AGRICULTURAL RESEARCH FOUNDATION
FINAL REPORT
FUNDING CYCLE 2020 – 2022

TITLE: Evaluating alternatives to chlorpyrifos in clover seed production systems

RESEARCH LEADER:

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COOPERATORS: none

SUMMARY/ABSTRACT: The Oregon Department of Agriculture finalized new rules in 2020 which will phase chlorpyrifos use out of agricultural production by December 31, 2023. At the same time, federal restrictions on chlorpyrifos use continue to be implemented, with all food/feed tolerances set to expire on February 28, 2022. A broad spectrum organophosphate insecticide, chlopyrifos has activity against a wide range of insect pests, and in many specialty cropping systems, may be the only pesticide tool registered to control some pests. Chlorpyrifos is a critical pest management tool for clover for seed producers, and is utilized to control aphids, symphylans, nitidulids, casebearer moth, omnivorous leafier, and others.

In 2020, two field efficacy trials were conducted to screen alternative chemistries for aphid control in red clover for seed fields in Washington County. Efficacious materials included Transform, Sefina, Sivanto, and Brigade. One additional field trial was conducted in 2021; however, because of the heat dome in late June 2021, the aphid population was killed and data were not able to be collected. Results from the 2020 efficacy trials were shared with growers at 2021 OSU Seed and Cereal Crop Grower Meeting and the 2022 Oregon Clover Commission Annual Grower Meeting.

With candidate alteranative materials identified, I worked with registrants to determine whether a path for registration existed. A clover seed label for Sefina is now available for use. Transform, while having promising results, has regulatory hurdles for additional registrations and cannot be pursued for new labeled uses at the present time. Sivanto and Brigade are currently registered for use in clover seed.

Additionally, in 2021, a field trial was established with Dr. Kaur in white clover for seed in Linn County to screen candidate materials for clover seed weevil control. Materials identified as promising include Exirel, Avaunt EvO, and Harvanta. I am seeking funding to continue this work in 2022 and beyond.

OBJECTIVES:

1) Assemble a short-list of candidate insecticides for control of clover aphid that are likely to provide adequate control and differ in mode of action from currently registered materials
2) Perform replicated field trials to determine the efficacy of control for these materials against clover aphid
3) Pursue registration of the most promising material(s) through ODA and the IR-4 Project, as appropriate for any given chemistry.

PROCEDURES:

Objective 1. The materials and rates used in the 2020 aphid/red clover seed efficacy trials are shown in Table 1. Several registered materials were included in the trial so growers can compare the performance of new materials against known material (Brigade, Sivanto, Lorsban). Beleaf, while already registered, was included because there is no known efficacy data for this product in clover for seed production. Three new materials were included in the trial: Transform, Sefina (2 rates) and Exirel.

Table 1. Materials included in the 2020 field efficacy trials.

Active ingredient (trade name)	**Rate/ac**	**IRAC[1] class**
Chlorpyrifos (Lorsban)	16 fl oz	1B
Bifenthrin (Brigade)	6.4 fl oz	3A
Flonicamid (Beleaf)	2.8 oz	29
Flupyradifurone (Sivanto)	10.5 fl oz	4D
Sulfoxaflor (Transform)	1.5 oz	4C
Afidopyropren (Sefina)	3 fl oz	9D
Afidopyropren (Sefina)	6 fl oz	9D
Chlorantraniliprole (Exirel)	18 oz	28

[1]IRAC – Insect Resistance Action Committee.

An additional field trial for aphid efficacy was conducted in 2021; however, because of the heat dome in late June 2021, the aphid population was killed and data were not able to be collected.

Table 2. Materials included in the 2021 clover seed weevil field efficacy trials.

