Detection of Clover Seed Weevil Insecticide Resistance and Mitigation Steps

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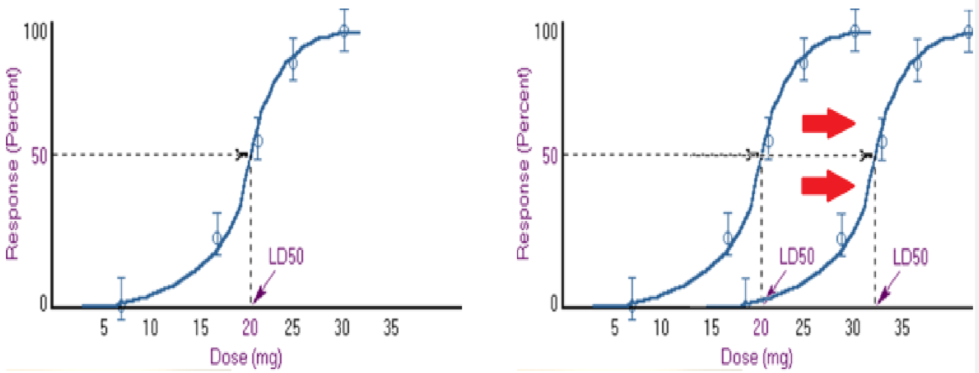
What is Insecticide Resistance?

- A heritable change in the sensitivity of a pest population

- reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species

- Risk of **cross-resistance** to other chemistries



What Causes Insecticide Resistance?

Selection Pressure

- Biology of the pest

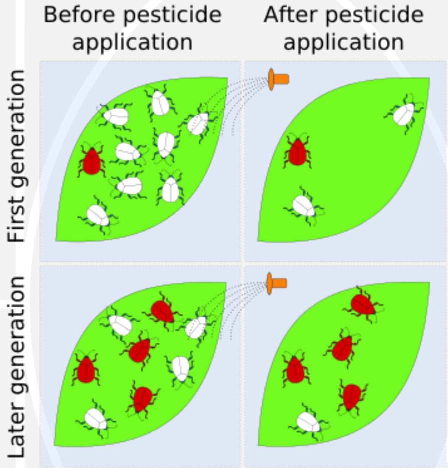
- multiple generations a year, do not migrate, and have a narrow host range as they have the highest potential for repeated exposure across multiple generations

- the insecticide and its specificity

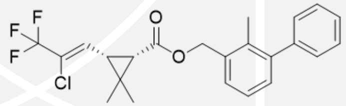
- single mode of action (MoA) and one target site

- Application strategy used

- Frequency of use and label requirements



Formulations:
Bifenture EC
Brigade 2EC
Discipline 2EC
Fanfare 2EC
Fanfare ES
Tundra EC



Bifenthrin
(Type I pyrethroid)

How to Combat Insecticide Resistance?

- Economic threshold
- Use diverse modes of action
- Use recommended rates
- Integrated control strategies
- Preserve susceptible genes

IRAC
Insecticide Resistance Action Committee

What is the Status of Insecticide Resistance in White Clover Seed Weevil?

- Two laboratory studies were conducted in 2019 and 2020
- Small-scale study and data were not indicative of true resistance development

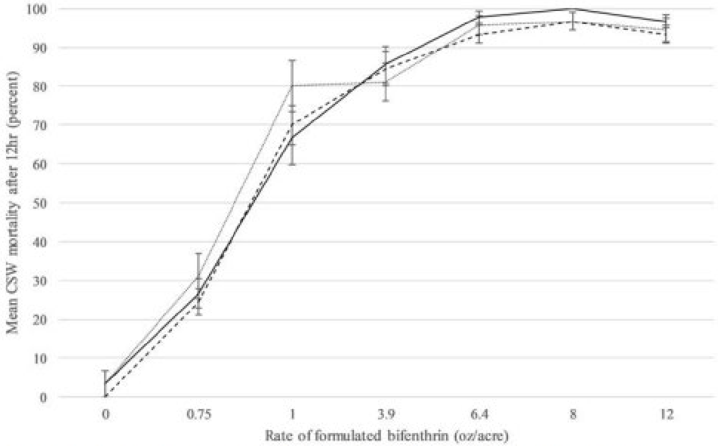


Figure 1. Dose-response curves for three field clover seed weevil populations collected in Linn County. Laboratory test with different rates of bifenthrin.

