Session 2.3: Pest, disease and weed control

Key learning points

- ❒ Control methods
- ❒ Management programmes using chemicals
- ❒ Biological control
- ❒ Integrated pest management
- ❒ Fumigation and soil disinfection (solar, physical, chemical)
- ❒ Soil and water contamination

Main objectives of the session

At the end of the session participants will be better able to:

- ❒ Understand the different methods available for pest, disease and weed control
- ❒ Select and apply chemicals effectively
- ❒ Understand national and European legislation and guidelines for chemical application, monitoring and contamination modelling
- ❒ Use preventative and integrated pest and disease control methods
- ❒ Effectively apply biological control methods
- ❒ Fumigate and disinfect soils

2.3.1 Control methods

The most important pests attacking fruit and vegetables are insects, nematodes, birds and mammals. Diseases included viruses, bacteria and fungi and all of which result in lower yields and reduced product quality. Weeds also compete with plants for light, water and mineral nutrients. All will result in yield losses if not properly controlled.

According to new trends in plant pathology, disease, pest and weed control can involve combining agronomic, physical, chemical, biological and biotechnological methods.

Agronomic methods are essentially part of the cultivation practice, such as: varietal selection, crop rotations, cultivation or pruning. For example, it is not good practice to follow a potato crop with another potato crop and so pass on or spread parasites and diseases, such as blight, black scurf, potato cyst nematode or cutworms.

Physical methods act both directly on the pathogen as well as indirectly by eliminating the conditions for its development (such as by the sterilisation of soils, protecting of pruning wounds with mastics or solar heating).

Chemical methods make use of active ingredients that act against the pathogen. The main categories are, fungicides, insecticides, miticides, nematocides and herbicides.

Biological methods include both direct interventions on the host through genetic improvements and direct interventions on the parasite by increasing their natural predators.

Biotechnological methods comprise essentially of the use of special substances (such as pheromones) that make it possible to monitor potentially harmful insects.

2.3.2 Management programmes using chemicals

Life cycles for most weeds are short and in warm weather are frequently no longer than six weeks from germination until flowering. Large numbers of seeds can be produced by a single plant, frequently in excess of 2000, and efficient dispersal mechanisms can guarantee the rapid spread of a weed. Another aspect of weeds is their ability to survive. Many can remain dormant for long periods before emerging when conditions are favourable. Crops weakened by competition from weeds are more likely to be susceptible to attack from pest and diseases.

Pests and diseases are among the most important causes of yield and quality losses in horticultural crops. Productivity is decreased by damage to seeds and tubers, by loss of vigour in growing crops and by deterioration in store. Also, the marketability of fruits and vegetables is largely dependent on their appearance, so the value of the crops, and thus the profitability of the farming enterprise, is dependent on effective control of pests and diseases.

Herbicides can be used to kill unwanted weeds, fungicides most plant diseases and insecticides most pests. These may be selective or non selective in their action. Non selective applications have a role to play in cleaning uncropped areas but in most cases growers prefer selective remedies and based on solving an identified problem. Unfortunately selectivity depends on a number of factors, some of which are outside the growers control, including the type of chemical, its concentration, the crop, its stage of growth, the soil type, weather conditions, soil moisture and temperature, the type of weed, pest or disease and the stage of growth.

Chemicals may be applied to either the soil or to the plant. In some cases they may also be applied to the seed prior to planting and can be applied in a number of different formulations. Over use of chemicals can result in long term concentrations that will effect future cropping programmes, it can also result in residual levels being retained on harvested crops.

Where chemicals are used they are effective only if they are applied at the right time, in the exact dosage, and if the entire field is uniformly covered. Normally chemical suppliers will supply a list of chemicals for specific crops, pest and diseases and provide detailed schedule of applications. An example of muskmelon is shown below:

