Reducing russeting of organically grown Elstar to increase quality

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Abstract

Sales organisations indicated that opportunities for organic apples sales can increase when quality increases, in particular reducing the amount of russeting.

The use of copper is probably the most important factor for russeting. Therefore a worst case scheme was compared with a scheme with reduced copper application. Furthermore, there was a particular interest in the effects on russeting of potassium bicarbonate (Armicarb) because this product might be an important element in a copper free fungicide scheme. Application of Armicarb was investigated on wet or dry canopy and effects of two different dosages were studied. All the schemes were compared with a worst case organic fungicide scheme with copper. The experiment was done on two year old Elstar trees because Elstar is the most important organically grown cultivar in the Netherlands. Effects of the schedules on russet and scab control were evaluated. At harvest no effects were found on scab. Between the different schemes with copper no differences were found in amount of russet. Only the highest dosage of Armicarb (10 kg/ha) and the schedules with Armicarb on a wet canopy gave more russet compared with the worst case scheme. Also effects on fruit rot were evaluated.

Keywords: apple, potassium bicarbonate, Armicarb, copper, scab

Introduction

The biggest problem for organic apple growing is the quality and in particular the amount of russet on the fruit. Therefore sales organisations indicated that opportunities can increase for organic apples sales in supermarkets when quality increases. Fruits are most vulnerable for from bloom till the six weeks after bloom (Gildemacher, 2000). Also in the weeks before bloom there is a building up for sensitivity for russeting (Babin, 1977; Berkett, 2005; Longstroth, 1997). The cause of russeting divers and is dependent on weather and type of cultivar. For example the use of some fertilizers or fungicides can promote russeting of fruit (Gildemacher, 2000). In organic farming the use of copper is probably the most important factor for russeting. One of the possibilities is to stop with the copper treatments a few weeks before bloom and replace the copper sprayings by sulphur or lime sulphur. Furthermore, there was a particular interest in the effects on russeting of potassium bicarbonate (Armicarb) because this product might be an important element in a copper free fungicide scheme. The objective of this study was to reduce the russet of organically grown Elstar.

Material and Methods

Field experiments were carried out in 2007 at an organically maintained orchard of Applied Plant Research (PPO) at Randwijk, The Netherlands. The experiment was done on Elstar on M9 rootstock because Elstar is the most important organically grown cultivar in the Netherlands. Trees were pruned as slender spindles. The trees were planted in 2006 in a single row at a distance of 3 x 0.94 m.

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Schedules were applied with a modified air assisted "Urgent" cross flow sprayer, manufacturer Homeco Holland, with 2 x 5 nozzles Albuz lilac (height 0.50 m – 2.00 m) at a pressure of 5 bar (300 l/ha). All schedules were applied according to the RIMpro warning system after an expected threshold of 100 points in combination with the weather forecast. Apple scab infection periods were determined by the Mety computer-based weather recorder at Randwijk and the RIMpro warning system throughout the ascospore infection period. The effect of previously used sprays was taken into account for decisions for next sprays. Tree growth stage was recorded according to Fleckinger-growth stage scale.

Six schedules were replicated four times in different blocks, completely randomized within blocks. Each plot consisted of 6 trees. Observations were only made on the four middle trees of each plot. The bordering trees served as a buffer for neighbouring treatments. A row of untreated trees served also as buffer between the two rows.

The schedules were applied from the 29th of March until the 21st of August in 2007. This was 9 days before the harvest on the 30th of August. Schedule 2 and 3 were schedules were no copper was sprayed compared with schedule 1. In schedule 4 to 6 only Armicarb and sulphur was sprayed. No untreated plot was included because there was particular interest in the effect of different schedules on russet. Because a change in a schedule can have an effect on scab control, also the amount of scab and fruit rot was evaluated. The schedules were:

1. Worst case organic fungicide scheme with copper which is a standard in most European countries. Copper (0.56 kg/ha) until pink bud stage, copper (0.56 kg/ha) + sulphur (3.4 kg/ha) until bloom, sulphur (6.7 kg/ha) in the six weeks after bloom and copper (0.34 kg/ha) + sulphur (3.4 kg/ha) until harvest.
2. Reduced copper scheme. Copper (0.56 kg/ha) and sulphur (3.4 kg/ha) until the two weeks before bloom. Sulphur (6.7 kg/ha) treatments afterwards until harvest.
3. Same as treatment 2 but with lime sulphur (11.2 l/ha) when a RIM value of more than 300 was expected.
4. Armicarb (5.6 kg/ha) sprayed on a dry canopy, during the ascospore period combined with sulphur (4.5 kg/ha)
5. Armicarb (5.6 kg/ha) sprayed (as much as possible) on a wet canopy, during the ascospore period combined with sulphur (4.5 kg/ha)
6. Armicarb (11.2 kg/ha) sprayed on a dry canopy, during the ascospore period combined with sulphur (4.5 kg/ha)

