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Reviewed Paper

First results of applying an automatically operating rain roof covering system in organic apple production

S. Buchleither, M. Schluchter and T. Arnegger[1]

Abstract

An automatic roofing system, called EAZYTop® invented by LOCK Drive GmbH Germany, is currently tested at the Kompetenzzentrum Obstbau Bodensee (KOB) in a pilot apple orchard. The automatic roofing system is opening and protecting the apple trees during rain events only. The trial is set over a period of three years, from 2022 to 2024. Up to now, the automatic roofing system has been tested for two years. The pilot orchard is planted with 5 apple cultivars ('Elstar', 'Gala', 'Pinova', 'Jonagold', 'Braeburn') on rootstock M9 with around 770 trees in total, divided into two blocks ('hail net' and 'roofing'). The block 'hail net' is treated with a standard plant protection programme, while the block 'roofing' only received insecticides (and no fungicides). In this treatment, the regulation of the major fungal diseases apple scab and sooty blotch is ensured only by the automatic, temporary roofing with nearly no additional fungicide input (due to technical/electronical issues 3 to 4 fungicides sprayings had to be carried out per year). The major aim of this trial is the reduction of fungicides to the greatest possible extend without negative effects on fungal diseases. On the one hand, the automatic roofing system showed positive results in comparison to hail net regarding the fungal diseases apple scab and sooty blotch. On the other hand, an increase of woolly apple aphid has been observed already in the first year.

Keywords: rain cover, fungicides reduction, protected farming

Introduction

Former trials with permanent installed rain-roof-covers led to positive results in fungal diseases regulation, in conjunction with strongly reduced fungicide sprayings. However, an uprise of several pests, especially the woolly apple aphid, has been observed. Therefore, it was not possible to reduce insecticide sprayings. Another disadvantage of permanent installed rain-roof-covers was the durability of the used plastic sheets, which are deployed during the growing period (from March to November). After three years in seasonal use, the plastic sheets started to break down and small particles came loose. Due to the good results regarding fungal diseases regulation but poor durability and insect issues, the rain roof covers have to be enhanced to a next level. Since 2022 an automatic roofing system called EazyTop®, invented by Lock Drives GmbH located in Ertingen South Germany, has been tested. The roofing system opens and closes itself automatically, controlled by several climate sensors. In this trial we also test different plastic sheet materials with regard on stability (see Figure 1) over a period of three years, from 2022 to 2024. The main objectives in this trial are to test the functionality of the automatic roofing system EazyTop® and its effects on the trees including disease incidence, physiological parameters as well as fruit quality. The automatic roofing system is compared to a standard production under hail net (Figure 1).

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Material and Methods

The trial takes place in an organically managed orchard at Kompetenzzentrum Obstbau Bodensee (KOB) located in the Lake Constance Region, southwest Germany. The pilot orchard (fig. 2) was planted in spring 2018 with five apple scab sensitive cultivars ('Elstar', 'Gala', 'Pinova', 'Jonagold' and 'Braeburn') on rootstock M9 and two pear cultivars ('Xenia', 'Conference') on rootstock 'Quince Eline' (Figure 2). In this paper, results for pear cultivation have been excluded due to different fungal diseases and insect pests. The pilot orchard is divided in two treatments: 'roofing' with a reduced plant protection, nearly no fungicides *(due to technical/electronical issues 3 to 4 fungicides sprayings had to be carried out per year)*, standard insect pesticides input and 'hail net' with standard plant protection (standard fungicides and insect pesticides input). Each apple cultivar has been planted with around 160 trees, with four randomized replications with 20 trees each per treatment. The first five trees of each of the seven rows of the roofing treatment stood outside the roofing construction, and served as untreated control for the fungal diseases assessments.

Red mite (*Panonychus ulmi*) incidence has been evaluated by the size of the clutches (corresponds to the quantity of eggs) at one detection point per tree at typical hideouts of the mites for all trees (all trees under the 'roofing' and the 'hail net' treatment plus the untreated trees). Severity of infestation has been categorized into four classes: up to 10, up to 50, up to 100, and more than 100 eggs.

