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Monitoring and Abundance of Brown Marmorated Stink Bug in Peach and Almond Orchards in the Northern San Joaquin Valley

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Introduction

Brown marmorated stink bug (BMSB), *Halyomorpha halys*, is a new invasive insect pest of a variety of crops and has been causing serious economic losses in the United States since its first detection in Pennsylvania in the early 2000s. In 2010, a significant crop loss ($37 million only in apples) has been reported due to *H. halys* feeding in tree fruits such as peaches, apples and other crops in the Mid-Atlantic region (Leskey et al. 2012), and since then, *H. halys* has spread to over 44 U.S. states (www.stopbmsb.org). *H. halys* attacks a wide host range more than 170 plant species include crops, ornamental and landscape trees (www.stopbmsb.org). The major host crops reported include apples, peaches, nectarines, pears, cherries, grapes, peppers, tomatoes, sweet corn, beans, soybean, and more. Both immature (except the 1st instar) and adult *H. halys* actively probe into fruiting structures (fruits and seed pods) by inserting their piercing-sucking mouthparts, release the saliva, and uptake the content. *H. halys* is also considered as nuisance as they move to houses *en masses* during the winter. *H. halys* overwinter in human-made structures such as houses, barns, and remain active in the orchard throughout the season after they emerge from the overwintering shelters in the Spring. *H. halys* remain active throughout the season in finding and infesting crops and other plants. Almond, *Prunus dulcis*, has recently been listed as a new host crop based on the finds of *H. halys* infestation in an almond orchard in Modesto, California in 2017 (Rijal and Gyawaly 2018). Based on the observations of the infested orchard and evaluations of developing fruits in 2017 and 2018, it is clear that *H. halys* are capable of doing significant damage to almonds throughout the season. Early season infestation (March-April) contributes to the nut abortion leading to the substantial nut drop (more than 95% in late March-early April) while mid-to-late season feeding results in damaged kernels based on the recent study (Rijal, Fisher, Zalom, unpublished data).

Although detected in 2002 in southern California (Lara et al. 2016), a large population of *H. halys* was found in urban areas of Sacramento in the Fall-2013 (Ingels and Daane 2018) and has since become a nuisance to the residents and businesses. Currently, there are 16 Counties with the established *H. halys* population in residential areas (https://cisr.ucr.edu/brown_marmorated_stinkbug.html). As the first reports, we documented the finds of *H. halys* in crops – peaches in 2016 (Rijal and Duncan 2017), and almonds in 2017 (Rijal and Gyawaly 2018) in Stanislaus County. In order to understand the extent of the spread, and potential damage caused by *H. halys* to peach and almond, we conducted trap-based *H. halys* monitoring as well as fruit damage assessment studies in 2017-2018.

Materials and Methods

H. halys monitoring using traps. Two types of traps (pyramid and sticky panel) were used to monitor *H. halys* activities in selected peach and almond orchards in both 2017 and 2018 seasons. Both types of the trap were baited with the *H. halys* lure (Trece Inc., Adair, OK). The

pyramid trap (Fig. 1A) is effective in catching both nymphs and adults, but this trap is expensive and more cumbersome for field use. Therefore, along with other researchers working on *H. halys* from other parts of the Country, we included the new trap type 'sticky panel trap' (Fig. 1B) in addition to the pyramid trap. *H. halys* lure along with an insecticide strip (to contain trapped insects) was placed inside a clear plastic container at the top of the pyramid trap (Fig. 1A). In sticky trap, the sticky panel was stapled to the top of a wooden stake, and the lure was hung near to the sticky panel by using a binder clip and a wire loop (Fig. 1B). Both traps were installed in the ground are 4 ft. tall. 3-4 traps of each of the two types were used to monitor 7 (3 peach, 2 almond, 2 walnut) and 14 (7 peach, 7 almond) orchards in 2017 and 2018, respectively. Traps were placed in between the trees in the border row, checked and cleaned them as needed. The lure were changed at 4-week intervals in 2017, and at a 12-week interval (manufacturer's recommendation) in 2018. Due to the accumulation of dust and other debris, sticky traps were changed at the interval of 4 weeks or less. Traps were placed in the Spring (April-May) through the Fall (October-November).

H. halys damage to almonds. Based on the field observations and evaluations of the developing fruits collected from the field and some controlled-cage studies conducted in 2017 and 2018, we summarized the nature of feeding damage by *H. halys* in almonds.