AGROIAMPIERI

Pest and diseases form for **MUSKMELON** june 20, 2001

		TIME			AGENT	PRODUCT	DOSE*	SHORTAGE days	CLASS.	NOTES
		Planting	Growth	Harvest.						
PESTS	*Wireworms*	x			Etoprofos	ETOPROSIP 10 G	30-40 kg/Ha	-	Xi	
			x	x	Furatiocarb	DELTANET	10 kg/Ha	-	Xi	
		x			Teflutrin	FORCE	15-20 kg/Ha	-	Xi	
	Miners		x	x	Azadiractina	OIKOS	1-1,5 l/Ha	3	MCP	
		x	x		Bensultap	STILL 50 WP	0,75-1 kg/Ha	7	N	
			x		Ciromazina	TRIGARD 75 WP	0,3-0,4 kg/Ha	14	Xi	
			x		Dimetoato	ROGOR L 40 e altri	0,75-1,5 l/Ha	20	N	max 3 treatments until 30 days before harvest
			x		Malation	SMART EW	1,5-2,5 l/Ha	20	-	
	Aphids		x	x	Pymetrozine	PLENUM	0,6-0,8 kg/Ha	3	-	
			x		Imidacloprid	CONFIDOR 200 SL	0,5 l/Ha	7	-	
			x		Dimetoato	ROGOR L 40 e altri	0,75-1,5 l/Ha	20	N	max 3 treatments until 30 days before harvest
			x		Fenitrotion	AFIDINA M e altri	1,5 l/Ha	20	N	max 2 treatments
			x		Fluvalinate	KLARTAN 20 EW	0,3-0,6 l/Ha	7	Xi	
			x		Pirimicarb	PIRIMOR 17,5	2 kg/Ha	14	-	
			x		Eptenofos	HOSTAQUICK	0,7-1 l/Ha	3	N	
	Slugs		x		*Bacillus turingensis*	LEPINOX e altri	1-2 kg/Ha	3	Xi	
			x		Dimetoato	ROGOR L 40 e altri	0,75-1,5	20	N	max 3 treatments until 30 days before harvest
			x		Fenitrotion	AFIDINA M e altri	1,5 l/Ha	20	N	max 2 treatments
			x		Fosalone	ZOLONE L34 e altri	1,5-2 l/Ha	21	N	
	Snail		x		Metaldeide	GASTROTOX E e altri	6-7 kg/Ha	20	-	
			x		Metiocarb	MESUROL N ESCA	6-10 kg/Ha	21	-	located treatment
	Red spider		x		Bromopropilato	NEORON 25	2 l/Ha	21	-	
DISEASES	*Oidium*		x	x	Zolfo	PRODOTTI DIVERSI	-	5	-	
			x		Esaconazolo	ANVIL	0,5-0,7 l/Ha	7	Xi	
			x		Fenarimol	RUBIGAN 12 SC	0,4 l/Ha	7	-	
			x		Penconazolo	TOPAS 10 EC	0,3-0,5 l/Ha	14	-	
			x	x	Zolfo	PRODOTTI DIVERSI	-	5	-	
	Blight		x	x	Anilazina	DYRENE SC	2-4 l/Ha	10	Xi	
			x	x	Azoxistrobina	ORTIVA	0,7-0,8 l/Ha	3	-	
			x		Clortalonil**	DACONIL 75 WG	1,5-2 kg/Ha	14	N	max 2 treatment until 40 days before harvest
			x		Fosetil-alluminio	ALIETTE	2,5 kg/Ha	15	-	
			x	x	Rame Solfato	PRODOTTI DIVERSI	-	20	-	
			x		Dimetomorf	FORUM R	3,5 kg/Ha	20	Xi	
			x		Cimoxanil	CURZATE R	2-3 kg/Ha	20	Xi	
	Sclerotinia		x		Dicloran	SCLEROSAN 50 PB	1,5-2 kg/Ha	20	-	
	Rubber cancer		x		Clortalonil**	DACONIL 75 WG	1,5-2 kg/Ha	14	N	max 2 treatment until 40 days before harvest
WEEDS		x			Glifosate	ROUNDUP BIFLOW	1,5-3 l/Ha	-	-	
		x			Glufosinate ammonio	BASTA	5-7 l/Ha	-	-	
		x			Trifluralin	TRIFLURALIN N 46	1-2 l/Ha	30	-	
			x		Fluazifop-p-butile	FUSILADE	1,5-2,5 l/Ha	30	Xi	
			x		Setossidim	FERVINAL	1,2-2,5 l/Ha	-	Xi	

Notes:

