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Disease management in organic apple orchards is more than applying the right product at the correct time

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Abstract

The relative importance of diseases on apple is varying with cultivar, management, time, and climate. Many aspects of the cropping system influence the development of diseases. The choice of the variety determines the disease management during the lifetime of the orchard. Cultural practices improve the growth and nutrial status of the tree, and therewith influence the susceptibility of the plant and fruits to diseases directly. Prolonged growth can also have an indirect effect by causing a microclimate and growing pattern that favours infection of tree, leafs and fruits by various diseases. Sanitation measures are common practise for most organic fruit growers and help to make other measures more effective by reducing infection inoculums. Despite all preventive measures, disease control in organic orchards at an economically feasible level still largely depends on the application of fungicides. Measures that allow reduction of fungicidal applications on key diseases, lead to the development of a secondary disease complex that can cause severe losses when not managed effectively and make a well thought-out control strategy necessary.

In research, advisory and practical decision making, disease management in organic orchards should always be seen in the perspective of the management of the total growing system. With all factors that contribute to disease management in organic orchards optimized, we are able to successfully implement new materials and methods that may not be as effective as common fungicides in themselves, but add to the effectiveness of the disease management system as a whole.

This total system approach makes organic fruit growing what it is.

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Keywords: Venturia, Apple, Organic, Disease management, System approach.

Principals of organic production require that management of pest and diseases should be based on a combination of preventive measures, including the choice of suitable cultivars, crop rotation, sanitation as well as other cultural measures, improving natural control, and the use of on chemical techniques. We try to provide a brief overview on how we succeed in this regarding the management of diseases in orchards, and where development and choices have led us so fare in the development of a disease management system for organic orchards.

Varieties

By choosing the apple variety, the grower determines to a large extend the disease management he has to apply during the lifetime of the orchard to ensure his production. The main apple varieties organically produced in Europe differ considerably in their susceptibility to diseases. (Table 1) As the focus in disease management in orchards is on scab control, most attention on differences between apple cultivars is on susceptibility to apple scab.

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In a four year trial on the former research orchard “De Schuilenburg”, Netherlands, (1994-1997) during spring a normal, a reduced and a minimal fungicide program was compared in orchard blocks planted with six different varieties. In all four years the susceptibility of the varieties proved to be more determining for the percentage scabbed fruits at harvested than the difference in fungicide input. A full fungicide program on a susceptible variety resulted in more scabbed fruits than a minimal fungicide program on low susceptible varieties. (Figure 1)

Over more than 50 years breeders have worked to find apple cultivars that combine resistance to apple scab with high yields, good storability, shelf live and consumer quality. After some disappointments with early released Vf resistant varieties, organic growers in more humid production areas in Europe have now planted the most promising ones. In The Netherlands about 30% of the organic apple production consists of Vf resistant cultivars. In the Integrated production this is well below 1% of the production. In Europe as a whole in 2007 12% of total organic production consisted of the Vf resistant varieties Topaz and Santana (ZMP, 2007) Unfortunately the Vf resistance can be overcome by the fungus and “resistance management” is necessary to delay the loss of resistance. (Trapman 2006)

For pear, Conference, the main variety in the Netherlands seems to be little susceptible compared to other cultivars. Nevertheless the control of pear scab on Conference in organic fruit growing is difficult. The variety Concorde has shown to be even less susceptible than Conference in various Trials (Kemp, 2000) and orchard situations. However, once the scab population has adopted itself to this variety, a full scale spraying program is necessary. Resistance management is probably needed here as with Vf resistant apple varieties.