Woolly apple aphid (*Eriosoma lanigerum*) incidence has been evaluated on all trees under the 'roofing' and the 'hail net' treatment with a nine-stage rating system, starting with level 1 (no infestation) and gradually increasing to level 9 where the complete tree (every branch) is infested.

Apple scab (*Venturia inaequalis*) has been evaluated both on shoots and fruit. For the assessment of apple scab on shoots, 25 shoots per cultivar and repetition have been evaluated. In the untreated control only 10 shoots per cultivar have been examined. Shoots have been assessed in a four-stage rating system, from level 0 (no infestation), to level 1 (1 scab spot), level 2 (2 scab spots) and level 3 (more than 3 scab spot). For the assessment of apple scab on fruit, 100 apples per cultivar and repetition have been evaluated in the 'roofing' treatment, and 150 apples in 'hail net' treatment. In the untreated control 50 apples per cultivar have been examined. The apples have been assessed in a 3-stage rating system, from level 0 (no spots), to level 1 (1 up to 3 spots), and level 2 (more than 3 spots).

Sooty blotch has been evaluated on fruit in a six-stage rating system, from level 0 (no infestation), to level 1 (< 5% of surface infested), level 2 (up to 10% of surface), level 3 (10% to 25%), level 4 (25% to 50%) and level 5 (more than 50%).

Figure 1: Top view of the pilot apple orchard. The trial is outlined in red (left: 'hail net' treatment, right: 'roofing' treatment).

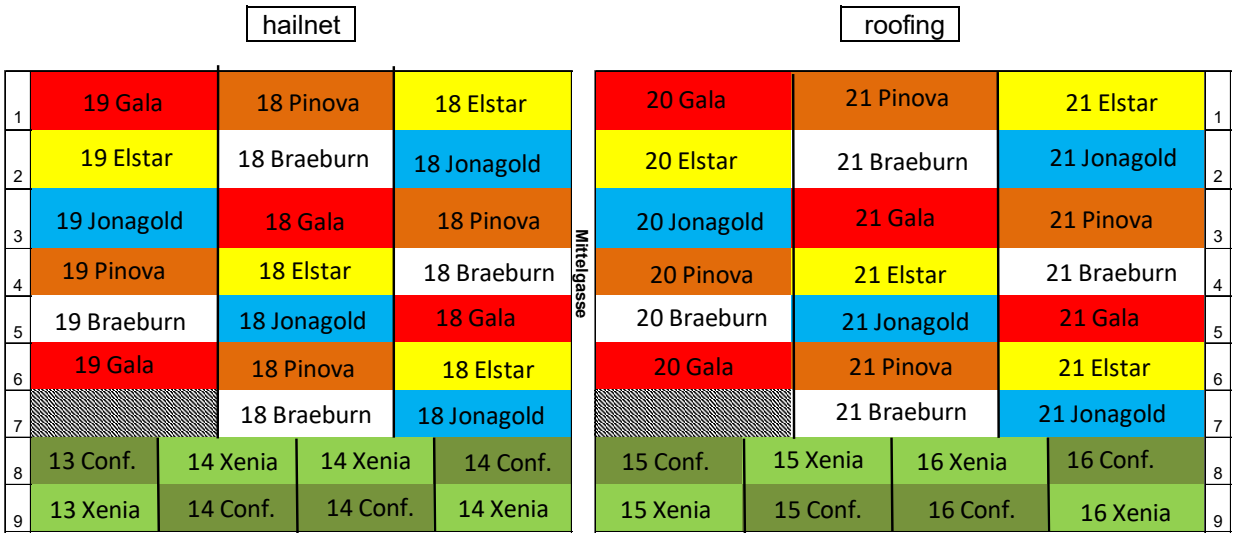

Figure 2: Design of the trial.