* 10 000 litres/1 ha of solution

** Clortalonil: Zero residues

The machinery used for applying chemicals can be divided into three categories, sprayers, dusters and fumigators. Sprayers are used to apply pesticides in a liquid state, dusters make it possible to spread them in a powdered state, and fumigators are used to introduce into the soil chemical products capable of spreading in a gaseous form.
Sprayers are the most common type used in horticulture and for fruit crops, and may be further divided into three types, mechanical atomisers, pneumatic atomisers and mixed atomisers. In mechanical atomisation sprayers the flow of liquid is broken up by nozzles placed along a horizontal bar set 80 – 100 cm from the crop. In pneumatic atomisation sprayers the flow of liquid is broken up by a very high-speed jet of air generated by a

centrifugal fan and in mixed atomisation sprayers the flow of liquid is broken up by nozzles and is assisted by a strong current of air generated by an axial flow fan.

By their very nature chemicals used are potentially hazardous and their application can have adverse effects well beyond their intended target. Only chemical formulations from reputable and known manufacturers and suppliers should be used. The use of pesticides must be regulated by good safety practices for the protection of both the operator and the environment. It is important that individual protection devices are worn during application, such as masks, goggles, gloves and protective clothing. The machines used for application should also be checked and inspected by an authorised workshop. Before beginning treatment data must be collected in case of possible problems. Most reputation chemical manufacturers will provide this information to the buyer and it should be included in all labelling and supporting information materials.

Case study

Blitecast

This computerised system has been available to growers since 1983 and is a programme for forecasting potato late-blight epidemics based on maximum and minimum temperatures, rainfall and relative humidity. Depending on conditions, growers are advised to postpone spraying, to be alert to potential blight favourable conditions, or to spray every 5 or 7 days.

2.3.3 Biological control

Organic farming systems also have to be carried out in a way that ensures that losses from pests, diseases and weeds are minimised. Emphasis is placed on the use of crops and varieties well adapted to the environment, such as developing a balanced fertilisation programme, fertile soils of high biological activity, adapted rotations, companion planting and green manures. The aim is to ensure that growth and development take place in a natural manner.

Weeds, pests and diseases can be managed by a number of preventive organic techniques which limit their development, e.g. suitable rotations, green manures, a balanced fertilisation programme, early and pre-drilling seedbed preparations, mulching, mechanical control and the disturbance of pest development cycles. The natural enemies of pests and diseases can be protected and encouraged through proper habitat management of hedges and other breeding sites and pests further regulated by understanding and disrupting their own ecological needs.

Monocultures are almost invariably prone to disease. Exposed fields and concentrations of a single crop species open the way for pest infestations by providing concentrated resources and uniform physical conditions that encourage insect invasions. The abundance and effectiveness of predators are reduced because these simplified environments provide inadequate alternative sources of food, shelters, breeding sites and other environmental factors. As a result, populations of specialised pests attain economically undesirable levels.

One strategy for minimising losses from plant diseases and nematodes is to increase the species and/or genetic diversity of cropping systems. The use of non-host crops in inter-plantings can significantly reduce the rate of virus spread in the field. Certain associated plants can function as repellents, anti-feedants, growth disrupters or toxicants. In the case of soil-born pathogens, some plant combinations and organic amendments can enhance soil fungistasis and antibiosis through indirect effects on soil organic matter.

Two hypotheses explain pest reduction in poly-cultures. The first, *the natural enemies hypothesis,* predicts greater mortality of specialist and generalist insect pests in poly-cultures because of greater numbers of insect predators and parasites. Greater numbers of these natural enemies result because of the better conditions for their survival. Compared with monocultures, poly-cultures can provide more pollen and nectar sources (which can attract natural enemies and increase their reproductive potential), increased ground cover (which favours certain predators like crabid beetles) and increased diversity of herbivorous insects (which can serve as alternative food sources for natural enemies and make them less likely to leave when the main pest species are rare).

The second hypothesis, *the resource concentration hypothesis,* predicts that specialised insect pests will be less abundant in poly-cultures when the mixtures are composed of host and non-host crops. Specialist pests will have a more difficult time locating, remaining on and reproducing on their preferred hosts when these plants are more dispersed spatially and masked by the confusing visual and chemical stimuli presented by associated non-host crops.

