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 include native stink bug species (e.g., green stink bug, *Chinavia hilaris*), leaffooted bugs (*Leptoglossus* spp.), and the invasive brown marmorated stink bug (*Halyomorpha halys*, BMSB). These pests pierce developing nuts with their piercing-sucking mouthparts, resulting in unmarketable kernels commonly referred to as "brown spot." Brown spot damage has increased in recent years, causing widespread economic losses for almond growers.

Our recent studies found that:

- The invasive BMSB has expanded its range, with new detections in almond orchards in the Sacramento Valley and continued spread in San Joaquin Valley orchards.
- There is a positive correlation between stink bug counts in orchards and brown spot damage at harvest, underscoring the importance of pest monitoring.
- Hemipteran feeding on almonds increases the risk of hull rot damage.
- A study exploring the relationship between hemipteran insect damage and aflatoxin contamination is underway.
- Many biological-based insecticides tested against the hemipteran pest complex show potential for inclusion in integrated pest management (IPM) programs.

Introduction

Current practices for controlling hemipteran pests in almonds involve scouting and spraying if pests are detected. However, the establishment of the invasive brown marmorated stink bug (BMSB) in almond-growing regions of the San Joaquin Valley has further complicated pest management decisions. Monitoring for BMSB in areas such as the Sacramento Valley is critical. Although monitoring-based decision-making is a key component of integrated pest management (IPM), no such criteria have been developed for hemipteran pests in almonds.

There is growing concern that stink bug feeding on almonds may exacerbate hull rot, mold, and aflatoxin contamination. Recently, almonds collected from trees with high stink bug populations and damage showed a high incidence of hull rot (unpublished data ; Rijal and Michailides), suggesting the need for further investigation of this potential correlation. The availability of biological and reduced-risk insecticides remains essential for the sustainability of the almond industry. This project aims to address these critical questions.


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 (PI: Rijal)

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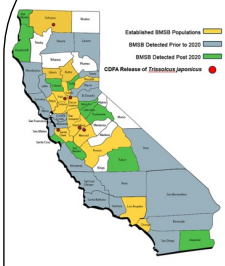
Results and Conclusions

Objective 1 Study Results

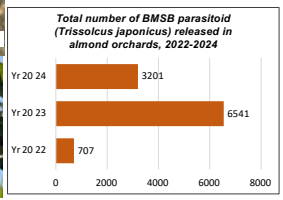


- Invasive BMBS was captured in 1 of 3 orchards in the Sacramento Valley in 2024. This is the first report of BMSB infestation in an almond orchard in the Sacramento Valley (Chico area). In Central San Joaquin Valley orchards (Fresno area), BMSB and damage have been found in the last 4 years, including in four orchards in 2024. In the 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.


T. japonicus parasitoid ready for release

- For biological control, in 2025, we released 6680 BMSB-specific egg parasitoid *Trissolcus japonicus* (Tj) in almond orchards in Stanislaus and Merced counties twice during the season.

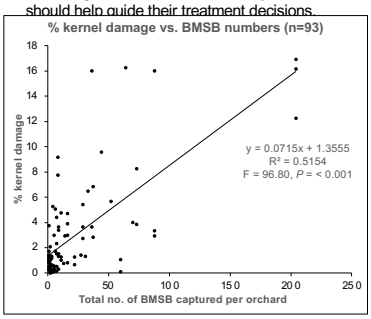

BMSB egg cards for parasitoid recovery



- 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. Detected *Trissolcus euschisti*

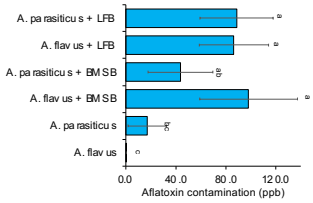
Objective 2 Study Results

- **Relationship between hemipteran populations and nut damage.** The data from 2021 to 2025, covering 93 orchard-variety combinations, showed a significant positive correlation between the number of BMSB recorded and the percentage of 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 in the existing dataset. The results will be presented in the annual report.
- A decision support tool will be developed to help growers identify the specific hemipteran pest and its damage at different times of the year, which should help guide their treatment decisions.

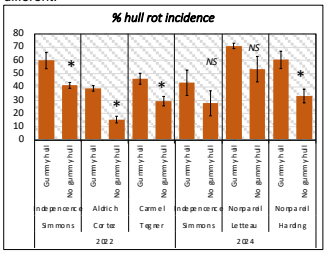


Objective 3 Study Results

Association between aflatoxin and hemipteran feeding. Aflatoxin concentrations (ppb) were significantly higher when LFB was present for both fungal species, and when BMB was present with A. flavus, compared to fungi without bug presence (Figure below)



Association between hull rot and hemipteran feeding. 4 of 6 orchards showed a significantly higher hull rot incidence (*Aspergillus niger* and *Rhizopus stolonifer*) in gummy fruits (Figure below). Pairs with * between are statistically different.

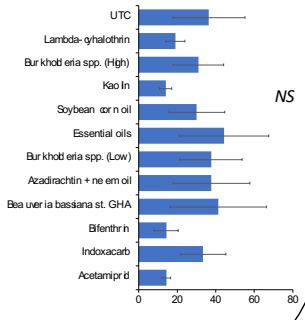


Objective 4 Study Results

Reduced risk and biological insecticide against hemipteran pests.

- The total number of gumming nuts observed on two trees per treatment was analyzed using one-way ANOVA, with Tukey-Kramer HSD post hoc tests at 5%.
- No treatments differed significantly from each other. The results are presented in the Figure below.

Mean ± (SEM) in season gumming nuts per treated tree, 2025



NS: No statistical difference among treatments

Methodology

Objective 1: Survey of Invasive BMSB and its biocontrol

- In 2025, all hemipteran pests, including BMSB, were surveyed over orchards in North San Joaquin (5) and Sacramento (3) Valleys using trap, visual, and beating tray samplings
- *Trissolcus japonicus* was released and sentinel egg cards were deployed to recover Tj and other parasitoids.

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

- Seasonal monitoring of all stink bugs was conducted across 54 orchard blocks from 2021 to 2025.
- 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 10-15 fruits were sprayed with aflatoxigenic *Aspergillus flavus,* and *A. parasiticus* fungus spores 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 no insect caging- 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 in 2024 and 2025. The results from 2025 will be presented in the final report.
- For the hull rot vs. hemipterans feeding study, almonds were collected at harvest from orchards with a history of stink bug activity during the season. The correlation between gumming fruits and the percentage of damaged nuts was analyzed and presented. The 2025 fruit evaluation is still in process.

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 hemipteran damage.
- Selected insecticides were applied twice in early May, with two trees as an experimental unit and four replications. In early June, the trees were inspected, and the number of gumming nuts caused by bug feeding was recorded.

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