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Reviewed Paper

Sooty blotch management in summer: alternatives to the use of copper

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Abstract

To date, copper is a very efficient and widely applied fungicide in organic fruit production. It is used to manage a multitude of fungal diseases in organic apple production, including sooty blotch. This paper presents two trials which compare copper to other available plant protection agents applied in summer regarding their efficiency in sooty blotch regulation, over a period of four years. Copper was able to reduce sooty blotch infection compared to an untreated control in all trials. However, the efficacy of copper treatments was comparable to other tested plant protection agents. The highest potential in reducing sooty blotch damage was observed in the application of wettable sulfur, Kumar®, and lime sulfur.

Keywords: sooty blotch, copper, plant protection

Introduction

Nowadays, national legislation in Germany limits the maximum amount of copper in organic production to 3 kg $ha^{-1}a^{-1}$. However, there are efforts to further reduce the amount of copper applied in agriculture. Although the applied copper amounts in organic apple growing in Germany are well below the maximum allowed number, ranging annually between 1.3 to 1.8 kg ha^{-1}, the relative share of copper applied after apple blossom is growing to date over 50 % (Kienzle et al., 2023). In organic apple production in Lake Constance area, the most important fungal pathogen is apple scab. Nowadays, the use of scab robust varieties in organic apple production allows a reduction of the amount of applied copper. However, in agricultural practice, there are concerns regarding the emergence of sooty blotch, if copper applications in summer months were reduced.

This study compares different plant protection agents in their efficacy to manage sooty blotch disease. Since copper is an important fungicide applied in summer, the emphasis is to examine if it is a suitable agent in reducing sooty blotch infection.

Material and Methods

This paper provides results of two trials. Both trials were conducted at the organically managed orchard planted in 2012 and 2013 at KOB, designed in a four-time replicated randomized block design, with each replication containing 10 trees. Spraying was conducted with a Wanner spraying machine, which was exclusively designed for operating in trials. Applied noozles were DG Teejet 80015VS green, and water volume was 500 l ha^{-1}. Prior to the beginning of the trials in summer, the trees received a customary plant protection program in spring. To assess the degree of sooty blotch infected apples, each apple was visually evaluated, using a 6-level ranking system (Table 1). Fruit evaluation was conducted just before harvest. In total, 600 apples were annually evaluated in each treatment (150 apples/replication).

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Table 1: Scale to visually rate the severity of sooty blotch infected fruit.

score	Definition of symptoms
0	No visible symptoms
1	< 5 % infected peel
2	5 - 10 % infected peel
3	11 – 25 % infected peel
4	26 – 50 % infected peel
5	> 50 % infected peel

The average infestation was subsequently converted into the 'degree of damage', which is expressed mathematically as percent of maximum possible damage (P):

P = degree of damage in %
$P = \Sigma (n*v) / (5*N) *100$
N = overall number of trees
v = value 0,1,2,3,4,5
n = number of trees rated the respective value

To analyse the data, it was compared across treatments using a Kruskal-Wallis-Test followed by a post-hoc Dunn's Test ($P<0.05$). The statistical analysis for both trials was conducted in R version 4.3.2.

Trial 1

The first trial was conducted with 'Natyra®' trees grafted on M9 for a period of 3 years, from 2019 – 2021. In each of those years, the trial took place from beginning of July until end of September. Prior to the trial, the trees received a customary plant protection program during primary season. Besides an untreated control, there were two groups of treatments. The first group received plant protection on a weekly basis (7 (days)), whereas the second group received plant protection every two weeks (14 (days)). Both groups received the same plant protection agents displayed in table 2. In every year of the trial, weekly applied treatments (7) received 10 applications. The treatments applicated every two weeks (14) received 5 sprayings in 2019 and 2020 and 4 sprayings in 2021. If possible, application took place prior to forecasted events of precipitation in a protective manner.

Table 2: Plant protection agents and application rates (trial 1)

treatment	application rate kg resp. l ha^{-1}
Cuprozin® progress (cu)	0.5
Netzschwefel Stulln (s)	4.0
Curatio® (lime sulfur (ls))	12.0
Kumar® (potassium bicarbonate (car))	5.0

Trial 2

The second trial was performed in 2023 with 'Shalimar' trees grafted on M9. In contrast to trial 1, treatments were applied as strategy, some consisting of an additional curative component. Figure 1 gives an overview of applied agents and the total number of applications for each treatment. Furthermore, the copper applications are subdivided for each month of the trial. The number (125 respectively 250) given in the copper treatments description indicate the amount of copper applied with a single application (125 g Cu ha^{-1}

resp. 250 g Cu ha^{-1}). In treatments containing copper, a maximum applicable amount of copper was determined at the beginning of the trial. As soon as the copper maximum was met in these treatments, additional protective applications were executed by applying the wettable sulfur product “Netzschwefel Stulln”. Moreover, the applied plant protection agents with the respective application rate are shown in table 3.

