Apple Scab: Experiences from 2009 to 2011 in Trentino

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Abstract

The scab is, in many years, the "key problem" of the apple production. After several years generally quiet, since the summer of 2008, it returned with an aggressiveness requiring major attention for its containment. The scab control in organic farms has highlighted the potential of the known lime sulphur and its use requires, in some conditions, an integration with other fungicides, particularly copper (in low doses) to be used before the rain,(in order to differentiate the defence in the larger reality), with sulfur (to be included in certain stages and certain varieties) in the window of germination and potassium bicarbonate used curative in combination with sulphur.

A series of experiments started in 2009 in order to find some answers to these questions. The choice of the optimal timing was performed with the help of RIMPRO (scab - model from Marc Trapman). The model has been validated in Trentino during the last twenty years and it is now used by a good group of organic producers.

Curious to note is that in recent years, scab - management showed more interesting results in the organic farms than in conventional ones.

Keywords: apple, apple scab, *Venturia inaequalis*, organic, disease management

Introduction

After a relatively quiet period in the years from 2000 to 2007, severe apple scab attacks started again from the summer 2008. The evolution of the disease can be summarised as follows:

- 2008: secondary infections were very serious during summer even where the situation was calm after primary infections. The secondary infections favoured the formation of a very high inoculum level for the next season;
- 2009: very severe primary infections resulting from the inoculum of 2008. Secondary infections were not very aggressive due to the summer weather conditions.
- 2010: the inoculum of 2009 and the weather conditions of spring 2010 caused grave primary infections. Very serious secondary infections, favoured by the summer weather conditions, resulted in severe damages at harvest, especially on Golden Delicious.
- 2011: primary infections were moderate. The short leaf wetting recorded during spring 2011 hampered severe primary infections, in spite of the great inoculum of the previous year. Also secondary infections were not very severe, with only one worrying period in the first decade of June.

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Several experiments aimed at continuing and deepening the knowledge of apple scab behaviour in our environmental conditions are ongoing at “Maso delle Part” (one of the experimental farms belonging to FEM-IASMA), located in Mezzolombardo municipality (Valle dell’Adige-Trentino). These activities are focused on:

- evaluation of pseudothecia development,
- survey of the ascospores flight,
- exposure of “bait plants” in order to follow the seasonal evolution of primary infections,
- monitoring of control plots in areas with different inoculum levels and assessment of the primary infections and duration of spots appearance within the same infection,
- confirmation of the RIMpro model developed by Marc Trapman (Bio Fruit Advies-Zoelmond, Netherlands) and preliminary attempts to fix threshold levels for the RIM values,
- evaluation of vegetative growths.

Furthermore, some studies have started since 2009 to support apple scab management in organic fruit farming. The main targets were to improve the knowledge of fungicide use and, on the other hand, to find answers to some practical requirements. These activities are conducted in collaboration with the Gruppo Produzione Biologica of the Stazione Sperimentale di Laimburg and funded by the Ufficio delle Produzioni Biologiche della Provincia.

As to show the results of three years (2009-2011) would be too long, only the year 2010, when scab attacks were very aggressive, and the results of the control experiments are presented here.

Material and Methods

Apple scab evolution on Golden Delicious (very susceptible to either primary or secondary infections) is described by the survey of:

- “bait plants”: potted plantlets exposed, in groups of three, to one rainfall during the primary infection period (from new growth to the end of May). Afterwards these plantlets are left under a tunnel and the presence of scab spots on flower fascicles or buds of each plant is surveyed before the end of June. With time, this survey allows establishing the duration of primary infections and the severity of every attack;
- “untreated controls”, regularly monitoring the development of scab spots on both leaf sides and on fruits. Observations are carried out in several control plots located in different microclimatic areas, which often show different inoculum levels due to the previous season. If possible, also the duration of spot appearance within the same infection is assessed;
- development of the pseudothecia, obtained by diseased leaves collected in fall and left in the orchard under natural conditions. From the half of February, every week, the developmental stage of 50 pseudothecia is observed by the microscope, classifying them as primordial, immature or mature;
- flight of ascospores with the “Marchi captaspores” during every rainy period.

