Prevention and control of apple scab

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***Abstract* – Improved prevention and control of apple scab caused by *Venturia inaequalis* is aimed at without the use of copper containing products in the Repco-project. Substantial progress is made in selection of potential products against summer epidemics. A patent application is made for E73. New effective biocontrol agents are selected to reduce inoculum during winter. The product potassium bicarbonate has shown good efficacy and Repco contributes to the registration of this product in Europe. Earthworms tended to be stimulated to consume apple leaves treated with amino acids or beetpulp, especially when applied fresh under controlled environmental conditons.[1]**

Introduction

In the cultivation of organic apples, crop protection is directed for a major part to the disease apple scab caused by *Venturia inaequalis*. Organic apple growers are much dependent on sulphur, lime sulphur and copper containing products to control the disease. Especially copper containing products are used frequently at the beginning of the season because of copper's good efficacy during cool weather conditions. As a negative side effect, copper affects soil organisms. Therefore the European Union (EU) stimulates reduction in use of copper containing products (Councel Regulation 2092/91, Annex II) and funded the Repco-project. The purpose of Repco is to find, develop and implement methods for the control of apple scab without the use of copper containing products.

Repco targets several points in the life cycle of *V. inaequalis*. New active products are screened for the control of the summer epidemic under controlled environmental conditions, then examined in small scale field experiments and finally tested in a standard organic treatment schedule. Nearly-ready-to-market products are tested during the summer epidemic as well. Selection of novel biocontrol agents are targeted at the summer epidemic. Another target of Repco is the reduction of overwintering inoculum of the fungus. For that purpose, novel endophytes are selected and tested, and leaf degradation is stimulated by addition of organic products to leaves in autumn and by improvement of leaf consumption by earthworms. Positive results will be communicated rapidly to practice.

This paper gives an overview of some of the first results of the different approaches to prevent and control apple scab in organic orchards without the use of copper.

Materials and methods

Individual papers are submitted, and will be presented at the Joint Organic Congress by participants of Repco. The reader is, therefore, referred to the more detailed descriptions of the materials and methods used in individual experiments and described in the papers by Bengtsson, et al., 2006; Heijne et al., 2006; Jong and Heijne, 2006; Köhl et al. 2006; Lindhard Pedersen and Paaske 2006; Speksnijder et al. 2006.

Results and discussion

New compounds

Both preventive and curative activity were tested of new compounds were tested against *V. inaequalis*. The efficacy was considered positive if new compounds at 2.5 or 5 % dilution rates were equally or more effective than sulphur at the rate of 0.27 %. Over 100 plant extracts and other materials were tested. Some nearly-ready-to-market products were also tested. Among them, positive results were obtained with eugenol (Bioxeda), potassium phosphonate (Resistim), coconut soap (Cocana) and potassium bicarbonate (Armicarb). Selection resulted in a list of compounds with good efficacy and little or no phytotoxic side effects. From these, 20 and 23 compounds were selected for small scale field testing in 2005 and 2006 respectively.

Small scale field testing

Only three out of 25 compounds showed an efficacy against apple scab comparable or better than the standard treatments of sulphur or copper in small scale field trials. These were rapeseed oil and compounds coded E73. In many cases, a marked contrast was noted between effective compounds in the screening under controlled environmental conditions and their efficacies under field conditions. It is sug-

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gested that break down of compounds by ultra violet radiation from sun light might be responsible for this effect, possibly in combination with wash off by rain.

Efficacy in standard schedule
Remarkable good efficacy was obtained with two nearly-ready-to-market products, potassium bicarbonate (Armicarb) and potassium phosphonate (Resistim) in 2004. These products were applied in combination with sulphur according to the scab warning system, Rimpro. The efficacy was as good as or even better than low-rate copper treatments or sulphur applied alone. Similar results are reported by Heyne et al., 2006, Kelderer et al., 2006 and Tamm et al., 2006. Also the compound E73 showed a better efficacy in a tank mix schedule with sulphur than the low-rate copper treatment or sulphur applied alone.