Applied products were: Frutogard (copper oxychloride, 50%, Cebeco Meststoffen B.V., The Netherlands), Thiovit Jet (wettable sulphur, 80%, Syngenta Crop Protection BV, The Netherlands), Lime sulphur (Polisolfuro di calico, 380 g/l, Polisenio, Italy) and Armicarb 100F (potassium bicarbonate, 85%, Helena Chemical Company, United States of America).

Disease assessments were made on leaves and fruits. No observations were done on the spur leaf because no scab was found on the spur leaf. Leaf scab was examined on 30 extension shoots on 20 July 2007. The disease incidence of leaves was calculated as the percentage of leaves affected. The disease severity was expressed as the mean number of lesions of all leaves assessed. Leaf phytotoxicity observations were made on the 11th of June 2007. Phytotoxicity was scored by estimating the frequency and intensity of the damage on leaves.

The phytotoxicity scale was: 1 = No phytotoxicity (pt), 3 = Light pt, 5 = Moderate p, 7 = Heavy pt and 9 = Very heavy pt. For each plot the mean phytotoxicity was calculated. Percentage of diseased fruits was assessed for all the fruits after harvest. Incidence of diseased fruit was calculated as the percentage of fruit diseased. The russet of the fruit was assessed according to the following scale: 1 = no russet (0%), 2 = light russet (1-10% surface covered with russet), 3 = moderate russet (11-33%), 4 = heavy russet (>33%). The russet was expressed as a russet index (Ri). The Ri = [(number of fruits in scale 1 x 1) + (number of fruits in scale 2 x 3) + (number of fruits in scale 3 x 5) + (number of fruits in scale 4 x 7)/ total number of fruits. Before the fruit rot assessment fruit were stored at 19°C with a mean of 97.5% relative humidity between the 11th of September and the 19th of October. The first assessment was done on the 26th of September. Rotten apples were removed at the first assessment. The second assessment was done on the 29th of October. The apples were stored at 4°C between the 19th of October and the second assessment. For the statistical analyses both assessments were combined.

All data were subjected to analysis of regression using GenStat Release 9.2 statistical package (Lawes Agricultural Trust, Rothamsted Research, UK). T-probabilities were calculated for pair wise comparison of treatment means. Significant F-tests ($P < 0.05$) were followed by a Least Significance Difference (LSD)-test for pair wise comparisons of treatment means using $LSD_{0.05}$ values.

Results

After a double check the flow rate was higher than was intended beforehand. Also the dosage per hectare was not adjusted for the age and the size of the trees. The amount of fungicide should have been 24% lower. In Table 1 the spraying data of the different schedules in 2007 are presented. The treatments are sorted by grow stage or spore period. In total 21 treatments were applied. Because of the dry spring no infections occurred before the beginning of May. The first ascospore infection was on the 7th of May. Therefore no scab was found on the spur leaves. Little scab was found on the extension shoots. On fruit only one apple was found with scab (Table 2). No sooty blotch or flyspeck was found on the apples.

On leaves the worst case organic fungicide scheme had the lowest leaf phytotoxicity, however not significant different from treatment 3 ($P<0.001$). All the schedules with Armicarb showed significant more phytotoxicity than the schedules with copper, sulphur and lime sulphur. When Armicarb was sprayed on a wet canopy it gave more phytotoxicity compared with the same dose on a dry canopy (Table 2).

Between the schedules (1-3) with sulphur and copper no differences were found in the amount of russet. The schedules Armicarb (5 and 6) on a wet canopy and the high dose of Armicarb caused a significant higher amount of russet compared with the worst case organic scheme (Table 1; $P=0.010$). No cracks or burning was observed on the apples. No significant differences were found in production per tree ($P= 0.674$), number of fruit per tree ($P= 0.796$) and the mean fruit weight ($P= 0.196$)(data not shown).

