AGRICULTURAL RESEARCH FOUNDATION
INTERIM REPORT
FUNDING CYCLE 2021– 2023

TITLE: Leveraging innovative insect pest management approaches for the management of red clover casebearer moth in Oregon's clover seed crops

RESEARCH LEADER: Navneet Kaur

COOPERATORS: Nicole P. Anderson, OSU- NWREC; Darrin Walenta, OSU-Union Co. Extension Service; Seth Dorman; USDA-ARS; Christy Tanner, OSU- South Valley Field Crops Agent

SUMMARY/ABSTRACT: The red clover casebearer moth, *Coleophora deauratella*, is an invasive pest in red clover production systems in western Oregon. Native to Europe and Asia, *C. deauratella* was introduced to Canada in 1991 and first sighted in Oregon in 2011. Although *C. deauratella* is considered a secondary pest in Oregon, significant reductions in seed yield from larval feeding have been recorded in Canada, and high moth populations have become more frequent in select regions across the Willamette Valley. However, during the 2021 growing season, the insect pressure remained low at all sites in eastern and western Oregon red clover growing regions. We will continue to monitor during the 2022 growing season in selected regions of western Oregon using pheromone traps to identify one or two field sites with high pest pressure to conduct a mating disruption trial. Archived data sets (2013, 2014, 2020, 2021) were subjected to analyses to develop a phenology model and understand the spatiotemporal distribution of this insect pest. Results are presented in the Appendix.

OBJECTIVES: The objectives of this study were to test the mating disruption method, identify the presence of any natural enemies, and understand the spatiotemporal distribution of this insect pest. Knowledge generated from this work will help formulate a management plan against red clover casebearer moth in red clover seed crops grown in Oregon.

Research Objectives:

1. To evaluate the effectiveness of mating disruption techniques against the red clover casebearer moth in clover seed fields.
2. To conduct an areawide survey of the natural enemies of the red clover casebearer moth in clover seed fields.
3. To assess the spatiotemporal distribution of the red clover casebearer moth in clover seed fields.
4. To develop a degree day-based phenology models of the red clover casebearer moth and predict the peak moth flights and egg hatching.

PROCEDURES:

1. Monitoring efforts: A sex-pheromone-bait utilizing pheromone blend of female *C. deauratella* (10:1 Z7-12:OAc to Z5-12:OAc, Evenden, 2010) was utilized to capture adult male moths in 23 commercial red clover, crimson clover, vetch (both hairy and common) seed production field sites and one experimental red clover site at OSU Hyslop Research Farm in western Oregon staring mid-May (Table 1). A single green UniTrap® was placed in each field at least 100 feet from the field edge and at crop canopy height. A septum baited with the pheromone lure was placed in the pheromone housing at the top of the trap, and the bucket on the bottom contained an insecticide vapor strip to euthanize captured moths. Pheromones were replaced after every three weeks. Traps were monitored weekly for 10 weeks. Monitoring efforts ended in mid to late July for all sites. Weekly monitoring activities included: 1) collecting adult moth specimens from each trap for identification and quantification, and 2) evaluating red clover heads for larvae presence and feeding damage. Traps were deployed at three red clover commercial field sites in Eastern Oregon (one third-year stand and two first-year red clover stands) in late April, and weekly data for adult captures was collected until the second week of August. Destructive head samples were evaluated for eggs/larvae/damage on 22 June, 29 June, 6 July, 21 July, 28 July, 4 August, and 9 August.

2. Identification of natural enemies: Several species of parasitoid wasps are known to be associated with *Coleophora* species in Europe, their countries of origin. It was exciting to encounter three different parasitoid species in red clover seed fields in Oregon in 2020, with one species that are specifically known to attack *Coleophora* species. An areawide survey consisted of collecting larvae-infested florets from the field and bringing them to the laboratory for future rearing.

3&4. Data from past and current monitoring efforts in commercial red clover fields (n = 53 total sites) for five years (2013, 2014, 2020, 2021) is being used for the model development. Trap catch data with male moths were used as a proxy to model flight phenology for *C. deauratella* populations using publically available climate data. The spatial distribution of *C. deauratella* abundance was also analyzed.