However, flower phytotoxicity occurred in treatments with potassium bicarbonate and potassium phosphonate. Also fruit russet was noted with potassium bicarbonate and E73. Non the less, both potassium phosphonate and E73 treatments resulted in higher percentages of first class fruit than the low-rate copper treatment. Unfortunately, residues of potassium phosphonate were found in wine from vine yards treated with this product. Therefore, further research with potassium phosphonate was abandoned.

Efficacy of potassium bicarbonate (Armicarb) will be investigated further to facilitate registration of the product in Europe (Tamm et al., 2006).

Antagonists against conidia
Various fungi were isolated from leaf samples with sporulating *V. inaequalis* lesions. From 159 fungal isolates tested so far in a screening programme, forty nine isolates were excluded from further testing because of potential risks for human health or because of low economic potential. Remaining isolates are now being tested for there potential to suppress sporulation of *V. inaequalis*.

First results showed that 13 fungal isolates suppressed sporulation of *V. inaequalis* by at least 80 % in experiments with apple seedlings under controlled conditions. This potentially creates an opportunity to slow down a summer epidemic of apple scab in future.

Antagonists to prevent ascospore formation
The presence of endophytic bacterial and fungal communities was demonstrated inside leaves with or without scab lesions in autumn. 16S-rRNA and ITS DGGE fingerprints of apple leaves were performed to describe the composition of these microbial communities. Sequence types were correlated with produced numbers of ascospores of *V. inaequalis*. Multivariant analysis indicated that some of the endophytic micro-organisms present in atumn-leaves were correlated with reduced number of ascospores in following spring. Moreover, the autumn treatment of leaves with amino acids (Aminosol) seemed to promote the proliferation of an endophytic fungal sequence type F56.1. Future sequencing of bands from fingerprints will reveal the identity of potential antagonistic endophytes.

Leaf degradation
Coniothyrium minitans, a well known antagonist, retarded leaf degradation during winter compared to untreated leaf litter and had no effect on ascospores. Also beet pulp (Vinasse), at a high dose rate, retarded leaf degradation during the winter of 2004-2005. Leaf degradation seemed to accelerate with increasing dose rate of beet pulp during the winter of 2005-2006.

Ascospore production of *V. inaequalis* was reduced only by beet pulp treatments during autumn 2004. However, the number of produced ascospores was lower with urea than beet pulp. And also, leaf degradation was faster with the non-organic product urea than with beet pulp.

Addition of extra earthworms to small plots in the field substantially accelerated leaf degradation.

Earthworms
There is a tendency that amino acids (Aminosol) and beet pulp (Vinasse) promoted leaf consumption by the earthworm *Lumbricus terrestris* under controlled environmental conditions. This leaf-eating earthworm is commonly present in orchards. For beet pulp, this was especially the case when the dose was increased or when it was freshly applied. In this way, earthworms might be stimulated to consume more leaves, at a faster rate in orchards and contribute to low inoculum orchards.

CONCLUSIONS

Substantial progress is made in selection of potential products with good efficacy against summer epidemics. A patent application is made for E73. New effective biocontrol agents are selected to reduce inoculum during winter. The product Armicarb has shown good efficacy and Repco contributes to the registration of this product in Europe.

ACKNOWLEDGEMENT

This work is funded by the European Commission (Project No 501452; Repco).

REFERENCES

Heyne, P., Kruse, P. and Maxin, P. (2006). In "Proceedings 12th International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit Growing", pp. 98-100, edn Fördergemeinschaft Ökologischer Obstbau e. V.: Weinsberg, Germany.

Kelderer, M., Casera, C. and Lardschneider, E. (2006). In "Proceedings 12th International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit Growing", pp. 93-97, edn Fördergemeinschaft Ökologischer Obstbau e. V.: Weinsberg, Germany.

Tamm, L., Amsler, T., Schärer, H. and Refardt, M. (2006). In "Proceedings 12th International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit Growing", pp. 87-92, edn Fördergemeinschaft Ökologischer Obstbau e. V.: Weinsberg, Germany.