The effectiveness of winter treatments with copper or lime sulphur to control Sooty Blotch on apple.

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Abstract
In 2002 and 2003 two randomized trials and three “on farm” trials where carried out to test the hypothesis that a single winter treatment could reduce the primary inoculum of Sooty Blotch sufficiently to prevent fruit disease during summer. copperoxychloride (0.2%-0.4%) and lime sulfur (4.0%-5.0%) were applied until run-off in March shortly before bud break. Assessments of Sooty Blotch incidence and severity where made immediately after harvest.
The winter treatments with copperoxychloride did reduce disease severity during summer in one case. The treatments with lime sulfur reduced the disease level in three sites to some extent. However, winter treatments alone were not nearly as efficient as summer treatments. Therefore, we see no reason to advise this kind of treatment with lime sulfur in practice as the effectiveness is poor, the necessary spray cover can not be reached under practical conditions, and with the amount of material needed for this single spray five sprays can be made in summer that will be more effective to control the disease.

Concept

Sooty blotch is an important disease in organic apple orchards where no summer fungicides are applied. In orchards with apple scab-resistant cultivars (Vf resistance) that are managed with minimum fungicide input, losses until 100% due to diseased fruit are regularly reported. Reports come form all over Europe: form the Alps until even in Denmark (Lindhard, 2003; Tamm, 1997; Fuchs et al., 2002).
The occurrence of Sooty Blotch greatly reduces the practical benefits of the culture of scab resistant apple varieties as the growers have to treat these varieties against Sooth Blotch during summer almost as frequently as they need to spray their standard varieties to prevent apple scab infections.

In general, in the first years after planting we experience no Sooty Blotch symptoms on fruits in Vf resistant orchards. However, in later years the level of fruit infection tends to rise every year and more than 50% diseased fruits in the 5th year after planting is not uncommon. As the causal fungi can infect and survive on the surface of the bark of apple trees (Williamson and Sutton, 2000) we presume that the primary inoculum is building up on the trees, causing more diseased fruits every year. If the hypothesis of build-up of primary inoculum on wood holds true, attempts to reduce the primary inoculum during winter might be a successful control strategy. Therefore, a treatment that reduces the primary inoculum on the wood could reduce the disease pressure and, as a result, reduce the necessity of summer treatments against sooty blotch in Vf resistant plantations.
In a unpublished trial at HRI, Eastmalling Research Station in 2001, a single early season spray with copperoxychloride reduced the fruit infection by Sooty Blotch during summer (Berrie, 2002). A winter treatment with lime sulfur was also the basis

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of the fungicide schedules that Kumar and Pandey tested to reduce infections of sooty blotch and fly speck on apple (Kumar and Pandey, 1994).
In this preliminary study we aim to (i) verify whether the primary inoculum of Sooty Blotch can be reduced by winter sprays and (ii) to assess the feasibility of this approach for organic apple growing.

Materials and methods

To test the concept we used in our trials copperoxychloride and lime sulfur as the most powerful preventive and eradicant fungicides available in organic agriculture and applied these at a fairly high rate. Copperoxychloride was used in 0.2-0.4 % (w/v) and lime sulfur in 5 %.(v/v) (Table 1). Treatments where made in March shortly before but break.

Table 1: Trial sites and treatments in 2002 an 2003. Trials in Zoelmond and Randwijk are complete randomized block designs. Trials in Pfyn and Aesch include larger plots and several varieties but no true replicates.

Year	site	Variety	winter treatment copper	winter treatment lime sulphur	date of winter treatment	summer treatments
2002	Pfyn, Switzerland	Maigold Glocken Topaz Resista	0.3% copperoxychloride	3% lime sulphur	08.03.2002	Cocana 1% during season
2003	Pfyn, Switzerland	Glocken Topaz Resista	0.4% copperoxychloride	5% lime sulphur	06.03.2003	no treatment vs cocana 1%
2003	Aesch, Switzerland	Rewena Ariwa Rubinola Topaz	0.4% copperoxychloride	5% lime sulphur	04.03.2003	no treatment vs cocana 1%
2003	Zoelmond, Netherlands	Jonagold	0.2% copperoxychloride	5% lime sulphur	13.03.2003	no treatment
2003	Randwijk, Netherlands	Topaz	0.2% copperoxychloride	5% lime sulphur	14.03.2003	no treatment vs cocana 1%

Experimental setup

In 2003 in the Netherlands two trials in a complete randomized block design where carried out:

1. Orchard Zoelmond, variety Jonagold, 4 replications, 7 trees per plot. In the previous year in 2002 100 % of the fruits in this orchard where infected by Sooty Blotch. The winter treatments where made on 13 march 2003. Trees where spayed with handgun until run-off. Additionally on 25 april 2003 a spray

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with copperoxychloride (0.03%) was made was made in all plots, including the untreated plots, to control apple scab. No other fungicides where applied in 2003.