Efficacy trials with newly introduced molecules for the apple scab management in organic fruit farming are conducted on Golden Delicious/M9 (7-year old in 2010) in an about 1100 m^2 wide plot where the efficacy of every treatment is compared to an untreated control.

For the different treatments considered, the single molecules are distributed in the key-moments of the primary infection period. Following the specific features of each molecule, they are used (Kelderer, M., Casera,C., Lardschneider, E., 2006; Trapman, M., 2008; Hinze, M., Kunz, S., 2010):

- **preventive** before rainfall (copper at 10 g/hl of active ingredient mixed with liquid and wettable sulphur),
- **"stop spray"** (sulphur in liquid formulation),
- **as curative** (potassium bicarbonate at 1000 g/hl mixed with wetting sulphur),
- the reference standard is represented by the "key molecule" for the practice: lime sulphur used as **stop -spray** at 1500 g/hl,
- sulphur used in the different treatments was standardised with the dosage for the reference lime sulphur (1500 g/hl of lime sulphur corresponds to 334 g/hl of sulphur).

Treatments are made by hand, distributing about 10 hl/ha in big parcels (without repetitions) and controls are conducted with three repetitions/variant. During each control, at least 300 shoots and 1500 fruits are observed (every variant).

Furthermore, in each strategy the side effects are evaluated by considering the equilibrium mite-fauna on leaves (100 leaves every variant were examined in July for the presence of phytoseiid mites) and the rustiness (all the fruits collected from three trees/treatment are visually inspected at harvest).

Results

Seasonal evolution of apple scab in 2010

In bottom-valley areas the actual primary infections observed can be ascribed to the rainfalls of the end of March-beginning of April, but especially to the weather conditions of the period 2nd–6th of May (in some bottom-valley locations, depending on the wetting duration, a further infection was observed the 16th-17th of April).

The season 2010 was characterized by a very serious series of secondary infections (the 2nd-6th of May, the 15th-18th of June, the 14th-17th of August) that caused severe attacks on both leaves and fruits.

"Bait plants" exposure

Figure 1 illustrates the historical evolution of scab primary infections. In 2009 and 2010 the severity of the disease increased, while in 2011 the infection level slimmed down.

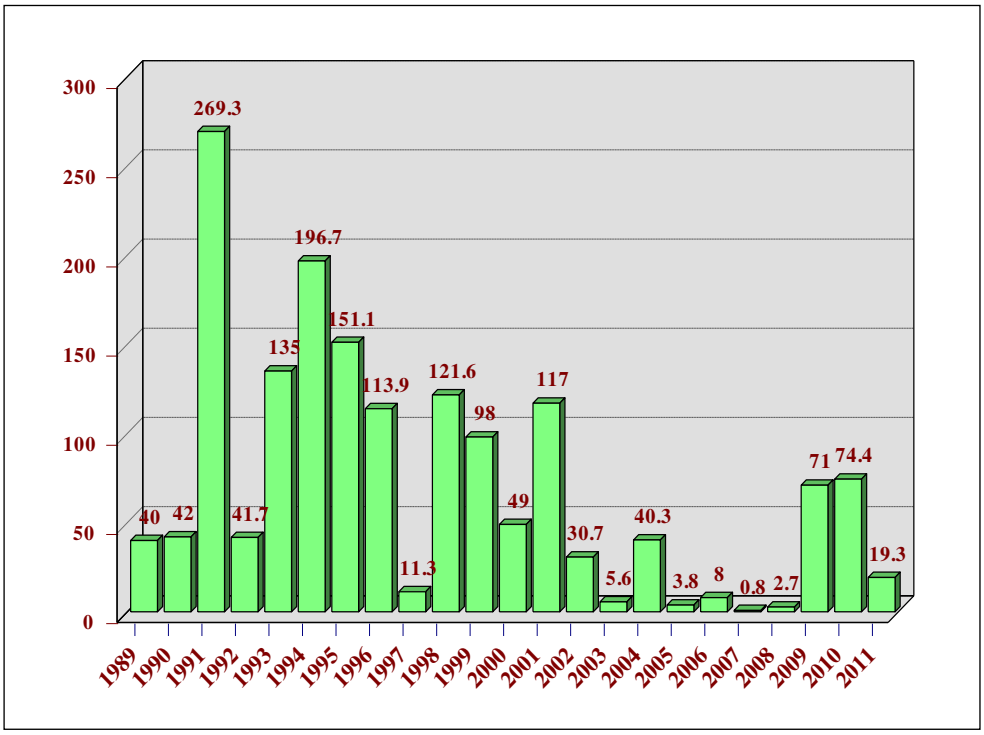

Figure 1: Potted plants – Maso delle Part. Sum of the scabbed shoot percentages during primary infections from 1989 to 2011.