Fig. 1. *H. halys* monitoring traps, a) Pyramid trap, B) Sticky panel trap

Results

***H. halys monitoring using traps*.** In 2017 season monitoring, *H. halys* adults were captured from three peach and two almond orchards along with the feeding damage in developing fruits (Fig. 2). Although low in number, nymphs were present in one peach and two almond orchard traps. *H. halys* adults were captured from the traps placed in two walnut orchards. However, there was no indications of feeding damage to walnuts, and also no nymphal activity was recorded in traps. As these are the first evidence of *H. halys* activities recorded in commercial orchards in California, the overall population was low (the highest number of adult captures was 64 adults from one peach orchard site). Although lacking a clear trend between

sticky and pyramid traps in capturing *H. halys* population in these low-infested orchards, adults were captured in both traps effectively (Fig. 2).

In 2018 season, *H. halys* adults were captured in traps from all seven peach orchards (total seasonal number of adults: 30, 27, 12, 11, 23, 26 from 7 orchards) while nymphs were captured from five out of those seven orchards. In almond orchards, *H. halys* adults were captured from all seven orchards, but the number varied from low (total seasonal number of adults: 1, 4, 6, 13, 14), moderate (total seasonal number of adults: 131), to high (seasonal total number of adults: 729) infestation levels. 6 out of 7 orchards captured nymphs (maximum number was 114 from the heavily infested block) in the trap. All of these peach and almond orchards monitored were located in Stanislaus and Merced counties. In general, the sticky panel captured more adults compared to the pyramid traps especially later part of the season (September – November). In contrast, nymphal capture was higher in the pyramid than the sticky panel trap. Seasonal phenology of *H. halys* capture in an almond orchard in the northern San Joaquin Valley is shown in Fig. 3.

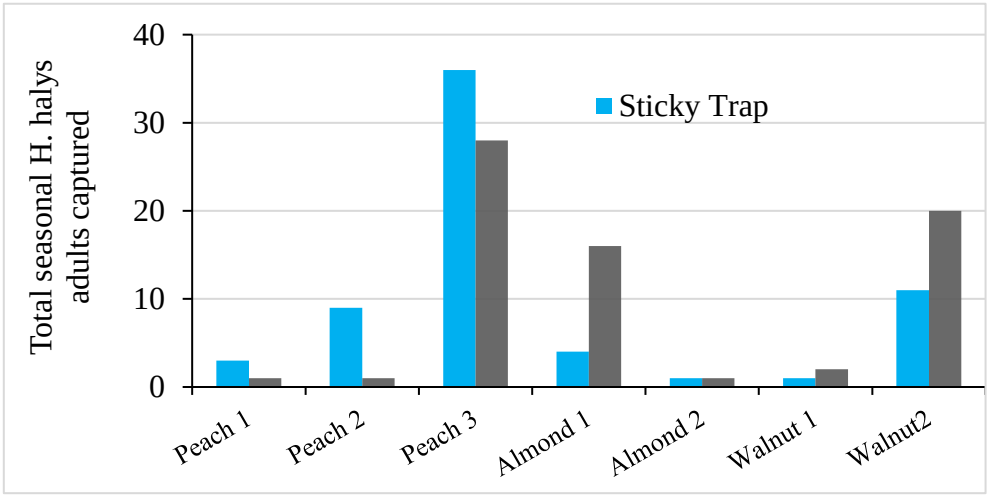

Fig. 2. Seasonal *H. halys* adult captures from 4 traps in seven orchards in Stanislaus

H. halys damage to almonds. *H. halys* feeding in almond in commercial orchard can begin as early as mid-March when the overwintering adults start to move to the orchard and may be present in the orchard throughout the season. However, early season feeding (from fruit set to before shell hardening) seems to be severely impacted as adult feeding causes fruit abortion and drop. Feeding by *H. halys* on developing fruits leads to the gumming nuts with multiple feeding spots within the nut. The injury can be external (multiple gumming (Fig. 4A), light brown speckles, yellowing) as well as internal (pinhole (Fig. 4B), water-soaked lesion, cork tissue (Fig. 4C), internal gumming). In 2018 season, we observed a substantial nut drop (with feeding injury) in a few orchards in the northern San Joaquin Valley during April this year. The presence of adults and the damage have been noticeably higher in the border tree rows next to the other host trees such as ‘tree of heaven’ and potential overwintering shelters (e.g., houses, barns, wood piles).

