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GUIDELINES FOR ORGANIC AGRICULTURE

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I. INTRODUCTION

What is organic agriculture?

The concept of organic agriculture evolved as a result of a new understanding and attitude to the problems of the environment and the health of the future generations. As a model organic agriculture has been borrowed from nature itself and as a philosophy and practice it strives to be in harmony with it without harming it.

Organic agriculture is a system of production which avoids or totally excludes the use of synthetic fertilizers, pesticides, growth regulators and additives to animal food and in which maintenance and improvement of the nutrition of the soil is achieved through crop-rotation, compost, manure, green fertilization and organic plant protection.

The World Food Organization gives the following definition of organic agriculture – this is a holistic system of management of production which promotes and increases agro-ecosystematic health, including biodiversity, organic rotation and organic activity of the soil. Managerial approaches are used with restricted input from outside the farm. Agricultural activities are realized by the implementation of agronomic, organic and mechanical methods, contrary to the application of synthetic materials, to satisfy the specific functions of the system.

The main principles and activities organic agriculture has to follow are described in the documents of the International Federation of Organic Agriculture (IFOAM):

- to produce food of high nutritional quality in production of sufficient quantity;
- to work in harmony with the natural systems with no dominance over them;
- to encourage and enhance biological cycles within farming system, involving microorganisms, soil flora and fauna, plants and animals;
- to maintain and increase the long-term fertility of soils;
- to use as far as possible renewable resources in locally organized agricultural systems;
- to work as much as possible within a closed system with regard to organic matter and nutrient elements;
- to give all livestock conditions of life that allow them to perform

all aspects of their innate behavior;
- to avoid all forms of pollution that may result from agricultural techniques;
- to maintain the genetic diversity of the agricultural system and its surroundings, including the protection of plant and wildlife habitats;
- to allow agricultural producers an adequate return and satisfaction from their work including a safe working environment;
- to consider the wider social and ecological impact of the farming system.

Of key importance for the development of organic agriculture are:
- the ambitio n of the farmers to reduce production costs and live economically;
- the consumers' interest in healthy foods, free of agrochemicals.
- financial stimuli because of the enormous ecological and social importance of this type of production.

Organic production is the most popular modern form of sustainable agriculture. The high-quality healthy products of organic agriculture most often have lower primary cost and get about 25-50% bigger prices, the demand on the market is bigger than the supply and for that reason they are more competitive than the conventional products.

History

The Austrian scientist and philosopher Rudolf Steiner (1861–1925), the founder of organic agriculture in Europe, started giving talks on biodynamic agriculture to a group of farmers in Silesia (present-day Poland) in 1924.

In the 30s and 40s of the XX c. organic agriculture began to develop in Switzerland, England and Japan.

Organic agriculture became organized, consistent movement of the farmers themselves in the 70s when the I*nternational Federation of the Movements for Organic (Organic) Agriculture (IFOAM)* was founded.in Paris in 1972.

In the beginning of the 90s the countries of the European Union

developed a *common strategy and principles* for the development of organic agriculture, formulated in Directive No 2092/91 – the founding regulatory document for that production which is constantly improved.

Main factors promoting the development of organic agriculture:
- problems with overstock of agricultural produce in the developed countries;
- negative influence of intensive agriculture on the environment;
- sizable growth of the market for organicly produced food because of human concern for their health.

Major rules which organic farmers have to follow:
- keep and maintain soil fertility over a long period of time by using manure, bio manure from Californian worms, green fertilization with suitable crops and compost preparation with all organic refuse to increase humus content;
- use a variety of crop-rotation, with a lot of leguminous plants with natural and artificial meadows and pastures included;
- no use of synthetic pesticides and fertilizers; apply mechanical and thermal methods of weeding and alternative means of fighting disease and pests such as resistant sorts, organic products, ferromones, essential plant oils, thermal sterilization and solarization of the soil, etc.;
- strict accountancy on the farm, keeping track of all products from the field to the sales counter, as well as of all materials and forage bought outside the farm necessary for the normal functioning of the farm;
- keep a buffer zone between the farm and the neighbouring conventional farms to avoid accidental pollution.

In organic stock-breeding farmers should: use breeds adapted to local conditions; apply rearing methods close to the natural way of life, which reduce stress and ensure good health status of the animals; have humane attitude towards domestic animals and provide the environment for them to show their natural behavior (free breeding in the open, sufficient space in the sheds and in the open, social contacts, etc.) keep strict balance between the number of animals and the size of the arable land;use forage produced on the organic farm; not use growth regulators and use antibiotics only as a last resort.

What do we have to know about organic products

According to the new legislation of July1st 2010 the producers of packed organic foods should use the EU organic logo.

The advantage of EU logo for organic agriculture is that the consumers in all member states can easily recognize organic products irrespective of their origin.

Buying products with EU logo, the consumers can be certain that:

- minimum 95 % of the components of the product of agricultural origin are manufactured by the method of organic production;
- the product meets the requirements of the official control scheme;
- the products comes straight from the producer or the processor in packed packaging;
- the product carries the name of the producer, processor or retailer and the name or code of the controlling body.

Organic producers, processors and importers have to observe strict legal requirements if they want to use the EU logo for organic origin. A strict system of control is necessary to ensure the observance of the requirements. Control is carried out at all stages of the cycle production delivery so that consumers can be certain they are buying organic food produced according tot European standards with the respective inspection procedures.

II. LEGISLATION

On 1 January 2009 new EU regulations went into effect for the production, control and labelling of organic products. However, some of the new provisions on labelling do not take effect un til 1 July 2010.

In June 2007 the European Council of Agricultural Ministers agreed to a new Council Regulations on organic production and labelling of organic products. This new Council Regulation contains clearly defined goals, principles and general rules for organic production.

The goal of this new legal framework is to set a new course for the continued development of organic farming. Sustainable cultivation systems and a variety of high-quality products are the aim. In this process, even greater emphasis is to be placed in future on environmental protection, biodiversity and high standards of animal protection.

According to the new legislation, producers of packaged organic food must use the EU organic logo as of 1 July 2010. The use of the logo on organic foods from third countries, however, is optional. When the EU organic logo is used, the place of production of the agricultural ingredients must be indicated starting on 1 July 2010.

The distribution of organic products from third countries is only permitted on the common market, when they are produced and controlled under the same or equivalent conditions. The import regime has been expanded with the new legislation. Previously, only organic goods from third countries recognised by the EU or goods whose production was controlled by the Member States and which had received an import licence could be imported.

The procedure for import licences will in future be replaced by a new import regime. Control bodies working in third countries will then be directly authorised and monitored by the European Commission and the Member States.

This new procedure allows the EU Commission to supervise and better monitor the import of organic products and the control of the organic guarantees. In addition, a basis for the acceptance of EU rules on organic aquaculture and seaweeds was laid in the new legislation.