Untreated controls

The infection evolution is followed at the same time in 4 untreated plots in the farms of Istituto Agrario; they are substituted every year and normally different inoculum levels are observed in the different areas (Figure 2). Interestingly, at the end of primary infections, all climatic conditions being equal, the damage level recorded is definitely different.

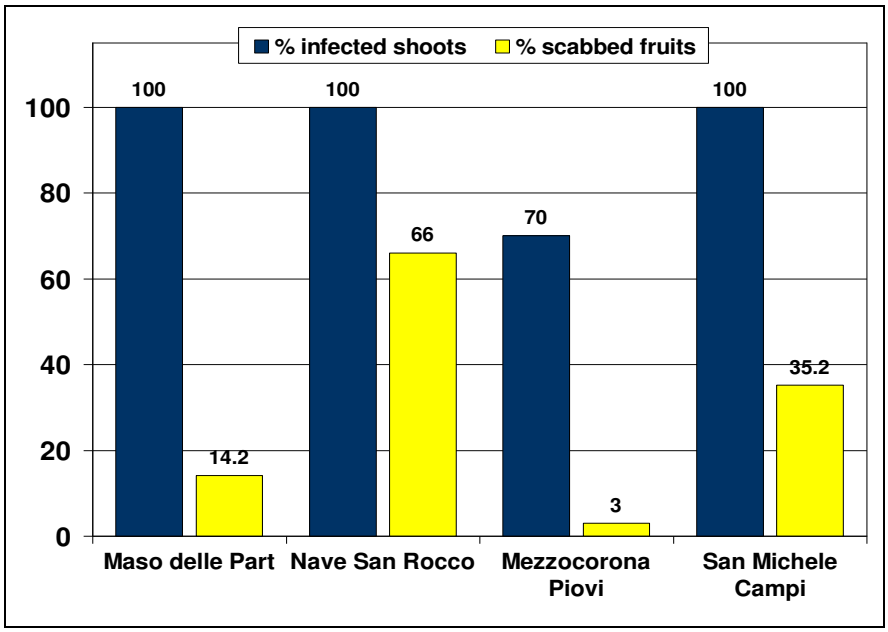

Figure 2: Apple scab presence on shoots and fruits in the untreated controls in the farms of Istituto Agrario (control at the end of primary infections-10th June 2010).

Survey on pseudothecia development and ascospores flight

The evolution of pseudothecia development and the flight of ascospores followed in a representative bottom valley area of Trentino are shown in Figures 3 and 4, respectively.

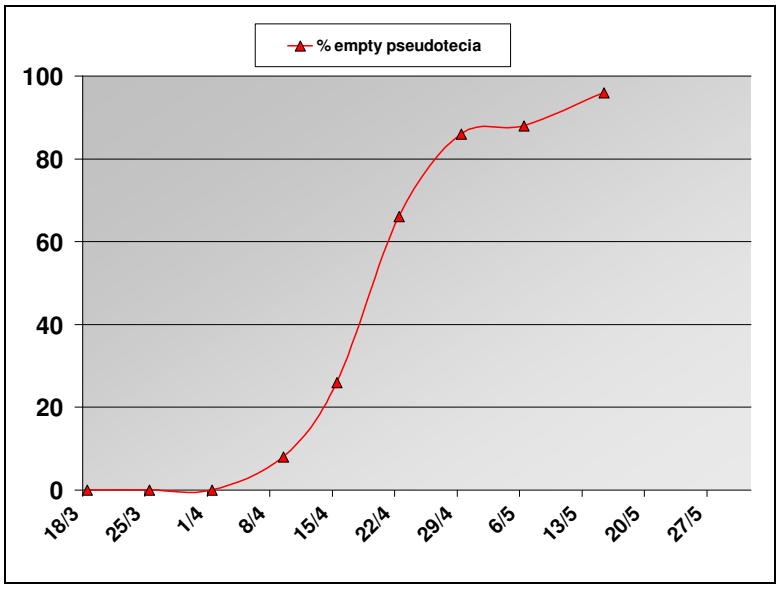

Figure 3: evolution of the pseudothecia development in 2010 at “Maso delle Part”. The percentage of empty pseudothecia is represented.