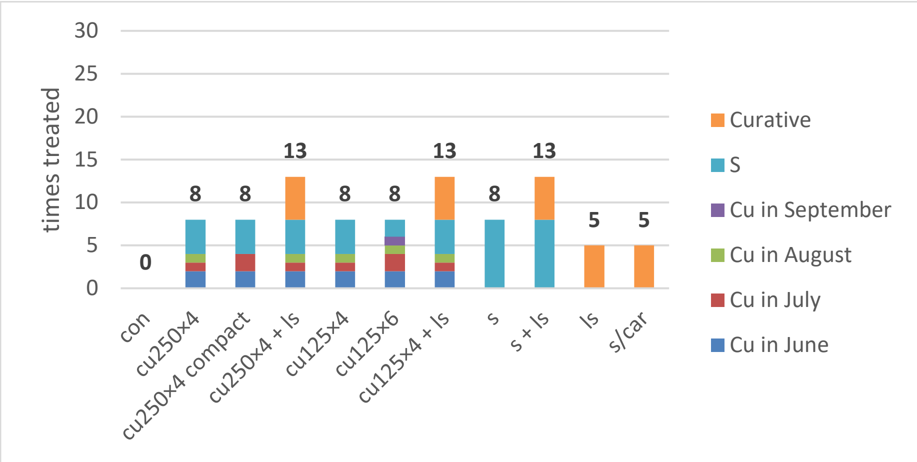

Figure 1: Overview of plant protection applications for each treatment (trial 2)

Table 3: Plant protection agents and application rates (trial 2)

Treatment	application rate kg resp. l ha^{-1}
Funguran® progress (cu 250)	0.716
Funguran® progress (cu 125)	0.358
Netzschwefel Stulln (s)	4.0
Curatio® (lime sulfur (ls))	12.0
Kumar® (potassium bicarbonate (car))	5.0

Results

Trial 1

The results of the 3-year experiment are displayed in figure 2 a-c. Though fluctuating over the years with highest infection potential in 2021, in every year the untreated control showed significantly highest infestation rates. Compared to untreated control fruit, copper treatments reduced infestation levels significantly in all 3 years. However, no difference was found in sooty blotch regulation success between the two tested frequencies of copper treatments (7-days or 14 days). Except for a significant difference between ls14 (P= 29.7 %) and cu7 (P= 23.9 %) in 2021, both copper treatments showed either comparable, or significantly higher numbers of infestation compared to all other tested treatments. In 2 out of 3 years (2019 (P= 20.4 %) and 2020 (P= 9.1 %)), weekly application of wettable sulfur led to lowest numbers of infestation. In addition to sulfur, Kumar® application also proved a high potential in regulating sooty blotch. In 2019, both Kumar® treatments (car14, P= 24.2%, and car7, P= 20.7 %) led to significantly lowest infestation levels along with the sulfur treatment (s, P= 20.4 %), and in 2021 a weekly application of Kumar® (car7, P= 12.3 %) reduced infestation levels significantly the most.

