Strategy to reduce the investment of copper for control of apple scab in organic apple growing

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Abstract

Apple scab (Venturia inaequalis) is still a major problem for organic apple growers. The control of apple scab requires a rigorous control strategy especially in the phase of primary scab infection. To develop a save scab control strategy it is necessary to work out the parameter of alternatives and their combinations thoroughly. In consideration of the ascospore potential, the phenological growth stage of the host plant and the potential of the plant protection products, an advice for a control strategy without or with reduced copper amount should be established in all situations.

In the context of the BÖLN project 'Establishing a strategy to reduce the investment of copper for scab control in organic apple growing' different products were tested in laboratory and in field trials.

In laboratory alternative products against apple scab such as potassium bicarbonates showed good efficacies. But in the field the products were not efficient enough (rain stability, UV stability…). Depending on the weather potassium bicarbonates in combination with wettable sulphur can be an additional option for scab control. Lime sulphur with specific treatment in the germination period proved to be the most effective and the most reliable alternative to copper. A significant reduction of copper can be achieved through the new generation of copper products in the form of copper hydroxide.

Keywords: apple scab, *Venturia inaequalis*, copper, lime sulphur

Introduction

The apple scab project "Establishing a strategy to reduce the investment of copper for scab control in organic apple growing", which is funded by the "Bundesprogramm Oekologischer Landbau und andere Formen nachhaltiger Landwirtschaft" (BÖLN) started in spring 2008. During the project period the beneficial effect of several plant protection products against apple scab is tested in an in-vivo test system by Bio-Protect GmbH (Dr. Stefan Kunz) in Konstanz. Products which promised good efficacy are then tested under field conditions at various locations of Germany. The field trials for scab control during the primary and secondary scab period are carried out at four different sites: Dienstleistungszentrum Ländlicher Raum Rheinpfalz, Öko-Obstbau Norddeutschland, Kompetenzzentrum Obstbau Bodensee and Sächsiches Landesamt für Umwelt, Landwirtschaft und Geologie. The geographical distribution ensured that regional climatic differences in west, east, north and south Germany were considered. The regional climatic differences as well as the intensity of scab infestation are important to detect side effects of the products such as fruit russeting.

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Material and Methods

At the DLR Rheinpfalz in Klein-Altendorf the trial was carried out in the variety 'Gala'. The testing variants have been repeated four times with always fifteen trees per testing plot. During the whole trial the control remained untreated. In the months April and May in treatment 2 three preventive treatments with copper and eight treatments with lime sulphur into the germination period were applied.

With the product 'Cuprozin progress' in total an amount of 800 g copper per hectare was used. Treatment 3 was sprayed three times with lime sulphur before rain and 8 times with lime sulphur into germination period. 9 treatments only with lime sulphur into germination period were applied in treatment 4. For details about treatments, application rate and dates see table 1. After the end of primary infection period all treatments were treated the same way.

Table 1: Treatment, application rate and date at DLR Rheinpfalz Klein-Altendorf

Treatment		Application rate per ha	Date
1	untreated control	---	---
2	preventative **copper** covering before rain + lime sulphur into germination period	200 g – 300 g Cu/ha from bloom without copper as variant 3 20 l/ha till bloom 15 l/ha from begin of flowering	**16.03.*** / **29.03. *** / 31.03. / 07.04. / **11.04.*** / 12.04. / 21.04. / 27.04. / 08.05. / 17.05. / 30.05. (11 treatments)
3	preventative **lime sulphur** covering before rain + lime sulphur into germination period	20 l/ha till bloom 15 l/ha from begin of flowering	**16.03.** / **29.03**. / 31.03. / 07.04. / **11.04**. / 12.04. / 21.04. / 27.04. / 08.05. / 17.05. / 30.05. (11 treatments)
4	lime sulphur into germination period	20 l/ha till bloom 15 l/ha from begin of flowering	16.03. / 31.03. / 07.04. / 12.04. / 21.04. / 27.04. / 08.05. / 17.05. / 30.05. (9 treatments)

