Impact of a rain-roof-covering-system on the incidence of fungal diseases, quality parameters and solar radiation in organic apple production

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Abstract

*Unsprayed organic apple trees growing under a rain roof covering system were assessed over three years for fungal diseases, fruit quality and irradiance conditions and compared to standard organic managed trees growing under hail-netting. The orchard consisted of about 550 trees of cultivar 'Topaz' on rootstock M9 divided between the two treatments. The incidence of apple scab on shoots and fungal storage rots (*Neofabraea spp.*) on fruit in the roof covered treatment was lower, compared to the standard managed trees. But there was no influence on other storage rots caused by* Penicillium, Botrytis *or* Monilia*. The incidence of sooty blotch was reduced in the covered treatment compared to the uncovered control. Apple russeting was also lower in the covered treatment than in the uncovered control. There was no clear treatment effect regarded frost damage. A positive effect was observed at slightly low temperatures, but at colder temperatures it turned into a negative effect with more damage to the fruit. Over all three experimental years incoming solar radiation was reduced by about one-third under the rain roof covers in comparison to the control trees under hail-netting. Due to the reduced incoming solar radiation, the foil wide treatment was not affected by sunburn on apple fruits whereas the control treatment showed a slight sunburn incident.*

Keywords: rain cover, fungicides reduction, storage fungal rots, protected farming

Introduction

After positive results in previous field studies with reduced sooty blotch incidence for fruits protected by temporary rain cover systems, experiments were conducted against several fungal diseases by covering trees with plastic foil during the whole growing season. To adequately control fungal diseases in organic apple production it is often necessary to spray very frequently according to regional weather conditions and cultivation methods. Nearly all fungal diseases need extended periods of rainfall for spore release and fruit infection. If apple trees can be protected from rainfall, then potentially large reductions in plant protection control measures could be possible. The main objective in this trial was to test the cultivation of apple trees under a protected rain roof foil system without using any fungicides in comparison of standard production under hail-netting with standard sprays. The effects of the roof covers and standard spray treatments on disease incidence, physiological parameters as well as fruit quality were examined over a period of 3 years (2015 to 2017) as summarised in the following report.

Materials and Methods

The organically managed experimental orchard was located at the Kompetenzzentrum Obstbau-Bodensee (KOB) in the Lake Constance region, Southwest Germany. In spring 2013, hailnets were erected over 17 rows and about 2000 trees of the cultivar `Topaz´

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planted on M9 rootstock at a distance of 1.0m x 3.5m. In spring 2014, a rain roof cover system (VOEN, Ravensburg, Germany) as is usually used in cherry production was installed. Eight lanes with a length of 146 m and a width of 2.40 m were erected above 4 adjoining rows of ~460 ‘Topaz’ trees (Figure 1) to completely protect them from rainfall (referred to as “foil wide” in the text below). In each treatment block a weather station was installed to record climatic conditions. In comparison to the rain roof covering system, `Topaz` trees under hail-netting were used as a comparison untreated control treatment consisting of 7 rows of 45 trees, a total of ~320 trees. For the evaluations, 4 rows of the standard sprayed control with 230 trees were compared with 2 rows of ~230 trees from the rain-roof protection treatment. In each treatment area, 20 randomised sample trees (4 repetitions of 5 trees) were used for the assessments. In the uncovered control a standard plant protection programme with the annually required amount of fungicide sprays was applied, while trees under the roof covers were not sprayed with any fungicides. The standard organic plant protection programme applied to the uncovered control was based on treatments with copper, sulphur, lime sulphur and potassium carbonates to control fungal diseases.

