EVALUATING NEW INSECTICIDES TO MANAGE CLOVER SEED WEEVILS IN WHITE CLOVER SEED CROPS (2022)

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Introduction

The clover seed weevil (CSW), *Tychius picirostris* Fabricius (Coleoptera: Curculionidae), is one of the primary factors limiting seed yield potential and economic sustainability in white clover (*Trifolium repens* L.) crops (Reeher et al., 1950). This species is a key insect pest in white clover seed production systems in Oregon's Willamette Valley, benefiting from the close proximity of other white clover fields, a lack of alternative hosts to reduce pressure on clover seed fields, and high selection pressure of broad-spectrum insecticides used throughout the prolonged growing season. Other minor clover species grown in Oregon, including alsike (*Trifolium hybridum* L.) and arrowleaf (*Trifolium vesiculosum* L.), are also known to be susceptible to CSW feeding damage.

Clover seed weevil adults are gray, small (approximately 0.1 inch in length), and have a characteristic long snout and brushes of gray and white hair (Reeher et al., 1950). First-generation adults move into clover seed fields from overwintering areas and lay eggs within developing florets. Larvae hatch and feed on two to four developing seeds per floret, resulting in a considerable reduction in seed yield if not effectively managed (Chaudhri and Johansen, 1967). Since second-generation adult weevils exhibit dispersing behavior and do not feed on developing seeds or lay eggs, management recommendations should be focused on first-generation CSW populations.

Chemical control of CSW in white clover seed crops poses several challenges. Current economic thresholds are based on adult activity and do not consider the severity of larval infestations. The current recommendation is to treat when an average of two or more adult weevils per single straight-line sweep (90°) are observed. However, the relationship between adult weevil densities and the crop-damaging larval stage during the mass influx of adults from overwintering habitat remains unclear. Past recommendations for insecticide timing were based on the crop stage reaching 20% flower brown-down (BBCH 65–66). This approach may vary with weather and crop variety and is not always a reliable indicator to appropriately time foliar insecticide applications targeting CSW in white clover (Chaudhri and Johansen, 1967).

In 2021, seven insecticides applied at BBCH 65–66 were evaluated for efficacy against CSW under field conditions (Mattsson et al., 2021). Grower standards used in that study (Brigade and Malathion 8 Aquamul) resulted in initial knockdown effects on adults but had minimal impact on larval counts throughout the growing season. Seed yield was not measured in this study.

We hypothesize that using more diverse modes of action applied at first larval detection targeting CSW larvae will reduce feeding damage and seed yield loss. The primary objective of this study was to evaluate the efficacy of newer insecticide chemistries for CSW management in commercial white clover seed fields when applied at first larval detection compared to a standard practice of applying pyrethroids (Brigade) at BBCH 65–66.

Materials and Methods

Experimental design

One large-scale field trial was conducted in a commercial white clover seed field in Linn County, OR, in 2022. Nine treatments, including an untreated control (Table 1), were evaluated for CSW control and

Table 1. Trade names, active ingredient, and application rate of treatments for a field trial in Linn County, OR, in 2022.

Trade name	Active ingredient (IRAC group)	Rate[1]
Untreated control	—	—
Brigade	Bifenthrin (3A)	6.4[2]
Exirel	Cyantraniliprole (28)	20.5[3]
Exirel + Brigade	Cyantraniliprole (28) + bifenthrin (3A)	20.5[3] + 6.4[2]
Harvanta	Cyclaniliprole (28)	16.4[3]
Harvanta + Brigade	Cyclaniliprole (28) + bifenthrin (3A)	16.4[3] + 6.4[2]
Malathion + Brigade	Malathion (1B) + bifenthrin (3A)	20.0[3] + 6.4[2]
Steward	Indoxacarb (22)	11.3[3]
Steward + Brigade	Indoxacarb (22) + bifenthrin (3A)	11.3[3] + 6.4[2]

[1]Rate in fl/oz/acre

[2]Applied at BBCH 65–66 (July 7)

[3]Applied at first detection of larvae (June 23)

seed yield. Plots were 29 feet wide x 300 feet in length. Insecticide treatments were arranged in a randomized complete block design with three replications. Insecticide treatments were applied with an ATV-mounted boom sprayer equipped with TeeJet 11002 VS nozzles calibrated to deliver 20 psi with at least 15 gpa. Newer chemistries targeting CSW larvae (Exirel, Harvanta, Steward) and malathion were applied at first larval detection on June 23, 2022. Brigade applications (Brigade only and Brigade combination treatments) were applied at BBCH 65–66 on July 7, 2022.

CSW abundance

Adult CSW populations were measured at 3, 7, 14, 21, and 28 days after treatment (DAT). Larval populations were estimated at 7, 14, 21, and 28 DAT. To measure larval abundance, developing inflorescences (seed heads) were collected from three random 1 ft^2 areas in each plot (approximately 30 inflorescences per plot). Inflorescences were placed in plastic bags, transported to the laboratory, and subjected to Berlese funnel extractions for 24 hours. Adult CSW abundance was estimated with two sweep net samples of five straight-line sweeps at two locations in each plot. The sum of sweep samples (ten total sweeps) was recorded for CSW adult abundance in each plot.