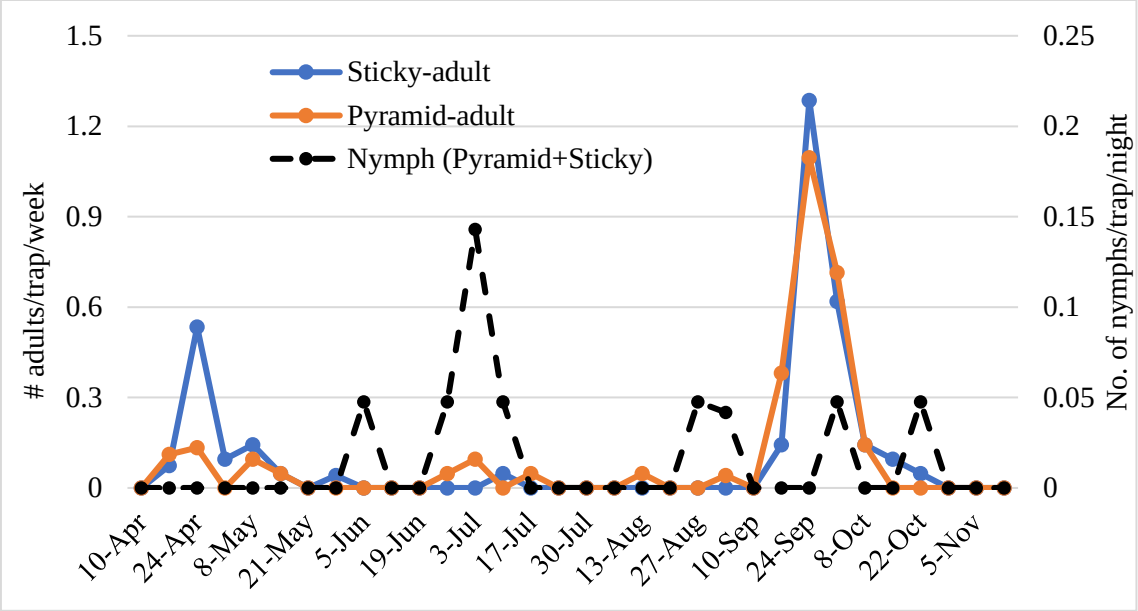

Fig. 3. Seasonal phenology of *H. halys* activity in pyramid and sticky panel traps in one of the almond orchards monitored in 2018 in Stanislaus County

In harvested almonds, multiple feeding spots (in many cases, in the form of distinct necrotic spots) can be seen on the hull as well as in the shell (Fig. 5A). Depending on the time and severity of the infestation, nutmeat (i.e., kernel) shows several types of injury (shriveled to the completely damaged kernel, light to severe gumming, presence of multiple dark spots, dimpled and deformed kernel) (Fig. 5B).

Some of the symptoms of *H. halys* damage resemble leaffooted and other stink bugs, but the severity and timing of damage seem to be different. *H. halys* damage occurs as early as mid-March and seems to continue for a few weeks to months, whereas leaffooted bug damage occurs in a point of time (around mid-April in general). Since *H. halys* is a landscape-based pest, *H. halys* can switch among different host crops within the season. *H. halys* are known to infest orchards in great numbers, and therefore, the degree of damage can be high compared to the leaffooted and other native stink bug damage. We also observed multiple feeding sites (up to 13 pinholes) within the nut and multiple numbers of injured nuts in a cluster within the branch, and this *H. halys* feeding pattern is less common in the leaffooted bug infested nuts. Also, *H. halys* feeding to the nuts showed necrotic spots in the kernels and presence of the multiple dark spots (Fig. 5B).