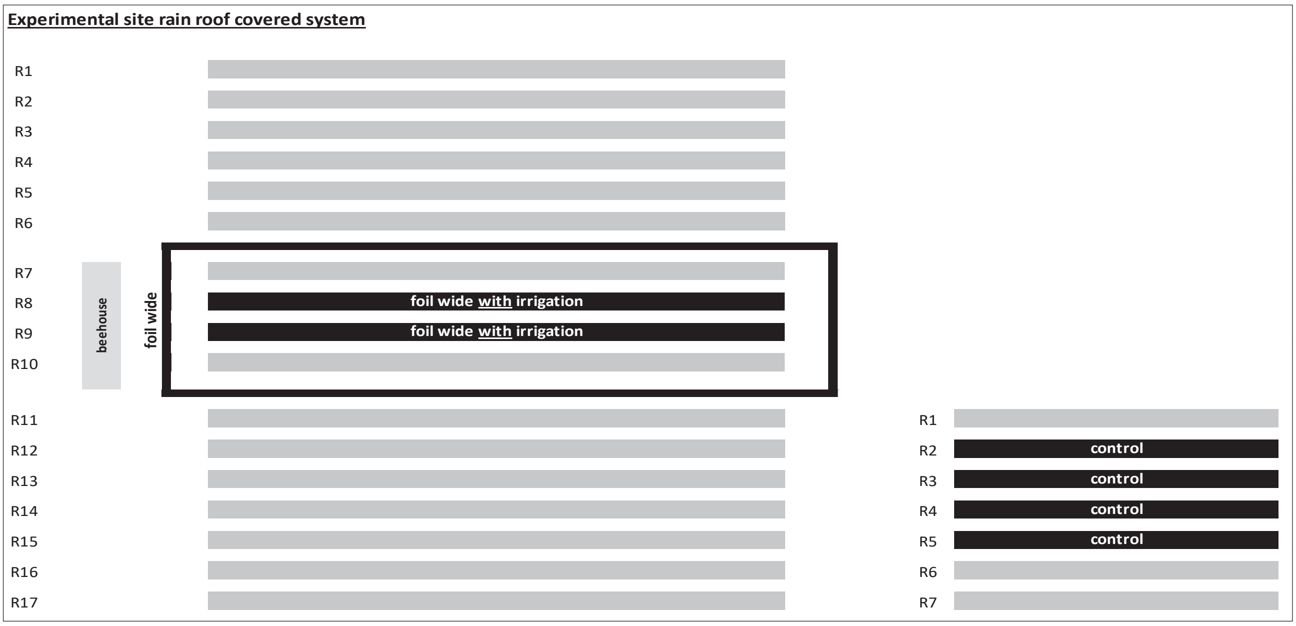

Figure 1: Scheme of experimental setting over years 2015, 2016 and 2017 at KOB Bavendorf.

Apple scab (*Venturia inaequalis*) incidence was assessed from 100 shoots per treatment. Every leaf per shoot was counted and assessed for the presence of apple scab symptoms.

For the fruit quality assessments (frost damage, apple russet, sunburn and sooty blotch) and storage diseases 6 fruit crates from the sample trees (760 fruits in total) were assessed from each treatment area. Fruits were stored for 4 months at 2°C in regular air. The first assessment was conducted at the beginning of January and a second assessment made after 8 days shelf-life at 20°C.

Solar radiation was recorded from the two weather stations located in both treatment areas. Incoming photo active radiation (PAR) sensors were installed at a height of 2.20 m below the foil and hailnets.

Results

Apple scab (*Venturia inaequalis*)

As shown in Figure 2, in 2015, no apple scab infestation on the leaves could been seen in either the covered or uncovered treatments. The following year 2016, was characterized by intensive spring rainfall in the Lake Constance region resulting in very suitable conditions for apple scab infestation. With a disease incidence of 1%, trees in the “foil wide” area were nearly free of scab symptoms. In comparison the control treatment showed an infestation of 9%.