Specifics of EU organic legislation

In addition to a new Council Regulation, two new Commission Regulations were adopted in 2008 regulating organic production, the import and distribution of organic products as well as their labelling.

Council Regulation

Council Regulation (EC) $N_{0.}$ 834/2007 of 28 June 2007 on organic production and labeling of organic products and repealing Regulation (EEC) $N_{0.}$ 2092/91.

This regulation establishes the legal framework for all levels of production, distribution, control and labelling of organic products which may be offered and traded in the EU. It determines the continued development of organic production through the provision of clearly defined goals and principles. General production, control and labelling guidelines were established by the Council Regulation and can therefore only be changed by the European Council of Agricultural Ministers. The previous Regulation (EEC) No. 2092/91 is simultaneously repealed.

The Council Regulation applies to the following agricultural products, including aquaculture and yeast:

- Living or unprocessed products
- Processed foods
- Animal feed
- Seeds and propagating material

Collection of wild plants and seaweed is also included in the scope of this Regulation

Not included in its scope:

- Products from hunting and fishing of wild animals.

Commission Regulations

The following Commission Regulations have been adopted thus far:

- Commission Regulation (EC) No. 889/2008 of 5 September 2008 with detailed rules on production, labelling and control including its first amendment on production rules for organic yeast

- First amending Regulat ion, establishing new production rules for the production of organic yeast.
- Commission Regulation (EC) No. 1235/2008 of 8 December 2008 with detailed rules concerning import of organic products from third countries

In Commission Regulation (EC) No. 889/2008 all levels of plant and animal production are regulated, from the cultivation of land and keeping of animals to the processing and distribution of organic foods and their control. They go into great technical detail and are, for the most part, an extension of the original organic Regulation, except where this was regulated differently in the Council Regulation.

III. BIODIVERSITY AND ORGANIC FARMING

The maintenance of bigger biodiversity on organic farms is a major priority in their sustainable development. The long-term aim of organic farms is to create a well-balanced farm in terms of rotation cycle of nutrients in it as well as maintaining optimum variety of cultivated and wild vegetation in the fields and their adjoining areas.

The maintenance of considerable biodiversity on and around the organic farm makes weed, disease and pest control on the farm easier as their development rarely reaches the levels to compromise the crop. Whereas the number of crops on a big conventional farm rarely reaches more than 5 to 6, the average number of crops on organic farms is 20 to 30 and sometimes reaches 50. The small number of crops grown on conventional farms requires the use of big quantities of pesticides, which kill both harmful and beneficial insects and a huge part of wildlife on the farm as well. Additional major source of biodiversity is grass growing on boundary strips in the fields, bushes, individual trees and groves, which can be found in the vicinity of the farm. The organic farmer is interested in looking after that vegetation as well.

The ideal structure of the organic farm includes rearing of various types of animals, production of the necessary forage for them and growing of a big variety of vegetables and fruits. However, it is difficult to simultaneously grow such a variety of crops and animals on a single farm. Specialization of organic farms (stock-breeding, plant-growing, mixed, vegetable-growing, fruit-growing) requires certain cooperation among them. It is necessary mainly because of the need to maintain soil fertility on farms with different lines of production.

Plant-growing farms add up to the forage balance of stock-breeders and get manure in return thus closing the cycle of nutrients. Fruit-growing and especially vegetable-growing farms need bigger quantities of manure they can receive from stock-breeders.

Biodiversity in vegetable field
(photo I. Manolov)

Biodiversity in fruit field
(photo I. Manolov)

Biodiversity in orange orchard
(photo A. Enamorado)

Chicken in olive orchard
(photo A. Enamorado)

IV. SOIL FERTILITY AND PLANT NUTRITION

1. Soil fertility

Two of the main aims of organic agriculture are related to the soil and its fertility:

- Long-term maintenance of natural fertility;
- Prevention of all forms of ecological damage to the soil as a result of the agricultural methods of production applied.

Major aspects of soil fertility are:

- its biological activity "living soil";
- levels of organic matter and nutrient extraction with the produce (balance of nutrients) and soil structure and status of nutrients.

The soil is the invariable factor for the existence of agriculture as a whole (plant-growing and stock-breeding). Unfertile soil causes various agronomic and financial problems to the organic farmer.

The soil is not a simple mixture of mineral particles, it is a dynamic system which has a great variety of living organisms of microscopic bacteria and fungi to bigger insects and earthworms. The "living" soil provides the normal decay of the organic matter and the release of nutrients for the good development of the plants.

In organic agriculture most nutrients are not easily available for the plants. Most of them are part of the soil organic matter (humus) and for that reason serious attention is paid to the presence of bigger quantities of organic matter in the soil.

The decomposition (mineralization) of organic matter is of paramount importance for plant-growing. If the process is not at its optimum, plants do not grow well and the yields are low, they cannot compete with weeds and are less resistant to pests and diseases.

Nutritional elements on the farm and their circle

For their growth and development plants need energy, which they get from the sun light, carbon and oxygen they get from the air, and water and nutrients they get from the soil. In organic agriculture crops can rely mainly on the organic matter in the soil and on the use of all plant residues and manure for fertilizing the soil as use of mineral fertilizers is not allowed.

The nutrients plants need most are nitrogen, phosphorus and potassium.

The principle of the closed system of nutrition of the plants and animals within the farm for the longest possible period of time is an important rule in organic farming. This implies minimum input of nutrients from the outside and loss of nutrients from and in the farm.
The rotation cycle of nutrients follows the scheme 1.
Plants uptake nutrients from the soil, produced biomass is used as animal feed when they utilize only a small part of the nutrients contained in the forage. The greatest part returns to the soil through manure and other crop residues. Crop residues and manure decompose, organic matter mineralizes and the released elements are absorbed by the next crop.
The aim of the farmer is to close this rotation cycle as much as possible, i.e. to decrease the loss of nutrients on the farm. This is best achieved in a mixed plant-growing – stock-breeding farm along the scheme above.
Successful management of an organic farm requires good knowledge of all aspects of the rotation cycle of nutrients. The farmer has to know about the export of nutrients from various crops, the possibilities to decrease losses and increase return back to the soil of exported nutrients, as well as the long-term effect of cultivation of the soil and crop rotation.
The main quantities of elements with direct participation in the rotation cycle of nutrients on the farm are stored in the soil organic matter (from 60 to 100 t/hectare), in organic matter formed by the crop grown at the moment (from1 to 10 t/hectare) and in manure.
Soil organic matter is the main source of nutrients for the plants in organic agriculture, it contains all nutrients necessary for the plants and is a source of energy for the life activities of microorganisms and building material for their bodies. Therefore farmers have to strive to increase the amount of organic matter in the soil as much as possible. By no means should crop residue be thrown away or burnt, it should be incorporated into the soil or composted. When green crop is incorporated into, after ploughing of grass - leguminous mixture or green manure, accessible energy is easily supplied to the soil. This stimulates the development of soil organisms and increases the decay

of organic matter and the release of nutrients into the soil. The sudden increase in activity lasts only two to three weeks. Usually crop residue can be ploughed in or molded into discs before spring sowing (green manure) or after the harvest of the crop. Therefore crops can suffer shortages of nutrients later during vegetation, when the amount of released nutrients is smaller.