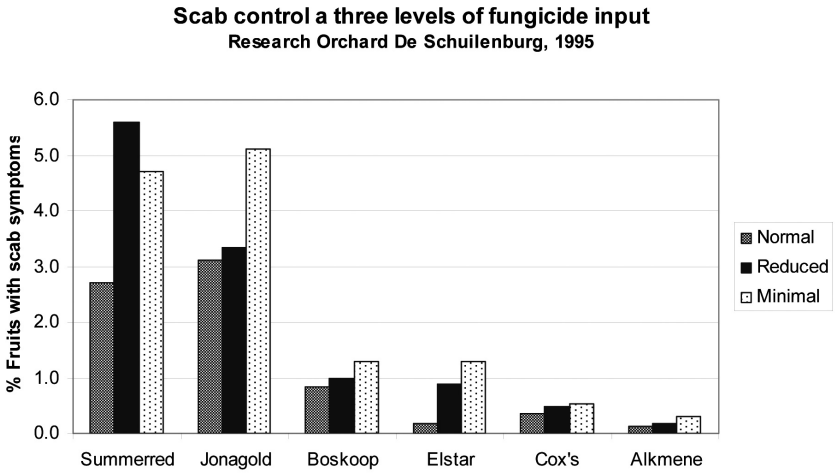

Figure 1: The relative influence of the susceptibility of the apple cultivar and the level of fungicide input on the fruit damage by apple scab in a trial in the Netherlands (averages of four replications.)

Table 1: Indicative susceptibility for key diseases for the main Apple cultivars in organic production in Europe.

Cultivar	European Organic Production*)	Scab	Mildew	Fireblight	Sooty Blotch	Storage Diseases	*Nectria* or Collar rot
Golden Delicious	16 %	+++	+	+	++	++	+
Jonagold/Jonagored	15 %	+++	+++	++	+++	+	++
Elstar	14 %	++	++	++	++	++	++
Topaz	11 %	R	+	++	+++	+++	+++
Gala	10 %	+++	+++	+++	?	+	+++
Braeburn	6 %	+++	+++	+++	?	++	
Cox's and Holsteiner	3 %	+	++	+	?	++	+++
Idared	3 %	+	+++	+++	?	+	
Boskoop	2 %	+	+	+	?	+	++
Pinova	2 %	+	++	++	?	+++	

+++ = highly susceptible, ++ = intermediate susceptibility, + = low susceptibility, R = resistant
? = not known while masked by fungicide applications against other diseases.
*) ZMP 2007

Cultural practises

Fertilisation, soil management, cover crops and pruning practises improve the growth and nutritious status of the trees as intended, but therewith also directly and indirectly the susceptibility of the tree and the fruits for diseases. Prolonged growth prolongs susceptibility of the shoots for scab and mildew infections until late in summer as only young leaves are highly susceptible to these diseases. Moreover it leads to a dense canopy with a microclimate that favours fungal infections.

Achieving nitrogen levels in the tree in the higher part of the optimum range increases yields, but leads to increased risk of losses caused by infections of apple scab, fly speck, and sootyblotch. (Lindhard 2002, 2003), and increased wood infections by *Nectria galligena*. (Lindhard 2006, 2007; Saure, 1961; Swinburne 1975; Scheer, 1977). There is probably no orchard disease that reacts as strongly to growing conditions as *Nectria galligena*. Good soil conditions, effective drainage, balanced fertilisation, and balanced growth are of major importance to prevent wood infections by this disease. Our impression is that most organic growers experience less *Nectria* infected trees in their orchards than their Integrated colleges probably due to the reduced Nitrogen levels in the trees, and reduced growth under organic conditions.

Growers recognize that the parts of their orchards with unbalanced growth suffer from disease problems. Reducing the growth of Conference pear trees by root pruning resulted in a 50% reduction of fruits with pears scab. (Jansonius, this conference)

The fact that fruits with higher N content and unbalanced potassium and calcium levels are more susceptible to storage diseases is generally accepted. Treatments with calcium either before or after harvest can reduce the losses during storage with up tot 50%. (Guzewska 1984, Conway 1992,1999, Tahir 2000, Creemers unpublished)

A cultural practice as simple as grafting the variety on an inter-stem to enlarge the physical distance between the inocculum in the soil, and the susceptible variety strongly reduces the infection risk for collar rot on the Vf resistant variety Topaz.

