Approaches how to reduce sooty mold on organically produced apples

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Abstract

In organic apple cultivation in South Tyrol (Italy) the losses caused by epiphytic fungi have increased considerably in recent years. Affected are mainly late varieties, varieties that are only extensively treated against fungal diseases, and orchards in humid locations. The damage pattern on the fruit is shown by dark spots on the skin. They resemble sooty blotch and can also be wiped off. The spots are not always visible at harvest. However, in long-term storage, especially with high humidity, the spots rapidly increase, making it difficult for the market to accept them. Various fungi are isolated on the fruits, but it is not clear which fungi are responsible for the damage. At the Laimburg Research Centre (RCL), field trials with PPPs and with the rain cover (Keep in Touch®, antiacqua system) have been conducted since 2014. In addition, tests were carried out before and after storage with various preparations, with hot water and with brushes. Brushing after storage has proven to be the best method, but Gloeosporium infestation increases slightly due to brushing.

Keywords: Apple, disease, sooty mold, sooty blotch, rain cover, Keep in Touch®, brush, hot water.

Introduction

In recent years, post-storage losses caused by epiphytic fungi have been increasing in all traditional apple-growing regions of northern Italy (Trentino Alto Adige, Piedmont, Emilia Romagna, etc.). Affected are mainly the organic farms, but these can also be found in integrated pest management (IPM) farms mainly on plants with late ripening varieties in humid locations. Many different fungi are isolated from the infested fruits (*Cladosporium* sp., *Alternaria* sp. *Schizothyrium* sp., *Aureobasidium* sp. *Phoma* sp. *Fusarium* sp. *Peltaster* sp., *Botrytis* sp., *Penicillium* sp., *Epicoccum* sp., *Geastrumia* sp., *Stomiopeltis* sp.). Who is responsible for the grey-brownish to green spots? This is not often clear (Öttl 2020). The infections are not always obvious at harvest since they spread in the warehouse and are also able to pass on to clean fruits. The humidity in the storage rooms plays a major role in this case. Aim of our experimental work from 2016 to 2019 was to find practical solutions for the fruit growers and/or cooperatives and to collect information about the occurrence of the infections.

Material and Methods.

Since 2016, the organic farming-working group at the RCL has been conducting trials to regulate sooty mold. For this purpose, spraying tests at the RCL and on private farms, effects of agronomic measures on infestation. Immersion tests before storage with different preparations adding hot water, and the use of brushes on the sorting machines before storage and/or after storage were carried out. The evaluations were made after harvest and after storage (3 months cold storage 2°C and 95% relative humidity). In addition to the sooty mold (% of infested surface of the fruits), burns on the fruits and the occurrence of rot were also assessed. Where repetition and randomisation were possible, the data were also statistically evaluated. The assessed data were compared across treatments using 1-way

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ANOVA, followed by Tukey's test (P<0.05) for post-hoc comparisons of means. All analyses were performed using the software IBM SPSS Statistics 24.

1) Spray tests:

2016: In 3 private orchards (VG, KD, HS), trials on the varieties Pink Lady/M9 and Braeburn/M9 were compared from September onwards in separate plots with Armicarb® 4.5kg/ha, and lime sulphur 15kg/ha to an untreated plot. The treatments were carried out by the fruit growers. The fruits were evaluated for sooty mold infestation after harvest and after storage in the cold store. Part of the fruits were immersed in hot water (52°C 3 min). A statistical evaluation is not possible due to lack of real field repetitions

In 2018 a time window spraying trial consisting of 66 field plots (10 trees/plot) was carried out on RCL Block 56, variety Cripps Pink. The preventive treatments were carried out on 14 moments at 10-day intervals from the beginning of July to November. The following traditional preparations or mixtures were used (Poltiglia Disperss 300 g/ha pure copper, lime sulphur 12 kg/ha, Armicarb® 5kg/ha and Vitikappa 7.5 kg/ha + Heliosoufre 1.5kg/ha). On the 1st spraying date the plots 1, 2, 3, 4 were treated with the above-mentioned preparations and plot 5 was left untreated. On the 2nd spraying date, the plots 1, 2, 3, 4, 6, 7, 8, 9 were treated with the preparations in sequence. The plots 5 and 10 were left untreated. In intervals of 10 days the plots were extended by 5 plots until the 14th treatment. The aim of this experimental design was to obtain information about the moments of infection in addition to the mean spraying test. A rain cover (Keep in Touch® antiacqua) was installed as a comparison to the spray treatments. The infestation in 2017 was very low. The trial was therefore repeated in 2018.