Results

Red mite (*Panonychus ulmi*)

Figure 3 depicts the infestation level with red mites for all five cultivars and both treatments ('hail net', 'roofing') for 2022 and 2023. In 2023, a higher level of infestation was observed compared to 2022 in both treatments. Except for Elstar in 2022, infestation levels were higher under the 'hail net' treatment compared to the 'roofing' treatment, regarding both incidence and severity. Comparing the cultivars in both treatments, 'Braeburn' was most susceptible, followed by 'Gala' and 'Elstar' in both years.

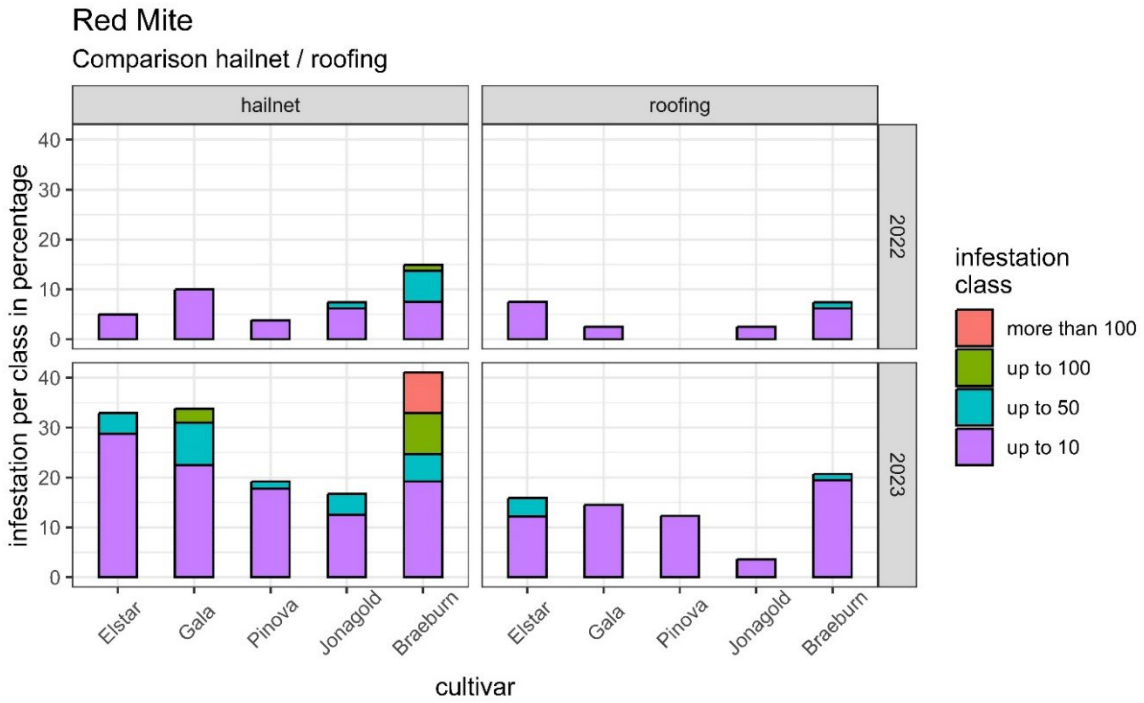

Figure 3: Infestation level with red mites for the treatments ‘hail net’ and ‘roofing’ for the five cultivars in the years 2022 and 2023. The bar height corresponds to the infestation incidence (percentage of observation points with red mites), and the infestation class to the severity.

Woolly Apple Aphid (*Eriosoma lanigerum*)

As for red spider mites, infestation levels of woolly apple aphid increased in the second year of the trial in both treatments (Figure 4). In 2022, the infestation in the ‘hail net’ treatment was barely visible, whereas high levels of infestation were already observed in the ‘roofing’ system. In 2023, both severity of infestation, and number of infested trees increased in the ‘roofing’ treatment. The same applies to the ‘hail net’ treatment, even though ‘Gala’ was barely infested. Furthermore, a cultivar difference was visible: ‘Jonagold’ showed highest infestation in both treatments followed by ‘Elstar’. ‘Braeburn’ was highly infested in the ‘roofing’ treatment, but only slightly infested in the ‘hail net’ treatment. While ‘Pinova’ showed moderate infestation, ‘Gala’ was least infested in both treatments.