Seed yield

To determine clean seed yield, plots were combined using grower's equipment and weighed using a Parkan weigh wagon on August 16, 2022. Subsamples of harvested seed were collected and cleaned to determine clean seed yield.

Data analysis

Adult and larval CSW abundance data were fitted to a negative binomial distribution and analyzed using a generalized linear mixed model framework with treatment and DAT as fixed effects, block as random effects intercepts, and random slopes for DAT. Clean seed yield was analyzed using a linear mixed effects model with yield as fixed effects and block as random effects intercepts. Differences between treatments were determined using estimated marginal means, and the Tukey method was used to calculate *P*-values with a significance level of $\alpha = 0.05$. Degrees of freedom were approximated using Kenward-Rogers adjustment for seed yield analysis.

Results and Discussion

Adult control

Both CSW adult and larval populations were detected throughout the bloom and seed fill periods. Adult CSW abundance using sweep net sampling was different among insecticide treatments across sampling dates (Figure 1A; $\chi^2 = 6.4$, $df = 8$, $P < 0.001$), and there was an interaction between treatment and DAT factors (Figure 1C; $\chi^2 = 1.6$, $df = 32$, $P = 0.02$). Across all sampling dates, CSW counts in Steward, malathion + Brigade, and Harvanta + Brigade plots were lower than in Brigade alone. When treatments were analyzed by DAT, insecticide treatments were different at 3, 7, and 14 DAT, with no differences detected at 21 and 28 DAT (Figure 1C). For 3 DAT, Steward and malathion had significantly fewer adults than the untreated control. At 7 DAT, fewer CSW adults were detected in Steward, malathion, and Harvanta treatments. Harvanta was the only treatment with significantly fewer adults than the untreated control at 14 DAT.

At 14 DAT, field plots reached BBCH 65–66, and Brigade applications were made for respective treatments. No differences were observed among treatments after Brigade applications. Adult CSW counts

Table 2. Insecticide treatment, mean number of CSW larvae per 30 inflorescences, and clean seed yield at harvest for a field trial in Linn County, OR, in 2022.

	--------------------- Larvae ---------------------				
Treatment	--- Pre-Brigade ---		--- Post-Brigade ---		Yield (±SE)[1]
	7 DAT	14 DAT	21 DAT	28 DAT	
Untreated control	1.7	12.3	1.7	8.0	539 (59)
Brigade	0.0	15.3	8.7	6.7	564 (83)
Exirel	0.7	9.0	1.7	8.0	591 (40)
Exirel + Brigade	0.3	6.0	0.3	3.7	635 (41)
Harvanta	5.7	3.0	8.0	15.0	550 (28)
Harvanta + Brigrade	1.0	4.0	0.0	0.7	636 (68)
Malathion + Brigade	1.0	4.3	1.0	2.0	607 (73)
Steward	0.3	2.0	0.0	8.3	605 (50)
Steward + Brigade	1.0	6.0	0.0	2.7	659 (55)
P < 0.05	0.55	0.67	0.33	0.30	0.17