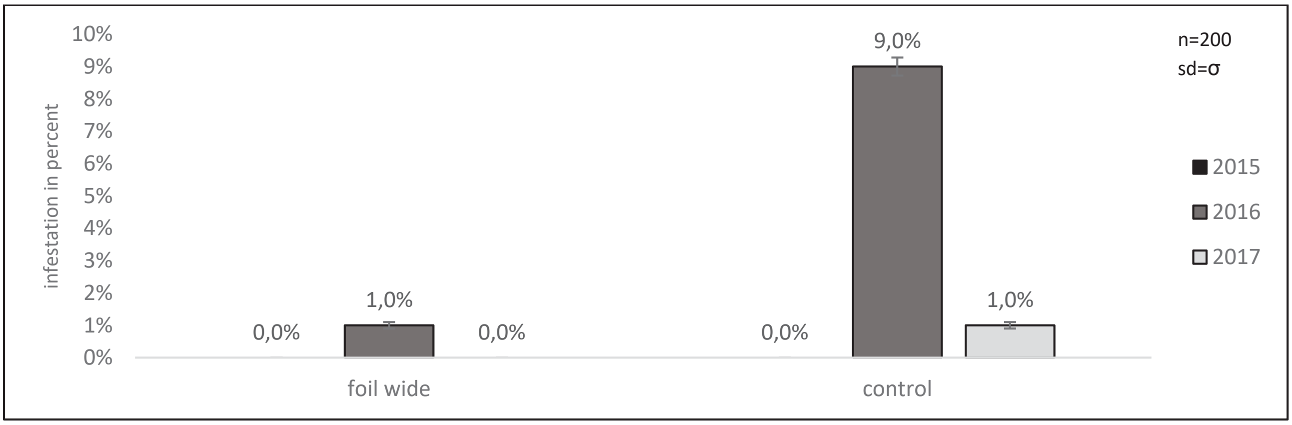

Figure 2: Incidence of apple scab (*Venturia inaequalis*) on leaves in 2015, 2016 and 2017 at KOB Bavendorf.

In 2017, the foil wide treatment showed no apple scab and with a 1% leaf infestation, scab incidence was also at a very low level in the uncovered control.

Frost

In 2015 there was no spring frosts. The following year a spring frost occurred on 18th March 2016 during very early flowering. The temperatures at night fell to -3.0 °C resulting in slight frost damage. In the foil wide treatment 7.9% of the apples showed frost damage. Whereas 14.8% of fruit in of the control treatment were damaged (Figure 3). In 2017, intense frosts occurred on 19th and 20th April 2017 during full flowering. The weather station recorded sub-zero temperatures at -2.78 °C on 19th April 2017 during the night.

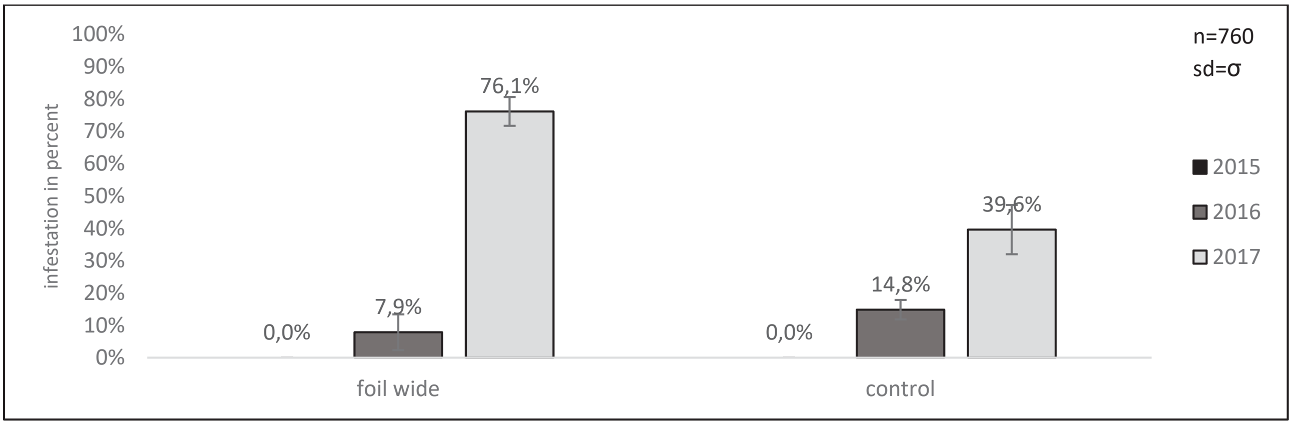

Figure 3: Incidence of frost damaged fruit in 2015, 2016 and 2017 at KOB Bavendorf.