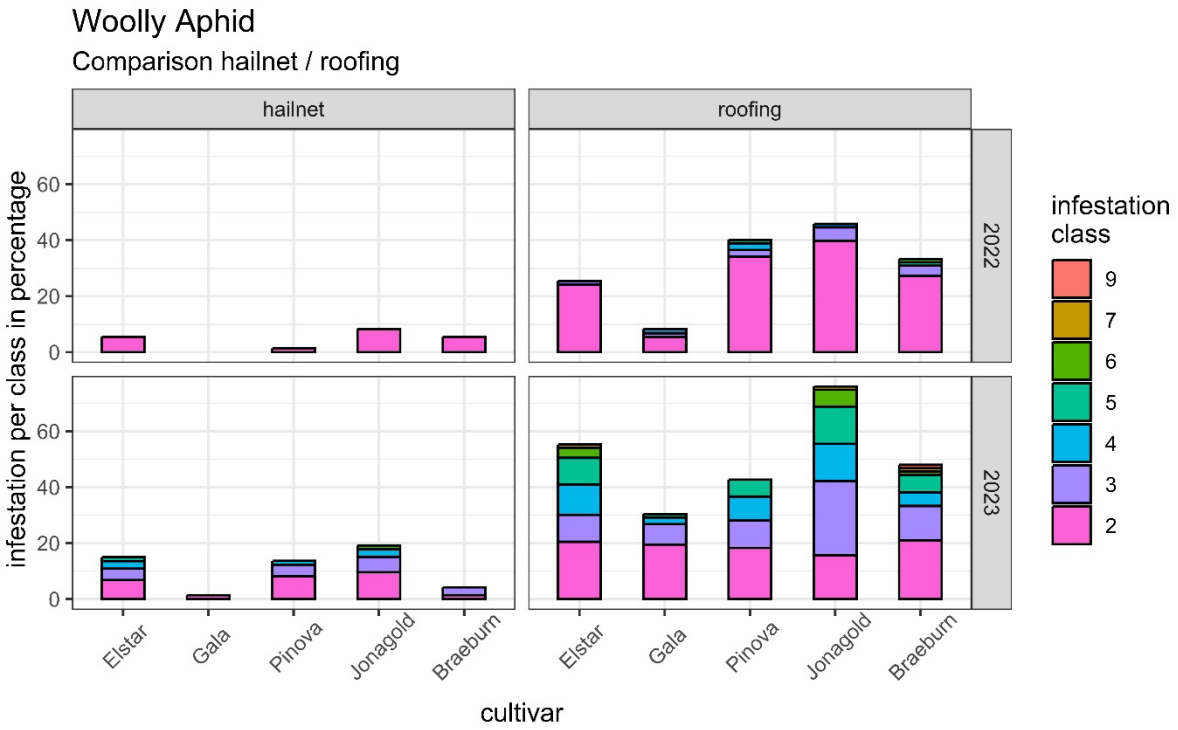

Figure 4: Infestation level with woolly apple aphids for the treatments 'hail net' and 'roofing' the five cultivars in the years 2022 and 2023. The bar height corresponds to the infestation incidence (percentage of trees with red mites), and the infestation class to the severity.

Apple Scab on leaves (*Venturia inaequalis*) (shoots)

In 2022, the overall incidence of apple scab on leaves in the 'untreated control' was about 50% to 60% (Figure 5). In the standardly sprayed 'hail net' treatment, an overall incidence below 3% occurred. In the 'roofing' treatment, with minimal fungicide sprayings, the overall incidence was also very low (below 4%). In 2023, the overall incidence in the 'untreated control' was at a lower level compared to 2022. The infestation level in both the 'hail net' and 'roofing' treatment, was below 3% as well.

