Challenges of Organic Arable Farming

3rd module: Monitoring, preventive and curative measures for pest and disease management

    

Module description and objectives

- Increasing the resilience of a cropping system is a major goal for organic farming in order to maintain productivity and crop health. In order to design organic production systems that are more resilient to disease and pest attacks, it is essential to provide a range of component strategies and combine different approaches, including new plant protection products, decision support systems and cropping systems adapted to specific crops and conditions.

- The objective of the module is to deliver a set of measures to be applied by organic farmers in order to efficiently manage diseases and pests, with an emphasis on system resilience and prevention. Special attention will be given to the replacement of copper compounds. Tools provided will offer some alternative methods in disease and pest control.

Module outline

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2 – Resilience of cropping systems	
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5 – Practical examples of pest and disease management	
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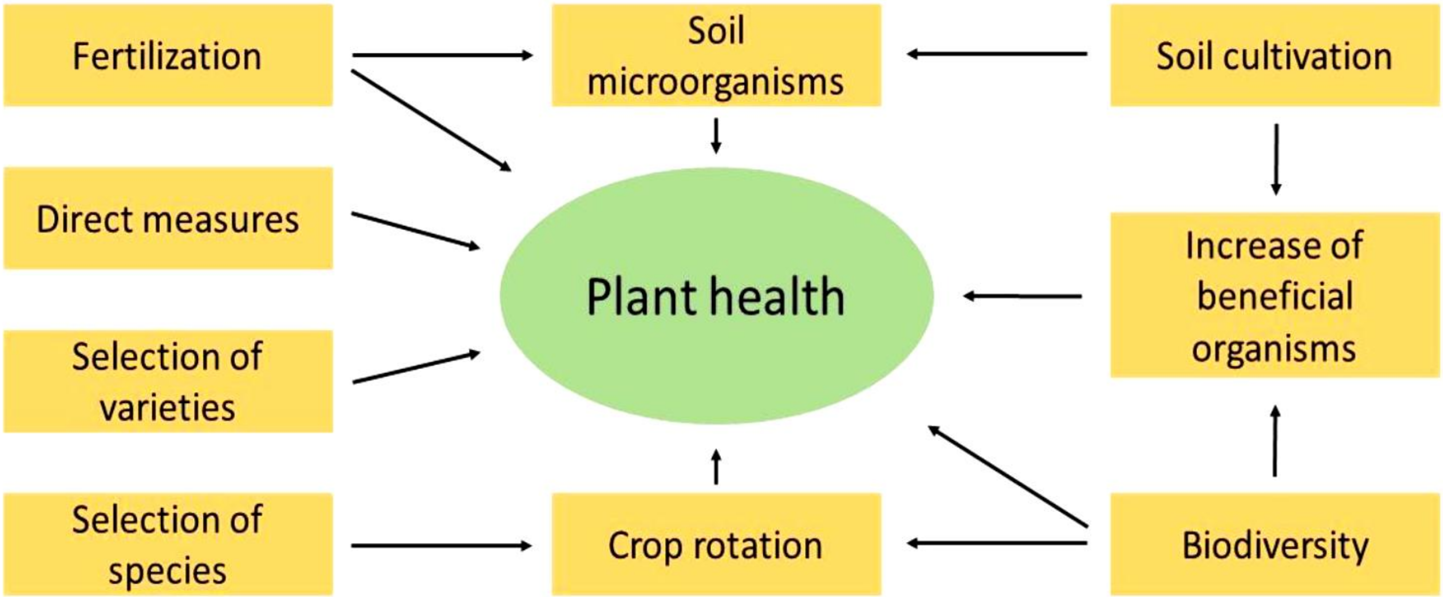
Introduction

In organic agriculture, all preventive measures to support plant health and productivity should be exploited first, before implementation of direct control measures. Since the occurrence of diseases depends on many factors (e.g. cultivar susceptibility, pedoclimatic or general weather conditions, etc.), the risk and virulence of diseases may vary in different environmental conditions and cropping systems.

Organic farmers face the same potentially severe pest problems as their colleagues in integrated pest management (IPM) and conventional crop farming. However, approaches to manage insect pests are different. In organic cropping systems farmers are supposed to apply preventive measures to keep pests abundance under damaging levels, thus minimizing the need for direct and curative pest control.