***** treatment with "Cuprozin progress" before high infection risk: 16.03. (300 g Cu/ha), 29.03. (300 g Cu/ha), 11.04. (200 g Cu/ha) = 800 g Cu/ha

The ÖON experiment was carried out in the Jork area during the primarily scab season in a randomized 'Elstar' block with four replicates. Additional to 11 wettable sulphur and 7 lime sulphur applications in all blocks, 960 g copper were sprayed in the treatments 3, 5 and 7. "TS-Forte" (Treatment 4, 5) and "Nu-Film-P" (Treatment 6, 7) were used as surfactant. Dosage and timing of applications are shown in table 2.

Table 2: Treatment, application rate and date at ÖON Jork

Treatment		Application rate per ha	Date
1	untreated control	---	---
2	preventative sulphur covering before rain + lime sulphur into germination period	3000 g S/ha 37,5 l/ha before blossom 25,0 l/ha as of blossom	30.03. / 06.04. / 09.04. / 20.04 / 22.04. / 25.04. / 27.04. / 02.05. / 05.05. / 08.05. / 11.05. / 14.05. / 19.05. / 23.05. / 26.05. / 29.05. / 30.05. / 06.06. (18 treatments)
3	preventative **copper** & preventative sulphur covering before rain + lime sulphur into germination period	105 g – 405 g Cu/ha before blossom 3000 g S/ha 37,5 l/ha before blossom 25,0 l/ha as of blossom	**30.03.*** / 06.04. / **09.04.*** / 20.04 / 22.04. / 25.04. / 27.04. / 02.05. / **05.05.*** / 08.05. / 11.05. / 14.05. / 19.05. / 23.05. / 26.05. / 29.05. / 30.05. / 06.06. (18 treatments)
4	preventative sulphur covering before rain + lime sulphur into germination period + TS Forte	3000 g S/ha 37,5 l/ha before blossom 25,0 l/ha as of blossom 2,5 l /ha	30.03. / 06.04. / 09.04. / 20.04 / 22.04. / 25.04. / 27.04. / 02.05. / 05.05. / 08.05. / 11.05. / 14.05. / 19.05. / 23.05. / 26.05. / 29.05. / 30.05. / 06.06. (18 treatments)
5	preventative **copper** & preventative sulphur covering before rain + lime sulphur into germination period + TS Forte	105 g – 405 g Cu/ha before blossom 3000 g S/ha 37,5 l/ha before blossom 25,0 l/ha as of blossom 2,5 l /ha	**30.03.*** / 06.04. / **09.04.*** / 20.04 / 22.04. / 25.04. / 27.04. / 02.05. / **05.05.*** / 08.05. / 11.05. / 14.05. / 19.05. / 23.05. / 26.05. / 29.05. / 30.05. / 06.06. (18 treatments)
6	preventative sulphur covering before rain + lime sulphur into germination period + Nu-Film-P	3000 g S/ha 37,5 l/ha before blossom 25,0 l/ha as of blossom 0,3 l/ha	30.03. / 06.04. / 09.04. / 20.04 / 22.04. / 25.04. / 27.04. / 02.05. / 05.05. / 08.05. / 11.05. / 14.05. / 19.05. / 23.05. / 26.05. / 29.05. / 30.05. / 06.06. (18 treatments)
7	preventative **copper** & preventative sulphur covering before rain + lime sulphur into germination period + Nu-Film-P	105 g – 405 g Cu/ha before blossom 3000 g S/ha 37,5 l/ha before blossom 25,0 l/ha as of blossom 0,3 l/ha	**30.03.*** / 06.04. / **09.04.*** / 20.04 / 22.04. / 25.04. / 27.04. / 02.05. / **05.05.*** / 08.05. / 11.05. / 14.05. / 19.05. / 23.05. / 26.05. / 29.05. / 30.05. / 06.06. (18 treatments)

***** treatment with “Cuprozin progress” before high infection risk: 30.03. (405 g Cu/ha), 09.04. (405 g Cu/ha), 05.05. (150 g Cu/ha) = 960 g Cu/ha