Interaction between roots and microorganisms

The number of microorganisms in close proximity to the root hairs are 100 to 1000 times bigger than in the remainder part of the soil. The root system of the plants releases between 5 and 20% of the energy produced during photosynthesis in the form of root exudates.
The longer the roots are active, the longer microorganisms have a constant source of energy which enables them to function effectively. In this way they can continue to decompose organic matter and thus provide nutrients for the plants.
Mutual cooperation or symbiosis is finely tuned to the needs of the plants. Their need of nutrients is the biggest in the period before flowering (vegetation). During that period root growth is fastest and the release of root exudes in the soil – biggest.
The farmer can enhance this process by creating suitable conditions for root and plant growth and by including crops with long vegetation period in crop rotation to ensure food for soil organisms while in between cultivating “cash” crops.

Benefit of the earthworms

The number of earthworms is an indicator of soil fertility. On a organic farm the average number of earthworms is between 300 and 500 per m^2, whereas in a conventional corn field there are 50 to 100 earthworms per m^2. The big population of earthworms shows that many other organisms decomposing organic matter, such as bacteria, fungi and bigger insects, live in the soil. In this way earthworms can be treated as bio-indicators of soil fertility. They give an idea of the degree of biological activity of the soil.
Benefits:

Create Bio-pores which are essential for gas exchange in the soil, ensure fast absorption of water after rain and swift drainage of excess water.
Earthworms decompose organic matter - about 80% of organic matter returned to the soil can be decomposed by earthworms, resulting in about 100 tons of excrements per hectare a year.
Earthworms – soil conditioners – excrements remaining in the soil are actually fine water stable aggregates with optimum distribution of pores in them.   .
Earthworms' need of food– organic fertilizers increase the number of earthworms. This number is twice as big in fields where manure is applied as well as in crop rotation of grass and grass - leguminous mixture or green manure.

Nitrogen fixing bacteria

Nitrogen fixing bacteria are one of the pillars of organic agriculture. Almost the whole quantity of nitrogen on an organic farm comes from the atmosphere. One liter of petrol is used to get 1 kg of nitrogen in the production of nitrate fertilizers, whereas bacteria living in the roots of leguminous plants offer this element for free.
Fixation of atmospheric nitrogen is a perfect example of cooperation between bacteria and plant roots. These bacteria live in the roots of leguminous plants (beans, lentils, peas, soya, clover, alfalfa, etc.) where specific nodules are formed.
Each type of leguminous plant is infected by a specific type of bacteria. Inside the nodules bacteria can absorb the free nitrogen from the air and transform it into ammonium nitrogen which is assimilated by the plants. Bacteria get carbohydrates from the plants as a source of energy. In return plants use part of the nitrogen fixed with the bacteria. When plants die, nodules decompose and the nitrogen stored in them can be used for the next crop.   .
The annual amount of fixed nitrogen depends on the type of plant, growth rate of the crop, growth conditions for the specific year and the specific field, the amount of nitrogen in the soil (Table 1).

Table1. Amount of fixed nitrogen by some legumes

Crop	Fixed N (kg/ha/year)	Variation
Grass-clover mixture 1st and 2nd year	200	150 - 300
Grass-clover mixture 3th year	100	70 - 150
Pasture	50	40 – 70
Alfalfa	250	200 – 350
Clover green manure (whole season)	150	100 – 300
Field beans	180	
Lupin	180	
Pea	140	
Clover	140	150 – 250

Source:
Growth rate of the crop. Nitrogen fixation in leguminous plants is weak in the beginning of vegetation and strongest during flowering. The degree of fixation lessens after this moment till maturity.
If the crop is grazed or mowed, a new period of vegetation commences and nitrogen fixation goes up again. For that reason grass – leguminous composites and alfalfa fix twice as much nitrogen than other annual leguminous plants.
Growth conditions. In cooler and wetter conditions nitrogen fixation is smaller. Photosynthesis is weaker (less energy), exchange of soil air is weaker due to the wetness of the soil. Not only oxygen but nitrogen should also penetrate into the soil. The bad structure of the soil can also be the reason for the same negative effect.
Amount of nitrogen in the soil. Nitrogen fixation is limited if there is mineral nitrogen in the soil.
Nitrogen fixing in grass-leguminous mixture. With perennial grass composites and pastures the process runs as follows. During vegetation some of the nodules and bacteria in them die and begin to decay. The grass which continues to grow begins to absorbs the free nitrogen. With the development of the crops more and more nitrogen is absorbed from the clover according to the scheme, even more that the clover itself.
Nitrogen fixation with grass-leguminous mixtures depends on climatic conditions and soil structure. Other factors, influencing the process are competition between grass and clover and grass – clover ratio in the stand.

Soil mycoriza and plant nutrition

Most cultivated plants live in cooperation with a kind of fungi named mycoriza, which is a specific type of symbiosis. Not all crops, however, “cooperate” with mycoriza. These are the cruciferous plants (rape, mustard, cabbage, etc.) and beetroot.
Fungi infect root hairs and grow in the root cells or in the spaces among the cells wherefrom they get organic nutrients (energy). About 20% of the stored energy by photosynthesis can be used by the plants in this way.

Fungi provide nutrients to plants

As a result from this symbiosis plants can get nutrients from much larger volumes of soil than their roots can encompass.This is not so important for soluble nutrients which can be transported with the soil solution (nitrogen, for example), but it is extremely important for elements, which are not connected and do not dissolve easily in water, for example phosphorus and microelements such as copper, zinc and manganese.
The presence of bigger quantities of organic matter favours the development of fungi. It has been established that mycoriza is more active in organic agriculture than in conventional agriculture.

Mycoriza and vegetable-growing

The influence of mycoriza has to be taken into consideration while planning vegetable crop rotation. After cruciferous plants (rape, mustard, cabbage, etc.) mycoriza population decreases and cannot be restored completely for one season. This means that if the next crop has weak root system, depending on mycoriza, this will be a bad choice. This is particularly valid for onion and leek in vegetable crop rotation.

2. Plant nutrition

Organic fertilizers are the main way for maintaining of soil fertility.
Manure, compost and green manure belong to the group of organic fertilizers. Organic manure application improves the quality of the soil and enhances the increase of organic matter in it. On the one

hand, organic fertilizers are a source of nutrients for the crops, and on the other hand – improve the physical qualities of the soil: moisture retention, aeration, drainage and improved soil structure. They are a source of energy and nutrients for the soil ecosystem.