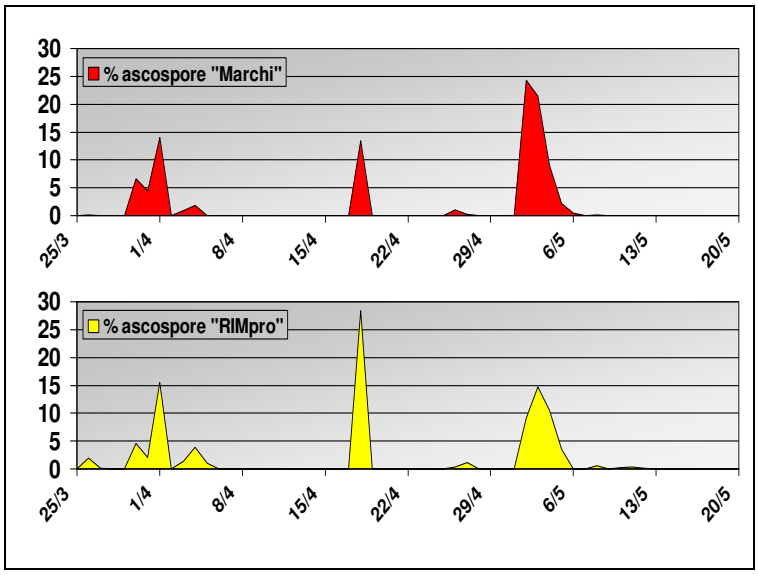

Figure 4: comparison between the ascospores air dispersal in 2010 at “Maso delle Part”. In the upper graph the flight is simulated with the “Marchi captaspores”, while in the lower one it is simulated by the “RIMpro” model.

RIMpro model confirmation

To confirm the effectiveness of the RIMpro model in our environmental conditions, at “Maso delle Part” the comparison between the observed severity of the infections and the simulation by the program is still ongoing (Figure 5). A twenty-year study with simulations and comparisons with field collected data points out very interesting results.

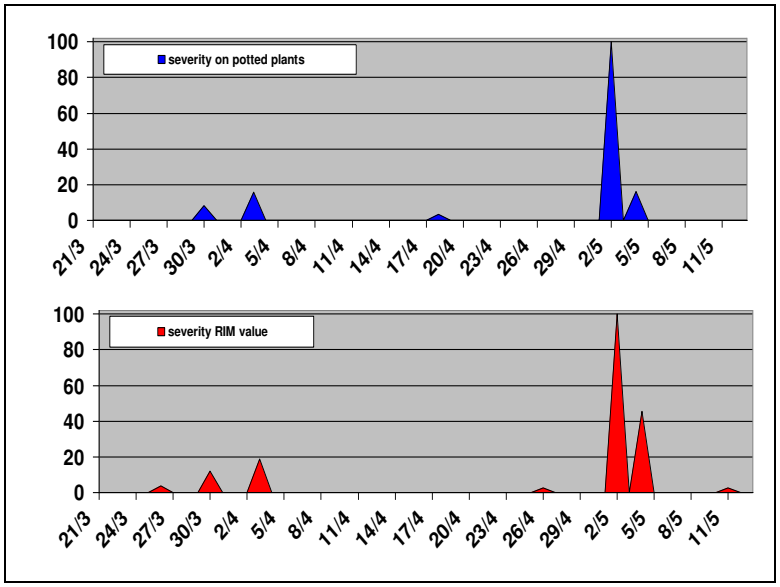

Figure 5: Comparison between the primary infection severity recorded on potted plants at "Maso delle Part" (Valle dell'Adige) and that simulated by the RIMpro model in 2010.

Some additional observations

Thanks to the observations carried out, much knowledge can be built up; some very interesting points concern:

- the duration of spot comparison within the same infection, which in our environment was observed lasting 11 days; such a duration can be precisely simulated also by RIMpro using the increase in the number of spots shown by the model for each infection (Figure 6).

