Field efficacy of new compounds to replace copper for scab control in organic apple production

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Abstract

Efficacy of compounds was investigated in field experiments in Denmark and the Netherlands according to EPPO guidelines. Some Yucca *extracts and potassium bicarbonate had an efficacy similar to sulphur on leaves. Addition of sulphur to* Yucca *1 and to potassium bicarbonate increased the level of efficacy to that of copper. This confirms results from earlier years. Although a dose increase resulted in better efficacy, this was more prominent for* Yucca1 *than for potassium bicarbonate.*

Introduction

The control of scab caused by *Venturia inaequalis* in organic apple production is still mainly focussed on the use of fungicidal compounds applied in spring and summer. Copper containing compounds are among the most effective, especially under cold conditions in spring. The approach of the EU Repco project is, however, to integrate several preventive measurements, such as stimulation of earthworms and micro-organisms to degrade overwintering inoculum, and endophytes to reduce numbers of spores in the orchards. It is EU policy to phase out the use of copper and the overall objective of the EU Repco project is to replace copper compounds by a combined strategy of newly developed measures. In this paper, we present work on the efficacy, under organic field conditions, of several newly found materials including yucca extract and, also potassium bicarbonate, a product already under development.

Materials and methods

Field experiments were carried out in Denmark in 2006 (experiment 1, abbreviated as exp1) and in the Netherlands (experiments 2 and 3, abbreviated as exp2 and exp3). Exp1 and 2 were carried out in the experimental orchards of the Danish Institute of Agricultural Sciences (DIAS) at Aarslev, Denmark and at the Applied Plant Research (PPO-fruit) at Randwijk, the Netherlands, respectively. Experiment 3 was placed at a commercial organic fruit grower at Tuil, the Netherlands. Experiments were done according to the EPPO-guidelines 1/5 (3) using the scab susceptible apple cultivar Jonagold on dwarfing rootstocks, pruned as slender spindles and planted in a single row system. The lay-out of all experiments was a complete randomised block design with five, five and four replicates for exp1, 2 and 3 respectively. Materials for orchard

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testing were selected on the basis of results from screening assays carried out at LIFE, University of Copenhagen, Denmark (Bengtsson, *et al*., 2006). Materials were also subjected to preliminary database screening for toxicological risks, economic feasibility and acceptability for use in organic growing. Treatments were applied with a experimental tunnel sprayer with 8 Tee-jet 110-02 nozzles delivering 1000 l/ha in exp1, with a modified air assisted "Urgent" cross flow sprayer, manufacturer Homeco Holland, with 2 x 5 nozzles Albuz Yellow at a pressure of 8 bar delivering 1000 l/ha in exp2 and with a handheld spray gun with a 1.2 mm ceramic hollow cone nozzle at a pressure of 8 bar, delivering a spray volume of 1000 l/ha, in exp3.

Treatments in exp1 were: 1. untreated, 2. copper oxychloride (Brøste kobberoxyclorid 51 %, 0.05 %), 3. sulphur (Kumulus S, 0.4 %), 4. rapeseed oil (Rapsodi, 2 %), 5. Yucca 1 (0.75 %), 6. Yucca 1 (2.5 %), 7. E52 (2.5 %), 8. E23 (5 %), 9. E62 (5 %), 10. Yucca 2 (0.75 %), 11. Yucca 2 (2.5 %), 12. E41 (5 %), 13. O43 (2 %), 14. V126 (5.0 %), 15. E40 (5 %), 16. E47 (5 %), 17. V101 (5 %), 18. V104 (5 %), 19. V108 (5 %), 20. V110 (5 %), 21. V111 (5 %), 22. V113 (5 %), 23. E72 (5 %), 24. Yucca 3 (2.5 %), 25. potassium bicarbonate (Armicarb 1.33 %), 26. S11 (1 %). All treatments were applied twice weekly for a total of 11 times during the primary ascospore season.