SIGNIFICANT ACCOMPLISHMENTS TO DATE:

Clover casebearer research updates to 200 adult education contacts including growers, industry professionals and extension agents was provided during the OSU Seed and Cereal Crop Grower Meetings. One extension article was published in the seed production research reports and was distributed to the seed growers throughout the state using the OSC mailing list of 1,350 individuals. In addition, the report is distributed to over 60 international seed researchers associated with the International Herbage Seed Group (*www.ihsg.org*). This report is available online through Oregon Seed Extension Program website. The project findings were also

presented during the 2022 81st Annual Pacific Northwest Insect Management Conference. Peer-review journal article is being prepared and will be submitted to the Journal of IPM.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM:

Funds were also provided by the Oregon Clover Commission to conduct this research during the 2020-2021 grant cycle. College of Agricultural Sciences and OSU Extension service provided travel support to foster collaborations between OSU and Canadian collaborators working on red clover casebearer moth.

FUTURE FUNDING POSSIBILITIES:

We do not have specific plans to apply for additional funding beyond this cycle of ARF funding.

APPENDIX
Results

2021 Monitoring. Data from western Oregon sites are presented in Table 1. Overall, the insect pressure remained low throughout the growing season at all sites. One field with crimson and red clover under sown had an uptick in number during week 3 with 15 adults (also the highest capture of the season). However, adult captures remained low during week 4, followed by the drastic decline in the capture rate each week. We have plans to continue sampling at this site and several additional old stands in mid-valley red clover growing region during the 2022 growing season to monitor the pest pressure in the red clover and conduct the mating disruption trial once reliable pest pressure is found. Adult captures in hairy and common vetch sites are also presented in Table 1, confirming our earlier DNA-based results that vetch crops (Vicia spp.) are suitable host plants for this insect pest.

A similar trend of low insect density was present in the Eastern Oregon sites. Only two sites had adult flight activity recorded in the pheromone traps during mid to late June, as presented in Fig. 1. Only three larvae were detected in the destructive head sampling at all sampling events.

Natural enemies' association. Only seven larvae were detected in clover head samples collected weekly at all sites monitored for adult flights in western OR during the growing season (Table 2). The larvae did not show signs of parasitization or pathogens. Sweep net samples were conducted to monitor the natural enemy densities at bi-weekly intervals. The predominant natural enemy was *Orius insidiosus,* a predatory insect in family Anthocoridae (on average 8.28 adults per sweep sample per site), and parasitic wasps in the family Ichneumonidae and Braconidae (on average 2 wasps per sweep sample per site).

Individual commercial fields (n=53) sampled in 2013–2014 and 2020–2021 are visualized in Fig. 2A. Significantly higher *C. deauratella* was observed in 2013 and 2014 compared to 2020 and 2021 growing seasons (Figs. 2B and 3A). In 2013 and 2014, average weekly *C. deauratella* counts in pheromone traps were high (>10) at several locations across the Willamette Valley, including Benton, Marion, Yamhill, and Washington counties (Fig. 2B).

To determine significant clustering of *C. deauratella* infestations across the valley, if present, we calculated the Getis-Ord General G statistic or clustering index, which measures significant spatial concentrations of high *C. deauratella* counts. Given significant inter-annual fluctuations in *C. deauratella* males captured in pheromone traps across sampling years, we measured the clustering index individually for each year. These results were then pooled together and visualized in Fig. 2C. Interestingly, when trap counts were analyzed by year, significant clustering of *C. deauratella* moths was found in Marion county traps all four years of the study. In other words, under a high-pressure and low-pressure scenario, most moths aggregated in commercial fields in

Marion county. Although, it is important to note that in high-pressure years (e.g., 2014), high moth counts were also found in the other counties listed above.