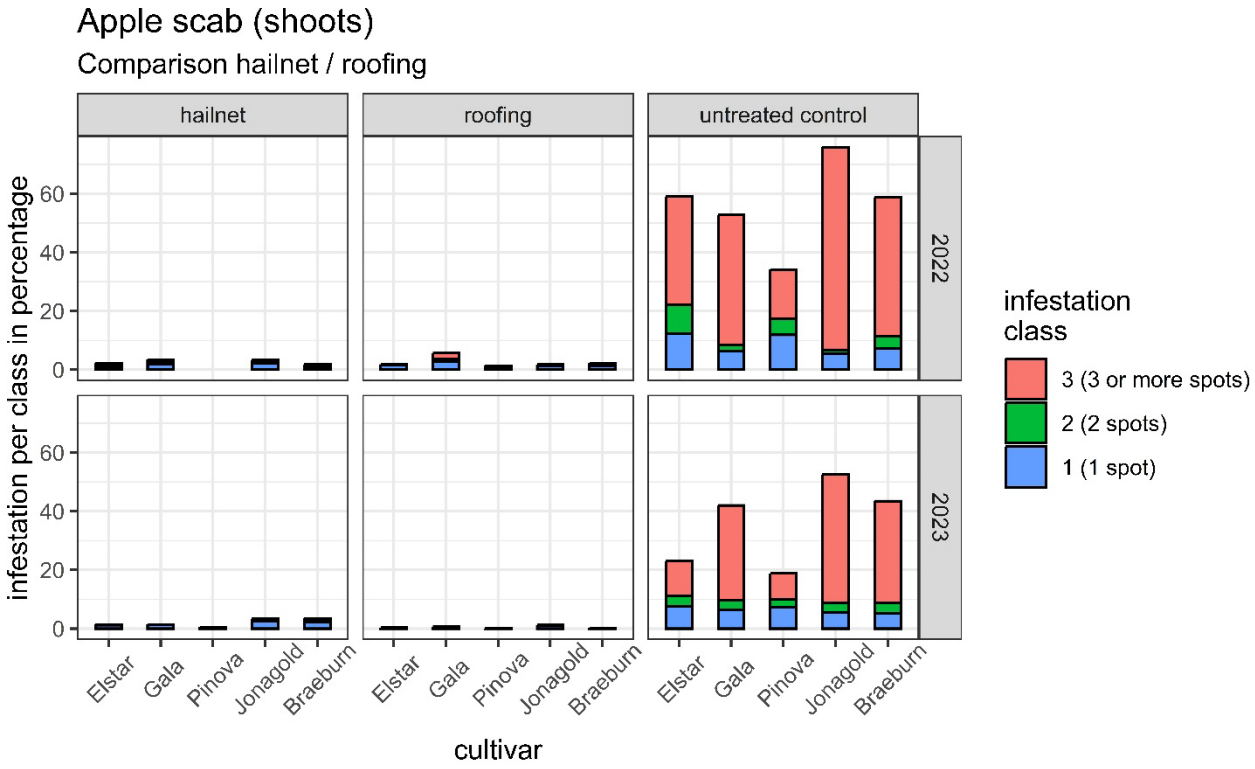

Figure 5: Infestation of apple scab (Venturia inaequalis) on shoots (infected leaves) for the treatments 'hail net', 'roofing', and 'untreated control' for the five cultivars in the years 2022 and 2023. The bar height corresponds to the infestation incidence (percentage of leaves with apple scab), and the infestation class to the severity.

Apple scab on fruit (*Venturia inaequalis*)

The infestation with apple scab on fruit was at a comparable level to the infestation with apple scab on leaves (Figure 6). In 2022, an overall incidence between 78% and 100% on fruit was registered in the 'untreated control', except for the cultivar 'Pinova', for which an infestation level of 48% occurred. Both in the 'hail net' and the 'roofing' treatment a very low apple scab infestation level below 4% was observed. The same tendencies could be observed in 2023 although at a lower level.