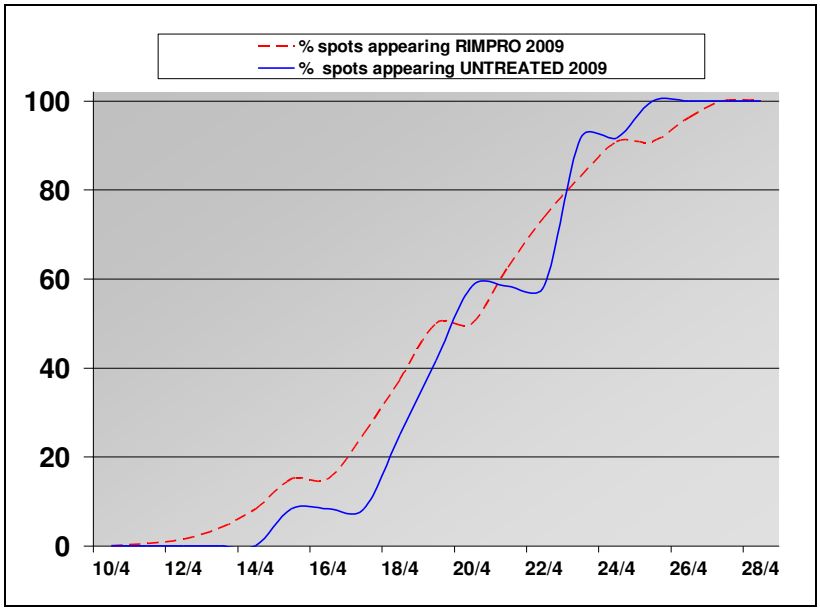

Figure 6: % of appearing of apple scab spots predicted by the RIMpro model (dotted line) and verified in an "untreated control" (continuous line). The infection considered took place April the 1st-2nd 2009 and 11 days went by between the beginning of spot appearance and their stabilization (April 15th-25th).

- During 2009 and 2010, while surveying the untreated control, it was possible to evaluate the varietal susceptibility that concerns, all climatic conditions being equal, Golden Delicious and Granny Smith. A higher damage level was found in the former variety (Table 1), which showed also more diseased fruits in plants with an average productive power than in plants with alternation (Table 2).

Table 1: harvest survey on two varieties planted in the same untreated control plot

Variety	% of diseased shoots 2009/2010	% of diseased fruits 2009/2010
Golden Delicious	100/100	79/99
Granny Smith	37/41	16/12

Table 2: harvest survey on Golden Delicious with different production power

Production power	% of diseased fruits harvest 2009	% of diseased fruits harvest 2010
Plants with average production	89	99
Plants in alternation	27	24

Efficacy of products

The control strategies and the time schedule for treatments are listed in Table 3. In the trial we had five variants (2 Preventive, 2 in Germination window and 1 Curative)

Table 3: treatment schedule in 2010

Preventive Copper 10 g/hl + Thiopron 550 g/hl Copper 10 g/hl + Sulphur 420 g/hl	**Germination window** Lime-sulphur 1,5 kg/hl Thiopron 550 g/hl	**Curative** Bicarbonate 1 Kg/hl + sulphur 420 g/hl
March 26th	March 27th	March 27th
March 29th	March 30th	
March 31st		March 31st
April 2nd	April 2nd (Lime-sulphur)	April 2nd
April 12th		
April 18th (Lime-sulphur)	April 18th	April 19th
April 22nd		
April 26th	April 27th	April 27th
May 1st		
May 3rd	May 3rd (Lime-sulphur)	May 3rd
May 5th (Lime-sulphur)	May 5th (Lime-sulphur)	May 5th (Lime-sulphur)
May 7th		
	May 11th	May 11th

The results of these trials are represented in Figure 7, which shows the damaged shoots and leaves at the end of primary infections (3rd of June), and in Figure 8, which shows the damage level on fruits in two different moments (3rd of June and 16th of July).