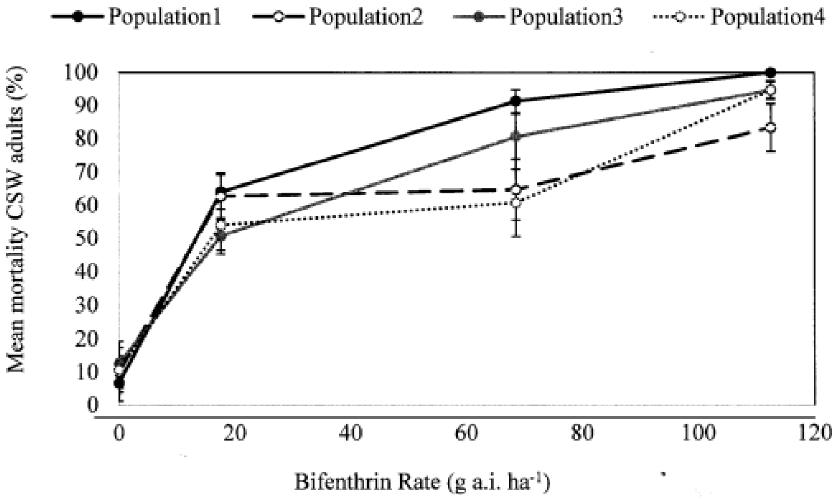


Figure 1. Mean mortality (%) of clover seed weevil adults exposed to different rates of bifenthrin in the adult vial test.

Kaur et al. 2020. Seed Production Research at Oregon State University.Ext/CrS 164

Kaur et al. 2019. Seed Production Research at Oregon State University • Ext/CrS 162

What is the Status of Insecticide Resistance in White Clover Seed Weevil?

- Field efficacy trials indicated that adult population in Brigade treated plots rebound after one week of treatment

- Few diamides (Harvanta and Exirel) were identified reducing larval activity

Table 1.

		Mean # adults per plot				Mean # larvae per plot
Treatment/formulation	**Rate (oz/acre)**	**3 DAT[a]**	**7 DAT**	**10 DAT[a]**	**14 DAT**	**14 DAT[a]**
Avaunt eVo	6.0	17.3bc	14.8a	14.5a	107.8a	10.0abc
Besiege	10.0	54.0d	41.8a	112.0b	139.3a	35.5bc
Brigade 2EC	6.4	9.8ab	20.0a	112.3b	118.5a	32.0bc
Exirel	20.5	39.0cd	33.0a	43.3b	102.3a	6.8ab
Harvanta 50SL	16.4	45.3cd	36.0a	60.0b	108.8a	4.8a
Malathion 8 Aquamul	20.0	4.5a	27.8a	98.3b	129.0a	25.5abc
Untreated check	na	56.8d	31.0a	52.3b	75.0a	30.5abc
Warrior II	3.8	39.3cd	23.7a	109.0b	126.7a	57.3c
P > *F*		<0.001	0.48	<0.001	0.32	<0.01

Means within columns followed by a common letter are not significantly different ($P < 0.05$).
[a]ln(X + 1) transformed data used for analysis, nontransformed means shown in table.

Mattson et al. 2021. Arthropod Management Tests, 46: tsab164, https://doi.org/10.1093/amt/tsab164

Approaches to Deal with this Problem

01

Target week links in insect life cycle to optimize insecticide application timing

02

Understanding extent of resistance to available chemistries

03

Evaluating diverse modes of action for efficacy data

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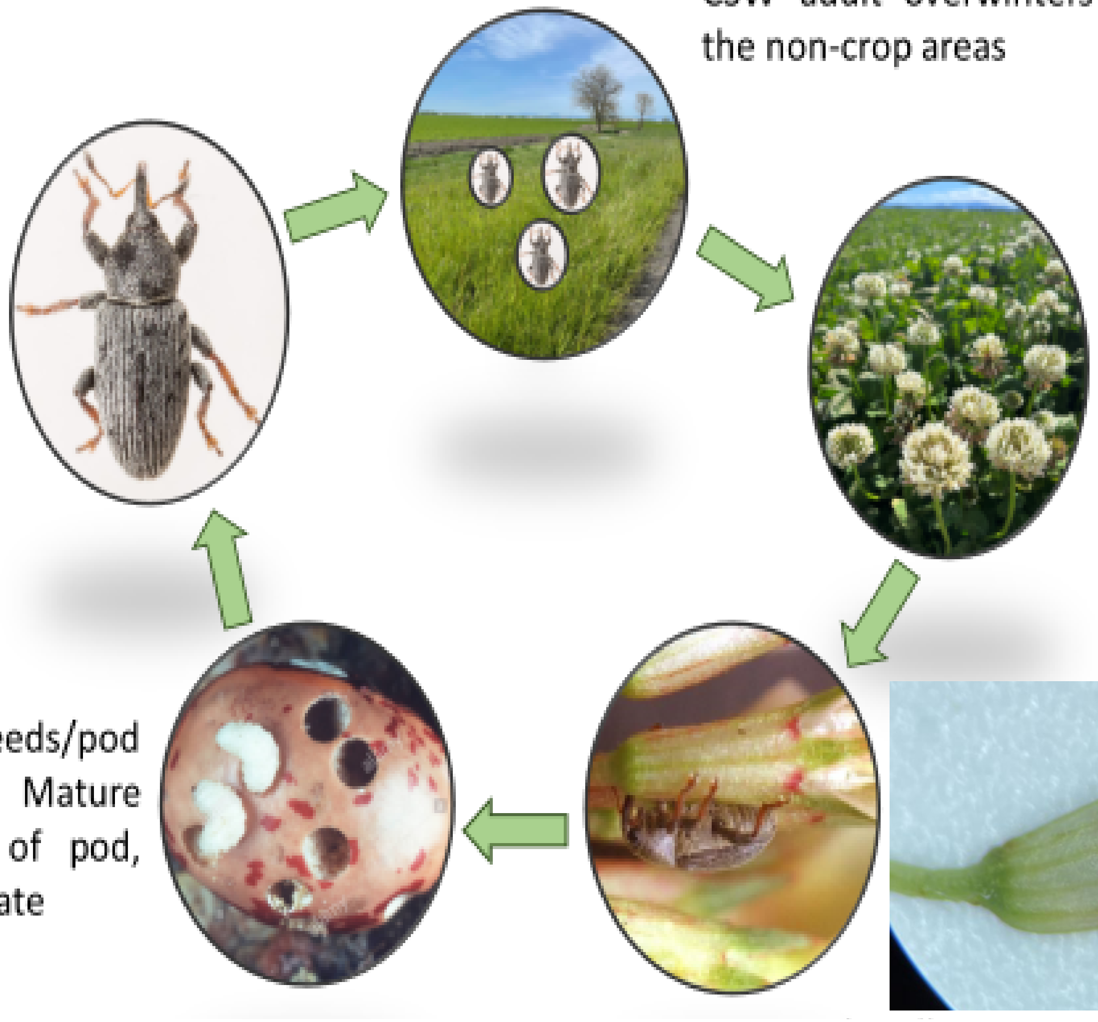
CSW Life Cycle