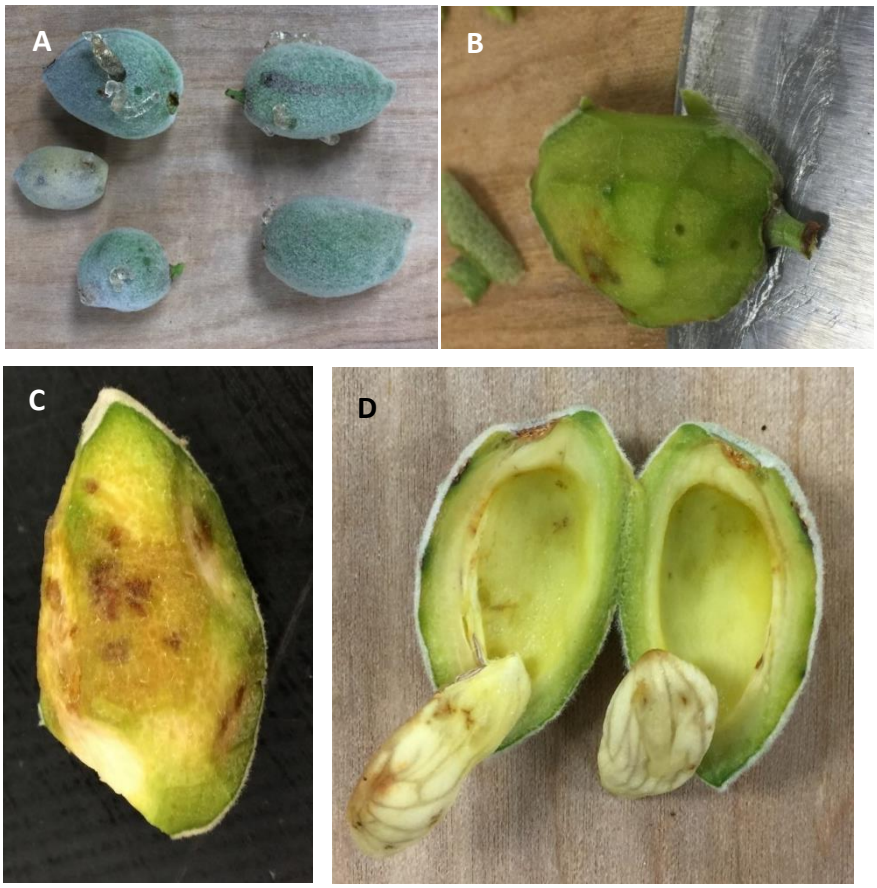

Fig. 4. *H. halys* feeding damage to developing almonds, A) External gumming, B) Pinhole damage, C) Necrotic spots on the fruit, D) Necrotic feeding spots on kernel

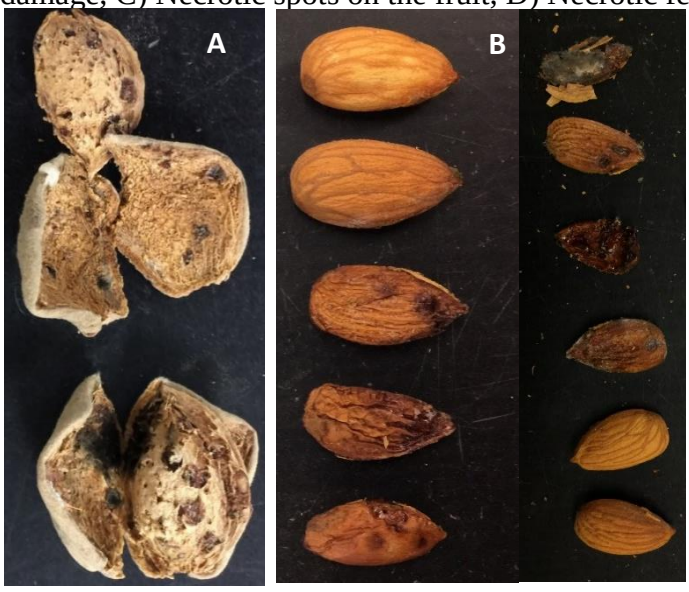

Fig. 5. *H. halys* feeding damage to almonds showed up at harvest, A) hull and shell, B) kernel

Conclusion

Brown marmorated stink bug has been spreading to crops in California and begun to cause damage to commercial peach and almond orchards in the northern San Joaquin Valley. It is critical that growers and pest control advisers (PCAs) pay close attention when monitoring fruit orchards for *H. halys* presence and potential damage. Early monitoring is very important, especially if the orchard is near to the areas with known infestations and areas with known tree hosts such as the tree of heaven, *Ailanthus altissima*. Placement of a few sticky panel traps in the border rows of the orchard beginning from March is recommended to detect *H. halys* activity and infestation. Visual observations of insects (egg masses, nymphs, adults) and damaged fruit (deformed fruits, fruits exuding gum) and beat tray sampling (shaking branches/twigs to dislodge insects) are also useful in detecting the *H. halys* population. Although taking sample nuts from the tree just before shaking can be a better strategy to see all injuries especially the external gumming, it is not necessary as regular harvest sample works just fine. Hand crack the sample nuts and carefully look for the feeding signs on the hull (external and internal), and the kernels for the potential *H. halys* damage.

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