# Integrated disease management

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***Abstract* - Integrated disease management in organic farming combines the use of various measures. The usefulness of certain measures depends on the specific crop-pathogen combination. In many crops, preventative measures can control diseases without the need of plant protection products. However, for certain disease problems, preventative measures are not sufficient. For example, organic apple production strongly depends on the multiple use plant protection products.**[1]

## INTRODUCTION

Disease management in organic cropping systems combines various components which can be divided into strategic preventative measures, tactical preventative measures and control measures. For each crop-pathogen relationship and cropping system such components will contribute to different extent to disease management (Termorshuizen, 2002). The development of integrated disease management systems depends on thorough knowledge of the cropping systems as well as of the pathogen and can only be achieved by interdisciplinary research.

## PATHOGEN CHARACTERISTICS AND DISEASE MANAGEMENT

Host-specificity and mobility are the two main characteristics of pathogens determining the choice of disease management measures (Wijnands et al., 2000). Strictly host-specific pathogens which are not mobile can be controlled by using cropping systems with low frequencies of the susceptible crop. Examples are cyst nematodes of potato or sugar beet. Pathogens which are not host-specific and not mobile can be controlled by the choice and sequence of crops grown in the rotation supported by preventative measures increasing soil suppressiveness and plant health. Examples are the soil borne pathogens *Sclerotinia sclerotiorum* and *Rhizoctonia solani*. Host-specific pathogens with high mobility such as *Phytophthora infestans* in potato cannot be controlled by crop rotation. Preventative measures are sanitation in a cropping area and the choice of crop structure and planting date in combination with resistant varieties. In many situations also control measures such as applications of plant protection products may be needed to achieve sufficient yield. Also pathogens which are not host-specific but highly mobile cannot be controlled by crop rotation. Disease prevention depends on strengthening the crop, escaping the disease by choosing proper seeding dates and creating an open crop structure. Disease control by using crop protection products may be needed in many cases. Example for a mobile pathogen with a broad host range is *Botrytis cinerea* causing grey mould in various crops such as beans, peas, strawberries, grapes and many other crops.
How differently various measures contribute to disease management in different crop-pathogen relationships will be illustrated by the comparison of two systems. In wheat, various *Fusarium* spp. can cause Fusarium Head Blight (FHB) leading to a decrease of yield and, more important, the production of mycotoxins in the grain. *Fusarium* spp. have a broad host range and also can survive saprophytically. Mobility of spores of most *Fusarium* spp. is low. In apple, *Venturia inaequalis* can cause apple scab on leaves and fruit resulting in reduced yields and quality of fruit. The pathogen is strictly host-specific and can survive only on apple tissues. The mobility of spores is low.

## STRATEGIC PREVENTATIVE MEASURES

Many measures for preventative disease control have a long-term strategic character. Various aspects of the farm management and the long-term cropping system as well as of the location including the farm neighbourhood have impact on diseases of crops and thus should generally be considered in integrated disease management.

*Avoidance of pathogen sources in neighbourhood of field and crop rotation in neighbouring field.* Since most *Fusarium* spores travel only a few centimetres, sources in the crop neighbourhood will not cause epidemics. Ascospores of *V. inaequalis* produced in neighbouring orchards may reach the crop. Abandoned orchards and orchards with high apple scab pressure should not be found in the neighbourhood of an apple orchard.

*Soil structure, soil suppressiveness, biological soil disinfection, and catch crops*. These measures are important for managing soil borne diseases but will have no direct effect on the above-ground development of *Fusarium* spp. and *V. inaequalis*.

*Crop rotation.* Main inoculum source of FHB are crop residues of preceding diseased crops. The best documented example is the high risk of FHB when wheat is grown after maize. Maize stubble are often colonised by the same *Fusarium* spp. affecting wheat and such *Fusarium* spp. can survive and multiply on maize stubble for several years. Avoiding growth of

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maize in rotation with wheat will substantially reduce risks of FHB epidemics. Rotation schemes with cereals grown after cereals should generally be avoided. In the perennial apple production crop rotation is no issue.