CSW adult overwinters in the non-crop areas

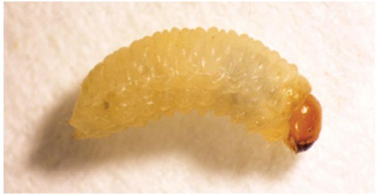
Once clover crop begins blooming, adult CSW start migrating inwards.

We need to protect for 35-40d (adults take 22d for egg laying and larvae feed up to 13-18d)

Second generation adults emerges, start dispersing back to overwintering habitats



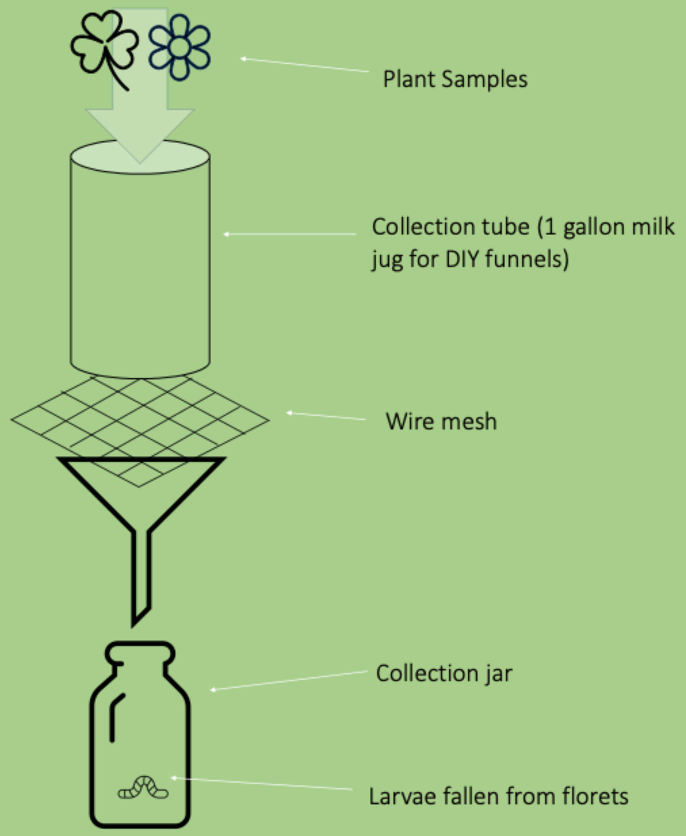
Larvae feed 2-4 seeds/pod for 2-3 weeks. Mature larvae bore out of pod, drop to soil to pupate