We used publically available climate data to develop phenological models that predict the median flight (50 percent) of *C. deauratella* in western Oregon based on cumulative degree days (CDDs) from 1 January. Climatologies (minimum and maximum daily air temperature) were obtained from Daymet: Daily Surface Weather Data on a 1-km Grid for North America, Version 4. Interpolated climate data at 1 km × 1 km spatial resolution was extracted for each unique field location. Nonlinear logistic regression was used to predict median *C. deauratella* flight using the single-sine method with a developmental threshold of 11.7°C (Mori et al., 2014). Phenological models were developed for data collected in 2013, 2014, and 2020; data collected in 2021 was omitted due to low *C. deauratella* counts. Median flight was predicted at 297.7°C, 281.8°C, and 331.9°C cumulative degree days for 2013, 2014, and 2020, respectively (Fig. 3B). The predicted CDDs for the phenological model with combined data across years was 309.6°C. This result equates to the 23rd through 26th of June for each sampled year. We can use this degree day threshold to predict precise median flight of *C. deauratella* based on CDDs, which likely occurs around the last week of June in western Oregon. Therefore, active scouting for *C. deauratella* is important during this time, especially in the Marion county area. Additional research is needed to collect data on larval and egg observations in commercial fields to model degree day intervals between susceptible life stages to inform management decisions and timely foliar spray applications.

Future research will investigate potential abiotic (climate) and biotic (landscape configuration and composition) descriptors that may predict or explain significant clustering observed in the Marion county area. These insights will allow us to further understand key risk factors that explain the spatial clustering and population dynamics of *C. deauratella* infestations and potential drivers of high-pressure years to inform pest management strategies.

Table 1. Site, crop, age, and weekly RCCB adult capture in the pheromone traps deployed in western Oregon during the 2021 growing season.

Site	Host Crop	Stand age	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
1	Red clover	1	0	0	0	0	0	0	0	0	0	0
2	Red clover	2	0	0	0	0	0	1	0	0	0	0
3	Red clover	2	1	0	0	1	0	0	0	0	0	0
4	Red clover	4	0	0	0	0	0	0	0	0	0	0
5	Red clover	2	0	0	0	0	0	0	0	0	0	0
6	Red clover	3	0	0	0	0	0	0	0	0	0	0
7	Common vetch	1	0	0	1	1	0	0	0	0	0	0
8	Hairy vetch	2	0	0	0	0	0	0	0	0	0	0
9	Hairy vetch	1	0	0	0	0	0	2	0	0	0	0
10	Red clover	2	0	0	0	0	1	0	0	0	0	0
11	Crimson/Red clover*	1	1	3	15	4	8	1	0	0	0	0
12	Red clover	1	0	0	0	0	0	0	0	0	0	0
13	Red clover	2	0	0	0	0	0	0	0	0	0	0
14	Red clover	2	0	0	2	1	0	0	1	1	0	0
15	Crimson clover	1	0	0	0	0	0	0	0	0	0	0
16	Red clover	2	0	0	0	0	0	0	0	0	0	0
17	Hairy vetch	1	0	0	4	0	0	0	0	0	0	0
18	Red clover	2	0	0	0	0	0	1	0	1	0	0
19	Red clover	1	0	0	4	3	0	1	0	0	0	0
20	Red clover	1	0	0	0	4	4	1	3	0	0	0
21	Red clover	2	0	0	2	0	1	3	0	0	0	0
22	Crimson clover	1	0	0	0	0	0	0	0	0	0	0
23	Red clover	2	0	0	0	0	0	5	2	0	0	0
24	Hairy vetch	1	0	0	0	0	0	0	0	0	0	0

*Red clover under sown and sampling for 2022 growing season will be followed.

Table. 2. Detection of larvae while assessment of clover seed heads per week in western Oregon trapping network

Host (Site)	Larvae per 25 clover seed head	Date detected
Crimson/ Red under sown (Site 11)	4	6/15/2021
Red clover (Site 1)	1	6/23/2021
Red clover (Site 3)	1	6/21/2021
Red clover (Site 14)	1	7/1/2021

