Organic field-testing of compounds to control apple scab (*Venturia inaequalis*) in combination with alleyway cover crops

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Aim

To find new potential fungicides acceptable to organic production preventing apple scab (*Venturia inaequalis*) infections on leaf and fruits during primary apple scab infection period.

Material and methods

The trials were carried out in combination with different cover crop treatments in single-tree plots. The formerly resistant variety 'Delorina' on rootstock M9, planted 1995 at a planting distance of 3.3 m x 1.6 m, unfertilized and with mechanical weed cleaning in the tree row, were used. The experimental orchard is located at Research Centre Aarslev (10^0 27´ E, 55^0 18´N).

In 2003, fungicides were sprayed preventively according to RIMpro warnings in the primary apple scab season, from bud break until the end of June, when ascospore discharge stopped. In 2004, weekly preventive treatments were carried out in the primary apple scab season. Application was done using a nap sac mist blower until incipient run-off.

The three alleyway cover crops:

1. Grass: A permanent weak grass mixture of Red fescue (*Festuca rubtra*) and Meadow grass (*Poa pratensis*).
2. Clover grass: A permanent clover grass mixture consisting of White clover (*Trifolium repens*) and Perennial ryegrass (*Lollium perénne*).
3. Annual: An annual cover crop consisting of Italian ryegrass (*Lolium multiflorum*) and Persian clover (*Trifolium resupinatum*) sown every year in July and mulched down the following year in April. Mechanical weed cleaning was practiced from April to July.

Control of apple scab

Both in 2003 and 2004 the best disease control was achieved with sulphur (Kumulus) (table 1 and 2) and some control was also seen with the alternative compounds in 2003. The reduction of apple scab infections was greatest on the rosette leaves. In 2004 the new compounds were tried alone and in combination with sulphur. In 2004 the alternative compounds were tried alone and in combination with sulphur, but the results were approximately the same as with sulphur alone (table 2).

Phenolics

Phenolics were extracted from frozen apples (fruit and peel) of the variety 'Delorina' and analysed by analytical HPLC. The major phenolics were identified as chlorogenic acid, catechin, epicatechin, a cyanidin glycoside, rutin and three other flavonol glycosides, respectively. Significant differences in the content of flavonol glycosides were observed between treatments with the highest content being found in the untreated apples and the lowest in apples treated with E15/Kumulus and Plant extract E52/Kumulus, respectively (table 2).

Table 1. Control of apple scab in the variety 'Delorina' in 2003 with sulphur and alternative fungicides: number of treatments, percentage of non-infected leaves on annual shoots, rosettes and fruits on 2nd July, two weeks after the end of the primary infection period. Yield and percentage fruits without russeting at harvest.

Alternative fungicides used	Number treatments 2003	Annual shoots: % leaves without scab	Rosettes: % leaves without scab	% fruits without scab	% fruits without russeting at harvest	Yield Kg/tree
1.Control	0	17,5 c	28,4 d	20,8 c	82,6 a	6,2 b
2.Kumulus S (0,27%)	8	51,8 a	87,8 a	71,7 a	52,9 b	12,7 a
3.Plant extract E52(5,0%)	8	23,1 c	35,9 cd	35,0 bc	60,9 b	8,8 b
4.C-pro (0,3%)	5	24,2 c	44,0 bc	26,7 c	83,7 a	8,2 b
5.E15 (0,2%)	7	33,2 b	54,1 b	45,0 b	29,6 c	7,1 b

Numbers followed by the same letters are not significantly different for p<0,05.

Table 2. Control of apple scab in the variety 'Delorina´ in 2004 with sulphur and alternative fungicides: Number of treatments, percentage of non infected fruits on 8th July, two weeks after the end of the primary infection period and yield, fruit quality and content of Flavanols in mg compound per g fruit at harvest.

Alternative fungicides used	Number treatments 2003	% fruits without scab	% fruits without russeting at harvest	Yield Kg/tree	Fruit size g/fruit	% surface colour	Flavanol glycosides Mg/g
1.Control	0	72,2 b	52,4 a	5,7 b	82 c	59,7 a	0,023 a
2.Kumulus (0,27%)	11	90,0 a	55,1 a	10,3 a	103 a	54,7 bc	0,012 b
3.E15 (0,02%)	11	77,8 ab	34,7 b	6,7 b	86 bc	51,7 cd	0,016 ab
4.E15 0,02% and Kumulus (0,27%	11	90,0 a	41,8 ab	9,6 a	98 a	50,0 d	0,011 b
5.Plant extract E52 (5%)	11	72,2 b	32,2 b	6,0 b	84 bc	57,3 ab	0,016 ab
6.Plant extract E52 (5%) and Kumulus (0,27%)	11	87,8 a	44,0 ab	9,2 a	95 ab	44,8 d	0,011 b

Numbers followed by the same letters are not significantly different for p<0,05.

Cover crops

The annual cover crop supplied the trees with a high nitrogen level in the soil, but it only resulted in differences in uptake by the trees in 2004 (table 3 and 4).