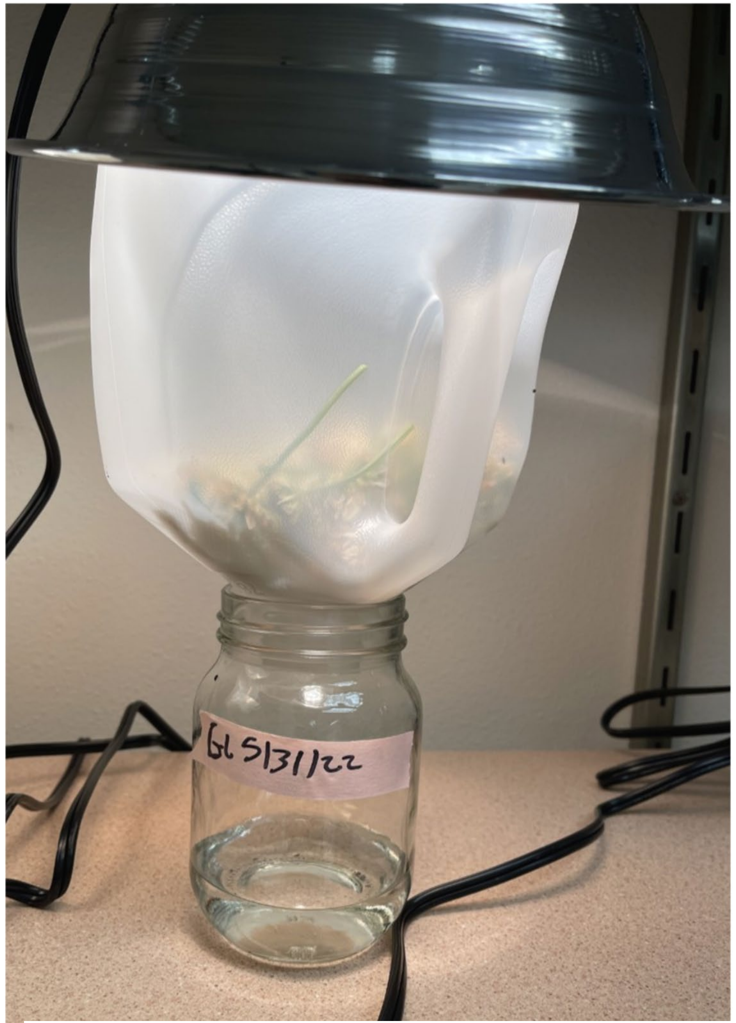


Refining Scouting Technique for Larvae Detection

What is a Berlese Funnel/ Tullgren funnel?

It is a method used to count the number of insects/arthropods in plant or soil samples. Sample material is placed in a container above a mesh screen with a collection jar to catch falling insects. The soil or plant-dwelling insects are driven to the bottom of the funnel by a light placed at the top.

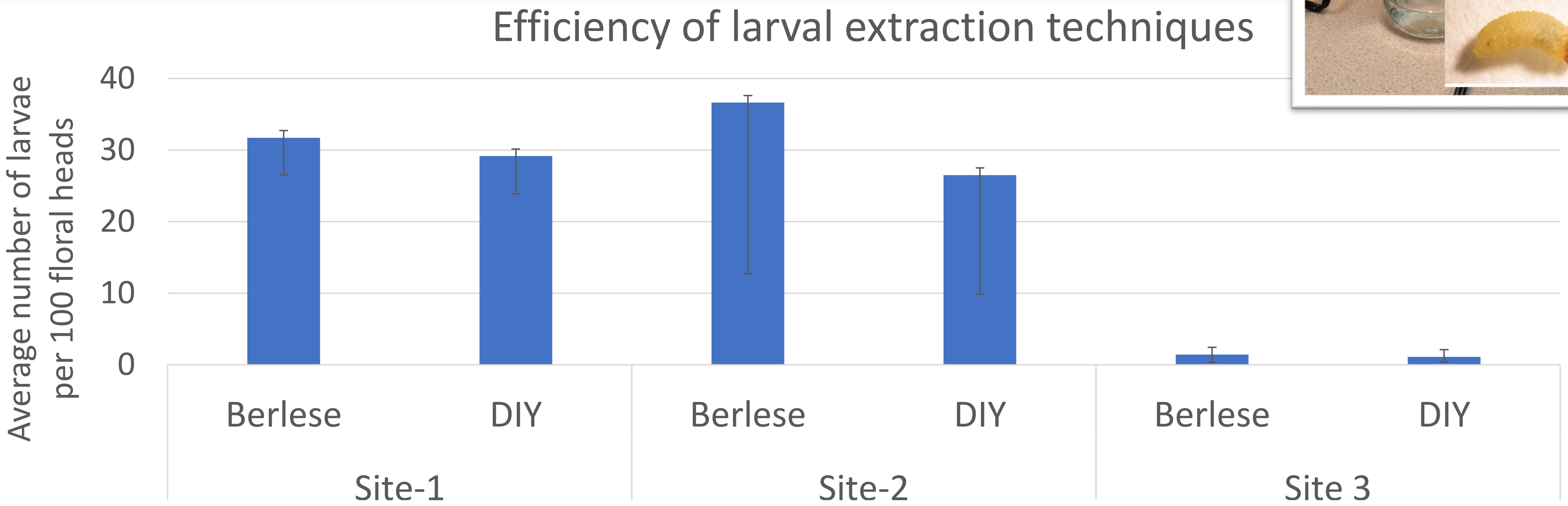




DIY Berlese

Standard Berlese

DIY Berlese vs Standard Berlese



Our Approach to Deal with this Problem

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Toxicology Bioassays- Technical material