At KOB Bavendorf the presented trial was carried out 2010 in a randomized block design with the variety ‘Jonagold’. During the phase of primary scab infection all treatments were sprayed seven times with lime sulphur (treatments 2, 3, 4) or sulphur (treatment 5) in the window of germination. In Treatment 2 and 3 four additional preventive treatments with copper (2) respectively sulphur (3) were applied. Application rates and dates are shown in table 3. Two treatments with sulphur + Vitisan were applied in case of high infection risk and rain periods longer than 48 hours in all variants. For modelling and forecast of scab infections RimPro apple scab model was used. After the primary infection period all

treatments were treated equally with a standard fungicide management based on sulphur and bicarbonate. The control treatment remained untreated until the end of the primary infection phase.

Table 3: Treatment, application rate and date at KOB Bavendorf

Treatment		Application rate per ha	Date
1	untreated control	---	---
2	preventative **copper** covering before rain + lime sulphur into germination period	100 g – 300 g Cu/ha till bloom + 20 l/ha till bloom 15 l/ha from begin of flowering	**30.03.***/ 04.04. / **09.04.*** / 14.04. / **20.04.*** / **25.04.*** / 27.04. / 01.05. / 02.05. / 05.05. / 10.05. (11 treatments)
3	preventative **sulphur** covering before rain + lime sulphur into germination period	5 kg/ha till bloom + 20 l/ha till bloom 15 l/ha from begin of flowering	**30.03.** / 04.04. / **09.04.** / 14.04. / **20.04.** / **25.04.** / 27.04. / 01.05. / 02.05. / 05.05. / 10.05. (11 treatments)
4	lime sulphur into germination period	20 l/ha till bloom 15 l/ha from begin of flowering	04.04. / 14.04. / 27.04. / 01.05. / 02.05. / 05.05. / 10.05. (7 treatments)
5	sulphur into germination period	5 kg/ha	04.04. / 14.04. / 27.04. / 01.05. / 02.05. / 05.05. / 10.05. (7 treatments)

***** treatment with “Funguran” before high infection risk: 30.03. (250 g Cu/ha), 09.04. (300 g Cu/ha), 20.04. (100 g Cu/ha), 25.04. (100 g Cu/ha) = 750 g Cu/ha

Results

At the DLR Rheinpfalz in Klein-Altendorf the apple scab infestation on the rosettes and on the young fruits of ‘Gala’ was evaluated on 28th of June. At this time the rosettes and the fruits of the untreated control showed a scab infestation of 82 % and 78 % (Figure 1). All treatments were highly effective with efficiencies of 90 % and more.

Nine treatments with lime sulphur into the germination period reduced the apple scab to 8 % and 4 % (rosettes and fruits). A further preventative lime sulphur covering led to a reduction of the scab infestation to 7 % (rosette) and 4 % (fruits), which equates to an efficiency of 92 % and 95 %.

The best result was achieved in the treatment protective application with copper before rain plus lime sulphur application in the germination period. The three copper applications (in total 800 g copper) with a following treatment with lime sulphur in the germination period reduced the infestation of the rosettes to 3 % and the infestation of the young fruit to 2 %. This corresponds to an efficiency of 96 % and 98 %.