2. Orchard Randwijk, variety Topaz, 6 replications, 3 trees per plot. In 2002 12.8% of the fruits in this orchards where infected by Sooty Blotch. The winter treatments where made on 14 march 2003. Trees where spayed with hand gun until run-off. Summer treatments scheduled by the use of an experimental infection model (Trapman 2004) for Sooty Blotch was an alternative strategy tested in this trial. In these plots 3 treatments with Cocana where made: 2nd july, 11th august and on 9th September. No other fungicides where applied in this trial orchard 2003.

In 2002 and 2003 in Switzerland a total of three “on farm trials” where run without replications.

1. 2002, Orchard Pfyn, varieties Maigold, Glocken Apfel, Topaz and Resista. The orchard was split in 4 quadrants. Two quadrants were treated with copper oxychloride 0.3% and lime sulphur 3% on the 3rd of March. During the season, the whole orchard was treated with the farmers standard spray program, which included 8 sprays with Cocana RF 1%. This preliminary trial allows to assess the ‘added value’ of a winter treatment.
2. 2003, Orchard Pfyn, varieties Glocken Apfel, Topaz and Resista. On 6th March 2003 16-18 trees of each varieties were sprayed by hand gun until run-off. The grower applied his regular sooty blotch summer program. For each treatment and varietiy 3-4 trees where left unprotected during summer.
3. 2003, Orchard Aesch, varieties Ariwa, Rewena and Topaz. On 4 march 2003 16-18 trees of each varieties were sprayed by hand gun until run-off. The grower applied his regular sooty blotch summer program. For each treatment and variety 4 trees where left unprotected during summer.

Assessments

In the Dutch trial assessments where made immediately after harvest (Topaz 2 October, Jonagold 10 October). Incidence and severity where assessed using a rating proposed by Hartman (Hartman, 2000): 0 = no disease, 1= trace- 5% of fruit surface, 2= 6-25 % of fruit surface, 3= 25-50 % of fruit surface, 4= > 50 % of fruit surface. The differences in disease incidence where tested using ANOVA.
In the Swiss trials assessments where made directly after harvest. Disease was accessed as % of diseased fruit surface (disease severity). For each treatment, at least 50 fruits were randomly chosen for the assessment.

Results

In the season 2002, Sooty Botch pressure was relatively high in the Netherlands and in Switzerland, leading to unacceptably high yield losses in untreated orchards. In contrast, 2003 was a very dry summer and there was much less Sooty Bloch compared to 2002. The disease incidence in both Dutch experimental orchards was only one third of that of 2002, and most infected fruits had less then 5% of their surface covered with the disease.

In the randomized block trials in the Netherlands early treatments with copperoxychloride had no effect on the disease level at harvest. The treatments with

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lime sulphur reduced the disease incidence by 28 and 48 %, but these effects are not significant. (Table 2 and 3) The alternative program of three Cocana treatments during summer reduced the disease incidence by significantly by 79%

Table 2 Results of winter treatments on Jonagold in the Zoelmond trial. Sooty Blotch incidence and severity at harvest.

		Sooty Blotch rating 10 October 2003 (% of the fruits)				
		1= trace	2	3	4	Total
1	Untreated	28.1	8.9	1.5	0	38.5 a
2	Copperoxychloride 0.2%	30.2	4.1	0.8	0	34.6 a
3	Lime sulfur 5.0 %	24.4	3.0	0.2	0	27.7 a

Numbers in the same column followed by the same letter are not significantly different.(P= 0.05)

Table 3 Results of winter treatments on Topaz in the Randwijk trial. Sooty Blotch incidence and severity at harvest.

		Sooty Blotch rating 2 October 2003 (% of the fruits)				
		1= trace	2	3	4	Totaal
1	Untreated	3.02	0.06	0	0	3.08 a
2	Copperoxychloride 0.2%	3.38	0.06	0	0	3.44 a
3	Lime sulfur 5.0 %	1.60	0	0	0	1.60 a
4	Summer Cocana 0,1%	0.64	0	0	0	0.64 b

Numbers in the same column followed by the same letter are not significantly different.(P= 0.05)

In 2002 in the Swiss trials, disease severity reached in untreated control plots 25-50%, whereas in 2003, disease severity was much lower (Graph 1). However, even under dry conditions, Topaz showed much higher rates of disease severity, indicating substantial differences of susceptibility between varieties. In the Swiss field trials in 2003, the disease level in the untreated plots in the varieties Ariwa, Rewena, Resista and Glockenapfel were so low, that no conclusions on the results of the treatments can be drawn.
However, in both trials on the variety Topaz, the winter treatment with lime sulphur reduced the disease incidence at harvest. In contrast, treatments with oxychloride on Topaz led to inconsistent results.
The summer treatments with Cocana controlled Sooty Blotch quite efficiently in all trials, regardless of previous winter treatments. These results suggest that winter treatments were not nearly as efficient against Sooty Blotch as summer treatments.