Treatments: Technical grade bifenthrin, malathion, chlorantraniliprole

Insect source: 4 Oregon populations, 1 susceptible Canada (5 reps/dose, 5 adults/vial, n=>200/test)

Dose range: 0.0125 to 128 µg/vial

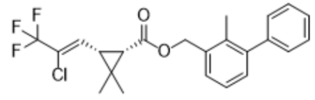
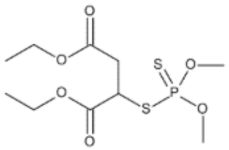
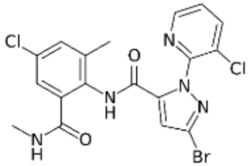
Solvent: Acetone solvent (contact);
10% honey-water solution onto floral plug (systemic)

Response: Moribundity at 24 h for contact and 48 h for systemic insecticides

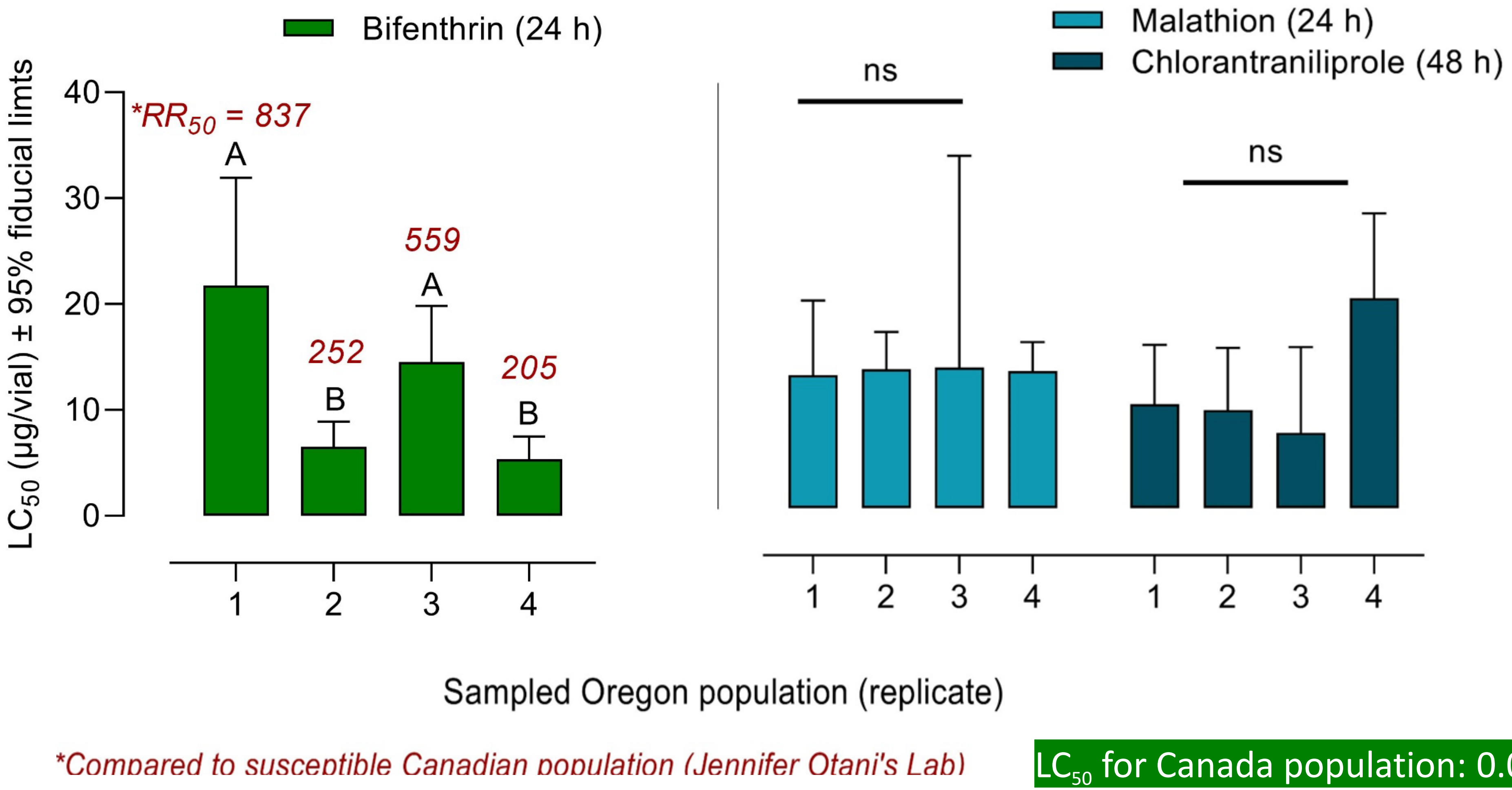
Data analysis: Probit analysis for LC50/RR50 value with 95% fiducial limits; corrected mortality determined using Abbott's formula (Abbott 1925)

