Poster Number: 1

Improving Integrated Pest Management Practices of Major Hemipteran Pests in Almond Orchards

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Abstract

Several hemipteran pests attack almonds in California. These pests include several native stink bug species (e.g., green stink bug, *Chinavia hilaris*), leaffooted bugs (*Leptoglossus* spp.), and invasive brown marmorated stink bug (*Halyomorpha halys*) (BMSB). These pests pierce developing nuts with piercing-sucking mouthparts, resulting in unmarketable kernels generally referred to as "brown spot". The brown spot damage has increased in recent years, causing widespread economic loss to almond growers. In our recent studies, we found that:

- The invasive BMSB has expanded its range, with new finds in almond orchards in Sacramento Valley and its continuous spread in San Joaquin Valley orchards.
- There was a positive correlation between stink bug counts in the orchard and brown spot damage at harvest. So, monitoring of the pest is critical.
- Hemipteran feeding in almonds increased the risk of hull rot damage.
- A study to explore the relationship between hemipteran insect damage and aflatoxin contamination is underway.
- Many biological-based insecticides were tested against the hemipteran pest complex, and the results show a potential to include these insecticides as a part of integrated pest management (IPM) program

Introduction

The current practice of controlling hemipteran pests in almonds is applying pyrethroid on a "first sight" basis in spring/early summer. However, establishing the invasive brown marmorated stink bug (BMSB) in the almond-growing regions of the San Joaquin Valley has further complicated pest management decision-making. Detection monitoring for BMSB in regions such as Sacramento Valley is important. Although monitoring-based decision making is one of the prerequisites of IPM, no such criteria have been developed for hemipteran pests in almonds. Moreover, there is increasing suspicion that the feeding by stink bugs on almonds may exacerbate hull rot/mold and aflatoxin contamination. Recently, almond fruits collected directly from the almond trees that had a high stink bug population and damage showed a high level of hull rot incidence (Unpublished data, Rijal and Michailides); further investigation is needed on this potential correlation between hemipteran feeding and hull rot. The availability of biological and reduced-risk insecticides is always critical for the sustainability of the almond industry. This project aimed to address some of the questions discussed earlier.


Green stink bugs in almonds

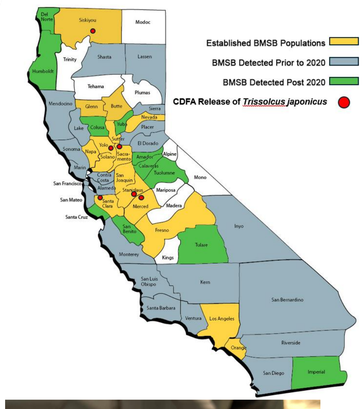

Brown spot in almonds

Objectives

1. Conduct season-long sampling of invasive and native stink bugs and their natural enemies in Sacramento and San Joaquin Valley orchards (PIs: Rijal, Bansal, Lara, Gyawaly)
2. Develop pest risk prediction and decision support tools for managing hemipteran pests in almond orchards (PIs: Rijal, Bansal, Gyawaly)
3. Explore a relationship between hemipteran pest damage and mold, as well as aflatoxin contamination (PIs: Rijal, Michailides)
4. Examine the efficacies of biological-based and reduced-risk insecticides against hemipteran pests in almonds (PIs: Rijal)

Results and Conclusions

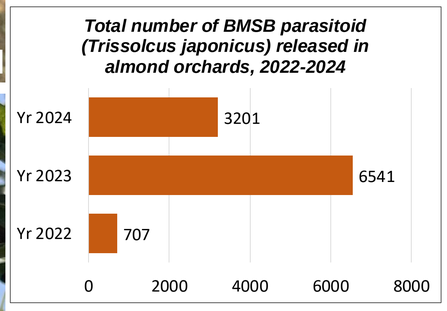
Objective 1 Study Results



- Invasive brown marmorated stink bug was captured in 1 of 3 orchards in Sacramento Valley in 2024. This is potentially the first report of BMSB infestation in an almond orchard in Sacramento Valley (Chico area). In Central San Joaquin Valley orchards (Fresno area), BMSB and damage have been found in the last 4 years, including in four orchards in 2024. In north San Joaquin Valley orchards, BMSB has been causing economic damage for several years, including this year in 8 orchards we surveyed. Green stink bug and leaffooted bug populations were observed in several locations as well.
- For biological control, in 2024, we have released BMSB-specific egg parasitoid *Trissolcus japonicus* (Tj) in two almond orchards in Stanislaus and Merced counties two times during the season with over 1500/parasitoids per location.


T. japonicus parasitoid ready for the release

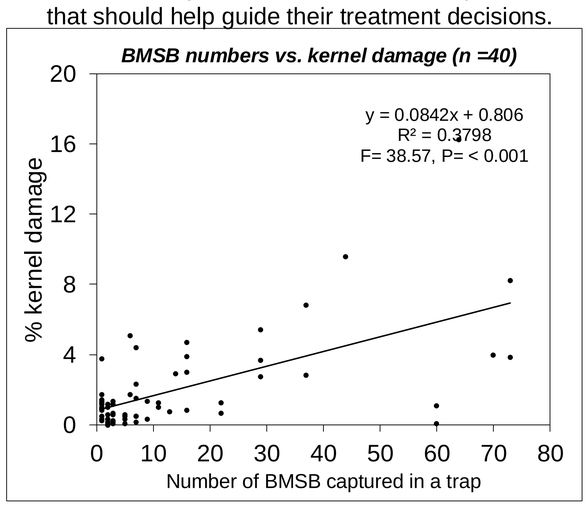

BMSB egg cards for parasitoid recovery



- In addition, four BMSB-infested almond orchards were surveyed for several weeks using 4-8 sentinel egg cards/orchards to detect the native parasitoids and recover field-released Tj. Egg card evaluation is underway.