Treatments in exp2 were: 1. untreated, 2. copper hydroxide (Funguran-OH 50 %, 0.05 %), 3. sulphur (Thiovit-Jet, 0.4 %), 4. *Yucca* 1 (0.25 %), 5. *Yucca* 1 (0.5 %), 6. *Yucca* 1 (0.75 %), 7. *Yucca* 1 + sulphur (0.25 % + Thiovit-Jet, 0.4 %), 8. *Yucca* 1 + sulphur (0.5 % + Thiovit-Jet, 0.4 %), 9. *Yucca* 1 + sulphur (0.75 % + Thiovit-Jet, 0.4 %), 10. potassium bicarbonate (Armicarb, 0.25 %), 11. potassium bicarbonate (Armicarb, 0.5 %), 12. potassium bicarbonate (Armicarb, 0.1 %), 13. potassium bicarbonate + sulphur (Armicarb, 0.25 % + Thiovit-Jet, 0.4 %), 14. potassium bicarbonate + sulphur (Armicarb, 0.5 % + Thiovit-Jet, 0.4 %), 15. potassium bicarbonate + sulphur (Armicarb, 1 % + Thiovit-Jet, 0.4 %). Potassium bicarbonate and copper were applied in a more or less weekly schedule. Sulphur was sprayed preventively just before a scab infection period according to the RimPro scab warning system and the weather forecast. If treatments consisted of two products, they were applied as a tank mix. Treatments in exp1 were applied a maximum of 9 times during the primary ascospore season.

Treatments 1, 2, 3, 6, 9, 11 and 14 in exp3 were the same as in exp 2. Potassium bicarbonate and copper were applied more or less on a weekly schedule. Sulphur was sprayed similarly to exp2. If treatments consisted of two products, they were applied as a tank mix. Treatments were applied a maximum of 9 times during the primary ascospore season.

For leaf assessments, 10 and 50 randomly chosen spur leaf clusters from the 3 middle trees per plot were examined in exp1 and exp 2 and 3 respectively. Scab lesions were also examined on 30 extension shoots from the 3 middle trees. Scab incidence was calculated as the percentage of leaves diseased and severity was expressed as the mean number of lesions per leaf.

Results

Infection of leaves is shown in tables 1, 2 and 3 for exp1, 2 and 3 respectively. The number of lesions was over 100 per leaf in some treatments in exp2. If lesions fused, it was not possible to accurately count lesion numbers in such cases. Therefore these data are omitted from table 2. In exp3, the level of scab was low at the beginning of the experiment. Even in untreated plots hardly any lesions were found on cluster leaves. Therefore, these data are omitted from table 3. It was noted that some *Yucca*

extracts at higher dosages and potassium bicarbonate had a similar efficacy on cluster leaves as standard schedules of copper and sulphur in exp1. However, these tendencies were no longer visible on extension shoot leaves in exp1. *Yucca* 1 has a similar efficacy at a dose of 0.75 % as sulphur at 0.4 % in exp2 and 3, while copper was more efficacious.

Tab. 1: Incidence (%) and severity (lesion number) on leaves of clusters and extension shoots 13th June & 11th July 2006 resp. in experiment 1 at Aarslev, Denmark.

treatment	dose	Cluster		extension	
	%	Incidence	severity	incidence	severity
untreated	-	44,3 A	4,2 ab	45,4 a	6,1 a
1. untreated	-	29,8 a-f	3,9 ab	42,1 ab	5,8 ab
2. copper oxycloride	0,05	13,4 c-g	2,2 a-g	32,1 ab	5,2 ab
3. sulphur	0,4	6,1 Fg	0,6 efg	30,0 b	4,4 b
4. rapeseed oil	2,0	12,4 c-g	1,1 c-g	39,1 ab	6,0 ab
13. O43	2,0	9,3 Efg	1,0 d-g	30,3 b	4,9 ab
26. S11	1,0	12,3 c-g	1,5 c-g	37,1 ab	5,3 ab
25. potassium bicarbonate	1,33	3,2 G	0,2 g	32,4 ab	5,0 ab
5. Yucca 1	0,75	19,1 b-g	2,0 b-g	40,8 ab	5,8 ab
6. Yucca 1	2,5	6,2 Fg	0,5 fg	30,8 b	5,0 ab
10. Yucca 2	0,75	22,0 a-g	2,8 a-e	40,4 ab	5,7 ab
11. Yucca 2	2,5	9,3 efg	0,7 efg	30,7 b	4,7 ab
24. Yucca 3	2,5	17,1 b-g	1,6 c-g	38,7 ab	5,8 ab
7. E52	2,5	20,8 b-g	2,5 a-f	37,7 ab	5,7 ab
8. E23	5,0	37,1 ab	2,3 a-g	37,6 ab	5,8 ab
9. E62	5,0	24,9 a-g	3,1 a-d	34,2 ab	6,0 ab
15. E40	5,0	28,7 a-f	3,3 abc	34,3 ab	4,6 ab
16. E47	5,0	33,7 a-d	4,0 ab	38,4 ab	5,8 ab
17. V101	5,0	33,6 a-d	3,3 abc	36,2 ab	5,8 ab
18. V104	5,0	28,0 a-f	3,1 a-d	39,2 ab	5,9 ab
19. V108	5,0	28,5 a-f	3,0 a-d	40,5 ab	6,2 a
20. V110	5,0	39,7 ab	3,3 abc	37,5 ab	5,7 ab
21. V111	5,0	34,4 abc	4,3 a	43,7 ab	6,1 ab
22. V113	5,0	32,1 a-e	3,4 abc	42,3 ab	5,9 ab
12. E41	5,0	9,8 efg	0,6 efg	34,1 ab	5,4 ab
14. V126	5,0	10,6 d-g	0,9 d-g	32,3 ab	5,1 ab
23. E72	5,0	24,0 a-g	2,2 a-g	39,5 ab	6,0 ab