Manure

Manure from stock-breeding, as well as crop residue on the farm has a substantial role in organic agriculture. Manure is a valuable source which close the circle of nutrients, allowing nitrogen from leguminous crops and forage to return to the soil, where it can pass on to the next crop.
According to the Regulations for organic agriculture only manure from an organic farm can be used for organic produce. For that reason animals are reared on the farm, they utilize plant crops and the nutrients, absorbed from the soil go back to it via the manure.
Manure is waste matter from animal excrements, urine and litter. They define its chemical composition, which varies depending on the type of animals (Table 2) type and quantity of food and litter, the correlation of the three components, etc.

Table 2. Content of nutritional elements and water in manure from different animals

Animals	Excrements : urine ratio	Moisture H_2O (%)	Manure (kg/t)		
			nitrogen (N)	phosphorus (P_2O_5)	potassium (K_2O)
Cattle	80 : 20	85	5	1.3	3.7
Pigs	60 : 40	85	6.4	3.0	5.4
Sheep	67 : 33	66	11.0	3.5	10.8
Poultry	100 : 0	62	14.9	7.0	3.5
Horses	80 : 20	66	7.4	2.2	6.5

Manure belongs to the group of full fertilizers, because it has all elements plants need. Nutrients returned with manure gradually pass into plant-available form during its mineralization by soil microorganisms.

Fresh manure is not fit for fertilizing for several reasons:

- The larger part of the nutrients in it are difficult to be assimilated by the plants;
- The carbon/nitrogen ratio does not favour nitrogen assimilation by the plants;
- Contains substantial amounts of live weeds and it is also possible to contain various types of pathogens;
- Big volume, mostly due to water.

For these reasons manure is kept for some time to get rid of these drawbacks. Intensive microbiological processes take place at that time, called fermentation of manure or composting.
During storage and fermentation of manure certain changes in appearance take place and this process can be divided into four stages.
With fresh and slightly decomposed manure the straw preserves its yellow colour and its strength.
Semi-decomposed manure is dark brown in colour. Straw is still discernible, but has lost its strength and breaks when pulled. The volume of semi-decomposed manure has decreased by 20 – 30 % in comparison with fresh manure
Decomposed manure is black greasy mass, straw still discernible and with about 50% decrease of initial volume.
Mature manure is earth-like in appearance. It has lost about 75 % of its initial mass.
Preservation of manure has to be done on special sites, best concrete with a draining system for collecting the manure liquid . The size of the site has to allow the collection of manure for the period animals are kept in the sheds and are not out grazing. In this way the manure can be used after its fermentation period and can be apply in at the most suitable time depending on the crop grown on the farm.
Storing manure in the open causes losses of nutrients because of evaporation and washing out which can reach up to 20% of nitrogen, 7% of phosphorus, 35% of potassium. To avoid these losses it is recommended to cover the heap with polyethylene foil or a special foil cover, which does not let rain water in but allows gas exchange between the manure heap and the atmosphere.

Compost

Compost is an organic fertilizer which we get through initial decomposition of plant and animal residue from agriculture, households and industry into simpler organic compounds.
Mature compost is humus material prepared by mixing and fermentation of organic residue. Generally speaking any organic material can be composted – straw, hay, weeds, manure, kitchen refuse, leaves, plant residue, kitchen waste, etc.
Nutrient content in compost is relatively low, but it brings about soil amelioration.

- Improves soil structure
- Improves soil capacity to retain nutrients
- Decreases the density of the soil and crust formation on the surface of the soil
- Decreases the need of fertilizers
- Facilitates soil cultivation
- Improves root growth and yields
- Improves water filtration and draught tolerance
- Prevents plants from diseases
- Increases population of microorganisms and earthworms
- Most common composts are produced from straw, household scraps, tree bark, other plant residues, etc.

Compost production

While composting organic matter mainly microbiological processes take place and they influence the physical and chemical indicators of the decaying matter. Plant residues contains all necessary microorganisms for the beginning of the decaying process.
The normal process of composting requires good aeration, enough humidity and optimum level of nutrients in the heap of organic matter (carbon:nitrogen ratio), which allows good development of microorganisms.
Good aeration of the compost heap of organic matter is of extreme importance for the normal breathing of the microorganisms, participating in the decaying process (Picture 4). The heap has to be stirred periodically (once a month), to maintain the necessary oxygen

content in the composting process.
High, narrow heaps are to be preferred in which air can penetrate easily to their centre, whereas with wider heaps anaerobic conditions can be created in the centre of the heap. Heap ventilation can be improved by putting vertical pipes as well as by forming canals at their base.
The speed of compost preparation depends on the way of collecting organic matter, the way it is cut into small pieces and mixed, etc. If the compost heap is built once, it is easier to balance the two main elements determining the activity of microorganisms – carbon and nitrogen. Materials can be laid on leyers, but subsequent mixing is also good practice.
Cut organic matter is heated more easily, decomposes faster and results in homogeneous compost. The degree of decomposition depends a lot on the size of the composted material. For faster decomposition it is essential for fibrous materials to be finely cut.
For the normal development of the composting process the material has to be wet, but over dampness causes anaerobic conditions and decay. Optimum humidity is within 55-70% of the full humectation.
Humidity can be easily defined by squeezing a handful of decaying matter. If no water comes out, the heap is too dry and vice versa – if there is too much liquid, the heap is overdamp. The ideal case is when there are water drops between the fingers and the material preserves its form after the unfolding of the hand.
While building compost heap the correct ratio between materials rich in carbon, called “brown” and material, rich in nitrogen, called “green” has to be observed. Dry leaves, straw, cornstalks, finely cut wood, wood shavings and sawdust are classified as “brown”. Fresh green matter, such as newly-cut grass, cover crops and green manure crops, manure and kitchen wastes are rich in nitrogen. Speed of decomposition can be influenced by mixing certain types or changing their ratio. Compost is usually completely ready in 4 to 6 months.

Time for application of organic fertilizers

The best time for application of organic fertilizers is before the main tillage of the soil (deep autumn ploughing). This should be done before growing the suitable crop in crop rotation. Farms rarely have sufficient

amounts of manure and other organic fertilizers for application each year to all crops, that is why it is essential to decide where and when to apply manure.
The general rule is for manure to be applied to crops extracting the greatest amounts of nutrients from the soil, such as vegetable and forage crops, maize, root crops, etc. Winter cereals (wheat and barley) usually rely on the residual effect of manure applied to their predecessor.
The basic principle is for manure to be applied to earthed-up crops in crop rotation before the deep ploughing of the soil in autumn. The aim is through cultivation of the soil to incorporate the fertilizer into the depth of the development of the main mass of the root system.
Ploughing should be done as soon as the application of manure on to the soil is done to diminish the losses from evaporation of ammonium from the organic fertilizer.