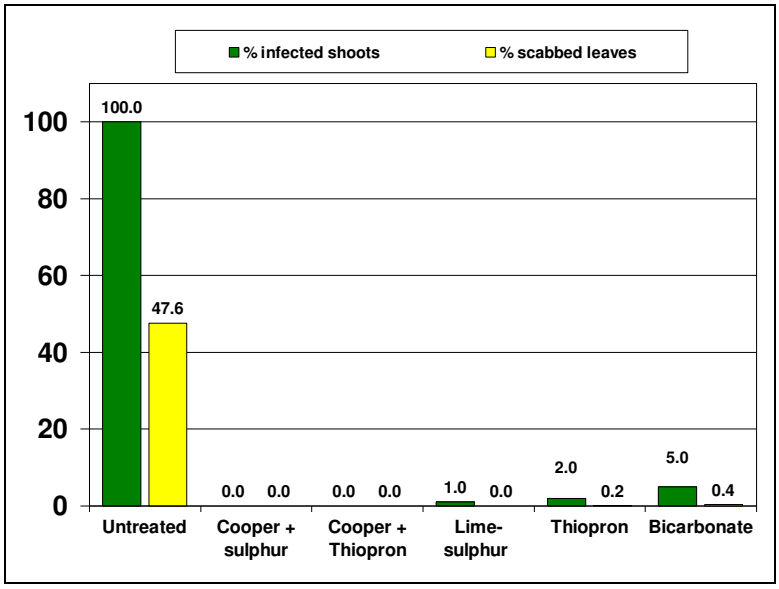

Figure 7: % of diseased shoots and leaves the 3rd of June. Trial for "Bio" control of apple scab in 2010.

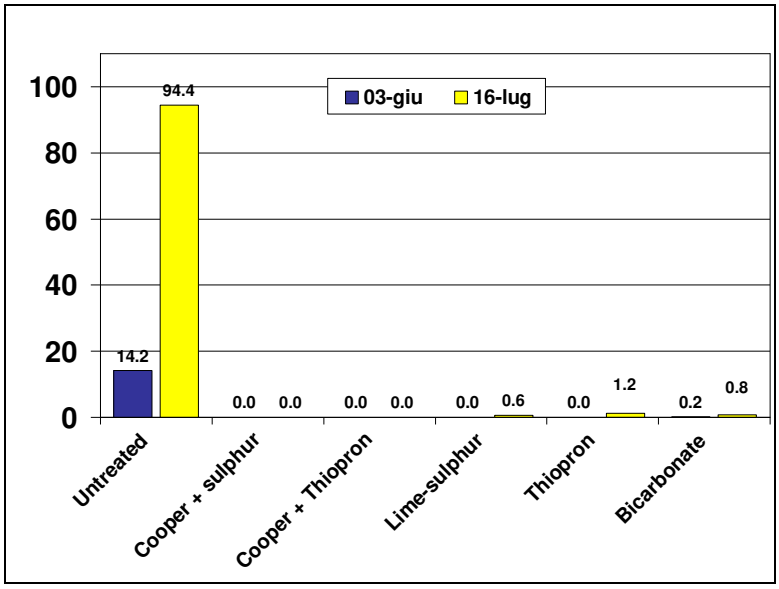

Figure 8: % of scabbed apple fruits surveyed the 3rd of June and the 16th of July. Trial for "Bio" control of apple scab in 2010.

As depicted in Table 3, the last treatment was done the 7th or the 11th of May. Afterwards, in spite of climatic conditions that favour secondary infections, treatments were stopped. The survey conducted at the half of July to evaluate the interference of secondary infections of June (Figure 9) and, at harvest, to evaluate the incidence on fruits (Figure 10).