Contact insecticide

Systemic insecticide

Bifenthrin IRAC 3A; Type I pyrethroid Na+ channel modulator	
Malathion IRAC 1; OP ACHE inhibitor	
Chlorantraniliprole IRAC 28; Diamide Ryanodine receptor modulator	

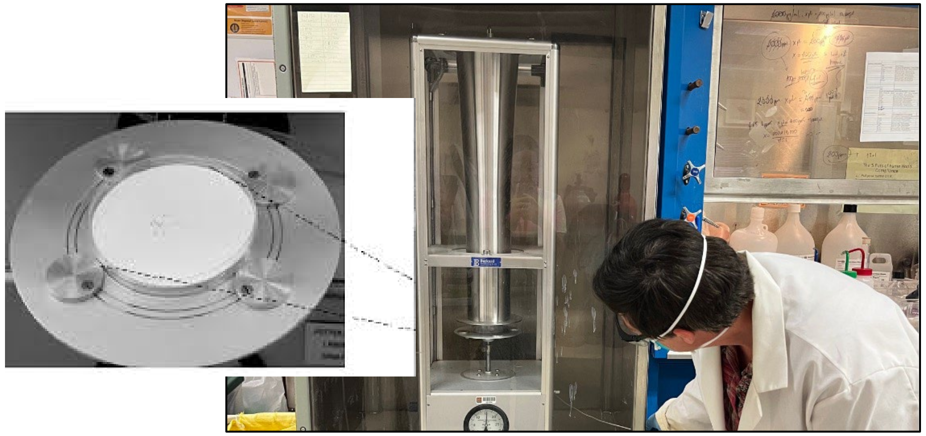
Toxicology Results

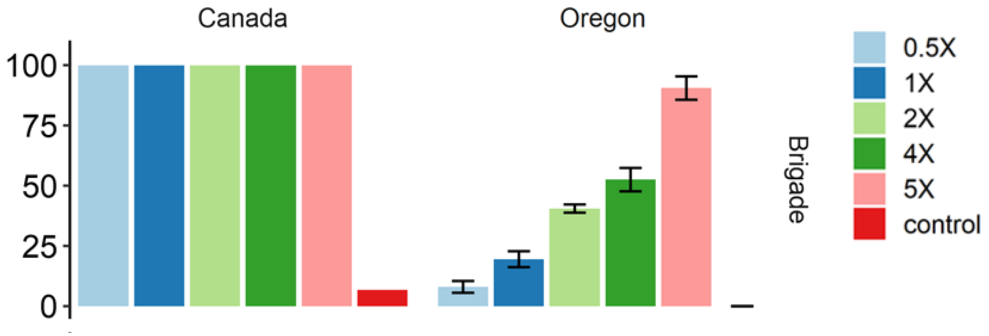


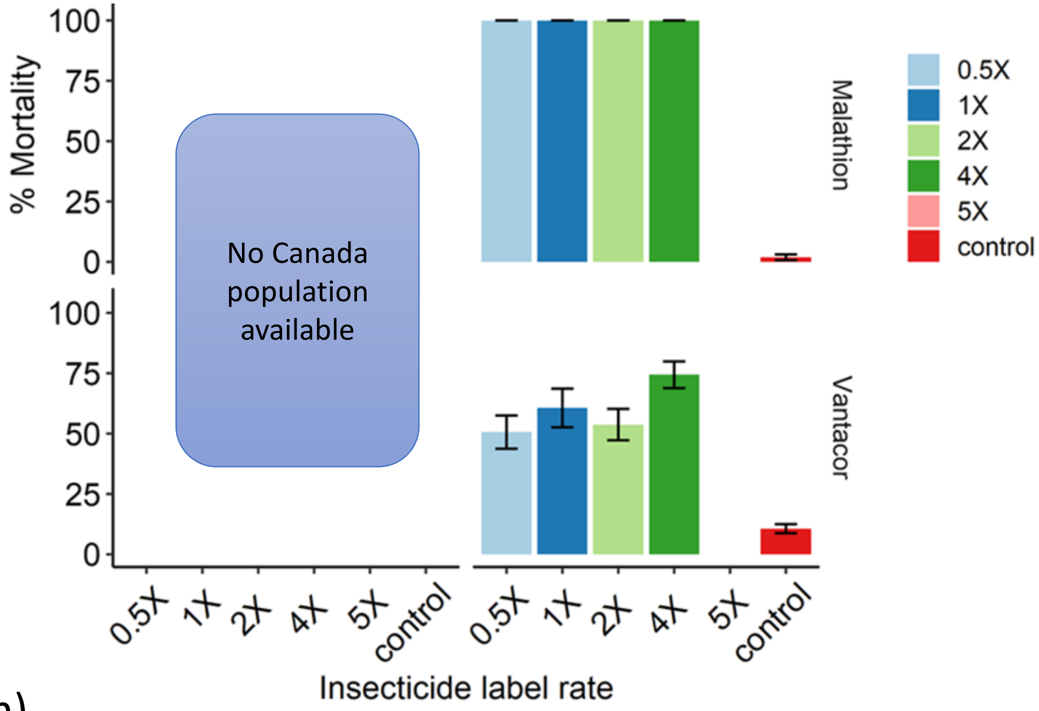
LC_{50} for Canada population: 0.026 ug/vial