*Tillage.* Primary inoculum of FHB are crop residues left on the soil after tillage. Using reduced tillage systems will increase FHB risks since much more residues will be present on the soil surface. In apple orchards, tillage is not an option.

### Tactical preventative measures

Tactical preventative measures deal with the planning and realisation of a certain crop. Typical measures are the choice of variety, seed quality, seeding time and crop structure.

*Resistant varieties.* In wheat, resistance breeding made considerable progress and partly resistant cultivars are used in practise. In apple, partly resistant varieties are available. However, the pathogen has the potential to adapt. Furthermore, changing varieties in a perennial crop needs high investments.

*Removal of crop residues from field*. *Fusarium* spp. threatening wheat crops are surviving primarily in stubble of cereals including maize. Removing this potential inoculum sources is not feasible, although physical removal especially of maize stubble may have a significant impact on disease development. In apple, removal of fallen leaves as the principle inoculum source of apple scab in spring is an interesting option. Removal of leaves by using specially designed vacuum cleaners has been demonstrated. However, mechanisation is difficult, cost intensive and application depends much on orchard circumstances.

*Biological crop residue treatments.* Microbial decomposition of crop residues is a natural process which can be supported by adding stimulating nutrients or selected micro-organisms. Also earthworms can be protected and stimulated to consume plant residues on the soil surface. Both possibilities are under investigation for apple scab prevention in REPCO. In arable crops, stimulation of resident microbial populations on residues may be achieved by creating a suitable microclimate, e.g. by using mulches.

*Healthy seeds and planting material*. Seeds of wheat can be infected by *Fusarium* spp. Producing healthy seeds is important to guarantee the establishment of a vigorous crop. For the development of FHB epidemics after flowering, the major inoculum sources are infested crop residues and thus field-borne. Reducing the seed-borne fraction of the disease inoculum may only have very limited effect against FHB. Using clean planting material of apple will not result in any disease prevention since *V. inaequalis* overwinters on the orchard floor and easily can enter disease–free young trees.

*Sowing time*. For infections of wheat ears by *Fusarium* spp., the crucial factor are the climatic conditions during the short window of flowering. Choosing early or late sowing times is not an option for disease prevention since weather during flowering cannot be predicted. Also for apple, no effect of planting time on apple scab can be expected.

*Crop structure*. Crop structure affects microclimatic conditions within the canopy and determines the distance pathogen spores have to spread to reach susceptible host tissue. A dense wheat crop will favour pathogen sporulation on the soil, but may block spore flights of *Fusarium* spp. depending mainly on splash dispersal during rainfalls. Vertical leaf positions may also block spore flights. Ears on taller plants may have a better change to escape infections which may have a moderate effect on FHB. The canopy structure of apple trees is managed to obtain sufficient yield and possibilities to create more open canopies are limited. Spores of *V. inaequalis* are very much adapted to infect trees and spread from orchards floors and within canopies. Possibilities to manage the apple scab by crop structure are low.

### Disease control measures

Disease control measures are used to control a certain disease of a crop. Physical, chemical or biological control measures may be used.

*Physical treatments*. *Fusarium* spp. on seeds can be controlled by warm water treatments. However, the effect on FHB will be limited.

*Natural compounds and biocontrol agents as plant protection products.* The control of FHB does not depend on plant protection products since preventative measures such as rotation, and tillage can be used. In apple, preventative measures such as removal of fallen leaves can delay the outbreak of epidemics. However, epidemics need to be controlled by multiple applications of plant protection products such as copper. Environmentally friendly new products are strongly needed.

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### References

Termorshuizen, A.J. (2002). In "Plant Pathologist's Pocketbook", pp. 318-327, eds, J.M. Waller, J.M. Lenné and S.J. Waller. (CAB International, Wallingford, UK).

Wijnands, F.G., Sukkel, W. and Booij, C. (2000). In "Biologisch bedrijf onder de loep: Biologische akkerbouw en vollegrondsgroenteteelt in perspectief", pp. 65-71, eds. F.G. Wijnands, J.J. Schröder, W. Sukkel and R. Booij. (Praktijk Onderzoek Plant en Omgeving, Lelystad, The Netherlands).