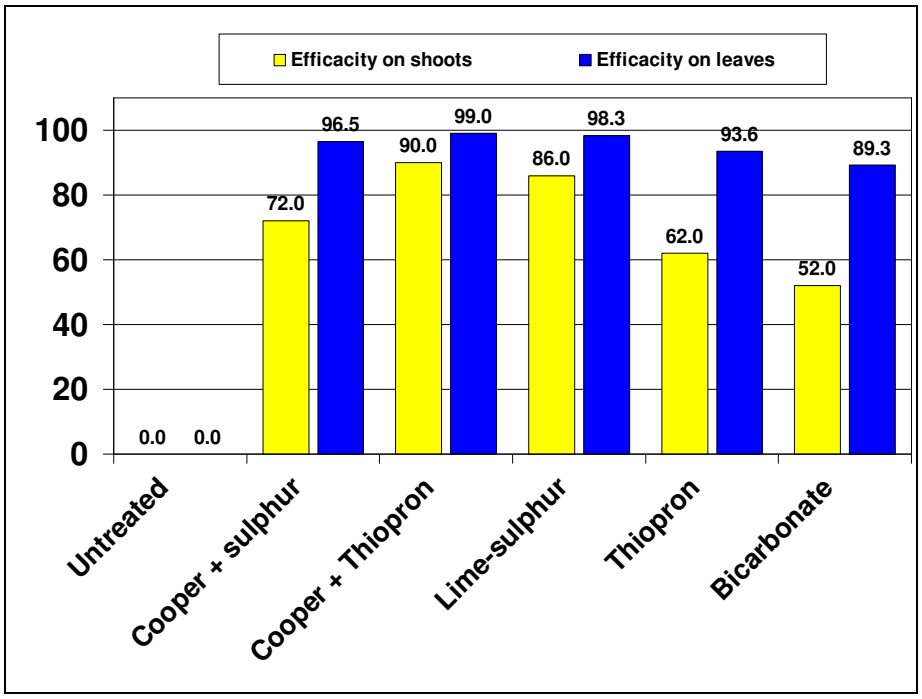

Figure 9: efficacy of the different strategies evaluated the 16th of July on shoots and leaves. Trial for "Bio" control of apple scab in 2010.

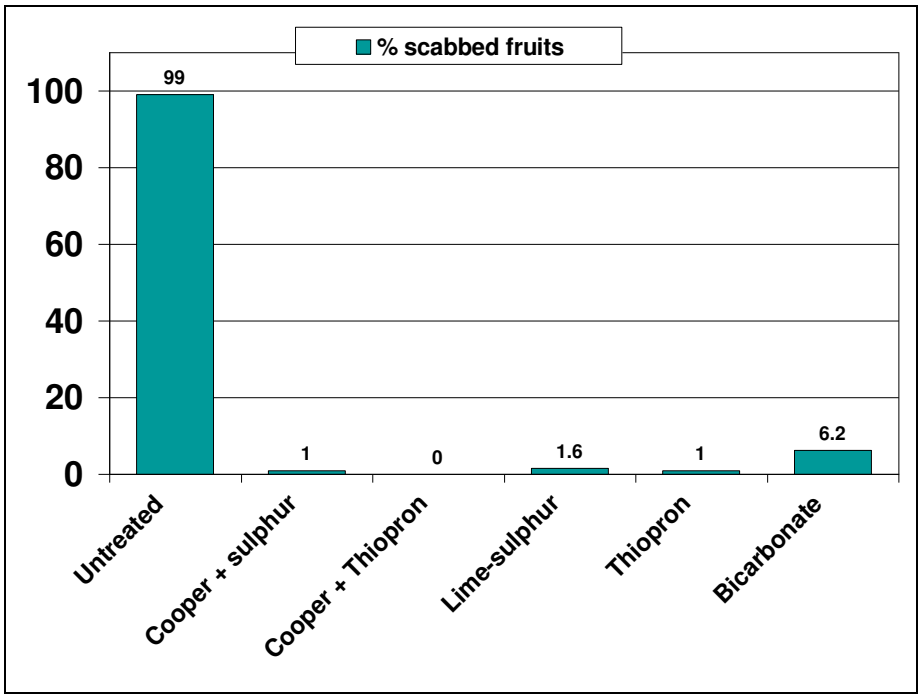

Figure 10: % of scabbed fruits evaluated the 10th of September in the different control strategies. Trial for "Bio" control of apple scab in 2010.

Side effects

A survey was conducted in July to evaluate the side effects on phytoseiid mites: the different treatments sowed no differences with the untreated control (Table 4).

Table 4: side effects in phytoseiid mites

Control strategies	N° phytoseiids/leaf
untreated control	1,76
thiopron + copper	1,08
sulphur + copper	1,08
polysulphide	1,16
thiopron	1,16
bicarbonate + sulphur	1,08

The results of the evaluation of rustiness conducted at harvest is represented in Figure 11; as shown by the untreated control, the climatic conditions were particularly favourable. The comparison between the different strategies results in an increase in the rustiness in the copper treatment.