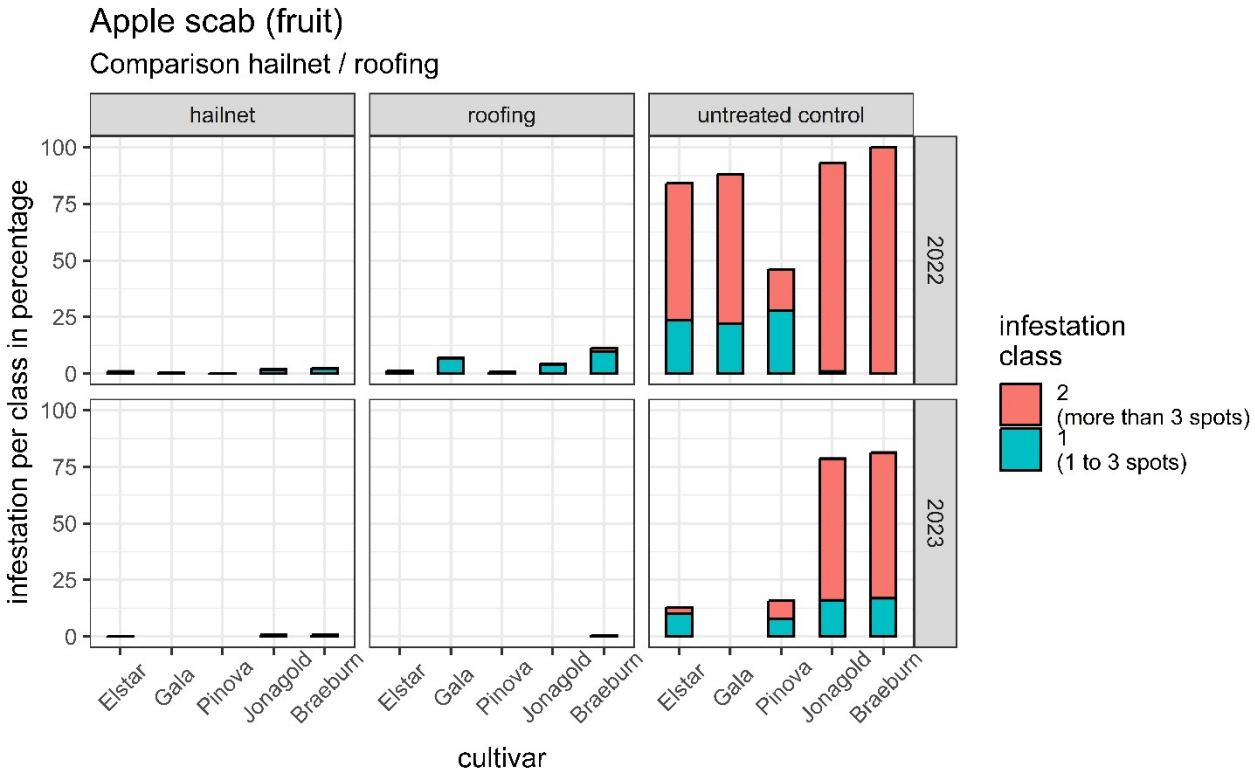

Figure 6: Infestation of apple scab (Venturia inaequalis) on fruit for the treatments 'hail net', 'roofing', and 'untreated control' for the five cultivars in the years 2022 and 2023. The bar height corresponds to the infestation incidence (percentage of leaves with apple scab), and the infestation class to the severity.

Sooty blotch

In both years, 2022 and 2023, high infestation levels with sooty blotch were observed in the 'untreated control', especially on later harvested cultivars (Figure 7). A comparable level of infestation was observed in the 'hail net' treatment, despite standard fungicide sprayings. All cultivars in the 'roofing' treatment showed no or a very low level of infestation with sooty blotch in both years, even with nearly no fungicide sprayings.

