 2 beetles/day, the action threshold set by the working group and its collaborators. We did, however, receive a call from a corn and dahlia grower in Tillamook county, where western corn rootworm were extremely abundant and causing damage to both crops (FIG. 2). We plan to continue monitoring and are interested in collaborating on future research efforts to investigate the impact of *D. virgifera* in western Oregon.

Trap counts were collected via ArcGis Field Maps, which integrates directly with the working group's real-time dashboard. The dashboard allows cooperating growers to view counts, activity peaks, and more. The system also has an accompanying website with general information about the pest, as well as identification, sampling, and management recommendations.

In the 'corn belt' of the midwestern United States, planting transgenic corn hybrids that express *Bacillus thuringiensis* (Bt) toxins was used as the main pest management tactic, but the pest has since developed resistance to all commercially available *Bt* products and lines. Other tactics, such as crop rotation, are key to reducing rootworm populations, but rarely practiced in the Midwest, where continuous corn is common. Out of 208 sites monitored by the Corn Rootworm Network, 134 of them had at least 2 years without rotation (Fig. 1). These same areas correlated with the highest populations of adult beetles.

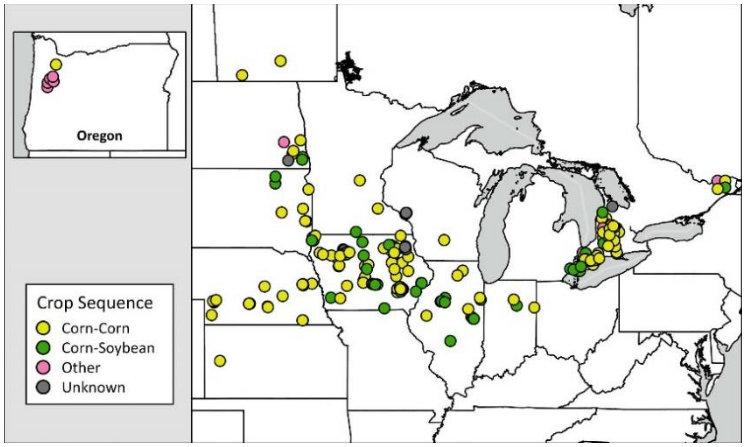

Figure 1. Of the 216 total monitored sites, 134 of them were placed in fields with continuous corn production (no crop rotation).

Figure 2. Photos submitted to the Oregon IPM Center from Tillamook county, October 2023.