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Table 2: Elements of practical disease management in organic orchards. (?) = efficacy doubtful, or not yet proven, or until now only proven under experimental conditions. *Italics* = methods that are not yet available to the majority of the organic growers in Europe.

Disease	Cultivar	Cultural methods	Sanitation	Fungicides	Alternatives
Apple scab	Prefer Vf resistant or low susceptibility	Avoid N excess	Leaf shredding Vinasse (?) *Antagonists(?)*	Copper Sulphur Lime sulphur *Bicarbonate*	*Antagonists* *Botanicals*
Powdery Mildew			Take out diseased plant parts	Sulphur Lime sulphur *Bicarbonate*	
Black Rot		*Fruit thinning (?)*		*Copper (?)*	
Sooty blotch and Fly speck		Create open tree		Lime sulphur Coconut-soap *Bicarbonate*	
"Topaz spots"				Yes but which (?)	
Storage diseases	Avoid varieties with high susceptibility	Avoid N and K excess Apply Ca leaf fertilizers	Take out diseased plant parts and mummified fruits	Copper(?)	Hot-water drenching *Antagonists* Ca drenching
Fruit tree canker		Avoid N excess	Take out diseased plant parts	$Ca(OH)_2$	
Collar rot		Use trees on inter stem		Copper	
Fireblight			Take out diseased plant parts	Copper(?)	*Antagonists*

Sanitation practises

After choosing the right variety for the location and applying cultural practices with the aim to prevent or slow down disease development, sanitary measures are the third key stone in disease management in organic orchards. The fact that crop rotation is not possible in fruit growing, makes that disease problems tend to accumulate during the lifetime of an orchard, and often determine the economic decision when to grub and replace the orchard. Cutting out the parts of the tree that are infected by *Nectria galligena* and other wood rots is common practise for both integrated and organic growers. The positive effect of reducing the ascospore inoculum of apple scab in spring by mulching and shredding fallen leaves, or even taking out the fallen leaves from the orchard has been demonstrated repeatedly in integrated orchards. This sanitation results in 50-90% less diseased fruits than a fungicide program without sanitation. (e.g. Triloff 2006, Creemers unpublished.) The natural leaf degradation proceeds in organic orchards faster that in integrated orchards. Nevertheless most organic growers try to further improve the leaf degradation by shredding and mulching leaves during winter, or digging them in with their mechanical weeding equipment.

Trials in Italy have shown that mildew control with sulphur is twice as affective after pruning away the previously infected shoots (Rizzolli 1999).

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Control measures

Despite all preventive measures disease control in organic orchards at an economically feasible level largely depends on the application of a series of applications of fungicides during the season.

In an orchard system changes in the strategy for the control of one disease have consequences for the occurrence of other diseases. Under both IP management and Organic fruit growing with traditional apple varieties, effective control of apple scab as polycyclic disease highly adapted to apple as its only host, an accurate and repeated input of suitable fungicides during the season in necessary. The required fungicide input leaves little space for the development of other diseases and even varietal differences in susceptibility for other diseases are largely masked. (Table 1)

When scab resistant or tolerant varieties are planted and the fungicide program is minimized or set to zero, secondary diseases develop, and differences in susceptibility between cultivars become apparent. Over time, the disease complex resembles that of an untreated orchard. These diseases can cause crop losses that are much higher than in the production of traditional varieties. For Topaz, the main Vf resistant apple variety planted in Europe, fruit skin damage by Sooty Blotch on 20 - 50% of the fruits is usual, and crop losses of 10-40 % due to *Gloeosporium* storage rot are not uncommon. A not yet identified symptom called “Topaz spots” may develop over years in these orchards causing crop losses up to 100% of the fruits. The loss of production capacity over the years by *Nectria galligena* and Collar rot (*Phythophtora cactorum*) is also much higher than with traditional cultivars limiting the potential lifespan of an orchard. In breeding programs and variety testing an early screening on susceptibility to other diseases than apple scab would add to the practical value of the outcomes the breeding projects.