Green manure

Ploughing of the green and sappy parts of the plants in order to improve soil fertility is called green manure. Green manure in organic agriculture, where the use of mineral fertilizers, herbicides and soil sterilizers is prohibited, is a basic means of maintaining soil fertility. Green manure crops could be cultivated as a pure crops, intercrops or undersown crops, or natural vegetation (weeds) can even be used for this purpose.
The effect of green manure on the quality of the soil and the crops is manifold:
- Increase of the stores of organic matter,
- Increase of the reserves of nutrients for the plants,
- Activation of microbiological activities after ploughing in of the crop,
- Decrease nutrient losses in deep soil layers by leaching when a main crop is not grown.
- Decrease of soil erosion as plants cover the soil in the period between the main crops in crop rotation and protect it from the destructive effect of raindrops and drainage water. This is of great importance for sloppy areas.

- Application of organic matter to the soil improves its physical qualities, water content and soil structure.
- Competition for light, water and nutrients suppresses the development of weeds.
- Leguminous green manure crops fix nitrogen from the air into the agricultural systems.
- Crops grown at the end of the season absorb and recycle soluble nutrients, which might have been lost.
- Increased biodiversity in the agricultural system creates favourable conditions for beneficial insects, which reduces the development of pests in plants.
- Facilitates the movement of machinery in the fields (especially with perennials crops);
- Decreases soil compaction;
- Provides additional forage for the reared stock;
- Improves the appearance of the field.

One of the major roles of green manure crops is to introduce organic matter into the soil. The crops can form 2 to 4 t of dry matter from one hectar of land which is to be incorporate in (fresh weight of green manure crops is 4 to 10 times bigger than the dry matter).

Another major aim in green-manure crop growing is the introduction of bigger quantities of nitrogen into the soil. As a result nitrogen nutrition for the plants improves as well as the quantity of other nutrients.

Yet another benefit from green-manure crop-growing is the suppresion of the development of weeds and soil-related diseases.

Green manure crops

The choice and management of green-manure crops depends on the aims of the farmer. For example, the structure of the soil can be improved by growing cereals and other non-leguminous crops, whereas leguminous crops or mixtures with leguminous plants enhance nitrogen content of the soil. Most often leguminous species are used for green manure while non-leguminous are grown more seldom .

Plants suitable for green manure have to meet the following requirements:

- To be adapted to the climatic conditions of the region (tolerance to high and low temperatures).
- To be less demanding towards the soil (heavy or light soil, soil reaction - pH, salt concentration), as l green manure crops are usually grown on less fertile soils.
- Produce huge quantities of high-quality vegetative mass in a short time.
- Have a shorter vegetation period so that it can be ploughing in when grown as intermediate crops. The most suitable plough-in time of crops is just before or during flowering when they have the biggest quantities of nutrients in their tissues.
- To develop strong root system with good dissolving abilities in order to carry phosphorus, potassium, calcium and other mineral substance from the subsoil to the plough layer.
- The green-manure plant seeds should have a high reproduction coefficient and high germination energy in soils with less moisture.
- Green-manure crops can survive shading and stampeding in fruit orchards.

The most widely used green manure legume crops are clovers (*Trifolium sp.*), alfalfa (*Medicago sativa*), trefoils (*Lotus sp.*), and other medics (*Medicago sp.*), vetches (*Vicia sp.*) and lupins (*Lupinus sp.*).

Rye (*Secale cereale*), oat (*Avena sativa*), wheat (*Triticum spp.*), oil radish (*Raphanus sativus*), mustards (*Brassica spp.*) and buckwheat (*Fagopyrum esculentum Moench*) are the most often cultivated non-legume crops.

Management of green manure crops

The effectiveness of green-manure crops depends on the amount of green mass formed and ploughing into a unit of area. Green manure crops are sowed after rains or irrigation so that their germination is guaranteed. During vegetation green-manure crops need only irrigation.

Green-manure crops should be ploughing in when there is a huge amount of green mass with high levels of nitrogen and nutrient content. With leguminous plants it is the phase of blossoming when the first beans are formed on the stalk.

In practice, however, it is the management of the next crop that defines the time of ploughing in. In between the ploughing in of green-manure plants and the sowing of the next crop there must be sufficient time for the ploughing-in organic mass to decompose. Young plants decompose faster than the old plants because they contain less cellulose, lignin and other stable organic compounds. In heavy, cold soils green mass has to be ploughing in 3 or 4 weeks before the sowing of the winter cereal crops. Green-manure crops in fruit orchards are ploughing into in autumn before the winter frosts or in early spring.
To achieve uniform distribution and dense coverage of the soil with green mass, plants are either rolled along, cut with a cutting machine or mown down. Ploughing in is usually 20-25 cm in depth.
Green manure crops can be sown in spring taking up the field for almost the entire vegetation period, and the green mass is usually ploughing into in autumn against winter crops.
In other cases these crops are grown as second crops after harvesting the cereals. Because of the dry climate in summer the development of the second crops, sown for green manure can happen only if irrigation is provided. The green mass is ploughed in during deep autumn ploughing.
Green manure and cover crops are good management tools for suppression of weeds development. Usually, the increased density of interseeded crops increases suppression of weeds.

Undersowing

Undersowing is practiced to ensure additional forage for livestock. After harvesting the main crop, it protects the soil from erosion and adds additional amounts of fixed N into the soil. Legumes such as clover, trefoil or alfalfa are the most utilized crops for undersowing because they increase N availability in soil for the main cereal crop. Undersowing of clover into cereals is a common practice for establishing leys. Ryegrasses are another option for undersowing crops. However, cultivation of ryegrasses can increase competition of the next crop for N because of the immobilization of the element during the decomposition of the ryegrass in the soil. Experiments showed a 25% decrease of grain yield of oats when undersown with wheat/

ryegrass. At the same time significant positive effects were detected for oats grain yield from undersown clover (white and red) which reached an approximately 1500 kg/ha higher yield than the control.
Legumes and grasses are sown in the spring by drilling or simply by spreading seeds over growing cereal crop. The seeding rates of undersowings are reduced by half compared to the normal ones typically utilized for pure crops. The optimum seeded rates for triticale and wheat, from 300 to 400 seeds m-^{2}, or seeds per m^{2} while seeded densities of red clover must be above 120 plants per m^{-2}.
After harvesting cereals, the undersown crop works as a cover crop during the autumn and winter prior to sowing of the following crop. Cereal harvest improves conditions for faster growth of undersowings since no competition for nutrients and water in soil and no overshadow over the ground occur thus ensuring feed for grazing livestock. The success of undersown crop requires sufficient precipitation and soil moisture during seed germination. Consequently, this practice is more popular in temperate regions of the world.
Undersown crops (particularly ryegrass) are one of the most effective measures to control nitrate leaching, particularly on sandy soils. Amount of of leached nitrogen could be reduced up to 60 kg/ha after plowing grazed unfertilized grass–clover and growing spring barley with under-sown ryegrass. Legume undersown crops are valuable nitrogen sources for grain production. White and red clover provided from 100 to 120 kg N/ha for the following unfertilized spring barley