2.3.4 Integrated pest management

Integrated pest management (IPM) systems aim to prevent pest outbreaks by improving the stability of the crop system rather than coping with pest problems after they occur. Many pest management systems are designed to suppress a complexity of pests while achieving maximum yield and quality and minimum environmental damage. These objectives may appear to conflict and when yield and market quality are overemphasised, they often do. However conflicts can be avoided when IPM systems are coordinated with more broadly related systems of land and water resource conservation, environmental protection and socio-economic development. IPM systems are designed to balance pests and beneficial organisms and based around known economic, social and ecological consequences.

Providing the right kind of plant diversity throughout the year and manipulating time of planting, size of fields and species composition of crop field borders can make habitats and food resources continually available for populations of beneficial organisms and make habitats less favourable for pests. An equilibrium of the crop fauna can therefore be established by organising the vegetational diversity within and outside the target crop fields. The following table illustrates best crop patterns according to the level of pest threat resulting from specific cultivation practices.

Figure: **Pest potential compared to cropping practice**

High pest potential → Crop species rotation

CROP ARRANGEMENT IN TIME

Monoculture → Crop species rotation
Continuous planting → Discontinuous planting
Asynchronous planting → Synchronous planting
Season favourable for pests Season unfavourable for pests

CROP ARRANGEMENT IN SPACE

Sole cropping → Row and strip intercropping → Mixed intercropping

Genetically uniform	←	Multi-lines
Low planting density	↔	High planting density
Large field	←	Small field
Large crop host area	←	Small crop host area
Host fields aggregated	←	Host fields scattered

Microbial pesticides are becoming cornerstones to integrated pest management (IPM) systems, particularly in some vegetables. Insect pathogens are safe to use and beneficial insects, and other non-target species and can often be tank mixed with commercial insecticides. Most do not become established in the field, however, and must be re-applied each time control is necessary. Since these products are living organisms, they cannot be stored at hot temperatures or below freezing. The only widely used pathogen at this time is *Bacillus thuringiensis (Bt)*, a microbial insecticide that is an effective control for many types of butterfly and moth larvae including some which are hard to control by other means. Bt products are generally considered safe for people, bees, predatory and parasitic insects, predatory mites and spiders and the environment in general.

2.3.5 Fumigation and soil disinfection (solar, physical, chemical)

Fumigants are high vapour pressure products that evaporate rapidly when entering the ground, creating gases that spread evenly through the soil. Soil fumigants are used to kill weed seeds and underground plant parts as well as nematodes and disease organisms before planting in areas where high-value crops are to be planted. Fumigation is most commonly used for the preparation of seedbeds but is sometimes used to treat potting soil or certain high-value areas. Especially careful attention must be given to label directions concerning soil temperatures and preparation, time between treatment and planting, and safety instructions.

Some fumigants kill beneficial soil fungi that form mycorrhizae, a root-fungus association that is needed for normal growth by most plants. The fungi that form the association are spread by airborne spores and they can re-infest fumigated beds quickly. However, the fungi associated with most deciduous plants produce their spores in the soil. It takes much more time for them to re-infest fumigated soil. Methyl bromide is the fumigant that causes the most damage to populations of mycorrhizae. Soil fumigants that are commonly used in nurseries include dazomet methyl bromide/chloropicrin and sodium methyl dithiocarbamate.

Soil fumigation will be most effective if undertaken in late summer or early autumn because the soil temperature is relatively high at this time. All fumigants are most effective if the soil temperature is above 12.7 degrees C at the time of application. Areas that must be fumigated in the spring can be covered with plastic for several days prior to treatment to raise the soil temperature. If needed, the same plastic can then be used to cover the treated area after application of the fumigant.

Proper soil preparation is essential for effective soil fumigation. The soil should be ploughed and cultivated to a uniform loose texture to a depth of 15 to 30 cm. At the time of application, the soil should be free of clods and fresh organic debris, moist enough for seed germination, and at a temperature suitable for the product being used. After fumigation, the grower must wait the length of time specified on the product label before planting. Planting too soon can result in the injury or death of the crop.

