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Invasive stink bug damages in fruit crops - Damage occurrence and development during storage

N. Haag and C. Dieckhoff[1]

Abstract

In 2021-2023 naturally occurring fruit damages, presumably caused by stink bugs, were examined in different apple and pear cultivars from plots at different distances from adjacent hedges. Fruits were stored at room temperature, cold storage and under controlled atmosphere conditions in order to assess damage development during storage.

The results showed that fruits picked from plots close to hedges are usually more often affected by stink bug typical patterns than fruits farther removed from hedges. The investigated cultivars showed differences in damage incidences. Although the reasons for this could not be sufficiently clarified in these studies, several factors such as different ripening times of cultivars, developmental stages of stink bugs, location of plots and influence of surrounding habitats are assumed to play a role. No differences were observed between storage conditions on the progression of stink bug damages. Further, storage does not seem to have a negative effect on fruit symptoms or to favour post-harvest damages during the observation period (six to ten weeks) in this study.

Keywords: *Halyomorpha halys*, *Nezara viridula*, fruit injuries, pome fruit cultivars, storage.

Introduction

The brown marmorated stink bug, *Halyomorpha halys* (Stål 1855), and the southern green stink bug, *Nezara viridula* (Linnaeus 1758), are two invasive pests that have been causing considerable economic damage to fruit production worldwide, including Germany. The ongoing climate change as well as international trade and tourism favor the rapid spread of these pest insects. Both species are extremely polyphagous having a broad host plant spectrum that comprises over 100 cultivated and wild plant species (Eben et al., 2022). Depending on the developmental stage and the crop variety, feeding on ripening and ripe fruits may lead to various types of damage (e.g. indentations, deformations, corking) and even fruit drop. It is often difficult to address the symptoms correctly and to distinguish them from other damage patterns occurring in fruit crops. Further questions exist regarding the susceptibility of different cultivars to stink bug feeding, influence of surrounding habitats, such as hedges or forests, as well as the development of fruit symptoms during storage.

Material and Methods

Six different apple cultivars, 'Santana', 'Elstar', 'Gala', 'Boskoop', 'Natyra' and 'Braeburn', were evaluated in 2021 and 2022 regarding the development of stink bug-typical symptoms. In addition, in 2022 and 2023 two pear cultivars, 'Conference' and 'Xenia', were included in the trials. For each cultivar two plots of a length of 15 m were established along orchard rows, one plot close to adjacent hedges and one plot farther away from hedges. The distance between plots in each row was 50 m. Distances from hedges of “close” plots were 10 m for apples and 20 m for pears (see figure 1). Hedge structures were dominated by wild blackberry, dogwood, privet, *Acer* spp., ivy, and wild cherry and trimmed in spring and fall.

From each plot 150-300 fruits were randomly picked at harvest time. Fruits were then examined for damage patterns putatively caused by stink bugs. Stink bug species present

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at the location and regularly observed in the experimental plots were: *H. halys* and *N. viridula*. *Pentatoma rufipes* and some native Coreid species also occur at low densities in the general area but were rarely seen in the plots. Damaged areas were manually outlined with a permanent marker and apple fruits were stored for at least six and up to ten weeks under the following storage conditions: i) room temperature (Ø 18 °C), ii) cold storage (3 – 4 °C) and iii) "controlled atmosphere" (CA) storage (~ 3 °C; O^2: 2.5 – 3.5 %, CO^2: 1.5 – 2.0 %). Pear fruits were stored under cold storage conditions (-1°C – 0 °C) only. Once removed from storage, apples and pears were examined again for both external as well as internal symptoms.

All tests took place at the Agricultural Research Center (LTZ) Augustenberg with its diverse orchards containing over 500 pome, stone, and berry fruit cultivars. The LTZ is located in the northern part of the Upper Rhine Valley where a highly structured landscape and generally dry and hot climatic conditions compared to other regions in Baden-Wuerttemberg predominate.

