FRUIT DAMAGES CAUSED BY BROWN MARMORATED STINK BUGS IN APPLES AND QUINCES

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Abstract. The brown marmorated stink bug (*Halyomorpha halys*), an invasive pest, poses a significant threat to fruit crops worldwide. This study investigates the nature and extent of *H. halys* injuries in apples (*Malus domestica* Borkh.) and quinces (*Cydonia oblonga*), focusing on the external and internal damage caused by their feeding behavior. In apples, external symptoms include sunken, discolored spots, while internal damage manifests as corking and tissue necrosis. Quince fruits displayed similar symptoms but were more severely affected, likely due to differences in texture and chemical composition. Feeding injuries also made both fruits more susceptible to secondary infections by pathogens, further reducing their marketability. These findings highlight the economic impact of *H. halys* on fruit production and emphasize the need for integrated pest management (IPM) strategies. Proposed measures include monitoring pest populations, deploying biological controls such as *Trissolcus japonicus*, and exploring RNA interference-based approaches to mitigate crop losses caused by this polyphagous pest.

Keywords: Hemiptera, Heteroptera, *Halyomorpha halys*, fruit injury, *Malus*, *Cydonia*

INTRODUCTION

Apples (*Malus domestica* Borkh.) are still one of the most important fruits cultivated worldwide, playing a vital role in global agriculture, contributing significantly to food security, economic stability, and rural revitalization (FaoStat, 2022). Quince, scientifically known as *Cydonia oblonga Mill.*, is a deciduous fruit-bearing tree belonging to the Rosaceae family being characterized by its fragrant, yellow pome-like fruits, which are rich in antioxidants, vitamins, and dietary fibers, making them beneficial for human health (Vaez et al., 2014). Quince is primarily cultivated for its high pectin content, which is valuable in the food industry for producing jellies and jams (Moradi et al., 2017). Due to the fact that apples are so widely cultivated across the world, they harbor a variety of pests and diseases. In recent years, the relationship between climate change and pest migration gained the special attention of farmers as rising temperatures and altered weather patterns influence the distribution and behavior of agricultural pests which cause severe damages in their orchards. Research indicates that climate change is driving shifts in the geographical range of various insect pests, affecting their overwintering areas and migration patterns (Hong et al., 2024). In this context, from one season to another, farmers are discovering new pests that attack their orchards.

The brown marmorated stink bug - BMSB (*Halyomorpha halys* Stål) is an invasive pest native to East Asia that has become a significant threat to agricultural crops worldwide, particularly in North America and Europe. Since its accidental introduction in the late 1990s, *H. halys* has expanded its range rapidly, inflicting severe economic losses across various cropping systems, including fruit orchards, row crops, and ornamental plants (Leskey et al., 2012). Among its favored hosts, apple (*Malus domestica* Borkh.) stands out as one of the most heavily affected, suffering substantial reductions in both yield and quality due to feeding injury. The feeding mechanism of *H. halys* involves sucking mouthparts that penetrate the fruit's epidermis, leading to symptoms such as necrotic spots, discoloration, and deformation. These damages not only compromise the fruit's marketability but also create pathways for secondary infections by pathogens, further exacerbating economic losses (Rice et al., 2014). In highly infested orchards, losses can reach up to 25–40% of the total apple yield, demonstrating the pest's potential to disrupt apple production significantly (Blaauw et al., 2016). BMSB adults emerge from overwintering spots (e.g. woodlots, artificial buildings) when the day duration reaches 13.5 hours. Egg laying occurs once 14 °C have been accumulated. Females lay up to 28 greenish-white eggs in clusters on the back of favored host plant leaves. Feeding and development take place through five nymphal stages, before reaching the adult stage (Fig. 1).

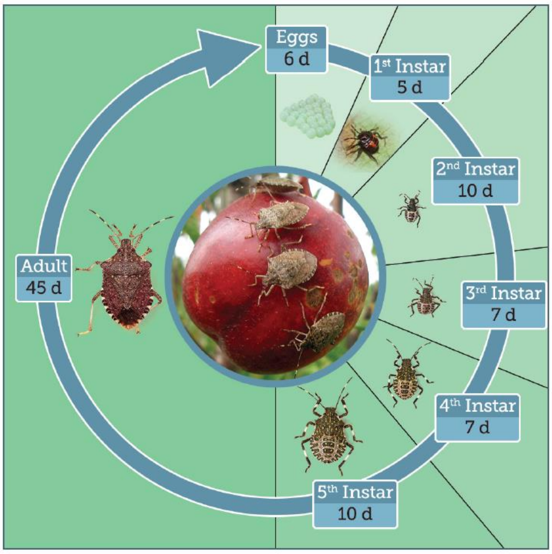

Fig. 1. The life cycle of brown marmorated stink bug
(Source: Bergh et al., 2016)

BMSB populations and possible damage to orchards increase during this period. The summer generation keeps feeding before moving to overwintering locations from early September to November. The adults produce an attractant, an aggregation pheromone, which has the role to attract other adults to the same location (Wilson et al., 2018).