Means followed with letters in common do not significantly differ ($P < 0.05$, Student-Newman-Keuls)

The tank mix of Yucca 1 and sulphur at the same dosage improved efficacy to the same level as that of copper. Potassium bicarbonate tended to be slightly less effective than copper but addition of sulphur increased its efficacy to the same level as copper in these experiments. Although a dose increase improved efficacy, this was more prominent for *Yucca 1* than for potassium bicarbonate.

Discussion

In exp1, all plots in the trial area, were treated with sulphur 4 kg/ha for apple scab control from green tip until start of the experimental treatments (24/4) and again after

finish of the experimental treatments (29/5) and until end of September. This might explain the reduced differences in scab infections on extension shoots, compared to cluster leaves.

Tab. 2: Incidence (%) and severity (lesion number) on leaves of clusters and extension shoots 31st May & 18th July 2006 resp. in experiment 2 at Randwijk, the Netherlands.

treatment	dose	Cluster		extension
	%	incidence	severity	incidence
1. untreated	-	5.7 f	16.4 f	52.9 g
2. copper hydroxide	0.05	0.1 a	0.2 a	14.6 a
3. sulphur (denoted as S)	0.40	1.5 cde	3.0 cde	25.4 cd
4. *Yucca* 1	0.25	2.3 e	4.6 e	37.3 f
5. *Yucca* 1	0.50	2.2 e	5.2 e	32.4 def
6. *Yucca* 1	0.75	1.7 de	3.4 de	32.8 def
7. *Yucca* 1 + sulphur	0.25 + 0.4	1.2 bcde	2.4 bcde	22.3 bc
8. *Yucca* 1 + sulphur	0.50 + 0.4	0.6 abc	1.6 abcd	22.2 bc
9. *Yucca* 1 + sulphur	0.75 + 0.4	0.4 ab	0.8 ab	16.5 ab
10. potassium bicarbonate	0.25	2.1 e	4.8 e	36.3 ef
11. potassium bicarbonate	0.50	0.7 abcd	1.6 abcd	33.7 ef
12. potassium bicarbonate	1.00	0.5 abc	1.0 abc	29.8 cdef
13. potassium bicarbonate + S	0.25 + 0.4	0.7 abcd	1.4 abcd	29.7 cdef
14. potassium bicarbonate + S	0.50 + 0.4	0.5 abc	1.0 abc	31.9 def
15. potassium bicarbonate + S	1.00 + 0.4	0.3 ab	0.6 ab	28.1 cde
F-test		< 0.001	< 0.001	< 0.001

Means followed with letters in common do not significantly differ

Tab. 3: Incidence (%) and severity (lesion number) on leaves of clusters and extension shoots 2nd June and 17th July 2006 resp. in experiment 3 at Tuil, the Netherlands.

treatment	dose	extension	
	%	incidence	severity
1. untreated	-	51.1 d	394.5 c
2. copper hydroxide	0.05	5.8 a	18.3 a
3. sulphur	0.40	20.3 c	110.8 b
6. *Yucca* 1	0.75	20.8 c	98.5 b
9. *Yucca* 1 + sulphur	0.75 + 0.4	6.1 a	25.0 a
11. potassium bicarbonate	0.50	12.6 bc	48.0 ab
14. potassium bicarbonate + sulphur	0.50 + 0.4	7.6 ab	34.5 a
F-test		< 0.001	< 0.001

Means followed with letters in common do not significantly differ

Conclusions

It is concluded that potassium bicarbonate and *Yucca* 1 could contribute to the replacement of copper in apple scab control and to a more sustainable organic apple culture in future.

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