This gave a slightly higher infection of powdery mildew, a higher infection of apple scab and more green fruits (table 3). Yield was significantly higher for trees grown in grass alleyways in both years (table 3 and 4)

Table 3: Infections of powdery mildew and apple scab at the end of the primary apple scab season.
Fruit colour and yield at harvest and nitrogen and potassium in leaf samples and available nitrogen in soil for the variety 'Delorina´ in 2003.

Cover crop used	Powdery mildew on shoots	% fruits without scab	% surface colour	Yield Kg/tree	% Nitrogen in leaves	% potassium in leaves	N_{min} in soil 0-50 cm depth
1.Grass	1,6 ab	42,0 ab	57,6 a	11,6 a	2,01	1,34	26,3 b
2.Clover grass	1,5 b	47,0 a	48,9 b	7,2 b	2,14	1,24	22,9 b
3.Annual	1,7 a	30,5 b	49,8 b	7,0 b	2,22	1,02	51,3 a

Numbers followed by the same letters are not significantly different for p<0,05.

Table 4: Infections of powdery mildew and apple scab at the end of the primary apple scab season.
Fruit colour and yield at harvest and nitrogen and potassium in leaf samples and available nitrogen in soil for the variety 'Delorina´ in 2004.

Cover crop used	Powdery mildew on shoots	% fruits without scab	% surface colour	Yield Kg/tree	% Nitrogen in leaves	% potassium in leaves	N_{min} in soil 0-50 cm depth
1.Grass	1,96 a	78,3 a	53,0 b	10,9 a	2,44 a	1,02 a	39,3 b
2.Clover grass	1,58b	83,3 a	56,4 a	5,2 c	2,53 a	1,00 a	41,8 ab
3.Annual	1,81 a	83,3 a	52,2 b	7,6 b	2,44 a	0,91 a	70,4 a

Numbers followed by the same letters are not significantly different for p<0,05.

Yield

Apple scab control using sulphur increased the yield. Combination of trees grown in alleyway grass using sulphur to control apple scab had the highest yield of fruits not damaged by apple scab (fig. 1 and 2). Especially for the clover grass alleyway in 2003, the apple scab control using E15 or Plant extract E52 seems to have had a positive effect on the yield (fig 1). In 2004 the use of sulphur increased the yield of not apple scab damaged fruits in the clover grass alleyway and annual cover crop (fig. 2).

Fig 1: Yield without apple scab for 5 treatments and 3 covercrops in 2003.

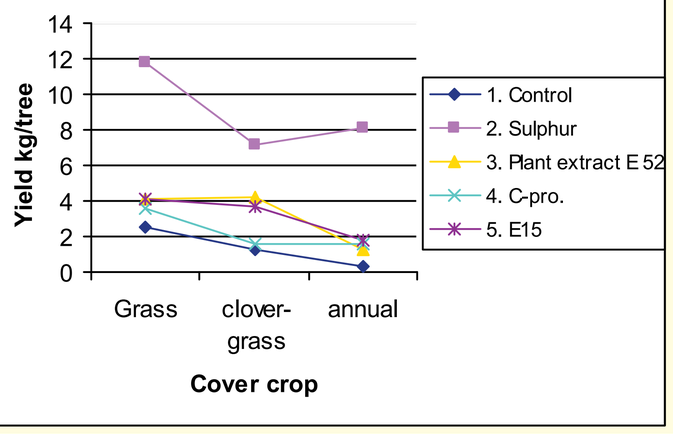
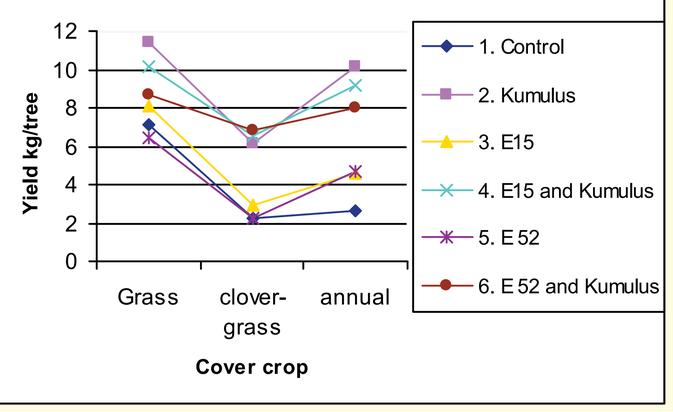


Fig 2: Yield without apple scab for 6 treatments and 3 covercrops in 2004.



Conclusion

Sulphur, had the best effect in these trials. The use of sulphur resulted in an increase of yield, because of more and bigger fruits.

Both in 2003 and 2004 the best disease control was achieved with sulphur and some control was also seen with the alternative compounds in 2003.

The use of sulphur in combination with a soil treatment that reduces the level of nitrogen available to the trees increased saleable yields.

An apparent correlation was found between severity of scab and the flavanol content of the fruits.

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