The following night on 20th April 2017 the temperatures dropped to -3.7 °C in control treatment and -4.8 °C in foil wide treatment. These two nights resulted in widespread fruit loss and damage on fruit. In the foil wide treatment 76.1% of the fruit were damaged by frost. In comparison only 39.6% of fruit without roof were frost damaged.

Sunburn

As shown in Figure 4, in 2015 and 2017 there was no sunburn damage to fruits. In 2016, 5.6% of the apples in the control were damaged by sunburn whereas in the foil wide treatment there was no damage.

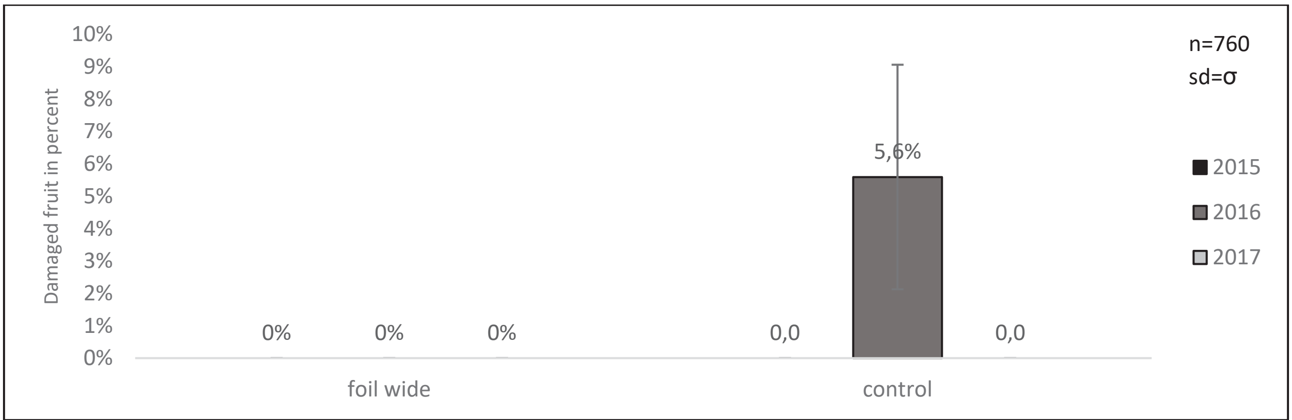

Figure 4: Incidence of sunburn damage on fruit in 2015, 2016 and 2017 at KOB Bavendorf.

Apple russet

Apple russet was not assessed in 2015. In 2016, the foil wide treatment showed a lower russet incidence of 11.7% compared to the control with 32.7% (Figure 5). In 2017, a similar pattern between the foil wide and the control was found with a russet incidence of 21.7% in the foil wide treatment and 74.0% in the uncovered control.

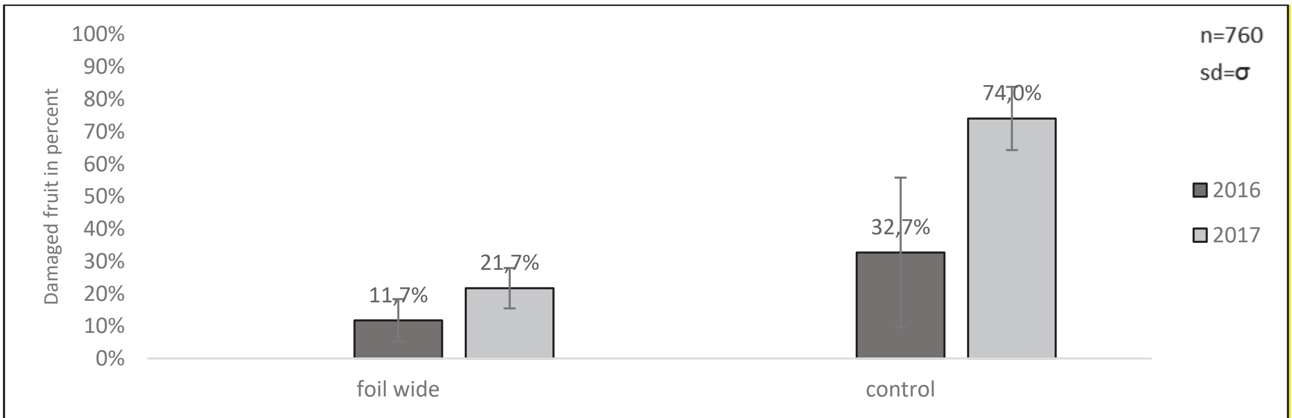

Figure 5: Incidence of apples with russet in 2016 and 2017 at KOB Bavendorf.