Here is very important to take into account regional and cultural differences as well as the economic realities and the local regulatory framework.

1. The concept of plant health in organic agriculture



The figure above illustrates the importance of the holistic approach in organic farming. We should take in consideration that not every farm can implement the entire **know-how** of disease and pest prevention. Sometimes, lowering a risk may enhance the risk for another disease and pest to arise. Eventually, certain weather conditions, the development of resistance, and other factors may lead to disease and pest outbreaks even when all possible preventive measures have been taken into account.

2. Resilience of cropping systems

- Increasing the resilience of a cropping system involves the increase in the ecosystem diversity through the establishment of non-crop habitats and biotope networks.
- Secondly, farmers can reduce damages by rotating crops, increasing crop diversity, planting at the right time, harvesting, transplanting, weed management, choice of resistant varieties, and by avoiding growing areas with high pest and diseases pressure.
- The combination of all these measures creates a broad and solid basis for healthy plant development, while direct control measures can be applied in case of threatening pest and diseases outbreaks.

3. Disease control
3.1 Preventive measures

Prevention is a key strategy for organic producers, since diseases can rapidly spread and their control can be difficult if farmers only resort to organic pesticides.

- For several crops and diseases, the risk of infections by plant pathogens can be lowered by the use of less pathogen-susceptible, tolerant and resistant varieties. However, resistant varieties are not available for all diseases.
- Local participative breeding programs for cultivars for niche markets are very interesting (Lammerts van Bueren *et al*., 2015).
- Seeds infested with pathogens are a major source of disease outbreaks in many arable crops. This can be avoided by the use of certified seeds. When seeds are produced on farm, they should be inspected and, if infested, they need to be treated by appropriate methods such as heat or PPPs suitable for organic farming.

3.2 Cultural measures

The implementation of optimal **crop rotations** is another important measure to reduce the risk of disease build-up. In cases of pathogens that can survive for several years in the soil, rotation breaks of several years for the same crop are necessary. For example, to avoid infection with *Sclerotinia sclerotiorum* in soybean or other legumes, cultivation breaks of at least 4 years should be performed for these crops and other host plants of the pathogen, such as sunflower and rape seed.

Tillage, such as deep ploughing after harvest, is a general measure to reduce inoculum for the next season, e.g. for infection structures of *S. sclerotiorum* or for pathogens causing seedling diseases in sugar beet. However, tillage choice will be influenced by soil type and trade-offs with soil organic matter storage, greenhouse gas emissions and weed management. We should also keep in mind that deep ploughing is in conflict with soil conservation and such aspects need to be considered as well.

3.3 Plant protection products (PPPs)

The use of PPPs authorized under organic farming is often the only way to restrict the spread of causal agents of diseases, thus helping maintain productivity. The number of PPPs allowed in organic farming is small with respect to the overall number of PPPs on the market.

All PPPs sold and used in the European Union have to be registered (Regulation (EC) 1107/2009). Products registered for organic farming need additional approval (Regulation (EC) 834/2007).

For many diseases, direct measures are not available. Hence, there is a strong need for the development of new alternative compounds.

We need to considered that the development of a compound, its registration and final market introduction generally takes much more than 10 years. This needs to be considered by farmers, when planning strategies for disease and pest control and by decision-makers when discussing future policies.

3.4 Challenges of the replacement of copper compounds

Copper-based products are among the most used PPPs to control downy mildews and many other diseases. To date, cupric fungicides or bactericides are still of high importance in organic (and integrated) production systems.

The European Union policies aim at the promotion of sustainable, quality-based agricultural production and at limiting environmental risks especially regarding soil contamination. Since copper can accumulate in soils (AGES, 2011) and have adverse effects on the environment (Kula *et al.*, 2002), there is an urgent need to reduce the dependency of organic (and low input) farming systems on copper use.

Currently, for organic farming, copper is registered in the EU until 2018.

3.4 Challenges of the replacement of copper compounds

The maximum amount of copper allowed by the EC for use in arable crops (e.g. potatoes) is 6 kg/ha per year. On a national basis, countries and organic farmers' associations have restricted themselves to lower amounts of copper, such as e.g. a maximum of 4 kg/ha per year in Switzerland or 3 kg/ha per year in Germany. Some countries, such as the Netherlands, or organic associations like Demeter do not allow the use of copper-based PPPs at all.