Table 2 Indicative relative importance of orchard diseases on apple as result of management practices, (fungicide input) and as consequence have the focus in practical disease management and research projects.

	Integrated production	Organic production			Untreated Orchards
	Traditional varieties	Traditional varieties	Scab resistant varieties Reduced input*)	Scab resistant varieties Minimal input *)	
Apple scab	**++++**	**++++**	**++**	**R**	**++++**
Powdery Mildew	**++**	**++**	**++**	**+++**	**++++**
Blackrot		**+**	**+**	**+**	**+?**
Sooty blotch and Fly speck		**+**	**++**	**++++**	**++++**
“Topaz spots”			**+**	**++++**	**++++**
Storage diseases (e.g. *Gloeosporium*)	**++**	**+**	**+++**	**+++**	**++**
Fruit tree canker	**++**	**++**	**+++**	**+++**	**++**
Collar rot	**+**	**+**	**++++**	**++++**	**+?**
Fireblight	**++**	**++**	**++**	**++**	**++++**

*) Depending on susceptibility of the variety. Here referring to Topaz as most planted Vf scab resistant variety in Europe.

*) R= Resistant until overcome by local scab population. After that ++++

The need for treatments against apple scab to prevent the fungal population breaking the Vf resistance, and the occurrence of secondary diseases requires a fungicide input that decreases the economical and environmental gain of the planting of these varieties. For commercial, economical and technical reasons organic apple growers in the main production regions for organic fruit in Europe tend to go back to the apple cultivars that are traditionally grown and marketed in their area.
This example illustrates that 'solving' the management of apple scab in organic orchards, by no way means that the application of fungicides is not necessary any more.

Alternative control methods
Management of the disease complex on apple in order to maximize the amount of marketable fruit does not always mean application of fungicidal materials. Most non chemical control methods are in agreement with the principles of organic farming, and can be integrated in the growing system. Hot water drenching to prevent *Gloeosporium* rot during storage as first studied in 1963 in at East Malling Research Station. (Burchill 1964), has been proven to be an elegant and effective method to reduce disease losses in organic production. Many institutes in Europe have in the last decade contributed to the development of this method into a practical applicable technique. The result is gratefully embraced by many organic growers in Europe.
Control strategies based on the application of antagonists to prevent ascospore or conidiospore production by apple scab, fireblight infections, or losses by specific storage diseases are at different stages of development and registration and will hopefully become available for ever organic fruit grower in Europe.

Conclusion
For the economic production of organic fruits effective management of a complex of diseases is necessary. Minimizing the input of fungicides leads to more diversity in the potential damaging diseases and requires an even more sophisticated, well thought-out control strategy.
Scab is in both apple and pear production the dominant disease. Varietal differences in susceptibility to scab are an import factor in determining the success of a spraying program. The choice of planting Vf resistant and low susceptible varieties is therefore a logical step on the road to develop organic fruit growing. The reduction in intensity of the spraying programmes offers the growers a relief in their work, minimizes the adverse effects caused by the spraying materials on the environment and beneficial organisms, and adds to the acceptance of organic fruit production by the public and consumers
However the reduction in treatments against apple scab in many instances has led to the build up of other diseases in the orchard. Reacting to this with the application of other fungicides will reduce the gain achieved by choosing for scab resistant varieties.
In order to keep the benefits of scab resistant varieties, other control measures have to be developed and integrated into a system that enables the control of the whole disease complex.
Also for the less scab-susceptible traditional varieties the development of a more elaborate disease management system that integrates cultural, sanitation and control measures, offers opportunities.
With all factors that contribute to disease management in organic orchards optimized , we are able to successfully implement new materials and methods that may not be as effective as common fungicides in themselves, but add to the effectiveness of the disease management system as a whole.
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