Active ingredient (trade name)	**Rate/ac**	**IRAC[1] class**
Malathion (Malathion)	20 fl oz	1B
Bifenthrin (Brigade)	6.4 fl oz	3A
Indoxacarb (Avaunt eVo)	6 oz	22
Chlorantraniliprole (Exirel)	20.5 fl oz	28
Cyclaniliprole (Harvanta)	16.4 fl oz	28
Chlorantraniliprole + Lamda-Cyhalothrin (Besiege)	10 fl oz	28+3
Lambda-Cyhalothrin (Warrior II)	3.8 fl oz	3

The materials and rates used in the 2021 clover seed weevil/ white clover seed efficacy trials are shown in Table 2. Two grower standards (Malathion and Brigade) were included in the trial so growers can compare the performance of new materials against known materials. New materials included in the trial were Avaunt, Harvanta, Exirel, Warrior II and Besiege.

Objective 2. For the aphid efficacy trials, two field trials were conducted at red clover seed fields in Washington County in 2020. Each site trialed the same nine treatments (Table 1, plus an untreated control) and were replicated four times. Treatments were applied at approximately 1-5% clover bloom. Plot size was 13 ft by 30 ft. Insecticide treatments were applied as a randomized complete block design with four replicates. All treatments included R-11 Spreader-Activator at a rate of 5 fl oz/ 100 gal mix. Treatments were applied with a four nozzle boom sprayer pressurized with CO2 calibrated to deliver 20 GPA through TeeJet XR11002VS nozzles at 30 PSI. Clover flower heads were collected on Day 0 (pre-treatment), and weekly for four weeks. Clover samples were frozen until aphid numbers and presence of other insects could be assessed using a dissecting microscope. Data were $\log_{10}$ (X+1) transformed and analyzed with ANOVA, and means separated according to Fisher's Least Significant Difference. Results from each of the two trials are shown in Tables 3 and 4.

Table 3. Average number of aphids per 12 clover flowers in one of the 2020 trial locations.

	Avg (adults + nymphs) aphids per 12 flowers			
Treatment	7 DAT[a]	14 DAT[a]	21 DAT[a]	30 DAT[a]
Beleaf 50SG	5.0 ab	13.5 ab	42.5 bc	74.75 ab
Brigade 2EC	10.0 a	3.5 b	16.75 bc	17.50 c
Exirel	18.0 a	51.5 a	159.75 a	192.50 a
Lorsban Advanced	2.0 b	29.75 ab	69.50 ab	89.5 a
Sefina	11.0 a	11.0 ab	16.75 bc	18.25 c
Sefina	13.75 ab	20.25 ab	18.25 bc	22.0 bc
Sivanto Prime	1.0 b	2.5 ab	12.75 c	14.25 c
Transform	1.75 ab	7.75 ab	15.25 c	17.0 c
Untreated control	21.25 a	25.25 ab	61.50 ab	83.0 a
P>F	<0.001	0.03	<0.001	<0.001

Means within columns followed by a common letter are not significantly different ($P \leq 0.05$, Fisher's LSD)

[a]Log_{10} (X+1) transformed data used for ANOVA analysis; non transformed means shown in table.

Table 4. Average number of aphids per 12 clover flowers in the second of the 2020 trial locations.

Treatment	Avg (adults + nymphs) aphids per 12 flowers			
	9 DAT[a]	13 DAT[a]	20 DAT[a]	27 DAT[a]
Beleaf 50SG	0.5 b	5.75	30.75	80.25 ab
Brigade 2EC	0.5 b	17.0	13.0	59.5 ab
Exirel	14.0 a	8.5	61.25	224.25 a
Lorsban Advanced	0.25 b	2	22.5	104.5 ab
Sefina	0.25 b	4.75	7.25	35.0 ab
Sefina	1.5 ab	1.25	13.0	17.5 b
Sivanto Prime	0.75 ab	3.25	11.0	58.5 ab
Transform	0.25 b	1.5	10.5	20.75 b
Untreated control	6.25 ab	19.0	32.25	140.25 ab
P>F	<0.01	0.7	0.3	0.02

Means within columns followed by a common letter are not significantly different ($P \leq 0.05$, Fisher's LSD)

[a]Log_{10} (X+1) transformed data used for ANOVA analysis; non transformed means shown in table.