Figure: Log-probit bioassays with adult CSW for technical-grade bifenthrin, malathion, and chlorantraniliprole

Toxicology Bioassays- Formulated Materials







Brigrade (bifenthrin)

LC_{50} = 1.4x label rate (89.4 ppm, 95% FL = 51.5 to 167.8 ppm)

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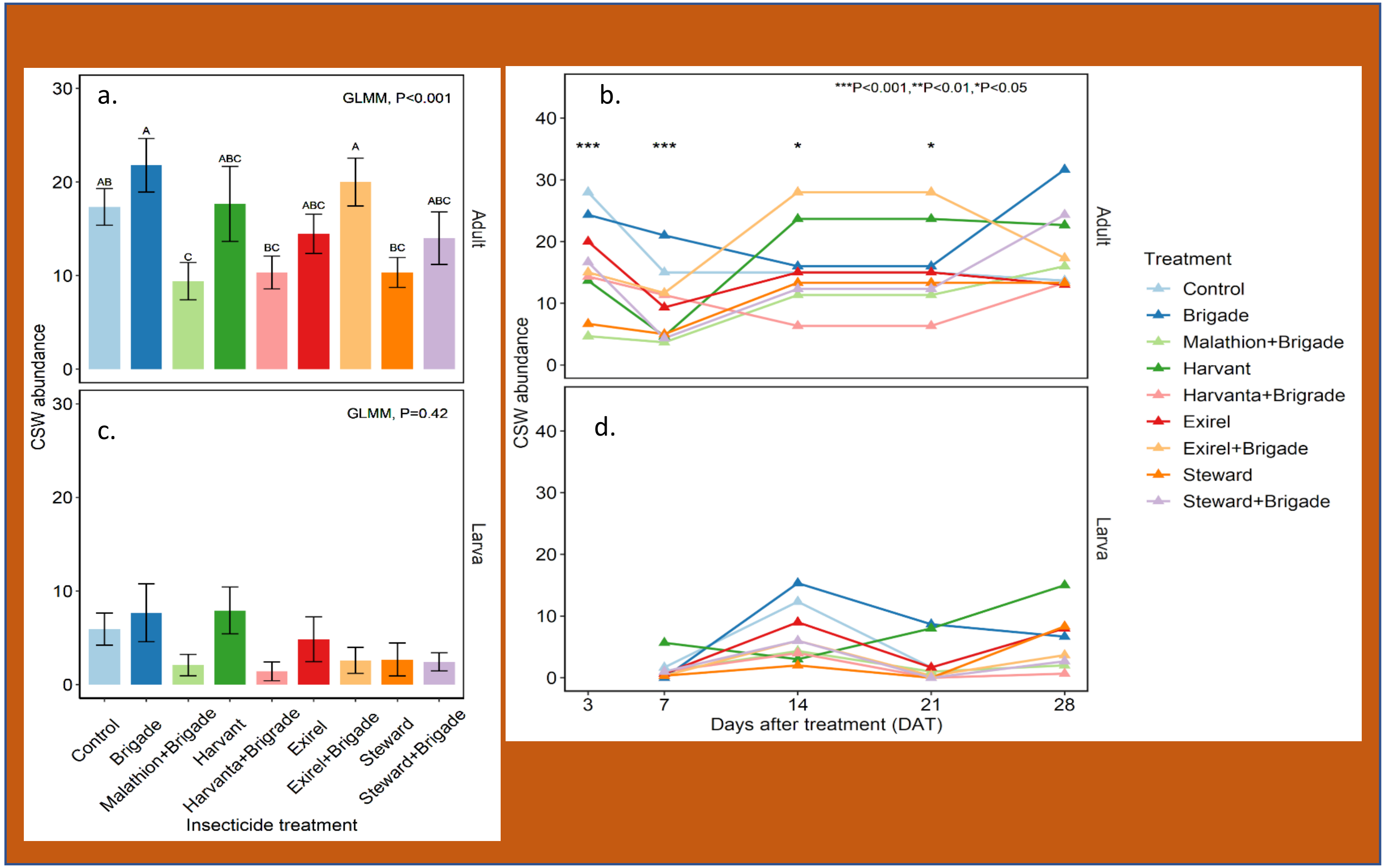
Field Efficacy Trial

