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New fungicides for apple scab control in organic growing

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Apple scab is caused by the fungus *Venturia inaequalis*. This disease is a major problem in both organic and conventional apple growing. The fungus winters in fallen leaves on the orchard floor, and in the spring it produces primary spores, ascospores, which are discharged after rain and dispersed to new leaves on the tree. The spores germinate on the leaf surface and attempt to penetrate the outer leaf layer, the cuticle, and grow between this layer and the outermost cell layer of the leaf.

These primary infections give rise to the secondary spores, the conidia, which also are dispersed and infect more leaves (**Figure 1**) and fruits in connection with rain events. Therefore, most apple growers are compelled to spray several times in the primary season when the ascospores are discharged (normally April-June) to avoid an explosive spread of apple scab in the orchard and scab on the fruit.

Many organic apple growers in Denmark spray preventively just before or during rain with elemental sulphur, whereas some of their European colleagues still are allowed to use some of the more effective lime sulphur and copper compounds. Because elemental sulphur sometimes has a low efficacy against apple scab, and the use of copper as a fungicide in EU is to be phased out from 2006, alternative fungicides are urgently needed.

The possibilities for using alternative fungicides to control apple scab is being investigated in the DARCOF project **StopScab** at the Department of Plant Biology, The Royal Veterinary and Agricultural University (KVL), and the Research Centre Aarslev, Danish Institute of Agricultural Sciences (DIAS).

Alternative fungicides

Plant protection products, for use in organic fruit growing, must comply with the principles for organic growing. Thus, potential materials include natural products such as plant extracts, essential oils, salts and biocontrol agents, and these must not have any harmful side-effects on humans, animals or the environment.

Oils, salts, microorganisms and natural compounds from plants may have a direct inhibitory effect on the apple scab fungus. The effect can be because the fungal spore is unable to stick to the leaf surface, or due to it being killed or inhibited during spore germination and growth, thereby preventing the fungus from establishing in the plant tissue. Furthermore, several compounds from plants but also oils, salts and microorganisms etc., may have an indirect effect by **activating (inducing) the plant's natural defence** reactions against fungal infections.

New fungicides for apple scab control in organic growing

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The research group at KVL is looking for alternative materials, through literature and Internet studies and via contacts with companies and other researchers, and also new ideas of potential materials are arising.

Some extracts and oils are supplied from companies, while other plant extracts are freshly prepared. The extracts are made from leaves, flowers, fruits, seeds, bark, stems, roots etc. of plant species originating from Denmark, but also from plant species from more foreign places.

The alternative materials are tested against the apple scab fungus in the laboratory and in the growth chamber on artificially inoculated apple seedlings. The materials are tested for preventive and curative effects, and the mechanisms behind the disease inhibition effect are studied. Treatments are compared with the effect of water (control treatment) and elemental sulphur (reference treatment).

Some interesting extracts and products

The successful use of a water extract from ivy (*Hedera helix*) to control apple scab was reported in Switzerland some years ago. Ivy contains compounds, which showed fungicidal effect against spores of *V. inaequalis*. The StopScab project has included testing of ivy extracts in the orchard at DIAS Aarslev this summer (2004), and the trials will be evaluated at fruit harvest.

Many other plants contain similar compounds, e.g. soapwort (*Saponaria officinalis*), and extracts from roots of this plant has been reported to be effective against apple scab on apple seedling in greenhouse experiments carried out in Germany.

Other very promising natural products are extracts of *Citrus* spp. However, it has recently been found that some commercialized products based on extracts from grapefruit kernels had been preserved with synthetic chemicals. These chemicals, which in themselves have been found to be active against the fungus, are absolutely not permitted in organic growing and future work on these products has been discontinued.

At KVL the testing of extracts and oils from many different plant species continues, and some of these natural materials have shown interesting results. Many of them seem to act directly on the fungus while others seem to act indirectly. Results from these experiments will be published later.

Further studies of alternative fungicides

Besides testing alternative products in the laboratory and growth chamber, the most effective and promising materials are also tested under natural orchard conditions. Such testing of a few potential materials was performed in 2003 and presently, in the growing season of 2004, testing is ongoing in the orchards at DIAS, Aarslev. These materials have been sprayed on the trees (8-10 times) in the ascospore season.

When a material indicates potential for use as an alternative fungicide in organic growing it must be evaluated for possible side effects on the environment, humans and animals, and the economic viability for its production and use in practice must be considered. However, these aspects are not included in the StopScab project, which ends this autumn (2004).

Major parts of the project continue in the recently started EU project, **REPCO**. In REPCO the development of new methods to control apple scab and downy mildew in organic apple and grapevine growing are under investigation, including testing and evaluation of new alternative fungicides. The REPCO project ends in 2007.

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