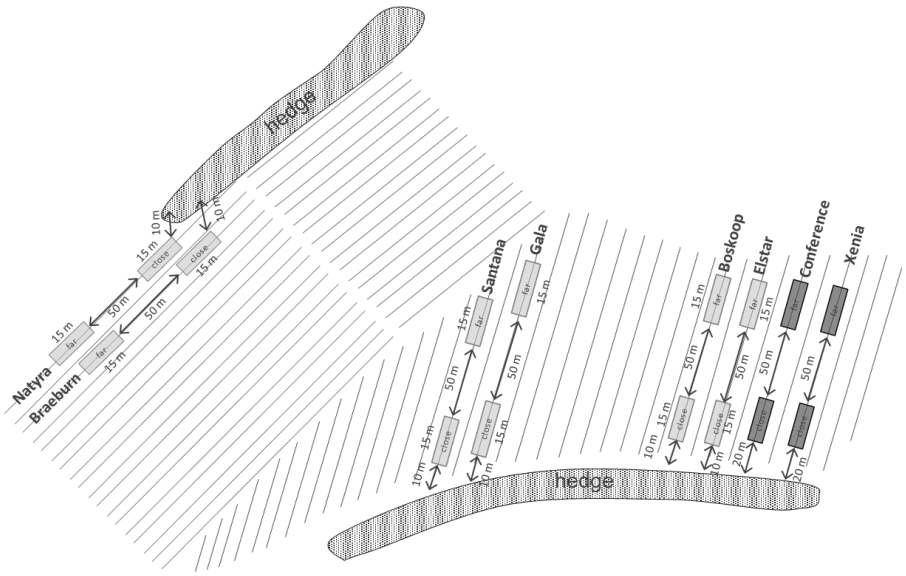

Figure 1: Schematic illustration of plot locations within orchards rows and their distances from adjacent hedges at LTZ.

Results

In general, for most apple cultivars the occurrence of stink bug-typical damages was considerably lower in 2022 than in 2021. Frequencies of symptoms after storage of fruits varied between 1.3 and 64.5 % in 2021 and between 0 and 14.5 % in 2022. Cultivars 'Santana' and 'Elstar' were the most affected by damages, whereas 'Natyra' und 'Braeburn' showed the lowest damage frequencies. In addition, fruits collected from plots located closer to adjacent hedges were more frequently damaged than those collected from plots farther away. However, these differences varied between cultivars (see figure 2 a).

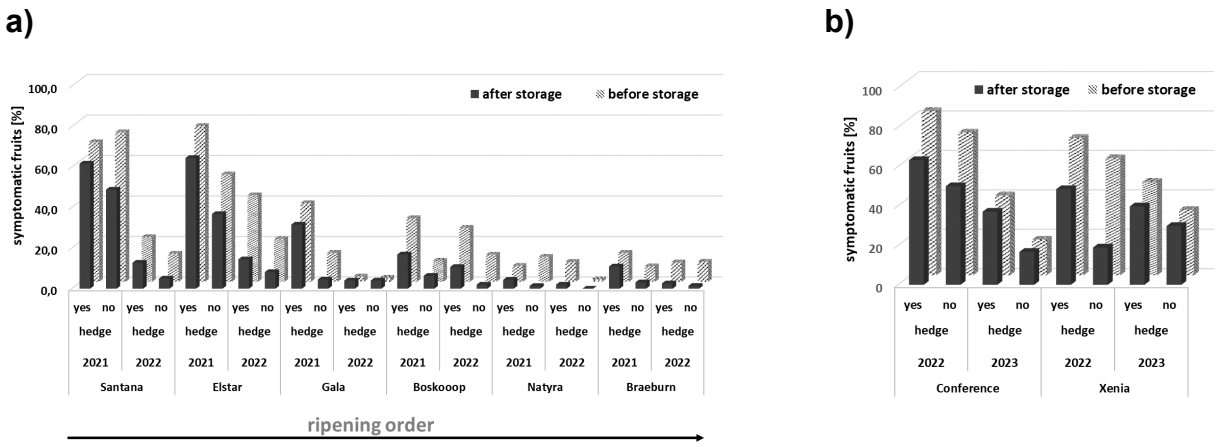

Figure 2: Proportion of a) symptomatic apples, b) symptomatic pears before and after storage, respectively.

Similar observations were made in pears. Damages in 2023 were generally less than in 2022 after storage, ranging between 18.9 and 63.2 % in 2022 and between 16.7 and 39.7 % in 2023. Observed differences between cultivars were low and not consistent over both years. Damages were more often observed in plots closer to hedges (see figure 2 b).

Averaged over all apple cultivars, fewer fruits were assessed as stink bug-symptomatic after storage than after harvest. With the exception of 'Gala' and 'Santana', the same holds true for all apple (see figure 3 a and b) and pear cultivars (compare with figure 2 b) examined in this study. Over both years, differences regarding the effects of storage conditions on the development of damages were not evident (see figure 3 a).