Sooty blotch

In 2015, the overall incidence of fruits with sooty blotch was low, nevertheless the foil wide treatment showed slightly less affected fruits with 2.3% incidence compared to the control with 2.4% (Figure 6). The climatic conditions in the following year 2016 were more suitable for sooty blotch and the foil wide treatment showed only 0.5% incidence compared to the uncovered control with 9.7%.

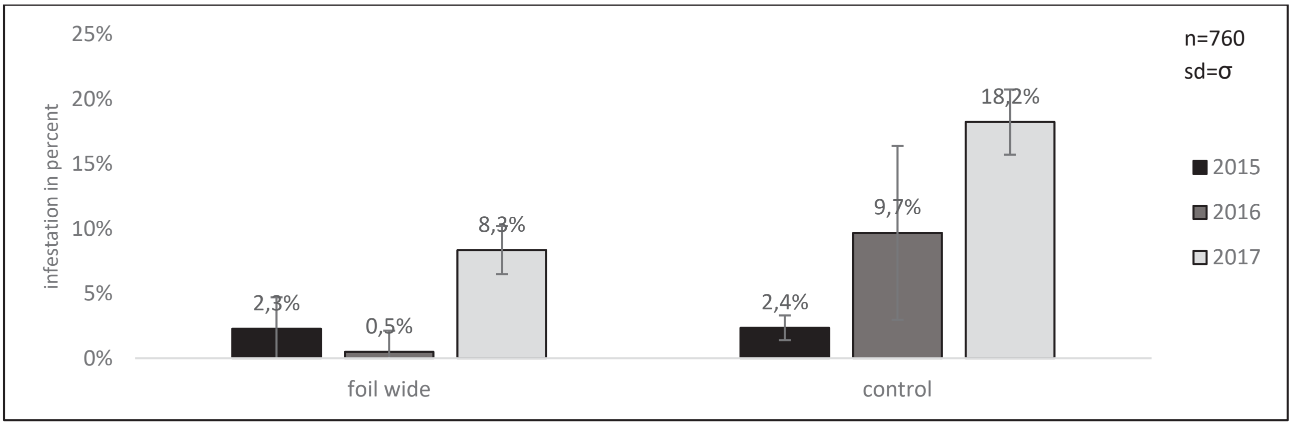

Figure 6: The incidence of sooty blotch in 2015, 2016 and 2017 at KOB Bavendorf.

In 2017 the foil wide treatment showed a reduced sooty blotch infestation of 8.3% in comparison the control with 18.2%.

<u>Storage rots</u>

Figure 7 shows that the non-sprayed roof covered foil wide treatment largely prevented rots caused by *Neofabraea* spp. during all three experimental years when compared to the uncovered control with a standard spray programme. From 2015 to 2017, the foil wide treatment showed 0.4%, 0.3% and 3.2% affected fruit, respectively, and were much lower when compared to control with steadily increasing infestation levels of 11.7%, 48.4% and 78,9% for the same years. The incidence of other fungal rots (e.g. *Penicillium*, *Botrytis*, *Monilia*, ...) was lower of the three seasons and comparable in both treatments.