2019: At RCL Block 56, variety Cripps Pink; a spraying trial with 12 preparations and 4 randomized repetitions was conducted. 8 preparations were applied preventively (Polyversum *Pythium oligandrum* 450g/ha, Amylo-x *Bacillus amyloliquefaciens* 3750g/ha Botektor *Aurobasidium pullulans* 600g/ha, Seranade *B. subtilis* strain QST600g/ha, Soptech 1500ml/ha ,mixture of fatty alcolhols, Soptech 6000 ml/ha, willow extract 30l /ha, 3Logy 4000 ml//ha, Poltiglia disperss 300 g Cu-met/ha, Cobre Nordox 300g Cu-met/ha); and 2 preparations (Vitikappa 7500 g/ha + wetting sulphur 3000g/ha and lime Sulphur 12kg/ha) were specifically applied to the wet leaves approx. 400 HD after the beginning of rain (stop treatment). A rain cover (Keep in Touch® antiacqua) (Kelderer et al. 2018) was installed as a comparison to the spray treatments. However, these plots require their own control plot because they are not directly randomized in the spraying trials.

2) Mowing intensity tests:

2016, 2017, 2018: At RCL Block 56, variety Cripps Pink; an area of 3000 m2 was divided into 3 parts. One part was not mowed from the end of June, the 2nd part was covered with a black foil and the 3rd part was mulched every three weeks. At harvest and after cold storage (3 months cold storage 2°C and 95% rh), the infestation with sooty mold was evaluated.

3) Dipping and brushing tests

2017, 2018: At RCL, Block 1, variety Fuji; fruits were taken and stored in cold storage. After storage, the fruits were divided into 2 calibres (smaller or larger than Ø 75mm) and treated with a mechanical apple brush. The machine was adapted to the calibre of the fruits or not. The evaluations were conducted after harvest, after removal from storage and after treatment with the brush.

2018: At RCL, block 56, variety Cripps Pink; fruits were taken randomized in boxes and subjected to combined treatments of dipping and brushing. Used were: 1) 0.5% NaHC 3 min. + brush before and after storage; 2) 20% wine vinegar (10% acetic acid) 3 min. + brush before and after storage; 3) hot water 52°C 3 min.+ brush before and after storage; 4) hot water 52°C 3 min.+ brush after storage; 5) 1% H_2O_2 3 min. + brush before and after storage; 6) 1% H_2O_2 3 min. + brush after storage; 7) control, brush before and after storage; 8) brush after storage.

Results

Spray test 2016: After harvesting, approx. 80 % of the fruits on the experimental plot of the VG farm were infested with sooty mold. No differences between the treated and untreated fruits could be seen. Markings on the infested areas showed an increase in the infestation in the storage area. The situation was similar at the KD farm, the differences between treated and untreated fruit were very small. Some of the fruits from the experimental plots were treated with hot water (52° 3 min.) before storage. The increase of sooty mold on the fruits in the storage was about 40% lower. Also in the HS farm, the treatments did not show clear differences. Some of the untreated fruit was treated with hot water (52° 3 min.) before storage. This reduced the growth of sooty mold during storage.

Spray test 2018: In the absence of real field repetitions, the experiment cannot be statistically evaluated. Nevertheless, some speculative statements can be made from the experiment. The evaluation of the fruits from the experimental plots after harvest (graph on the left) shows an infestation of almost 20% to 30% of the fruit surface, with the exception of some plots which show up to 40% infestation.