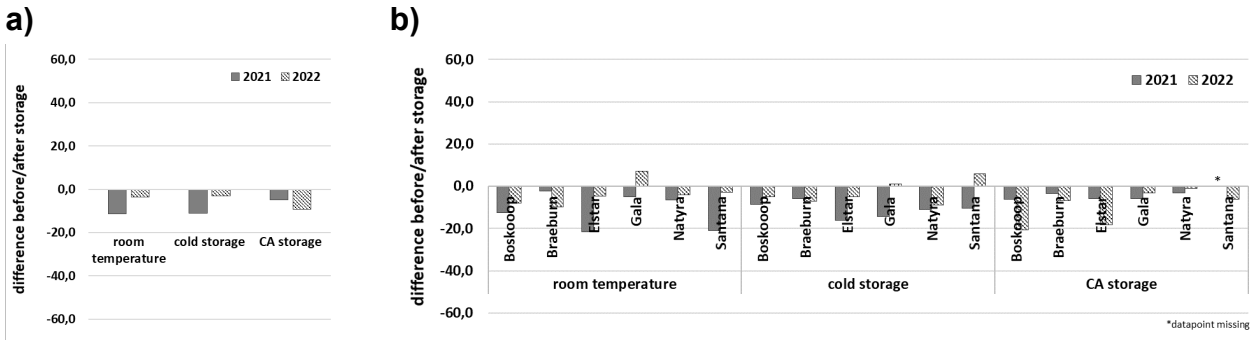

Figure 3: Development of fruit symptoms during storage by a) storage condition averaged over all cultivars and by b) cultivar and storage condition. Damage development is indicated as difference between symptom frequencies before and after storage.

Discussion

Differences between apple cultivars were most pronounced in 2021 when damage symptoms were generally higher. Overall, incidences of external injuries most frequently occurred in cultivars 'Santana' and 'Elstar', in particular in 2021, while 'Natyra' und 'Braeburn' were less affected, and 'Gala' and 'Boskoop' ranged somewhere in between. This is in fair contrast to other studies finding other cultivars to be more susceptible (e.g. Brown *et al.*, 2006; Unterthurner & Ladurner, 2021). However, these studies are often inconsistent among themselves and not all of the investigated cultivars in the present study were evaluated in other studies, making a comparison difficult. To our knowledge, the contribution of genetic

factors to cultivar differences has not yet been elucidated. Nonetheless, it seems likely that factors, such as different ripening times of cultivars, developmental stages of different stink bugs species feeding throughout the season, location of plots and influence of surrounding habitats affect the occurrence of fruit damages. For example, Shanovich *et al.* (2020) argued that fruits exposed during the mid- to latter portion of the season showed the highest number of injuries later in the season when pest populations were supposedly highest. In contrast, our results showed the lowest external symptoms in cultivars harvested later in the season. We assume that surrounding habitats and microclimatic conditions have a strong impact on pest population behaviour on a local level and may, therefore, have a greater effect on the occurrence of feeding injuries than cultivar-related influences.

Evaluations of damage patterns at harvest time and post-storage revealed a decrease in almost all cultivars expect for 'Gala' and 'Santana' which showed a slight increase in 2022, yet not under all storage conditions. To a certain degree, these findings are in contrast to data obtained by Bergh *et al.* (2019) who observed either no change for the cultivars 'Redspur Delicious' and 'Fuji' or even a substantial increase in most cases for 'Smoothee Golden' and 'Honeycrisp' regarding the proportion of fruits with external injury and the number of injuries per fruit between harvest and post-storage. They even observed that external symptoms at harvest and post storage often tended to underestimate internal damages. As we commonly observed lower damage frequencies post-storage, we assume an overestimation of "stink bug-typical" injuries which could not be confirmed when fruits were eventually cut open. Overestimations tend to slightly decrease over the course of this study which might indicate a certain improvement in the damage assessment process over the years (figure 3 a and b).

The higher feeding injuries that were observed in fruits adjacent to hedges should not be overrated. *Halyomorpha halys* is a highly mobile, polyphagous pest and there is a continuous influx of individuals into the orchards from a diverse array of near and far reservoirs (Maistrello *et al.*, 2017; Bergh *et al.*, 2021). Surrounding structures, such as hedges or woodlands, are important refuges and habitats for beneficials which play a critical role in the biological control of *H. halys*.

In order to further elucidate the differences in the occurrence of external and internal injuries between pome fruits cultivars and damage development during storage, more complex and extensive studies may be advisable in the future.

Acknowledgements

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