For the fruit rot measurement the results of the two assessments were combined. The treatment with the high dosage of Armicarb (10 kg/ha) resulted in a lower infection percentage of what presumably was Black Rot (*Botryosphaeria obtuse*) (Table 1). When all schedules of copper and sulphur were combined and compared with all the schedules with Armicarb, a tendency was found that Armicarb had a positive effect against senescent breakdown and *Gloeosporium* ($P=0.09$).

Table 1: Spraying data of the different schedules sorted by grow stage or spore period in 2007

Stage	Schedule	1	2	3	4 + 6	5
Until Pink stage	Ascospore period	29/3	29/3	30/3 + lime sulphur	29/3	30/3 (w*)
Until Bloom	Ascospore period	No treatments				
Until 6 weeks after bloom	Ascospore period	4/5, 6/5, 7/5, 8/5, 10/5, 15/5, 18/5	Date as schedule 1	Date as schedule 1 but on 7/5 and 10/5 + lime sulphur	Date as schedule 1	2/5 (w), 6/5 (d*), 7/5 (w), 8/5 (d), 10/5 (d), 15/5 (d), 18/5 (w)
	Conidia period	25/5, 31/5	Date as schedule 1	Date as schedule 1	Date as schedule 1	25/5 (d), 31/5 (w)
Until harvest	Conidia period	14/6, 20/6, 28/6, 5/7, 10/7, 13/7, 24/7, 31/7, 10/8, 17/8, 21/8	Date as schedule 1	Date as schedule 1	Date as schedule 1	14/6 (d), 20/6 (w), 29/6 (w), 5/7 (d), 10/7 (d), 13/7 (d), 24/7 (d), 31/7 (d), 10/8 (d), 17/8 (w), 21/8 (w)

*LS = lime sulphur, d/w = Armicarb was sprayed on wet or dry canopy

Table 2: Percentage of leaves and fruit infected by scab, phytotoxicity of leaves, russet of the fruit, percentage of fruit lost due Black Rot, *Gloeosporium* and senescent breakdown after treatment of the 6 different fungicide schemes.

Schedule	Scab leaves (%)	Scab fruit (%)	Phytotoxicity on leaves (1-9)		Russet on fruit (1-7)		Black Rot (%)		*Gloeosporium* (%)	Senescent breakdown (%)
1	0	0.23	2	a	3.3	a	3.1	b	5.0	3.8
2	0	0	4	b	3.6	a	0.4	b	2.7	3.3
3	0.5	0	3	ab	3.8	a	0.7	b	6.1	3.9
4	0	0	5.5	c	4.2	ab	1.8	b	3.3	1.8
5	1.25	0	7	d	4.8	b	0.5	b	1.7	0.5
6	2	0	6.33	cd	4.9	b	0.0	a	2.2	2.2

Discussion

A low infestation level of scab was found in 2007. This was because of the dry period in April. Another reason was that there was a low build up of inoculum because the orchard was in the second growth year. Therefore it is not possible to conclude about the efficacy of the different schemes.

The trees got a higher dosage of fungicides than on beforehand was intended. In combination with the more frequent sprayings and two times under arid conditions (50 to 60% relative humidity) probably led to a higher amount of phytotoxicity compared with other organic orchards. Especially the schedules with Armicarb caused more phytotoxicity on leaves compared with the schedules with copper and sulphur. On fruit more russet was found on the fruit treated with Armicarb sprayed on a wet canopy and with the high dosage. That indicates that the use of Armicarb on a wet canopy or at higher doses should be used with great care.

On the other hand, fruits that were treated with the high dosage had fewer problems with presumably black rot in 2007. At the time of writing the isolations of the fungus were not finished and therefore symptoms could not be identified as black rot. In other experiments done in the Netherlands it was found that using the not formulated product potassium bicarbonate gave less problems with phytotoxicity and russet (pers. com. Marc Trapman). In another experiment flower damage was found on Jonagold because of Armicarb spayings, this was only observed in one year (data not shown).

Schedule 1 had significant less leaf damage than schedule 2. The difference between schedule 1 and 2 was that in schedule 2 copper sprayings should stop two weeks before full bloom while in schedule 1 copper was sprayed until bloom. Because of the dry period in April no sprayings were needed from end of March until full bloom. Therefore there were no differences in sprayings between schedule 1 and 2 from the end of March until the time of the leaf damage assessment. The difference in leaf damage between the two schedules could therefore not be explained. On the other hand this might explain why no differences were found in the amount of russet between schedule 1 and 2 because there were during the two weeks before bloom and during the sensitive period no differences between schedule 1 and 2.

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