Crop rotations in organic agriculture

Crop rotation is a consecutive, annual alternate of crops in time and place on a specific piece of arable land. Crop rotation is the basic means of weed, disease and pest control in a organic system. It allows various cultivations of the soil at different times of the year with the result that no weed can dominate in the field.
The major advantages of crop rotation are:
- Stabilization of yields
- Preservation of soil structure
- Improvement of soil fertility

- Weed, pest and disease control
- Decrease in erosion and surface water flow
- Optimization of cultivation systems

The main principles and requirements for reasonable organization of one crop rotation are:

- Choice of crops and varieties according to soil and climatic conditions on the farm;
- Correct choice of previous crop;
- Good and timely cultivation and tillage operations;
- Alternation of crops with deep roots (alfalfa) and shallow roots (cereals), helping to keep the soil structure open and assisting drainage;
- Alternation of crops with high root biomass (alfalfa) and low root biomass (rye);
- Inclusion of more leguminous crops in the rotation; Sufficient crop rotations of leguminous plants;
- Alternating leguminous plants with nitrogen demanding plants;
- Alternating slow-growth crops with fast-growing, weed-suppressing crops;
- Alternating of row crops with cereals;
- Alternating annual and perennial crops (e.g. cereals and meadows);
- Leguminous plants, green manure crops and perennial grass mixtures (meadows and pastures) usually take up 30 to 50% of crop rotation area on organic farms;
- Inclusions of cover crops and green manure crops, undersowing techniques annual and perennial crops to keep the soil covered as much as possible, protecting it from erosion risks and reducing nutrient leaching, in winter time.

The various ways of growing crops can give rise to conditions for the appearance, growth and development of weeds. The growing of one and the same crop or of similar crops can lead to weeds best suited for the existing conditions. For example, winter-spring and early spring weeds start growing almost simultaneously with winter cereal crops either in autumn or in early spring. At that time cultivated crops are in their early stages of development and cannot suppress the development

of weeds. Late spring weeds do not find suitable conditions with winter cereal crops because they germinate when the cereal crops have already developed and suppress them strongly.

Of the winter cereals the rye is the most resistant to weeds as it develops quickly and is mature relatively early. Even dangerous weeds as corn-thistle do not grow as high as rye. Therefore rye is a very suitable crop for cleaning the weeds on organic farms.

Perennial forage crops (alfalfa, clover and grass-clover leys) are also suitable crops for suprasing weed's growth. In their first year they grow slowly with a lot of weeds among them. In the following years plants grow stronger and suppress the grown weeds while regular mowing doesn't allow weeds to form seeds.

Plant diseases and pests transferred from one crop to another can be reduced if the host crop of a specific disease or pest is replaced with a crop which is not appropriate hospitable to it.

Many plant pathogens and pests are specialized to a certain crop or a group of crops. Sowing on the same place for the second year, monoculture or alternative crops with common diseases and pests creates conditions for increasing of their population . Thus, for example, the second cultivation of a cereal after cereal crops (especially wheat after wheat) creates favorable conditions for increasing the damages of corn ground beetle (*Zabrus tenebrionis*).

One of the ways for plant protection from diseases and pests is space isolation of fields with the same crop. The larger the distance between the fields with the same crop, the smaller the possibility for diseases and pest to spread from one crop to another. To reduce the onset of diseases and pests to a minimum, some crops are to be grown on the same place after a certain period of time – sunflower in 7-8 years, clover – in 6-7 years, peas and cabbage – in 5 years, wheat, barley and potatoes – in 3 years, with alfalfa it is the same number of years as the length of time it has been grown before.

To protect crops from disease and pests in some cases interim crops which are not attacked by the same diseases and pests are to be included. In crop rotation they reduce erosion of the soil and to a certain extent decrease the negative influence of the second sowing of a given crop.

The presence of some “weeds” in the crops or in the boundary strips is not dangerous because they provide a niche for beneficial insects which control pests in cultivated plants or serve as bait for other pests. Plant diseases and pests transferred from one crop to another can be reduced if the host crop of a specific disease or pest is rotated with a crop which is nonhost.

Many plant pathogens and pests are associated with a certain crop or a group of crops. Sowing on the same place for second year, monoculture or rotating crops with common diseases and pests create conditions for growth of their populations. Thus, for example, the repeated sowing of a cereal after cereal crop (especially wheat after wheat) creates favourable conditions for increasing the damages from corn ground beetle (*Zabrus tenebrioides)*.

Space isolation of fields with the same crop is one possible technique for plant protection from diseases and pests. Increasing the distance between the fields with the same crop reduces spread of specific pests and pathogens from one crop to another. To reduce the onset of diseases and pests to a minimum, it is recommended some crops to be grown on the same place after a certain period of time: sunflower - 7-8 years, clover – 6-7 years, peas and cabbage – 5 years, wheat, barley and potatoes – 3 years, alfalfa – the same number of years as the length of time it has been grown before.

To protect crops from disease and pests in some cases interim crops which are not attacked by the same diseases and pests are to be included. In crop rotation they reduce erosion of the soil and to a certain extent decrease the negative influence of the repeated sowing of a given crop.

The presence of flowering bushes in the vicinity of the crops could influence positively the survival of the beneficial organisms (predators and parasitoids) which control pests on cultivated plants.

Table 3. Possibilities for mixing different crops in the rotation

Next crop	Wheat	Barley	Rye	Oat	Maize	Pea	Beans	Alfalfa	Ley
Wheat	- -	- -	0	0	0	++	++	0	0
Barley	0	- -	0	0	- -	+ +	-	0	0
Rye	0	0	0	0	0	+ +	+ +	0	0
Oat	0	0	0	-	+ +	+ +	+ +	+ +	+ +
Maize	++	++	++	++	-	++	++	++	++
Pea	++	+	++	++	++	- -	- -	- -	++
Beans	+ +	+	+ +	+ +	+ +	- -	- -	- -	++
Alfalfa	+	0	++	0	0	- -	- -	- -	- -
Ley	0	0	+ +	+ +	0	+ +	+ +	0	0

++ very good possibility; + good possibility; **0** – possible; - restricted application; - - not recommended.
Source: Lampkin (1999).