Copper-reduced or copper-free production systems may be achieved by:

- Reducing the dependency of agricultural systems on PPP use by increasing the intrinsic tolerance of the production system (e.g. use of disease-resistant/tolerant cultivars and/or reduction of disease pressure);
- Providing decision support systems - DSS, (e.g. Öko-SIMPHYT or Bio-PhytoPRE) that facilitate optimal application of PPPs;
- Providing alternative compounds with a similar range of activity as copper.

3.4 Challenges of the replacement of copper compounds

With respect to research on copper reduction/replacement, several international and national research projects were carried out or are in progress:

- Blight-MOP12
- Repco13
- CO-FREE14

In organic arable crops, copper-based PPPs play a major role in the control of *P. infestans* on potato. Swiss organic farmers apply on average only 2.5 kg copper per hectare and year in potatoes, although the maximum permitted quantities are 4 kg (Speiser *et al*. 2015). Their strategy for minimizing copper applications involves resistant cultivars, adaptations in crop management, optimized copper applications and the use of alternative products.

Here you will find how to reduce use of copper on potato.

4. Pests management

In arable farming, yield limitations are mainly due to diseases, insufficient nitrogen supply or weeds. Severe, unsolved pest problems only occur in oilseed rape (pollen beetle *Meligethes aeneus*, stem weevil *Ceutorhynchus* ssp., flea beetle *Psylliodes chrysocephalus*) and in potato production (wireworms, mainly *Agriotes* spp. but also others from the family Elateridae). In all other arable crops, insect pests rarely lead to severe yield losses.

Interactions between cultural practices, biotic and abiotic factors have a huge impact on plant health: the use of direct control methods can have side effects on beneficial arthropods, thus adversely affecting ecosystem services needed for pest prevention. The use of non-selective bio-pesticides should therefore be limited as much as possible.

4.1 Crop habitat management for pest control

A vast variety of measures and strategies are used for habitat management at field level (Malézieux *et al*. 2009, Parolin *et al*. 2012):

Intercropping and **mixed cropping** stand for the simultaneous growing of different harvested crop species in one field.

Under-sowing crops, often clover, are sown with or after the main crop and are not harvested; their most intensive growth occurs before covering the main crop or after harvesting it.

Companion plants are non-crop plants grown within the fields for different purposes:

1) Attraction and support of natural enemies by providing pollen and nectar (insectary plants)
2) Repellence and/or interception insect pests (repellent plants) and
3) Influence on nutrition and/or chemical defense of crop plants (Parolin *et al*. 2012).

4.1 Crop habitat management for pest control

In cabbage production, inter- and cover cropping are implemented as efficient strategy for *Delia radicum* prevention: oviposition of *D. radicum* is significantly reduced in cabbage fields intercropped with clover, because non-host plants interfere with host plant location of this specialist cabbage pest (Finch and Collier 2000, Meyling *et al*. 2013). If we keep higher weed numbers and diversity around organic farms, a similar effect can be achieved or the following solutions can be used to keep beneficial arthropods in our field:

- **Banker plants**, mainly used in greenhouse production, are a mini-rearing system for natural enemies (Huang *et al*. 2011): They supply a non-pest prey (e.g. aphids which infest the banker plant but not the crop plant) and therefore sustain the natural enemies within the greenhouse.
- **Beetle banks** – grass covered earth banks in the middle of the field – are shelter habitats that provide suitable over wintering sites for predatory carabid and staphylinid beetles or spiders (Jonsson *et al*. 2008).

4.1 Crop habitat management for pest control

- **Cover crops** are sown after harvesting the main crop before sowing the new crop mainly to prevent nitrogen leaching and soil erosion.
- **Flowering strips** usually consist of plants attractive for insects sown at field margins and aim at attracting natural enemies by providing food and shelter.
- **Barrier plants** are also sown at field margins and aim at intercepting immigrating pest insects (Parolin *et al*. 2012).
- **Trap crops or trap plants** are of preferred growth stage, cultivar or species and attract, divert, intercept, and/or retain targeted insects because they are more attractive than the main crop (Parolin *et al*., 2012).

4.2 Cultural pest management

Cultural control practices aim at prevention, avoidance or suppression of pests by creating conditions that are detrimental to the pest or favorable to natural enemies (Hill, 2014). Optimal and expedient implementation of cultural practices requires in-depth knowledge of pest biology and careful long-term planning.