The BMSB can be recognized by its white and black banding on the antennae and abdominal margins (Fig. 2). It also has white banding on tibiae, especially distinct in nymphs. Adult males have fork-shaped last sternite on the last ventral abdominal segment, which distinguishes them from females (Zamljen et al., 2021). The BMSB damages fruit by feeding on it, leading to disfigurement and making it susceptible to pathogens, which can render the fruit unmarketable (Beus et al., 2024). The pest's rapid spread is facilitated by global warming, which allows for more generations per year, increasing the risk of infestation and crop damage (Beus et al., 2024).

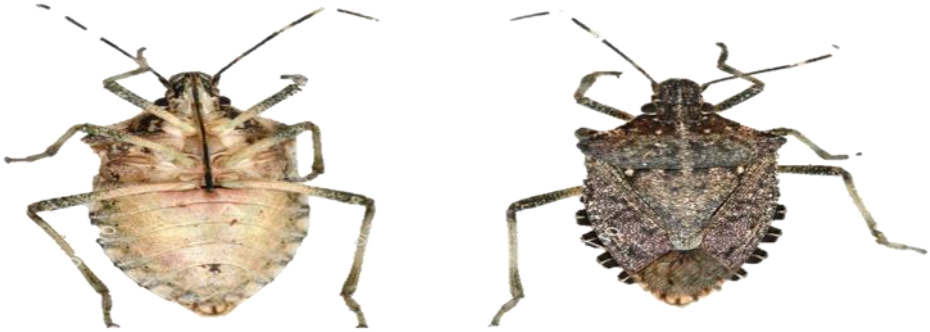

Fig 2. *H. haly*
(Source: www. horticultorul.ro)

Efforts to manage *H. halys* in apple orchards remain challenging due to its broad host range, high mobility, and overwintering behavior in sheltered environments, which make even more difficult population control. Additionally, the pest's tendency to aggregate and cause extensive damage over a short period requires integrated pest management (IPM) strategies that combine chemical, biological, and cultural practices (Leskey & Nielsen, 2018).

Therefore the main aim of this article was to explore the nature and extent of *H. halys* damage on apple and quince fruits, evaluate the pest's economic impact on fruit production, and review current management approaches to mitigate its effects.

MATERIALS AND METHODS

The current research has been carried out in the experimental orchard of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania (46°46′0″N 23°35′0″E). The orchard selection was made based on the presence of brown marmorated stink bug infestation and the availability of both apples and quinces as hosts. The experimental sites consisted of “Golden Delicious” apples grafted on M9 rootstock (Fig. 3) and quince “Bereczki” grafted on Quince A (Fig. 4), both planted in 2011 at a spacing distance of 1,5 x 3 m.

Fig. 3. “Golden Delicious”

Fig. 4. “Bereczki”

Visual observations have been carried out between the 1st -14th of October 2024. The BMSB injured apple and quice fruits were harvested and stored in wooden apple crates and stored at 4°C with 80% humidity. As control, healthy fruits were stung by using a sterilised syringe to monitor fruit degradation due to mechanical injury. During storage and until complete degradation of the fruits, measurements have been carried out to evaluate the extention of the injured/sunken area on the fruits.

RESULTS AND DISCUSSIONS

The results of this research revealed that the brown marmorated stink bug (BMSB) injuries on apple fruits are characterized by small, irregular, sunken, or dimpled spots on the skin. Beneath these external blemishes, the flesh may appear corky or discolored, leading to internal damage that affects fruit quality (Fig. 5).

Fig. 5. BMSB injured fruits under degradation (08.10.24-22.10.24)
Authors' own collection

The injuries are caused by the piercing-sucking mouthparts of the bug, which inject saliva and extract plant juices. A previous study suggest that this polyphagous insect uses both extra-oral and gut-based digestion thwarting protein- or nucleotide-based control strategies. The enzyme profiles of the two tissues and saliva differ significantly. In the gut, proteases have an optimal pH of 6, with cysteine proteases being predominant. In contrast, the salivary gland and saliva exhibit alkaline pH optima for protease activity (8–10 and 7, respectively), dominated by serine proteases and cathepsins. RNase enzymes are most abundant in saliva, while dsRNase and DNase activities are higher in the salivary gland and saliva compared to the gut. These distinct enzyme profiles reflect the biphasic digestive system of this invasive species, enabling efficient nutrient processing from plants. Understanding the digestive physiology of *H. halys* can inform strategies to target its digestive enzymes or protect protein- and nucleotide-based pest management tools (Liu et al., 2018).