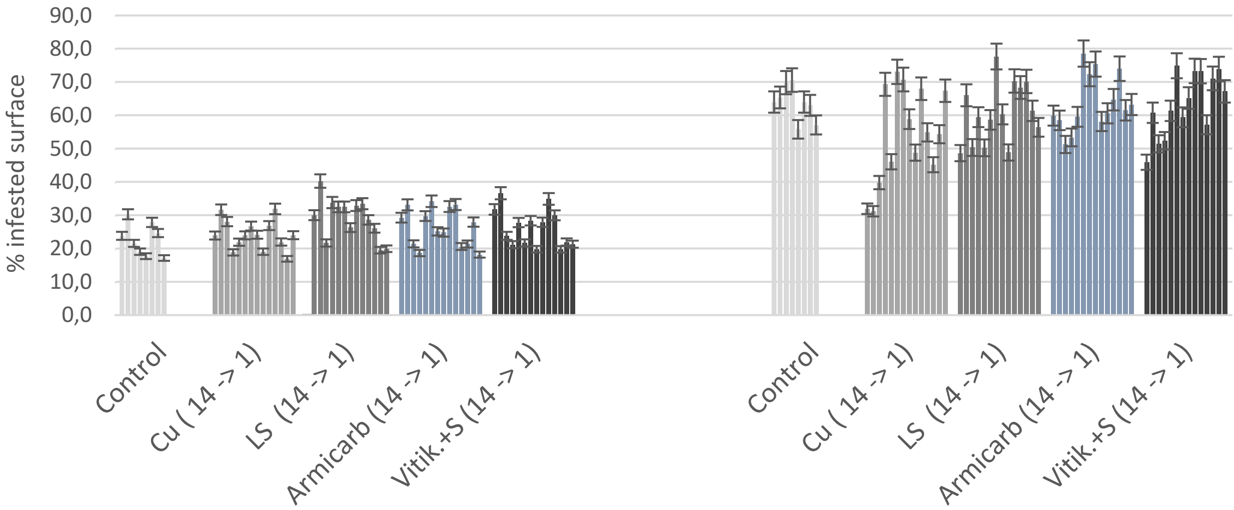

Figure 1: Infestation intensity in % of the fruit surface; left the evaluation before storage; right the evaluation after storage

There is no clear correlation between the number of treatments and the occurrence of infestation. Furthermore, from a practical point of view, there are no relevant differences between control plots and treated plots. During storage, sooty mold has increased by about 100%. Also this increase does not correlate clearly to the number of treatments with the preparations and there are no relevant differences between the preparations. The copper preparation Poltiglia disperss also caused burns on 6.8% of the treated fruits.

Spray test 2019: From the 12 treatments with different products, only 2 (Soptech in 2 doses) showed less infestation than the untreated control and even these differences cannot be statistically verified. The other variants increased even up to tripling the infestation, in some cases statistically significant. The following treatments also caused burns on the fruits surface (expressed in %) (Soptech 1.5 l/ha 15%, Soptech 6 l/ha, 56% Salix extract 65%, Poltiglia Disperss 16%, Cobre Nordox 30%, Vitikappa + sulphur 7%). However, they could not be statistically confirmed.

Mowing intensity trials 2016, 2017, 2018: For mowing intensity trials between the treatments a) soil covered with foils, b) intensive mulching (every 3 weeks) and c) no mulching, no relevant differences in infestation intensity in % of the fruit surface could be observed.

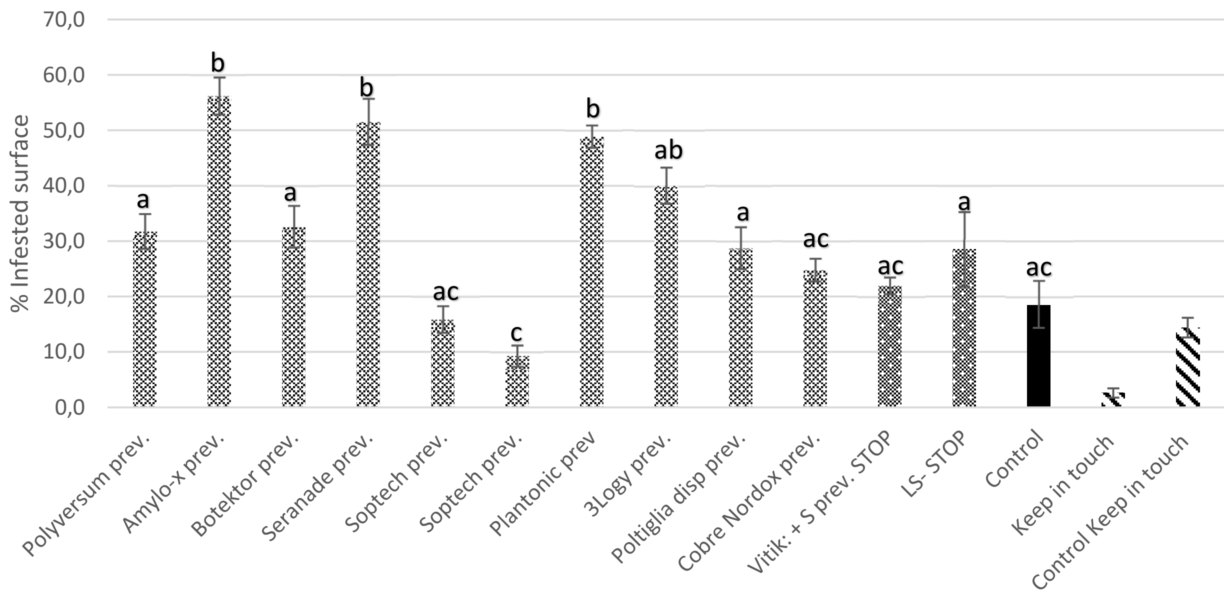

Figure 2: Infestation intensity in % of the fruit surface at harvest 2019

Brushing test 2017: By using the apple brushing machine the infestation could be greatly reduced. However, in order to achieve the best possible result, the fruits must be pre-calibrated.