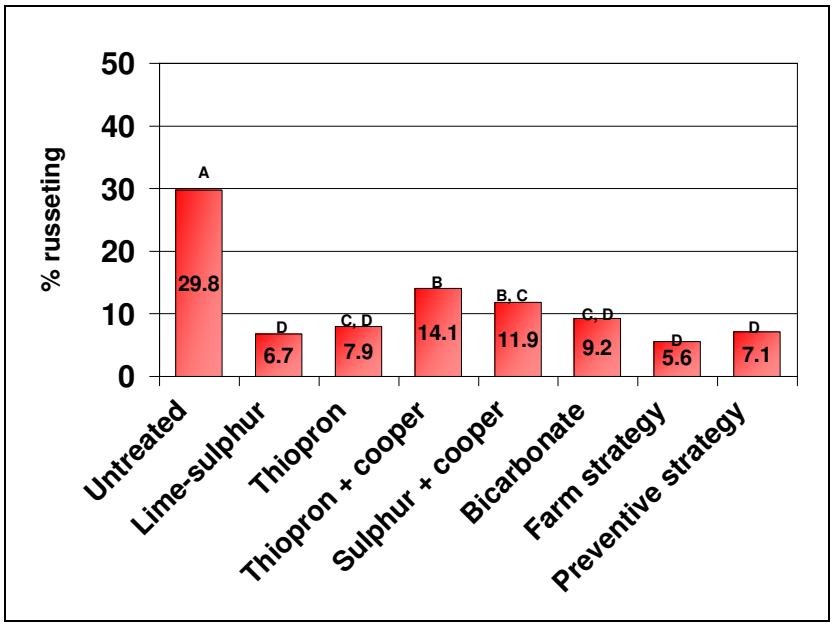

Figure 11: evaluation of fruit russeting at harvest. Trial for “Bio” control of apple scab in 2010.

Discussion

As the knowledge of apple scab biology in different environmental conditions is the key factor for its management, it is very important to follow the historical evolution of this disease but also its behaviour year by year. The reduction of the primary infection level allows, in our environments, eliminating or at least holding down summer treatments.

The use of tools as RIMpro model results very useful for supporting decisions in the management of the disease.

Calcium polysulphide is the most important compound in apple scab management not only in organic fruit farming: also IPM shows an increasing interest for it due to the small number of new molecules available. Another reason to be considered is the probable reduction in number of the treatments with products as “dithianon”, following a new European guideline for the sustainable use and marketing of pesticides.

The products tested for apple scab management in organic fruit farming seem very interesting, even though they need further experimental validations. Anyway, these results are confirmed also in the years 2009 and 2011, although the pathogen evolution was quite different.

In 2010 at the end of primary infections (3rd of June) all the products and the management strategies resulted very efficacious compared to the infection level of the untreated control (initially higher on leaves and shoots than on fruits). At the half of July, after the attack on fruits by the secondary infection of June, a very interesting difference emerged between the control and all the treatments, in spite of the lack of specific summer treatments. This difference lasts until harvest even if a stronger attack of fruits is recorded in the bicarbonate treatment compared to the other products.

Copper is confirmed effective at low doses and the addition of sulphur seems to reduce its phytotoxicity. It should be worth to use it in wide farms, where it could be difficult to treat the entire surface with polysulphide during rainfall. Moreover, it could be used with other varieties different from Golden Delicious and its efficacy and persistence should be tested even at lower doses.

The good results obtained with the mixture potassium bicarbonate + sulphur have to be confirmed in further trials where treatments are done with atomizer in wider experimental plots. This mixture, at the doses used, does not show severe phytotoxicity problems; on the contrary, a slight “growth retardant” effect can be observed in 2010 and 2011.

The evaluation of side effects picks out no interference either as favouring agent for phytophagous mites or as disturbing agent against phytoseiids, while copper causes more rustiness problems than the other molecules on Golden Delicious.

Acknowledgements

Sincere thanks go to all the colleagues from Maso Part that allowed these studies.

To Marc Trapman (fruit Advies) who allowed us to use RIMpro.

To Umberto Piva e Lorenzo Colombo who helped us in all these jobs.

Thanks to Federico Pedrazzoli for the translation of this publication.

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