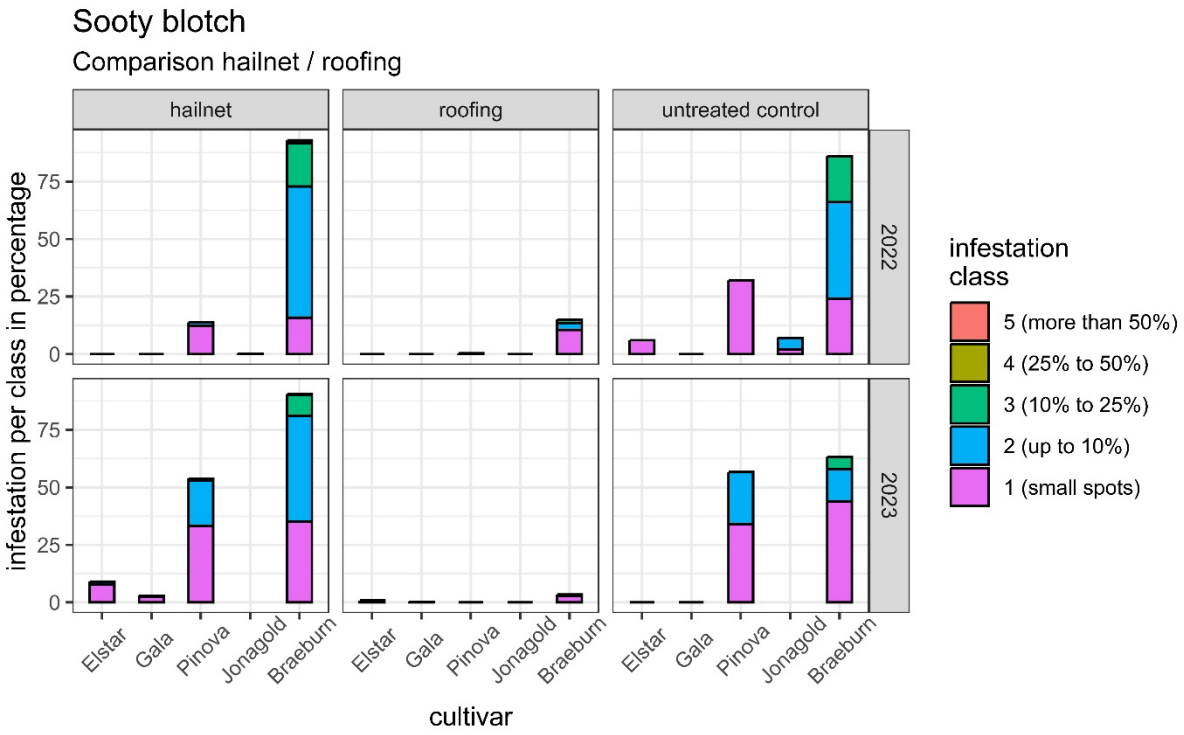

Figure 7: Infestation of sooty blotch on fruit for the treatments 'hail net', 'roofing', and 'untreated control' for the five cultivars in the years 2022 and 2023. The bar height corresponds to the infestation incidence (percentage of leaves with apple scab), and the infestation class to the severity.

Discussion

Over two years of observation, the automatic roofing system has shown positive results regarding fungal diseases with nearly no fungicide sprayings. Regarding the infestation with apple scab resp. sooty blotch there have been comparable lower levels of infestation under the roofing system compared to the 'hail net' treatment with standard fungicide sprayings. With the tested automatic roofing system *EAZYTop*® a sufficient regulation of the major fungal diseases could be achieved with nearly no additional fungicide spraying. Furthermore, the infestation with red mites tended to be lower under roofing than under hail net. Nevertheless, an increase of woolly apple aphid has been observed under the roofing compared to the hail net, which was also higher than observed under permanent roofing system, although the roofing system is only closed temporarily during rain events.

Both the positive effect on fungal diseases – achieved with nearly no additional fungicide sprayings – and the red mites, as well as the negative effect of increase of woolly apple aphid will be observed in a further year. Another main aspect of the trial was to test the durability of the used plastic sheets in the roofing system. Former trials with permanent roofing systems showed a relatively short durability of the used sheets of about three years. Hopefully an automatic system will increase the life span of the plastic sheets, because the plastic sheets aren´t exposed to sun radiation as long as permanent roofing systems during the growing season. After two years of observation, no final estimation of the tested materials can be given.

Acknowledgements

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