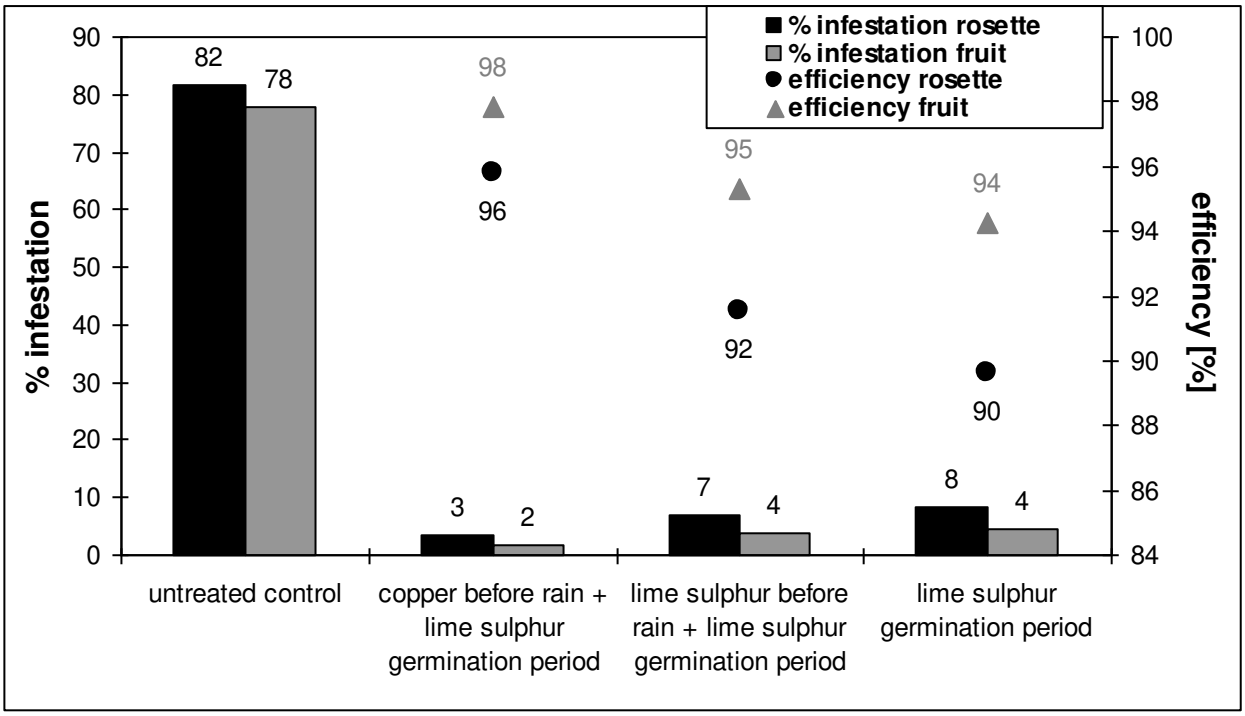

Figure 1: Percentage infestation and efficiency of the different treatments for the variety 'Gala', DLR Rheinpfalz Klein-Altendorf (2011)

Evaluations of apple scab infection in the Jork area were carried out at the 3rd of June for infection on the rosette leaves and on 13th of July for fruit infections. Rosette leaves and fruits in the untreated control were totally infected with apple scab and scored with 100 % and 98 %, respectively.

Apple scab infections on leaves and on fruits were significant reduced in all treatments compared to the untreated control. In between the different treatments the highest infection rate of leaves (3 %) and on fruits (11 %) was observed in treatment 2 (Figure 2).

The use of "Nu-Film-P" and "TS-Forte" lead to a reduction of the infection rate with apple scab both on leaves and fruits (treatment 4, 6).

A lower level of infections on leaves and fruits were observed in all treatments that included copper as a protectant coverage (treatments 2, 5 and 7); efficacies here varied in between 98 % and 100 %.