The results demonstrated that similar to apples, quince fruits exhibited puncture marks and tissue necrosis, with feeding injuries extending into deeper fruit tissues. These results are in ccordance with those reported by Acebes-Doria et al. (2016). Quantitative analysis revealed higher levels of damage on quince fruits compared to apples, which might be explained due to differences in fruit texture and chemical composition (Zhu et al., 2017). These findings underscore the polyphagous feeding behavior of *H. halys* and its ability to damage a wide range of fruit crops, leading to significant economic losses in affected regions.

Regarding control fruits, it has been observed that those fruits remained unaffected due mechanical sting and no tissue necrosis has been observed in none of the fruits (Fig 6).

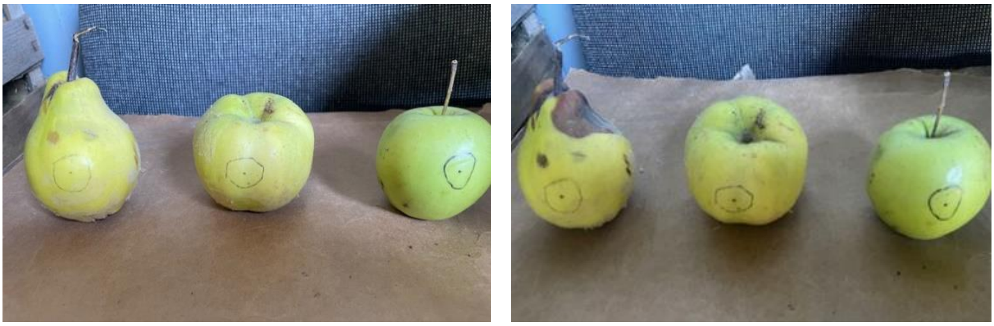

Fig. 6. Control fruits (08.10.24-22.10.24)
Authors' own collection

Regarding the fruit degradation dynamics, the initial injured area measured for apples was 3 cm (Ø) in the 8th of October, while in quince 2 cm (Ø). The results showed that during storage tissue necrosis has been extented on an average of 0.81 cm/day in apples and between 1,66 and 2.25cm/day in quince fruits (Fig 7).

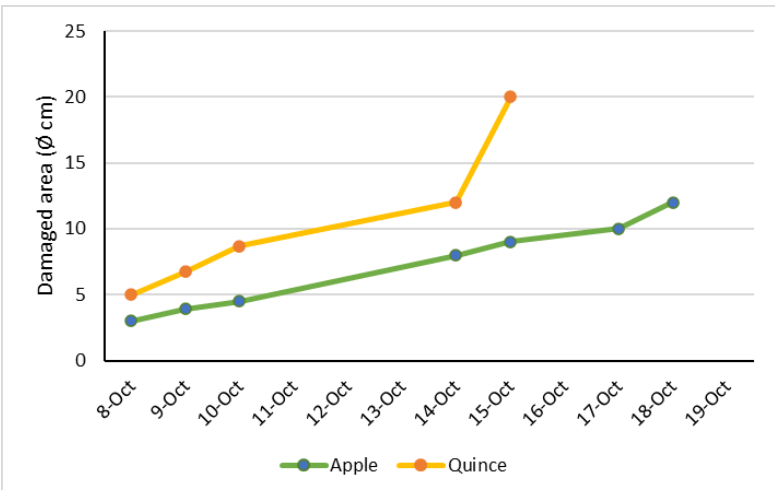

Fig. 7. Fruit degradation dynamics due BMSB injuries

The findings of this research demonstrated that the severity of degradation varies with fruit type, ripeness, and duration of exposure. Softer or ripening fruits often experience faster and more extensive breakdown due to higher sugar content and reduced structural integrity. Understanding the dynamics of this degradation is crucial for developing effective pest management and postharvest strategies to mitigate quality losses.

The results further suggest that the enzymes in the stinging and sucking apparatus of the H. halys bug, which comprise 22 protease sequences and 2 nuclease sequences, quickly and aggressively break down the cells of the pricked fruits in order to prepare them for ingestion. The oral apparatus of BMSB is also responsible for the propagation of phytopathogenic agents that lead to a more pronounced degradation of the fruits, agents that find a favorable substrate for development instead of the incision.