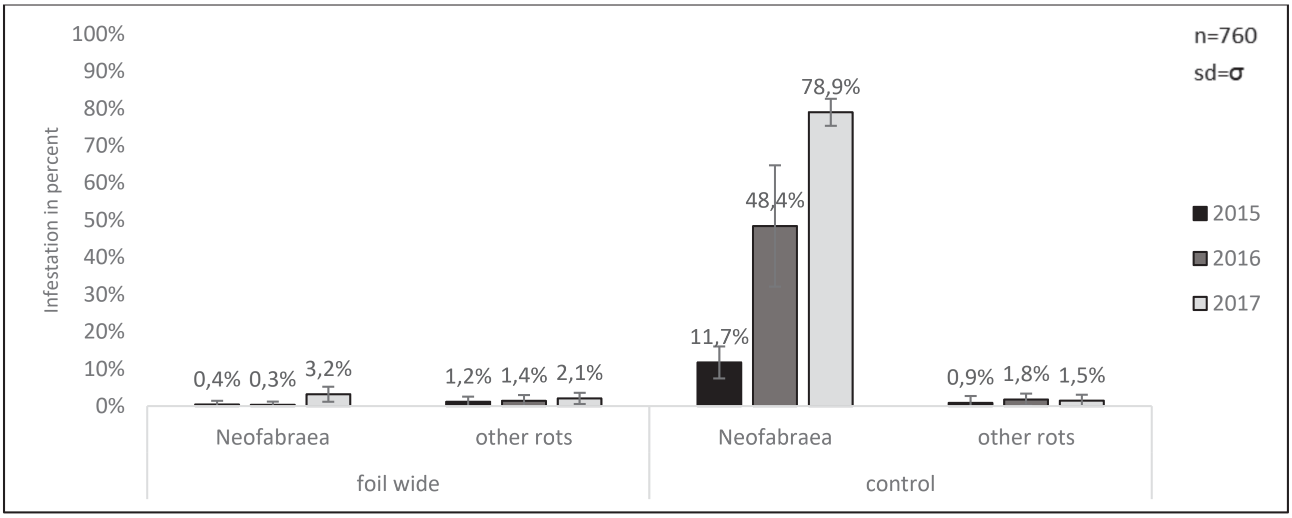

Figure 7: Incidence of storage fungal rots in 2015, 2016 and 2017 at KOB Bavendorf.

<u>Irradiance</u>

Clearly, the plastic foil roof covers strongly reduce the intensity of incoming solar radiation in contrast to the hail net in the non-covered control (Figure 8). Overall of study years there was an average reduction of 36% in the PAR values with annual reductions of 30%, 36% and 42% during the month of July in the years 2015, 2016 and 2017, respectively. A reduction in incoming radiation by the foil could been shown for both sunny and cloudy days.