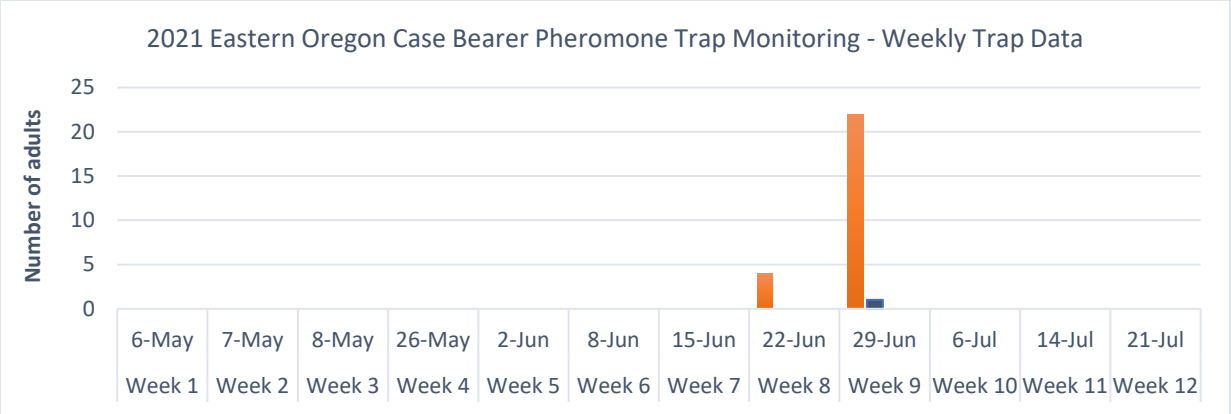

Fig. 1. Weekly pheromone trap results for male red clover casebearer moths (RCCB) for each commercial red clover seed production field monitoring site in eastern Oregon.