The clover seed weevil efficacy trial in 2021 was conducted in a white clover seed production field in Linn County. Treatments are shown in Table 2. A randomized complete block design was used with four replications, except for Warrior II, which had three replications. The plot size was 30 ft long and 13 ft wide, with a 3 ft untreated buffer surrounding each plot. Treatments were applied using a CO_2 pressurized backpack sprayer equipped with a four-nozzle boom calibrated to deliver 20 GPA through TeeJet XR11002VS nozzles at 25 PSI. Adult weevils were sampled 3, 7, 10 and 14 days after treatment with a 15-inch diameter sweep net down the center of the 30 ft plot length (10 sweeps per plot), frozen, and counted. Weevil larvae were sampled 14 days after treatment by collecting all inflorescences within five randomly selected 2 ft by 2 ft quadrats (20 ft^2) per plot. Inflorescences were placed in Ziploc bags, shipped to laboratory in a cooler and subjected to Berlese funnel extractions for 48 hours. Larvae were then counted once dropped into collection cups with ethanol. Data were ln transformed if they violated the assumptions of equal variance or normality (specifically, adult 3 and 10 DAT samples; larval 14 DAT sample) and were analyzed with one-way ANOVA. Means were separated using Tukey's HSD ($\alpha = 0.05$). Results from the trial are shown in Table 5.

Objective 3. With candidate alteranative materials identified for clover aphid, I worked with registrants to determine whether a path for registration existed. A clover seed label for Sefina is now available for use. Transform, while having promising results, has regulatory hurdles for additional registrations and cannot be pursued for new labeled uses at the present time.

Conversations are ongoing with the registrants of Avaunt eVo, Exirel and Harvanta for additional research needs to obtain registrations in white clover seed for clover seed weevil control.

Table 5. Average number of weevil adults and larvae per plot in the 2021 clover seed weevil trial.

Treatment	Avg Number Adults per Plot				Avg Number Larvae per plot
	3 DAT[a]	7 DAT	10 DAT[a]	14 DAT	14 DAT[a]
Avaunt eVo	17.3 bc	14.8 a	14.5 a	107.8 a	10.0 abc
Besiege	54.0 d	41.8 a	112.0 b	139.3 a	35.5 bc
Brigade	9.8 ab	20.0 a	112.3 b	118.5 a	32.0 bc
Exirel	39.0 cd	33.0 a	43.3 b	102.3 a	6.8 ab
Harvanta	45.3 cd	36.0 a	60.0 b	108.8 a	4.8 a
Malathion	4.5 a	27.8 a	98.3 b	129.0 a	25.5 abc
Untreated control	56.8 d	31.0 a	52.3 b	75.0 a	30.5 abc
Warrior II	39.3 cd	23.7 a	109.0 b	126.7 a	57.3 c
P>F	<0.001	0.48	<0.001	0.32	<0.01

Means within columns followed by a common letter are not significantly different ($P \leq 0.05$, Fisher's LSD)

[a]ln(X+1) transformed data used for ANOVA analysis; non transformed means shown in table.

SIGNIFICANT ACCOMPLISHMENTS: Three robust field trials targeting two priority clover seed insect pests were completed in 2020 and 2021. The data produced from the trials will further the registration process and help growers make informed choices about which materials are best for aphid and weevil control. The materials trialed offer diverse modes of action to ensure that rotational options are available to growers for insect management to prevent resistance development.

BENEFITS & IMPACT: Growers have multiple insecticides with several modes of action available for clover aphid management. These insecticides have multiple modes of action, which will allow for rotation of materials and help to prevent resistance development. The data produced from the trials helps growers to make informed choices about insecticide selection. The trials identified three materials with efficacy, across three insecticide classes.

For clover seed weevil, three materials with potential efficacy have been identified. These trials have provided the initial data to secure additional funding for research into 2022.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM: Funds to increase the scope of this project to other insect pests (beyond aphids) in clover for seed was awarded as part of a 2020 Oregon Specialty Crop Block Grant (lead PI: Rondon); funded amount $162,794.

Funding was awarded through ARF to Dr. Nicole Anderson to continue research into clover seed weevil; funded amount $15,000.

FUTURE FUNDING POSSIBILITIES: I am pursuing funding with Drs. Kaur and Dorman from the Western IPM Center and Western SARE to continue with clover seed weevil research in white clover seed production.