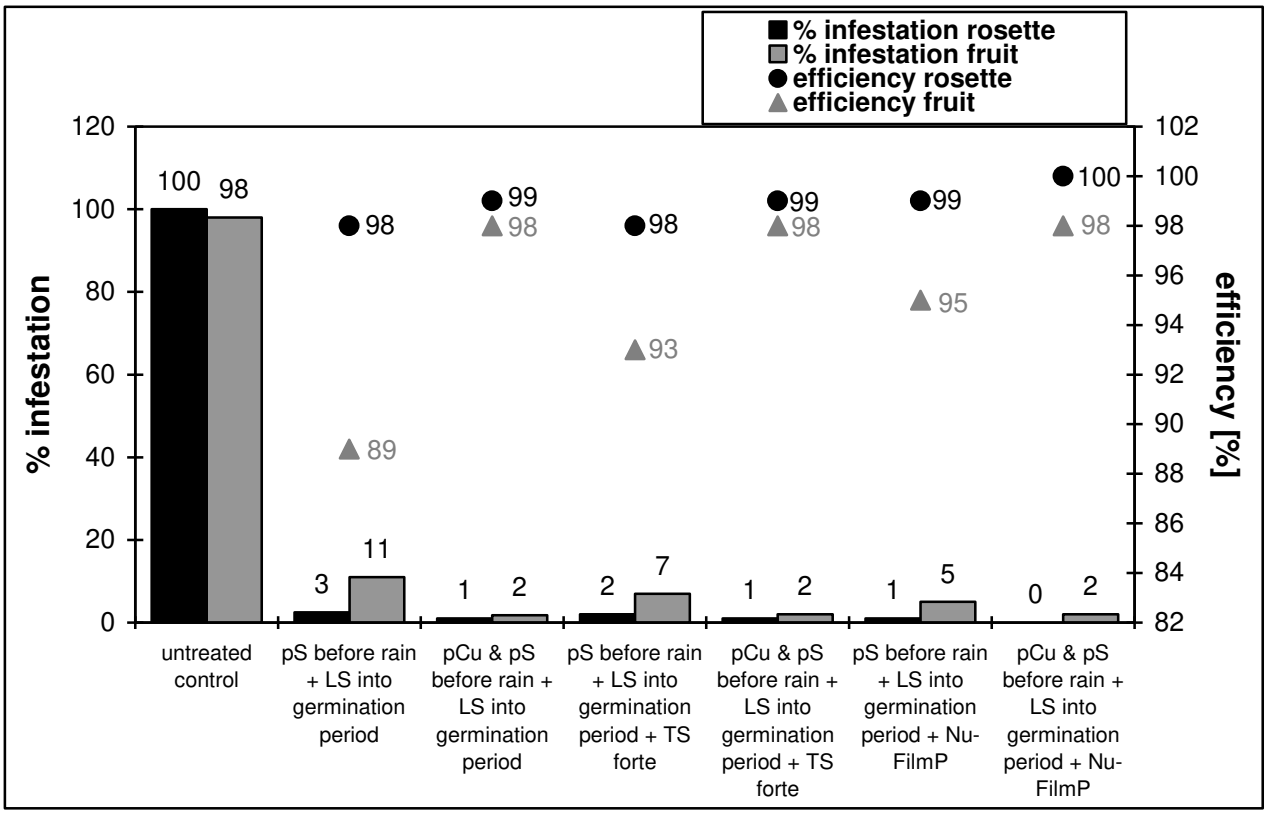

Figure 2: Percentage infestation and efficiency of the different treatments for the variety 'Elstar', ÖON Jork (LS = lime sulphur ; pS = preventative sulphur ; pCu = preventative copper)

At the KOB Bavendorf the apple scab infestation on the rosettes was assessed on 8th of June and accordingly on the fruits on the 9th of August 2010. Compared with the high infestation of the untreated control with 65 % affected rosettes and 91 % affected fruits, all treatments lead to a clear reduction of the scab infestation (Figure 3).

Seven treatments with lime sulphur into the window of germination reduced scab infestation to 6 % (rosettes) and 20% (fruits) which corresponds to an efficacy of 90 % and 78 % respectively.

Alternative treatments with sulphur in the germination period lead to a higher infestation with 15 % infested rosettes and 69 % scabbed fruits. Compared to lime sulphur applications exclusively in the germination period, four additional preventive treatments with sulphur lead to a further reduction of scab infestation to 2 % (rosettes) and 18 % (fruits).

The best results were achieved with lime sulphur in the germination period and four additional preventive copper treatments. In this treatment the infestation of the rosettes could be reduced to 1 % and on the fruits to 12 %. This corresponds to an efficacy of 98 % (rosettes) and 87 % (fruits).