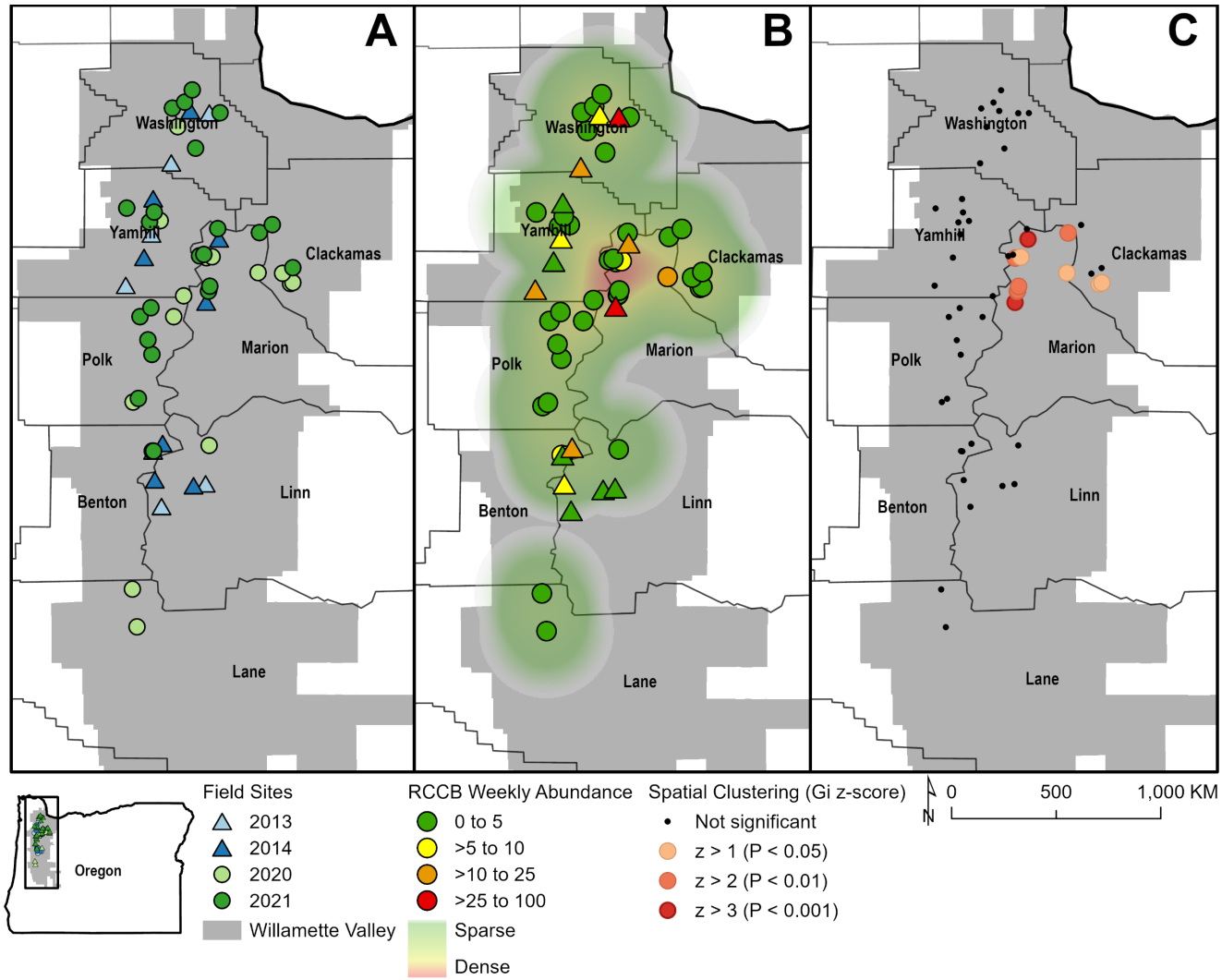

Figure 2. (**A**) Commercial fields (n=53) sampled for *C. deauratella* (RCCB) in 2013–14 and 2020–21 across the Willamette Valley. (**B**) Weekly average RCCB abundance data for all sampled fields. (**C**) High spatial clustering statistic (z-score > 1 indicates significant clustering).

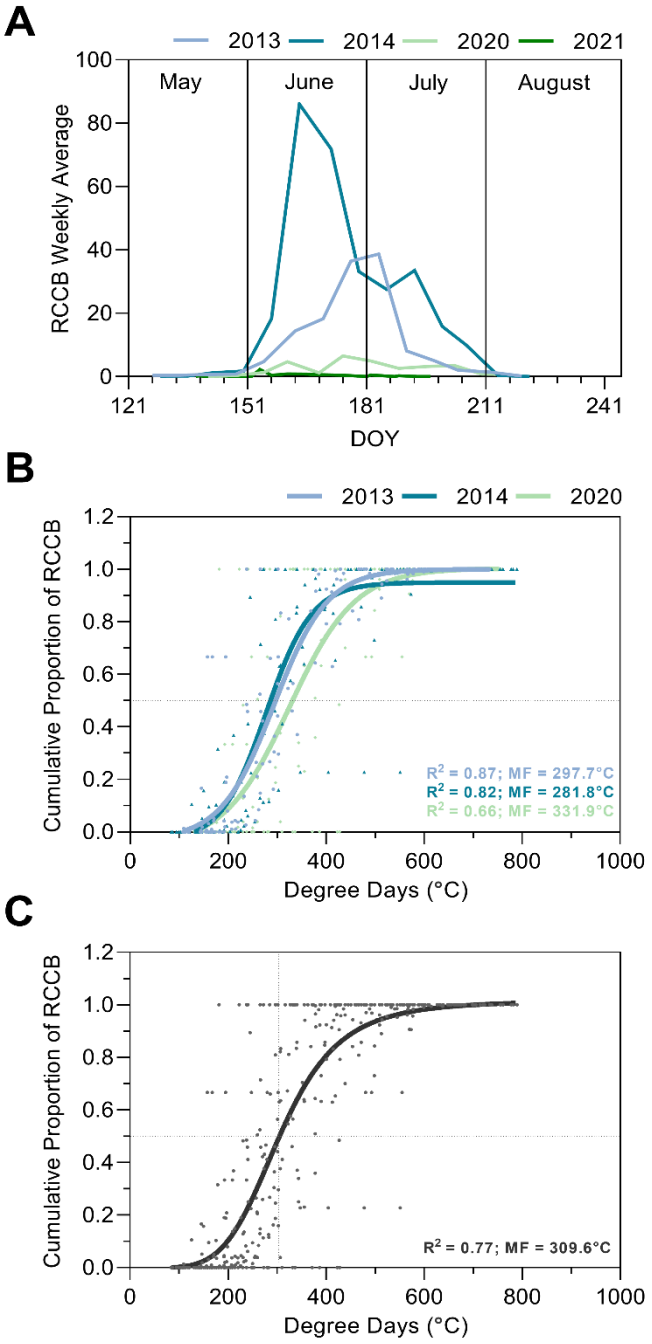

Figure 3. (**A**) *C. deauratella* weekly trap catch throughout the sampling season (DOY = day of year). (**B**) Phenological models for 2013, 2014, and 2020 based on cumulative degree days (CDDs; 11.7°C base threshold). (**C**) Complete phenology model with all data from individual models.

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