Objective 2 Study Results

- **Relationship between hemipteran populations and nut damage.** The data from the year 2021-2023, from 40 orchard blocks, showed a significant positive correlation between the number of BMSB recorded and the percent brown spot damage at harvest.
- A similar relationship will be developed for the green stink bug. The results should help the pest control advisers estimate the potential harvest damage based on seasonal hemipteran counts. The final analysis will be done after including over 10 orchard sampling data from 2024 to the existing dataset. The results will be presented in the annual report.
- A decision support tool will be developed to help growers identify the particular hemipteran pest and its damage at different times of the year, and that should help guide their treatment decisions.



Objective 3 Study Results

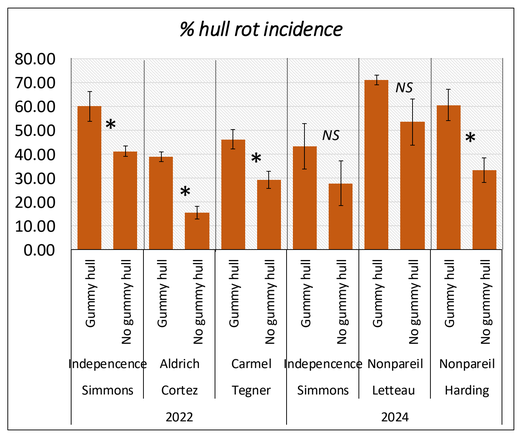
Association between aflatoxin and hemipteran feeding.

- Almonds were harvested in August and stored in the freezer for aflatoxin evaluation. The results will be included in the final report.


Caged hullsplit almonds ready for insect and Aspergillus inoculations

Association between hull rot and hemipteran feeding.

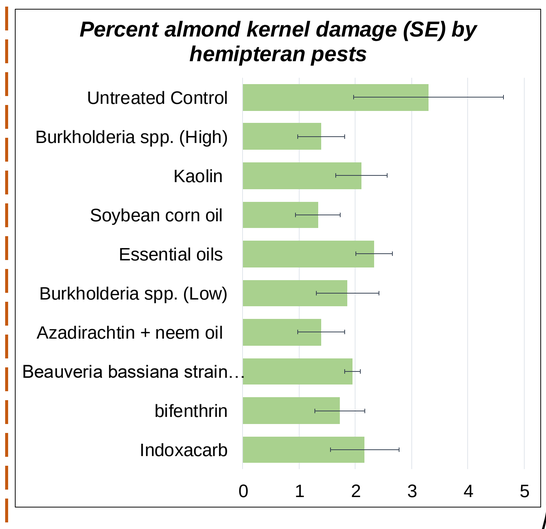
- Gummy almond fruits (due to Hemiptera feeding) had a higher incidence of hull rot (*Aspergillus niger,* and *Rhizopus stolonifera*) than the fruits without gumming. 4 of 6 orchards representing several varieties showed a significantly higher hull rot in gummy fruits (see figure below). Pairs with * between are statistically different.



Objective 4 Study Results

Reduced risk and biological insecticide against hemipteran pests.

- The average number of no. necrotic kernel "brown spots" were analyzed using one-way ANOVA, with Tukey-Kramer HSD mean separation at 5%.
- The highest level of damage was observed in Untreated Control (3.3%). No treatments were statistically different from each other. The results are presented in the Figure below.



Methodology

Objective 1: Survey of Invasive BMSB and its biocontrol

- In 2024, all hemipteran pests, including BMSB, were surveyed over 13 orchards in San Joaquin (11) and Sacramento (3) Valleys using trap, visual, and beating tray samplings
- For biological control, in collaboration with CDFA, BMSB-specific egg parasitoid *Trissolcus japonicus*, were released and recovered using sentinel egg cards.

Objective 2. Development of pest risk prediction and decision support tools

- Seasonal monitoring of all stink bugs was conducted over 54 orchard blocks between 2021 and 2024.
- Utilizing this dataset, the risk prediction models for green stink bug and BMSB will be developed by exploring the relationship between stink bug feeding and kernel necrosis "brown spot' damage. Preliminary results are presented.

Objective 3. Relationship between mold and stink bugs

- Nonpareil almond fruits were sprayed with aflatoxigenic *Aspergillus flavus* fungus spore in the tree, and the fruits were caged with stink bug or leaffooted bug. The separate groups of fruits were sprayed with fungal spores but without insects - Control treatment. The applications were made twice – before the hullsplit (mid-June) for one group of fruits or after the hullsplit (mid-July) for another group of fruits. The study was done at UC KARE, Parlier. Almonds were harvested and stored in the freezer for aflatoxin evaluation. The results will be included in the final report.
- For the hull rot vs. hemipterans study, almonds were collected at harvest from multiple orchards with a history of stink bug activity during the season. The correlation between gumming fruits and percent damaged nuts was analyzed and presented.

Objective 4: Insecticide Evaluation

- A study was conducted in two border tree rows of an almond orchard (var. Independence) to evaluate the efficacy of registered and experimental biological insecticides. The orchard had a history of brown marmorated, green stink bug, and leaffooted bug.
- Selected insecticides were applied twice in early May using three trees as an experimental unit and replicated four times. Harvest samples were collected and evaluated for hemipteran bug damage.

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