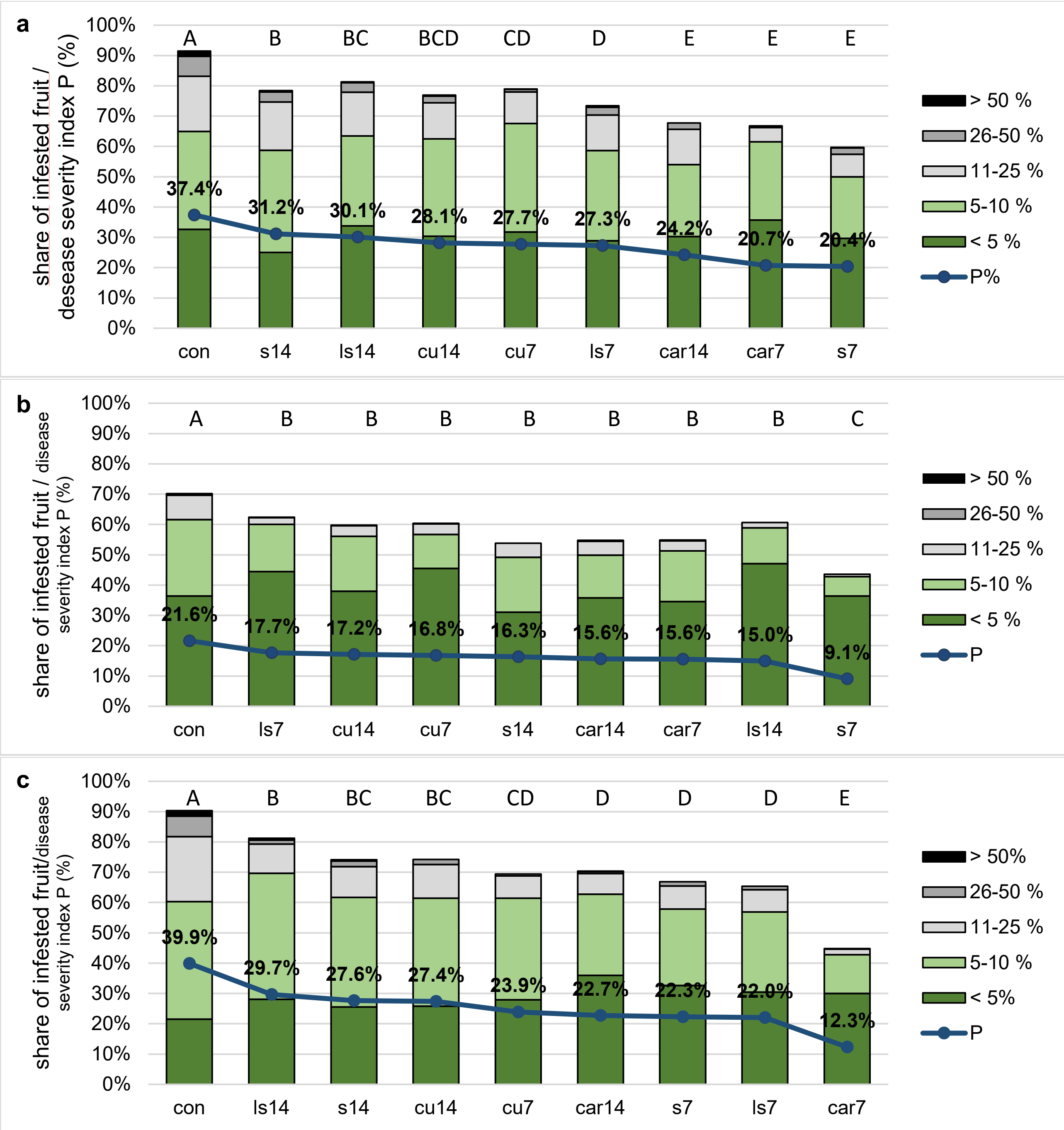

Figure 2: Results of sooty blotch infestation displayed in degree of damage P and stacked in classes of severity for all 3 years of experiment (a: 2019, b: 2020, c: 2021). Different capital letters indicate significant differences.

Trial 2

Similar to trial 1, the untreated control (P= 31.1 %) showed the biggest share of sooty blotch infected apples. No significant difference was observed between the untreated control and cu125×6 (P= 28.6 %). A second group significantly less affected than control, but not significantly different to each other, consists of cu250×4 (P= 26.2 %) and cu125×4 (P= 25.0 %). Six treatments cu250×4 + ls (P= 21.1 %), cu250×4 compact (P= 20.7 %), s (P= 20.7 %), ls (20.1 %), cu125×4 + ls (P= 17.0 %), and s / car (P= 17.0 %) form a group with significantly lower amount of sooty blotch infected fruit than the above mentioned. Results show, that the 5 treatments with a combination of sulfur and/or Kumar (s/car) lead to comparable results to strategies including 8 to 13 treatments with a total amount of copper of 1 kg. However, best results were observed in the treatment sulfur + lime sulfur (P= 12.6 %).