[1]Yield in lb/acre

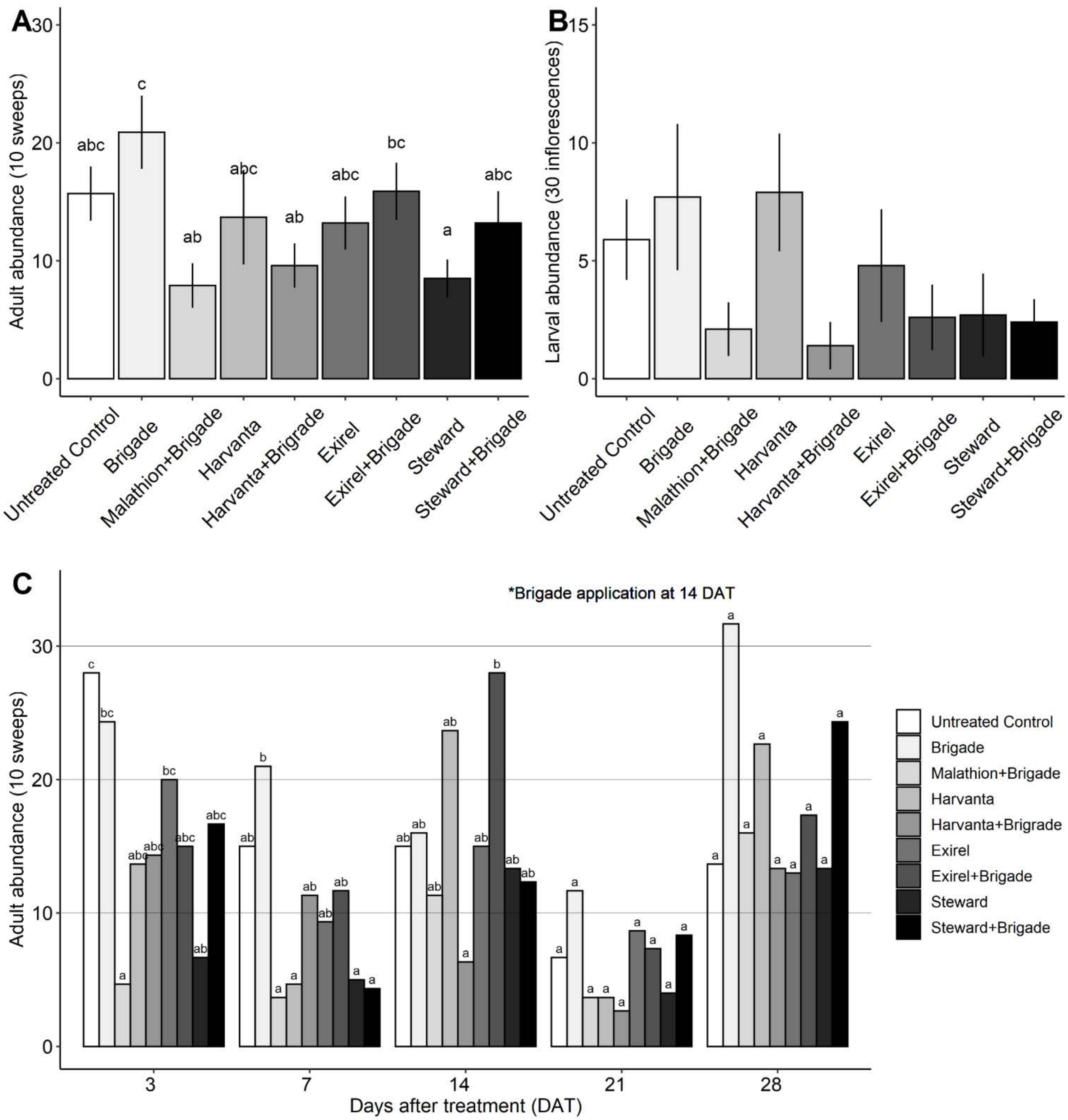

Figure 1. (A) Mean clover seed weevil (CSW) adult abundance (±SE) in straight-line sweep net samples (ten sweeps/plot) across all sampling dates. Treatment bars with the same letters are not significantly different ($P < 0.05$) using Tukey separation. (B) Mean CSW larvae (30 floral heads) across all days after treatment (DAT). (C) Mean CSW adult comparisons among insecticide treatments at 3, 7, 14, 21, and 28 DAT. Bars with the same letters within DAT groups are not significantly different ($P < 0.05$) using Tukey separation.

in the Brigade treatment were not different than the untreated control after application (DAT 21 and 28; Figure 1C). Phytotoxicity was not observed in any treatment.

Larval control

The number of larvae per 30 inflorescences was not different among treatments (Figure 1B; $\chi^2 = 1.2$, $df = 8$, $P = 0.29$), and no differences were detected among treatments at each sampling date (Table 2). Brigade did not provide adequate control of adult or larval populations. In summary, limited efficacy of Brigade to reduce CSW adult and larval populations in a field trial aligns with preliminary laboratory assays suggesting high levels of pyrethroid resistance within local CSW populations using technical-grade chemistry and formulated product.

Seed yield

No differences in total clean seed yield were observed among treatments in 2022 (Table 2). Similar field trials will be conducted in 2023 to further evaluate insecticide treatments on seed yield and to determine the best recommendations regarding insecticide chemistry selection for CSW control in Oregon white clover seed production.

References

Anderson, N.P. 2020. Pests of clover grown for seed. In C.S. Hollingsworth (ed.). *Pacific Northwest Insect Management Handbook*. Oregon State University. https://pnwhandbooks.org/insect

Chaudhri, Y.M. and C.A. Johansen. 1967. Bionomics of the clover seed weevil, *Microtrogus picitrostis* (Fabricius) in southeastern Washington and adjacent Idaho. Washington Agricultural Experiment Station 53.

Kaur, N., W.P. Jessie, C.S. Sullivan, D.L. Walenta, E.C. Verhoeven, and N.P. Anderson. 2019. Evaluation of bifenthrin resistance in field-collected clover seed weevils. In N.P. Anderson, A.G. Hulting, D.L. Walenta, and C.A. Mallory-Smith (eds.). *2019 Seed Production Research Report*. Oregon State University, Ext/CrS 162.

Mattsson, M., N. Kaur, L.V. Slambrook, and D.M. Lightle. 2021. Evaluating insecticides for clover seed weevil control, 2021. Arthrop. Manage. Tests 46:tsab164. https://doi.org/10.1093/amt/tsab164

Reeher, M.M., L.P. Lockwood, E.A. Dickason, and D.C. Mote. 1950. Control of the clover seed weevil. Oregon State College Agricultural Experiment Station, Circular of Information 485.

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