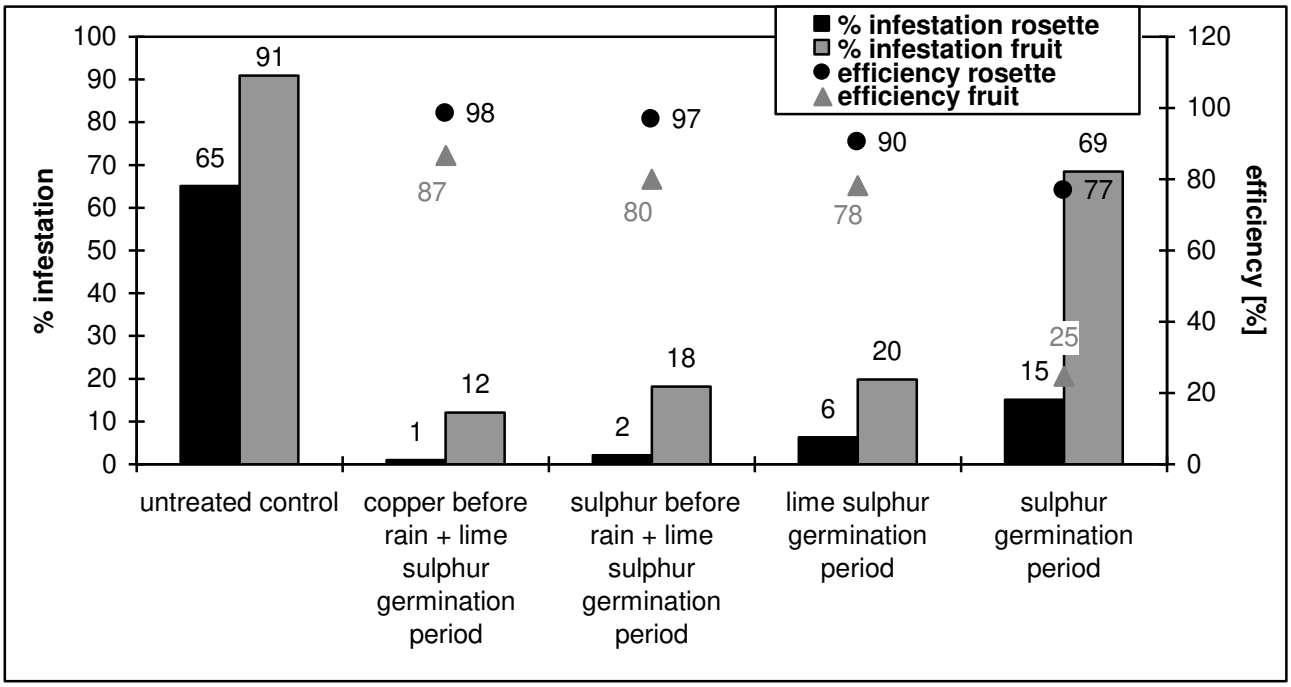

Figure 3: Percentage infestation and efficiency of the different treatments for the variety 'Jonagold', KOB Bavendorf (2010)

Discussion

Summarising all field trial results a reduction of the copper application rate (application per hectare and year) is possible by optimization and substitution of copper. But a total substitution of copper products for the control of the apple scab is not possible yet. Lime sulphur with specific treatment in the germination period seems to be a good and safe alternative, because the best potential of reducing copper applications was reached with this method. A further alternative for the control of the apple scab is the combination of wettable sulphur with a potassium bicarbonate during the germination period at the time of infection or within 24 hours after the infection on the dry leaf (Benduhn *et al.*, 2011). But in the field the efficiencies were not constant during trial years. An explanation for the different efficiencies is the rain intensity and quantity. At the moment the exclusive use of wettable sulphur with potassium bicarbonate could only be recommended during minor infections. As an extra treatment for middle and serious infections, especially under difficult weather conditions during the primary apple scab period, this combination is a good opportunity for an effective apple scab control. With an additional application within 24 hours after infection the efficiency of the first lime sulphur application can be increased. The addition of additives to the copper compound or wettable sulphur adduced a slight increase in the efficiency.

Acknowledgements

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References

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