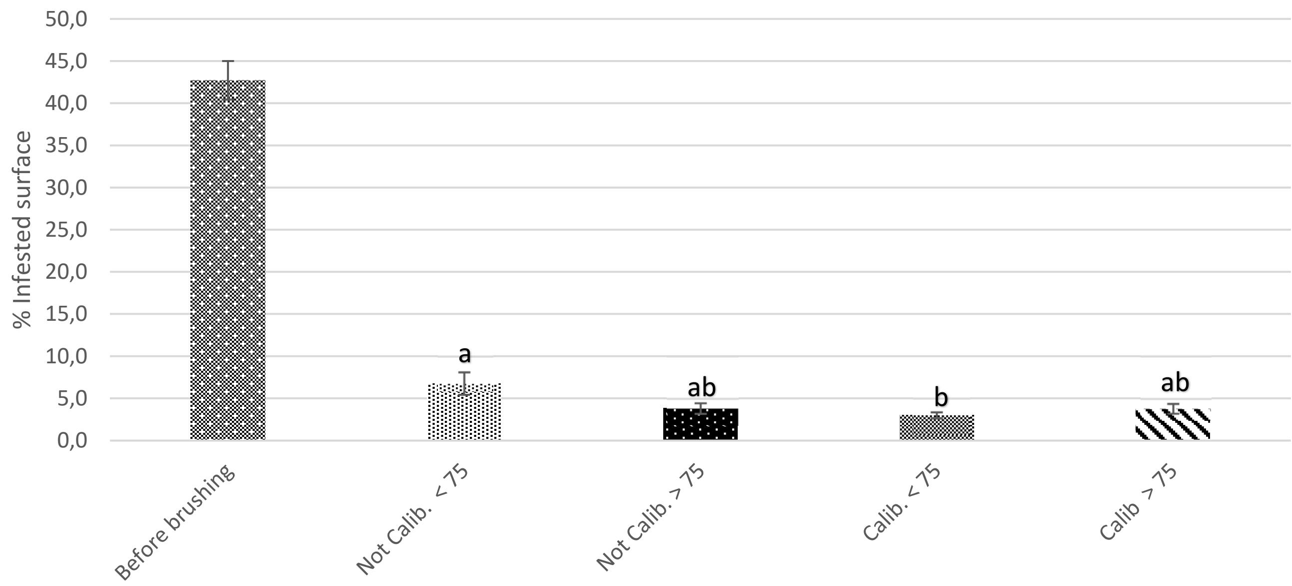

Figure 3: Infestation intensity in % of the fruit surface after storage after treatment with brush, sorting the fruits in 2 groups (smaller or larger 75mm) with or without adjustment to the calibre

Dipping and brushing Test 2018: As can be seen from the graph, the randomisation of the fruit after harvesting made it possible to establish a uniform infestation of the experimental fruit in the boxes and the fruit was subjected to combined treatments between dipping with different products and brushing prior to storage. The evaluation prior to storage confirmed the effect of the brush in a statistically significant manner, while the dipping variants (Kiran Fareed, 2019) showed no effect either in combination with or without brushing.