The machines for applying fumigants are made up of soil injectors similar to large syringes, which are inserted into the ground at the desired depth, injecting the fumigant. For efficient use of fumigants, the operation should be carried out at least 25 days prior to the planting of the crop, at a depth of 25 cm.It is a good practice to do this when outside temperatures are not too high and to follow the fumigation with a light spray or sprinkler irrigation, so as to avoid dispersion into the atmosphere and a consequent loss of the effect.

Soil disinfection is a real problem in horticultural cultivation, especially for protected crops under greenhouses and poly-tunnels. Soil parasites such as nematodes (*Meloidogyne sp.*) and agents of root rot (*Cladosporium, Verticillium, Fusarium,* etc.) require special containment measures. In the past methyl bromide was widely used; however, the use of this product creates problems of a toxicological, health-sanitary, and environmental nature. It has been demonstrated that when this compound is dispersed into the atmosphere after application, it contributes to the thinning of the ozone layer, and its use is currently subject to increasingly strict laws. Thus it has become urgently necessary to find possible alternatives. Among other chemical treatments include those based on metam-sodium, with a mainly fungicidal action, and nematicide treatments based on fenamiphos.

One valid alternative is to treat the soil using *solarisation* techniques, i.e. exposing the top layers of soil to high summer temperatures for 4 to 8 weeks. Solarisation is effective against nematodes, although some of these escape the sterilizing action either because they are resistant or because they are not reached by the direct action of the heat. Regarding physical treatments, one of the most widely known and used is that of injecting sterilising steam into the soil, which causes the death of nematodes and root rot agents.

2.3.6 Soil and water contamination

The extensive use of pesticides in agriculture can entail risks for the environment and non-target organisms. Hence the need to assess the nature and degree of the risk and at the same time to take preventive measures aimed at minimising possible damages. Different types of soil and water contamination include:

- Sludges and petroleum contamination and their chemical constituents
- Chlorinated hydrocarbons;
- Pesticide and heavy metal (especially lead) contamination.

Assessing levels of soil contamination consists of a detailed assessment of the site and including proper use of field sampling techniques and statistical design, sample handling and preparation and assessment methodologies.

In most EU countries applications to register pesticides must be made to an appropriate Ministry and conform to national legislation, which for most EU countries is in line with uniform principles of assessment set forth by EC Guideline no. 94/43/EEC of July 27, 1994 and the data requirements for the assessment of the fate and behaviour of pesticides and related risks for non-target species (Guideline 95/36/EEC or 96/12/EEC).

Under EU Guideline no. 94/43/EEC both short and long-term predicted concentrations of substances in the soil, in groundwater, in surface water and in the air must be calculated for all pesticides prior to commercial application and by using appropriate calculation models to assess the predicted concentration of active ingredients in the environment. The resulting concentration prediction levels are used to predict the theoretical exposure of non-target species, as well as the rates between experimentally estimated exposure and the measured toxicity in non-target species. These parameters are used as an assessment tool when deciding on admissions of pesticides according to the uniform principles of assessment.

Different approaches exist for forecasting possibilities for soil contamination and ranging from simple to more complex simulation models that predict pesticide concentrations in the soil. Increasingly more complex models normally follow at various stages within the testing procedure. Simple models are based on a restricted amount of information that allows calculating the product concentration on the soil surface immediately after its application. These calculations alone are generally enough to show whether product concentrations are below ecotoxicologically significant levels. More complex models are later used to test specific circumstances. Levels of risk assessment are also able identify specific ecotoxicological effects, such as acute or long-term effects on earthworms and/or other soil organisms.

The need for standard procedures and calculation models for the assessment has prompted the EUs advisory committee for pesticide products to develop uniform criteria for the assessment of active ingredients and formulas and so as to ensure increasingly unbiased and transparent decisions. This assessment process usually involves using computer models for predicted environmental concentrations that cover groundwater, surface water, soil and air. According to the EU Directive 91/414, all models should be validated at the European level but so far common and objective assessment tools acknowledged by pesticide specialists, manufacturing companies as well as national governments and the EU do not exist. Specific national and EU legislation however does exist in relation to contaminant levels resulting from agricultural practices, such as, the European Union Directive 91/676 on the protection of waters from pollution caused by nitrates coming from agricultural sources.