Table 4. Examples of high-input crop rotations for mixed crop-livestock farms

1.* spring barley/ley**, 2. grass-clover, 3.winter wheat/grass, 4. pea/barley - grass
1. winter wheat:grass, 2. pea/barley:grass, 3. spring barley:ley, 4. grass-clover
1. grass-clover, 2. potatoes, 3. field beans, 4. winter wheat, 5. spring wheat, 6. winter rye (cereals were undersown with red clover-grass mixture)
1. winter wheat, 2. oat–clover intercrop, 3. sunflower, 4. spelt, 5. grass-clover, 6. silage maize
1. barley, 2. grass-clover, 3. grass-clover, 4. barley/pea, 5. winter wheat, 6. fodder beets
1. ley, 2. ley, 3. ley, 4 winter wheat, 5. winter triticale
1. ley, 2. ley, 3.winter wheat, 4. spring cereal, 5. winter wheat
1. ley, 2. ley, 3.winter wheat, 4. spring wheat, 5. winter cereal
1. ley, 2. ley, 3. winter wheat, 4. winter oats, 5. winter beans, 6. winter wheat, 7. spring barley
1. ley 2. ley 3. ley, 4 winter wheat 5. winter oats, 6. winter beans, 7. winter wheat, 8. spring oats
1. Pea, 2. winter wheat, undersown with clover/grass, 3. set-aside, 4. winter rape, 5. Field bean, 6. winter wheat, undersown with clover/grass, 7. set-aside, 8. winter rye
1. potato, 2. spring barley/Intercrop, 3. clover with grass, 4. clover with grass, 5. winter wheat/after crop
1. oat +insown green manure, 2. green manure, 3. spring wheat, 4. oat + insown green manure, 5. green manure, 6. potato 1 rye (cover crop)
1. clover/grass-ley, 2. clover/grass-ley, 3. winter wheat + cover crop, 4. silage maize, 5, winter rye + cover crop
1. barley + insown red clover, 2. red clover, 3. winter wheat + insown red clover, 4. beans + insown red clover, 5. potato, 6. peas + insown ryegrass

* Number of year; ley** - arable land put down to grass, clover, etc., for a single season or a limited number of years, in contrast to permanent pasture

Source: Lampkin (1999)

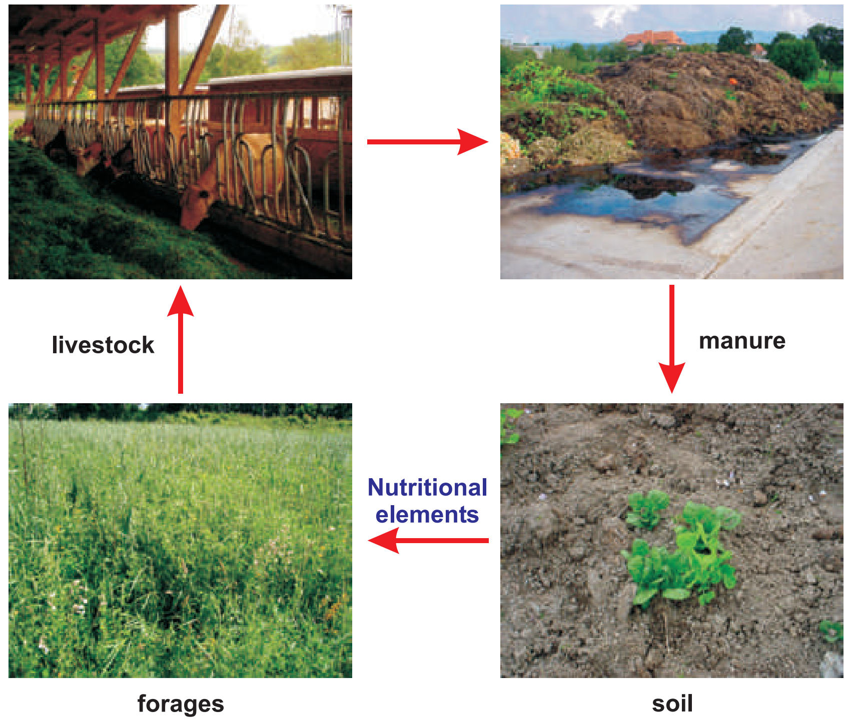
Soil cultivation

Cultivation practices have the most significant impact on the soil of any agricultural practices. The soil cultivation practices has to achieve: the production of suitable tilth or soil structure; the control of soil moisture, aeration and temperature; the destruction or control of weeds and soil pests – this could be achieved indirectly by the improvement of conditions for plant growth; clearing crop residues and incorporation of manures in the soil remedying of compaction.

Organic farming emphasize the use of cultivations which seek to maintain soil structure and allow the soil to have vegetative cover for as long as possible within the rotation. Shallow cultivations and mixing of only the surface soil layers are an important element of this approach because organic systems tend to utilize shallow than deep ploughing, as this retains near the soil surface, where they break down more rapidly and where most rooting occurs, while achieving sufficient aeration. Deep cultivations when in wet soil create compact layers in the soil that can limit plant growth.

There are also arguments in favour of traditional cultivations under certain conditions. Whether a ploughing or no-ploughing approach is used, deep cultivations to loosen and aerate the soil are important on most soil types. Light sandy and silty soils need annual topsoil loosening by ploughing.

Any late autumn or spring cultivations should be carried out in the top 10-12 cm of the soil, maintaining the biologically stabilized structure in the lower soil layers.



Scheme 1. Circle of nutritional elements in the farm (I. Manolov)

Earthworm's casts
(photo I. Manolov)

Manure storage ground with drainage
system (photo I. Manolov)

Manure covered by plastic film protecting
the heap from rain water but allowing
ventilation (aeration) (photo I. Manolov)

Mixing of compost heap for better
aeration inside (photo I. Manolov)

Moistening of compost heap
(photo I. Manolov)

Spreading of manure
(photo I. Manolov)

V. BIOLOGICAL CONTROL OF PESTS, DISEASES AND WEEDS

1.Introduction

The Context of Biological Pest Management

Agricultural activities have created ecological systems that largely differ from the natural ecosystems that would otherwise characterize a given region. Obviously, the most important difference is that agricultural production focuses on one or a few plant species – but in any case, very few species compared to the original plant diversity – and aims at keeping these species and increase their yields, attempting to utilize all the available sources of the ecosystem to reach these goal. This results in artificial, much simplified community structures in agricultural areas. Such systems may be maintained only by regular human intervention and are typically externally regulated. The first trophic level (producers) is strongly reduced and it is often composed of non-indigenous species. The age, quality and genetic traits of plants are much more uniform than in natural systems, these uniform plants of excellent quality are present in high densities, providing optimal conditions for several noxious species. Crop rotation(if applied at all) does not resemble natural succession, field sizes increase parallel to intensification, farms cultivating similar plants often aggregate in space and these factors all contribute to decreasing local and regional landscape diversity. Beneficial and neutral organisms living in agro-ecosystems under intensive cultivation are subject to frequent disturbances, including periodic food shortages, lack of alternative prey and pesticide applications.