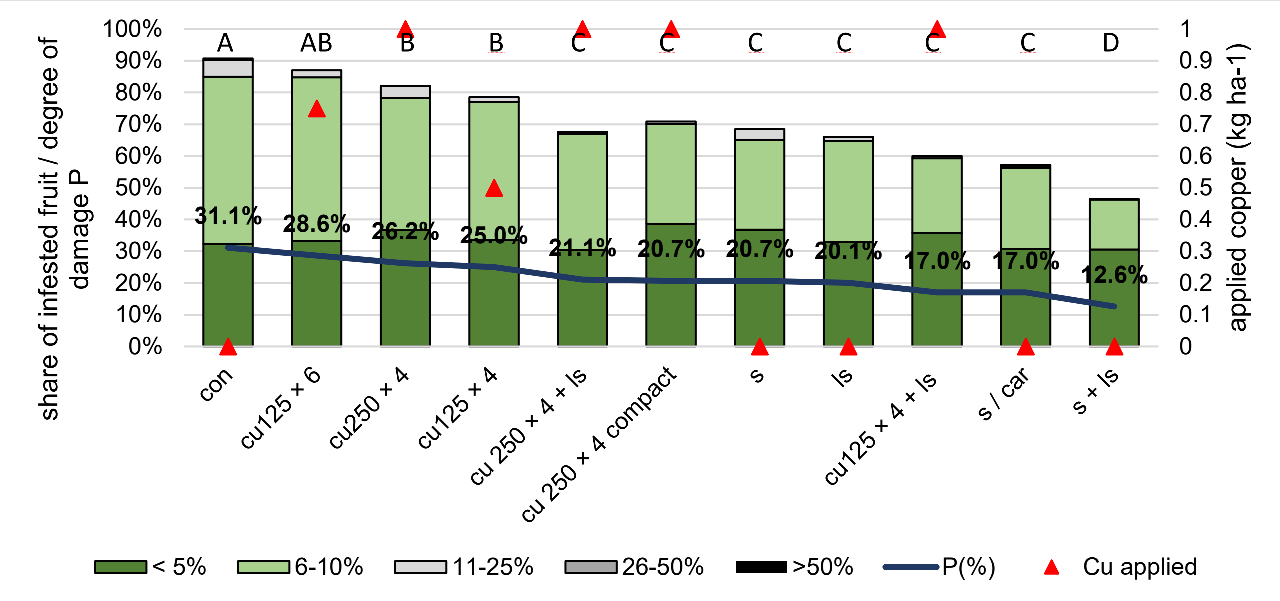

Figure 3: Results of sooty blotch infestation displayed in degree of damage P and stacked in classes of severity. Triangles display copper applied in each treatment. Different capital letters indicate significant differences.

Discussion

This study compares the efficacy of different plant protection agents, including copper, against sooty blotch disease in summer under climate conditions of the Lake Constance area on a 4-year basis. Results of trial 1 highlight that there are either plant protection agents of equal value or even agents that are better suited for regulating sooty blotch than copper. In 2 out of 3 years (2019 and 2020), treatments with wettable sulfur led to lowest sooty blotch infection. Kumar® proofed its potential in sooty blotch regulation as well. In 2021, weekly application of Kumar® led to lowest sooty blotch infection, and in 2019 both Kumar® treatments depicted the best results together with sulfur. With treatments including different amounts of copper compared with different application rates and times of treatment, the main focus of trial 2 was to get more into detail. Results of trial 2 emphasized our findings in trial 1. Significantly best results were achieved by a strategy of protective sulfur spraying in combination with a curative application of lime sulfur. Promising results were achieved with only 5 curative treatments with a combination of sulfur and Kumar®. Strategies with copper (up to 1 kg Cu) did not show better results in sooty blotch regulation, compared to completely copper free strategies. Moreover, copper free strategies containing sulfur, lime sulfur or Kumar®, applied with the same or even less frequency of copper treatments, showed comparable or even better results than treatments containing copper.

Due to its broad fungicidal mode of action and its comparative low rain induced removal of active ingredient, copper is in many cases practitioners first choice. Furthermore, using copper is convenient due to its property to be mixable with granulovirus agents, which need to be applied regularly in summer. Protective application of sulfur showed good efficiency against sooty blotch in both trials. However, there are concerns that under warm conditions with direct solar irradiation, sulfur may increase the risk of sunburnt fruit for some cultivars. In our trials sulfur application to ‘Natyra®’ and ‘Shalimar’ trees did not lead to a noticeable increase of sunburnt apples.

Focussing on the prevention of sooty blotch infection in summer, this study highlights available and effective alternatives to the use of copper. Adapted spraying strategies in sooty blotch management can be one piece in the puzzle to further reduce copper input.

Acknowledgements

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