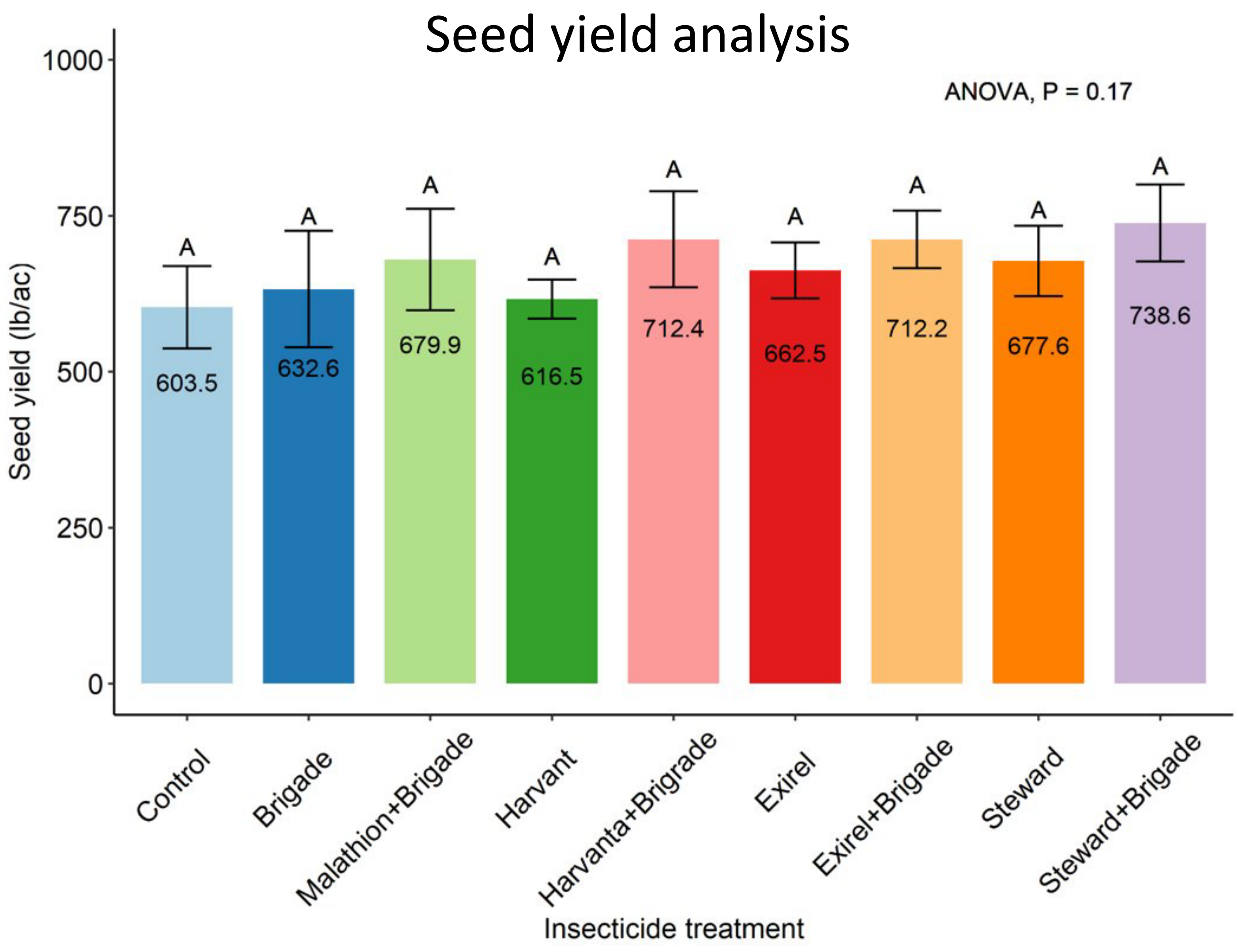
- Experimental design: RCBD (Plot size: 92*9 sq meter). White clover cultivar 'Crusade'
- 8 treatments, 3 reps, 2 application timing (first larval detection and 20% browndown)
- ATV mounted boom sprayer at 20 psi, spray volume of 15 gpa
- Larval and adult CSW monitoring using Berlese funnel and straight-line sweeps, respectively
- Seed yield (lb/ac) was determined using weigh wagon

Field efficacy trial



- Overall, the mean number of clover seed weevil adults in insecticide treated plots did not differ significantly from those in the untreated plots except Malathion+Brigade
- At 7 DAT, adult CSW abundance was significantly reduced within insecticide treated plots (P<0.001)
- Although some degree of suppression of larval densities in clover seed heads samples was present at 7 DAT, and 21 DAT, no statistically significant results were detected among insecticide treatments and control plots (P> 0.05)

Field Efficacy Trial



Approximately 20% increase in seed yield was obtained with the application of Steward and Brigade (738.6 kg/ha) or Harvanta+Brigade or Exirel+ Brigade (712.2 kg/ha) as compared to untreated check (603.57 kg/ha).

Summary

- Elevated levels of bifenthrin resistance compared to susceptible Canada population
- Multiple field trials needed to generate data on optimizing control timing and support the need for diverse mode (s) of action
- Preventing larval feeding damage can reduce seed yields

Acknowledgements

Team Effort at OSU

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Qualtrics Survey for our Project Team

- https://survey.az1.qualtrics.com/jfe/form/SV_6xpxOOyhrpQp0aO