Cultural practices for pest control include crop rotation, sanitation, use of healthy seed and planting material, choice of adapted/resistant/tolerant cultivars, agronomic measures aiming to improve soil quality and functioning (minimum tillage, animal and green manure, compost) as well as agronomic measures favouring healthy plant development (irrigation, optimal nutrition, weed management, row spacing) and adapted timing for planting or harvest in order to disrupt the crop-pest phenological synchrony.

4.2 Cultural pest management

Crop rotation for pest control is useful against pests which have a narrow host range and a limited dispersal ability. For instance, maize rootworm (*Diabrotica* spp.) is efficiently controlled by a three-year rotation. Crop rotation is also an important control method for the cabbage pest *Contarinia nasturtii*, which overwinters in the soil of the previous crop and migrates over less than 100 m. In addition, there are indirect effects of crop rotation on pest incidence: legumes in a crop rotation are an important source of nitrogen and nitrogen availability influences and often increases susceptibility of plants to pest damages.

Fertilization can have a significant impact on pest occurrence. Examples from few studies follow: in cabbage production, lower densities of flea beetles, aphids, and caterpillars were observed on organically manured plants compared to chemically fertilized and unfertilized plants (Arancon *et al*. 2005, Culliney and Pimentel 1986). Phelan *et al*. (1995) showed that females of European corn borer preferred plants in conventional soils for oviposition.

4.2 Cultural pest management

Physical methods of pest control include nets, fences, particle films, or inert dusts (Vincent et al. 2003). Crop netting is used in cabbage production against *C. nasturtii*, *D. radicum*, Lepidoptera or flea beetles *Phyllotreta* sp.. Although this method is highly efficient, it has the disadvantage of excluding natural enemies from the crop.

In oilseed rape production, the good efficacy of inert dusts (i.e. clinoptilolithe) against pollen beetles was shown to increase yield by 23% (Daniel *et al*., 2013). Kaolin particle film technology has been developed for fruit production (Daniel *et al*., 2005) but was recently registered for pollen beetle control in Switzerland (Dorn *et al*., 2014).

Here you will find practical information about the use of rock dust against the rape pollen beetle.

4.2 Cultural pest management

Different **other agronomic measures** are used in order to reduce or avoid pest damage:

- **Certified seed and planting material** are a prerequisite for healthy plant development.
- **Adapted timing for planting or harvest** can disrupt the crop-pest phenological synchrony; two examples follow:
  - In areas with high pressure of the Swede midge (*C. nasturtii*), Broccoli is mainly produced in spring and autumn instead of summer. During summer, cauliflower which is less susceptible to the Swede midge is produced as substitute.
  - Damage by autumn oilseed rape pests, such as flea beetles (*Psylloides chrysocephala*) or *Athalia rosae*, is lowered by early sowing and by creating conditions favorable for rapid plant development.

4.3 Insecticides

Insecticides for organic farming are of natural origin. For example:

Neem can be used against *Aleyrodes proletella*, but the efficacy is only sufficient if drop-leg technology for under–leaf application is used.

Spinosad is used against different Lepidoptera larvae, thrips, *C. nasturtii*, and *D. radicum*.

The advantage of most natural products lies in their lack of persistence and bioaccumulation in the environment, because they generally degrade faster in sunlight, air and moisture than synthetic products.

However, some insecticides used in organic farming (such as spinosad and pyrethrum) can have detrimental side effects on non-target organisms. Hence, all efforts to establish conservation biological control can be annihilated. In order to avoid negative impact of direct control measures on ecosystem functionality, selective methods for pest control should be preferred and the necessity of applications should be carefully assessed.

4.3 Insecticides - Biorationals

Insecticides vary in their toxicity to people and to non-target organisms, and in their potential ecological impact. The term "Biorational" has been recently proposed to describe those insecticides that are effective against the target pest but are less detrimental to natural enemies.

At the beginning the term was used to describe only those products derived from natural sources, i.e. plant extracts, insect pathogens, etc. Later on, a common way to define a biorational insecticide was "*any type of insecticide active against pest populations, but relatively innocuous to non-target organisms and, therefore, non-disruptive to biological control*".

Here you will find the database that farmers can use by selecting Pest Type, Pest Name, Active Ingredient or Beneficial Organism or Pesticide Trade Name to obtain a list of appropriate biorationals, their efficacy and possible side effects.