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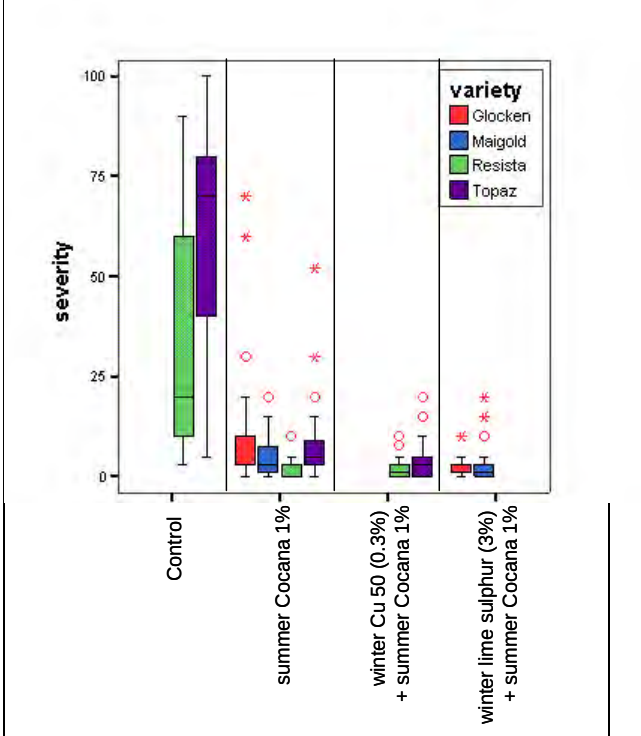
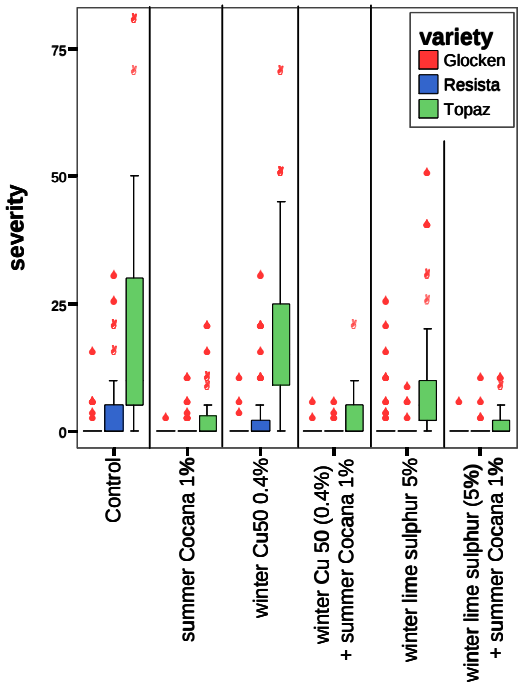
Graph 1: Effect of winter treatments with copperoxichloride or lime sulphur on Sooty Blotch control during summer in 2002 and 2003 in Switzerland.

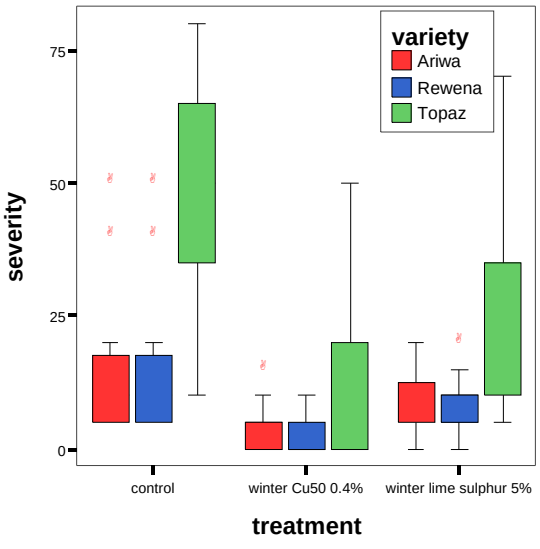
Pfyn 2002



Pfyn 2003



Aesch 2003



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Conclusion and discussion

An early treatment with copperoxychloride at a high rate did not reduce the number of fruits infected by Sooty Blotch during summer, whereas an early treatment with lime sulfur reduced the disease level to some extent.
This means that either Sooty Blotch inoculum hibernating on the bark of the apple tree is only of minor importance for the primary infection of the disease, or that even intense treatments with the most powerful fungicides available in organic apple growing are not effective enough to have an measurable influence on the disease level at harvest.
Whatever the reasons for the poor efficacy of winter treatments are, we conclude that there is no reason to advice such a application strategy in practice. First, we believe that the complete spray cover that was reached by spraying individual trees with hand gun until run-off will not be reached by the spraying technique the growers use. In practice, the efficacy of early sprays can therefore be expected to be even worse. Second, the rates of copperoxychloride and lime sulphur applied here in one single spray in spring are equivalent to a total of least 5 sprays during summer. However, by applying 3-8 well-aimed sprays in summer a better result in Sooty Blotch control can be expected.

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