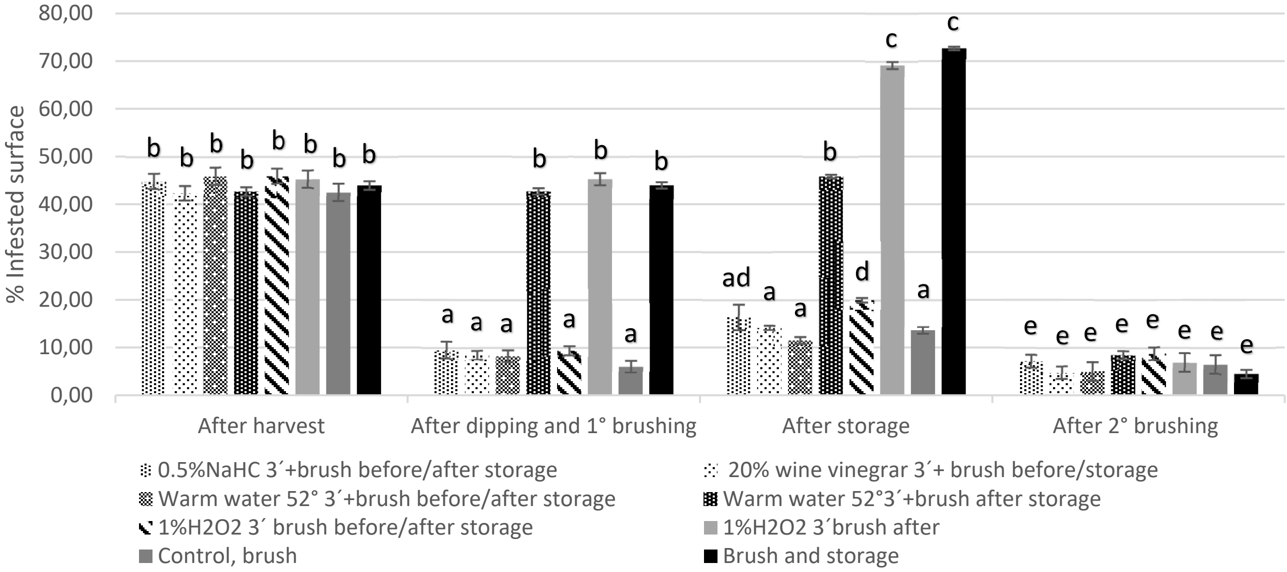

Figure 4: Infestation intensity in % of the fruit surface after harvest, after subsequent treatment with brush, after cold storage and after final treatment with brush

After removal from storage, a differentiated picture emerged. In almost all treatments the infestation increased, but to varying degrees. Fruits which had not been brushed before storage showed more increase in infestation than the brushed fruits. The dipping methods also show an effect on the growth in some cases, but dipping with hot water should be mentioned first. Finally, all test variants were brushed again after storage. The infestation was largely eliminated and statistically speaking, no differences between the different treatments could be observed independently of all the treatments before.

Discussion

In many apple-growing areas in northern Italy, the incidence of sooty blotch is increasing at an alarming rate. This applies to IP cultivation but especially to organic cultivation.

An initial microbiological examination of the epiphytic flora of leaf, fruit peel and bark from ten organically managed apple orchards in South Tyrol in 2019 suggests that there is both a temporal and a geographical dynamic in microbial colonisation. It is also questionable which of the isolated fungi cause sooty mold in individual cases (Öttl 2020). Spraying tests with the traditional preparations (Mayr, et al. 2008; Sutton,.2002), used in organic farming, but also with other experimental preparations, did not give satisfactory results despite repeated preventive or targeted use. More, some of them caused burns on the fruits depending on the variety and frequency of treatments. The same applies to the preparations used in the dipping process. The hot water treatment seems to slow down the increase of symptoms during the storage phase under the conditions as it is also used against *Gloesporium* rot. We could only achieve clear effects with the physical barriers, but the application has not only positive aspects (landscape, carbon footprint, amount of work etc.). The use of the apple brush, after storage has produced useful results if the fruits are not too dirty, especially in the calyx of the fruits, which is difficult to clean. Some concerns are still on the influence of brushing on the shelf life of the fruit, especially for varieties that are sensitive to *Gloeosporium* rot and the occurrence of mechanical damage on the fruits.

References

Kelderer, M., Casera, C., Lardschneider, E. and J., Telfser (2018) Field trials in apple orchards with different covering methods to reduce plant protection treatments and yield losses due to pests and diseases. 18th International Conference on Organic Fruit-Growing: Proceedings of the Conference, 19-21 February 2018, Hohenheim, Germany 2018 pp.64-70 ref.5.

Kiran Fareed, Muhammad Jamil Ahmed, Mehdi Maqbool, Noosheen Zahid, Abdul Hamid and Syed Zulfiqar Ali Shah (2019) Effect of surface disinfectants on fruit blemishes (Sooty blotch & Flyspeck) and quality of apple (*Malus domestica* Borkh.) cv. Banky during cold storage. *Pure and Applied Biology. Vol. 8, Issue 1, pp1126-1134.*

Mayr, U., & Späth, S., (2008), Efficacy of different application strategies. Proceedings of the 13th International Conference on Cultivation Techniques and Phytopathological Problems in Organic Fruit Growing, 82-86.

Öttl S. (2020) oral communication

Sutton, Turner B. und Williamson, Sharon M. (2002) Sooty Blotch of Apple: Etiology and Management. In: Boos, Markus (Hrsg.) *Ecofruit - 10th International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit-Growing: Proceedings to the Conference from 31st January to 2nd February 2006 at Weinsberg/Germany, S. 43-48.*