5. Example - Potato

Specific problems for potatoes are Colorado potato beetles (*Leptinotarsa decemlineata*). Early-maturing varieties and quick emergence help prevent the infestation by the beetle. Other preventive steps avoid both volunteer seeds to emerge and adjacent fields with potatoes in the last year. In addition, insecticides may be used to prevent economic losses in organic farming. The combination of Neem (NeemAzal-T/S) + B.t.t. (Novodor FC) achieved good control of young larvae.

Wireworms, the larvae stage of click beetles (*Elateridae*), are other serious potato pest. Different agronomic practices or the use of pheromone traps can reduce the damage of wireworms. Furthermore, between entomopathogenic fungi and the insecticide Spinosad, synergistic effects were observed.

Here you will find a video that integrates many aspects for control of wireworms in organic potato cultivation.

5. Examples - cereals

	• Disease	Solution
All Cereals	• Blotch (*Septoria* spp.) • Take-all (*Gaeumannomyces graminis*) • Powdery mildew (Erisyphe/Blumeria f. spp.) • Rust (*Puccinia* spp.) • Ergot (*Claviceps purpurea*)	Testing own seeds and if needed: • Treatment with warm or hot water or dressing with Tillecur®, Cedomon® and Cerall® • Certified seed 4, 5 • Resistant varieties

Here you will find booklet on the risks that may occur in the production of small grains, from sowing to harvest and storage.

5. Examples - legumes

Legume cultivation is subject to **problems** like **"clover fatigue"**, a generic term for growth problems in clover. This phenomenon reduces the input of nitrogen from the grass-clover leys to the arable crops.

The most used practice to tackle this problem is cultivation break to decrease infestation levels into the soil.

Here you will find simple testing method that can be easily adopted by farmers to examine the soil for legume-fatigue symptoms.

5. Examples - legumes

	• Disease	Solution
Grain legume crops	In legumes in case of soil fatigue, possible pathogens are: • *Verticillium* spp. • *Sclerotinia* spp. • *Fusarium* spp. • *Rhizoctonia* spp.	• Crop rotation • Fertilization with compost • Cultivation of beneficial plants, e.g. biofumigation with mustard (*Brassica juncae*)

Pests examples: Fava beans and peas can be infested by aphids and thrips, which usually remain below the economic threshold. Aphids can be controlled by neem applications. Severe damage to fava beans and peas can be caused by the pea weevil *Sitona* sp., especially in spring and early-summer under hot and dry weather conditions. In order to limit their damages, intercropping peas with mustard or phacelia is effective.

5. Examples – carrots and cabbage

	Disease	Solution
Carrots	• Carrot leaf blight (*Alternaria dauci*)	• Crop rotation • Resistant varieties • Certified seed • Fungicide: Cu-preparations, Serenade (*Bacillus subtilis* QST713)
Cabbage	• Black rot (*Xanthomonas campestris*) • Clubroot (*Plasmodiophora brassicae*)	Blackrot: • Avoidance of other cruciferae nearby • Plant density <4 plants/m Clubroot: • Increase pH above 7 with lime • In case of occurrence, cultivation break of all cruciferae for at least 7 years

Future prospects in diseases and pest management in organic arable farming

- Currently, organic farming still largely depends on varieties bred by conventional breeders. Nevertheless, further activities with respect to breeding of varieties especially suitable for organic farming should be intensified.

- As pest and disease problems do not end at farm gates, a closer collaboration between neighbouring farmers could tackle pest problems at regional scale and might increase the impact of conservation biological control and cultural measures. Regional control measures, especially for highly mobile pests, will play a bigger role in future pest control.

- In order to fully exploit the benefits of functional agro-biodiversity, the use of non-selective insecticides that are also used in organic agriculture has to be reduced. This can only be achieved if tolerant and resistant cultivars are planted.

Additional tools

Here some additional tools that concern this module, available in other languages:

- Manual for potato management / German
- Agrometeo: decision support tool for pest prognosis and risk assessment / German / French / Italian
- Atlas of agricultural entomology - a knowledge base of pest insects / Italian
- Description of biological control agents and agro-environmental measures for plant protection / Polish
- ECOPHYTOPIC – The portal for integrated crop protection of arable crops / French

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Enjoy the module!