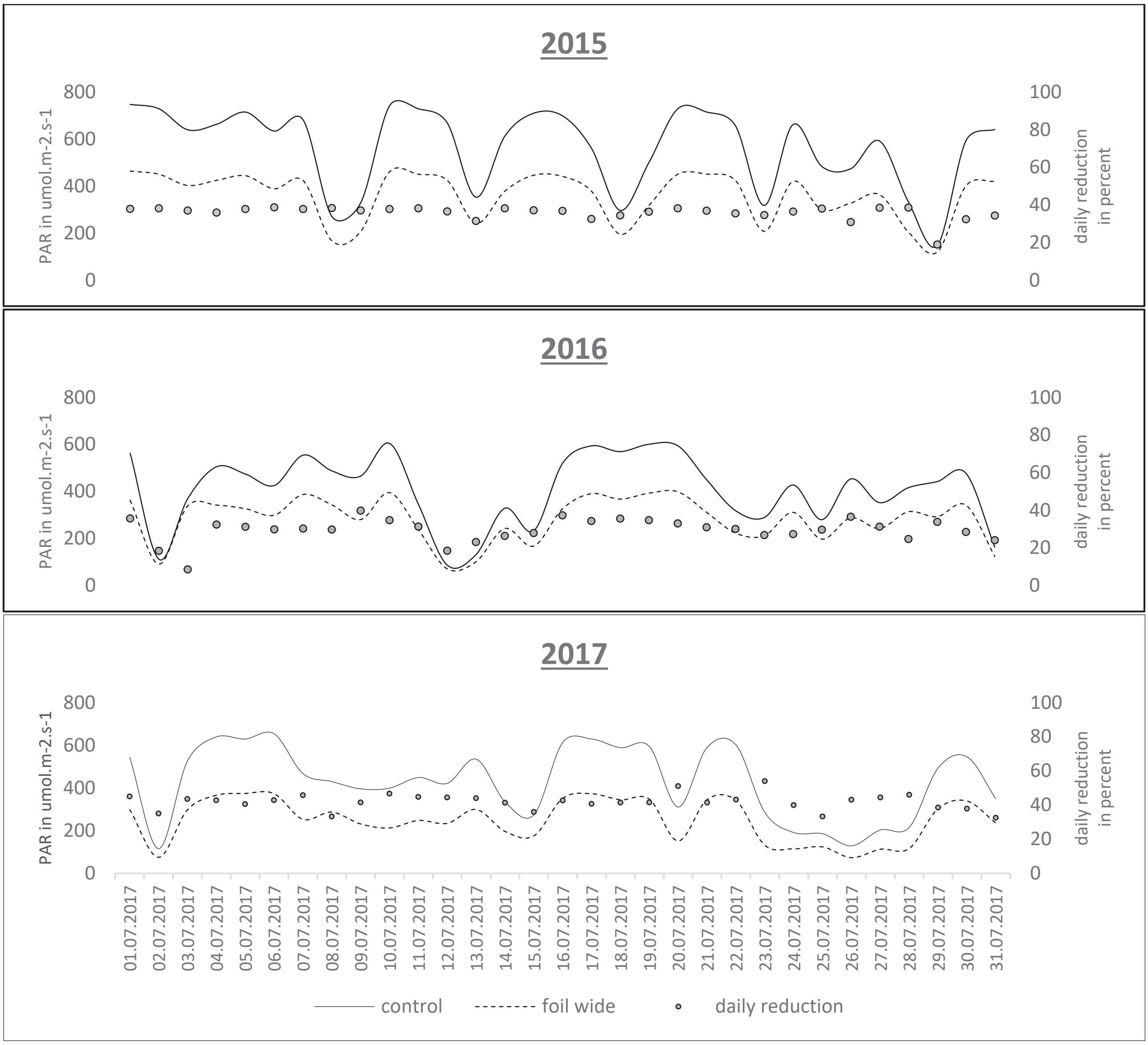

Figure 8: Daily solar irradiance (PAR) values recorded during July in 2015, 2016 and 2017 at KOB Bavendorf.

Discussion

During three years of observations, completely covering 'Topaz' apple trees with a 'VOEN' foil system (Ravensburg, Germany) showed a positive impact especially on fungal diseases. Infestation with the most important fungal diseases in Lake Constance fruit growing region could nearly be completely be prevented by the foil covering system alone, without any additional fungicide treatments. A standard organic fungicide spray programme in the uncovered control could not reduce the incidence of several fungal diseases to the same level. In 2017, the incidence of fruit infested by sooty blotch was reduced by ~10% and by ~75% for rots caused by *Neofabraea* spp. when compared to the uncovered control. Probably because of the lower level of solar irradiance under the foil covers, losses caused by sunburn were reduced as well. Furthermore, the incidence of fruit russet was reduced by covering. If these positive effects are referable to the roof covers, lesser sprayings or a continuous irrigation finally could not been asserted in this trial. Due to the reduced losses from fungal diseases, sunburn and fruit russet damage, the yield of marketable fruit was substantially higher in covered treatment when compared to the standard managed trees in

the untreated control. Savings of plant protection control sprays generates a positive impact both economically and environmentally.
On the other hand, higher costs for the roof cover system compared to hailnet have to be considered. Economics of a foil coverage system will also be influenced in particular by the lifetime of the plastic foil.
The results show, that the foil roof used in this trial continuously reduced the incoming radiation by ~36% in contrast to the hailnet. Thereby a negative impact on fruit colouring can be expected, particularly with increasing tree canopy. In the three years of observations, no negative effects could be observed. How far the reduced light levels will affect tree grow will have to be determined in future studies. As expected, an increased occurrence of several insect, like woolly apple aphids and spider mites could be observed under the roof covers because of the changed microclimate, these changes in pest dynamics will also need be observed in following years.

Acknowledgements

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