Combating brown marmorated stink bug (BMSB, *Halyomorpha halys*) in orchards presents several challenges due to its unique biology, behavior, and adaptability and requires an integrated pest management (IPM) approach based on the followings:

1. *Monitoring and Identification*
   - Deploying pheromone-baited traps (e.g., pyramid traps) around the orchard to monitor BMSB populations and movement.
   - Performing regular visual inspections, particularly along orchard borders and in nearby wooded areas.
   - Monitoring should be started in early spring when temperatures rise above 10°C (50°F) to detect emerging adults.
2. *Cultural Control*
   - Wild hosts such as Tree of Heaven (*Ailanthus altissima*), wild cherry, or other fruit-bearing shrubs should be removed from the surroundin areas.
   - Overwintering sites like woodpiles, clutter, or other sheltered areas near the orchard should be eliminated.
   - Plant trap crops such as sunflowers or sorghum around orchard borders should be planted to concentrate BMSB populations away from apple trees.
3. *Physical Barriers*
   - Fine mesh netting over vulnerable apple trees should be used to exclude stink bugs, particularly during peak activity periods in late summer and fall.
   - Protective row covers for high-value apple varieties are recommended.
4. *Biological Control*
   - Native predators and parasitoids, such as predatory stink bugs or *Trissolcus japonicus* (samurai wasp), a parasitoid of BMSB eggs shoul be considered.
   - Broad-spectrum insecticides that harm beneficial insects should be avoided.
   - Insectary plantings should be established to enhance habitats for natural enemies’ populations.
5. *Chemical Control*
   - Targeted application of insectisides with proven efficacy against BMSB, such as pyrethroids (e.g., bifenthrin, lambda-cyhalothrin) or neonicotinoids (e.g., dinotefuran) should be practiced.
   - Systemic insecticides should be used in early-season applications, while contact insecticides closer to harvest date.
   - Focus sprays during critical periods of BMSB activity, especially late summer and early fall should be applied.
   - Thorough coverage of trees should be ensured, as BMSB tends to congregate on the upper part of the tree canopy.
   - Insecticides with different modes of action should be applied by rotation to prevent resistance development.

6. *Mass Trapping and Attract-and-Kill*
   - Pheromone-based attractants combined with insecticide-treated nets or traps should be used to reduce adult populations.
   - Traps should be installed at orchard edges or hotspots where BMSB are prevalent.
7. *Post-Harvest Management*
   - Monitor bins and storage areas should be installed for overwintering adults.
   - The prompt removal of culled fruits and other debris reduce habitat and food sources.
8. *Community and Regional Coordination*
   - Collaboration among nearby growers are highly recommended to manage BMSB populations at wider level.
   - Sharing monitoring data and coordinate treatment timings help to reduce reinfestation from surrounding areas.
9. *Evaluation*
   - The assessment of treatment efficacy through continued monitoring and damage evaluation during and after the harvest season should be carried out.
   - Treatment plans should be adapted to population trends, pest pressure, and environmental conditions.

This plan combines immediate pest suppression with long-term strategies to minimize BMSB impact sustainably.

The injuries caused by *H. halys* in apples and quinces underscore the significant economic impact of this invasive pest on high-value fruit crops. The external blemishes and internal tissue degradation reduce marketability, while the increased susceptibility to secondary infections further compromises fruit quality. These findings highlight the need for an integrated pest management (IPM) program tailored to mitigate *H. halys* infestations. A comprehensive program should combine monitoring tools, such as pheromone traps and visual inspections, with cultural controls like timely removal of wild host plants near orchards. Biological control efforts, including the introduction of natural enemies like Trissolcus japonicus (the samurai wasp), should be augmented with targeted chemical controls using insecticides with minimal non-target effects. Additionally, promoting netting or exclusion strategies and integrating novel approaches, such as RNA interference-based pest control, could provide sustainable solutions. Such an IPM strategy will be crucial for safeguarding fruit production and minimizing losses caused by this polyphagous pest.

CONCLUSIONS

Based on the findings regarding the fruits injured by *H. halys*, it can be concluded that the intensity of their degradation is due to the inoculation of enzymes through the oral apparatus, which rapidly degrades the proteins in the cells and tissues of the fruits. It is a degradation that has never been encountered in the orchard and is totally different from the attack of bees, wasps, birds and other insects. In the case of storage after harvesting the fruits, we recommend checking and sorting them no later than 7 days after storage, aiming for this process to be resumed 14 days after harvesting, knowing that the affected fruits can be a hotbed of infections for the healthy fruits in the warehouse as well.

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