Sustainable Agricultural Production and Integrated Pest Management (IPM)

The introduction of intensive production systems held the promise of simplified agricultural production and cheap, immaculate and “problem free” products in excess quantities. However, ever since the early 70s, problems related to intensive agricultural production have been increasingly prominent. The most obvious risks are represented by the excessive use of chemicals (human health risks, local extinction of beneficial/neutral organisms, accumulation of poisonous compounds in the food-web, contamination of ground waters, etc.) Other problems, though not as clear-cut as those above or harder to interpret, are equally important, such as decreasing biodiversity, social problems or overproduction. Specific controversies related to crop protection, such as resistance against certain pesticides or sudden gradation of pests previously considered as of only secondary importance might even question the productivity of these systems.

Sustainability means that a given agricultural system is able to produce the desired product in the required quality and quantity, without degrading the environment. Production in the long run is characterized by stable yields and ecologically viable production methods, with increased biodiversity, closed nutrition cycles, favorable soil structure and soil flora, sustainable energy consumption and minimized use of external sources. Such a system cannot be realized without considering the local cultural and social environment, the creation (or rather re-creation) of sustainable systems requires the co-operation of several scientific disciplines.

Sustainable production is a holistic system of production elements, relying basically on cultural and biological input and applying chemical input only as an auxiliary measure that can be integrated into the system. It aims at minimizing the use of non-renewable sources while carefully regarding soil productivity, biodiversity, yield and incomes as well as ecological, social, animal-wellness and nature conservation considerations.

Integrated crop protection is an important element of sustainable agriculture. The concept of IPM that is Integrated Pest Management (or earlier IPC, Integrated Pest Control) conceived as early as the 1950s and has become increasingly popular from the 1970s. According to its definition, IPM is a crop protection strategy that aims at keeping pests of a given plant below a damage threshold, utilizing characteristics of the plant, environmental features and technological methods, always paying attention to social and economic considerations. Practical IPM, unfortunately, does not ultimately cover all the fields mentioned above. IPM typically relies on restricted pesticide use based on pest monitoring and resistant or tolerant varieties and though these methods indeed yield positive results, the basic approach of the stakeholders in production has not changed. Applying IPM in its original sense is

problematic. Keeping noxious organisms under a complex damage threshold while achieving proper yields and minimizing environmental load cannot be realized as long as the only evaluation criteria are yields per production unit and "immaculate" products.

IPM would requires comprehensive scientific background and continuous attention from producers as well as from advisors and presumes basic changes in customer approach, for example "cosmetic damage" should not be regarded as a problem any more.

As long as agricultural products are characterized by low prices and high quality requirements we cannot blame producers if they want to produce huge quantities of excellent quality. Producers at the same time are under pressure from consumers who demand „healthy" food and environment as well as from the government that aims at radically reducing pesticide use. In an ideal IPM system, a farmer has to manage the whole pest community (in other words, he cannot concentrate on the ad hoc treatment of some chosen species) otherwise he will not be able to comply with all the economic and ecological requirements. Such a management requires a novel, holistic approach.

2. Biological Pest Management

2.1. Definition

Biological pest management is a pest control system that mostly relies on natural processes, such as herbivorism, predation, parasitism, phermone-induced responses but also on the use of agro-technical methods, plant-derived chemicals and natural minerals. Biological control may be an important element of IPM and represents an alternative to continued reliance on pesticides.

Most often, biological control is defined as a method that uses natural enemies to reduce the damage caused by pest species. Accordingly, a distinction should be made between biological and natural control. In the latter case we can talk about a natural process, where natural enemies control pest populations whereas in the case of biological control, human intervention and planned actions are presumed.

It should be noted here at the beginning that even though several biological methods and products are available for organic growers for the purposes of pest control, all their efforts will be to no avail if they do not select growing sites carefully, in accordance with the needs of the particular crops. Preferably, such varieties should be chosen that are resistant to or at least tolerant of the most common pests and diseases. Planting or sowing times as well as plant care (irrigation, fertilisation, etc.) should be optimised, so that a strong and healthy plant population can face the threats represented by pests and diseases.

2.2. Advantages and Disadvantages of Biological Control

<u>Advantages</u>

Biological control, when applied as part of an IPM programme, may reduce the legal, environmental, and health hazards of using chemicals. Most of its methods are rather species specific, representing no harm to other living organism but the targeted pest. There is also less danger to the environment, water quality and human health. Resistance is less likely to develop against biological control agents.

<u>Disadvantages</u>

Biological control is an extremely knowledge-intensive field that requires careful planning and a thorough knowledge of the agricultural system as well as the biology of the pests and beneficial organisms we are dealing with. It might be time consuming, requiring lots of patience, education, training, field observations, etc and even then results may be unpredictable and much dependent on local characteristics. Hence, biological control is still more popular in protected cultivation (where environmental parameters can be regulated) than in field cultivation. Combination with other IPM methods may require great care as beneficial organisms are usually quite sensitive to pesticides. In some cases, biological control is less economical than pesticides and quite often the results are not spectacular .

Sometimes, the introduction of natural enemies may cause unforeseen ecological problems

A classic example of ecological problems caused by the lack of sufficient knowledge on complex living networks is the decline of the large blue butterfly in the UK as a result of introducing the *Myxoma* virus to control rabbits. As rabbits disappeared, the grassland was not grazed any more and this created an unfavourable habitat for a certain ant species that nurses the caterpillars of the butterflies.

2.3. Classical Methods of Biological Control (Natural Enemies)

Classical Biological Control is the control of pests introduced from another region through importing specialized natural enemies of the pest from its native range. The aim is to establish a sustained population of the natural enemies. It was first applied in modern times in the 1880s, when the lady beetle called vedalia (*Rodolia cardinalis*) was introduced into California from Australia, to combat cottony cushion scale (*Icerya purchasi*), a non-indigenous pest. Some kind of intervention was essential, as cottony cushion scale made citrus production nigh impossible; growers were cutting down trees and burning them while trying to get rid of the pest. Orchard values were plummeting. A year later however, the pest was completely controlled in the areas of introduction (the cost of the project was $1500)

The intervention was a spectacular and thoroughly successful one, starting the modern career of biological control and has been referred to in textbooks ever since.

The most classical example of *Inoculative Biological Control* is 304 AD when the Chinese used the yellow citrus ant for pest control in mandarin orange orchards. The ant was reared by village people and sold at the markets in little silk-like bags. (The Chinese were in any case enthusiastic observers of natural processes, describing the beneficial role of for example frogs against various insects, mynah birds against locusts or even the less visible carabid beetles against noctuid caterpillars, while people in Switzerland took the cutworms to court where the archbishop excommunicated them). Inoculative biological control means that biological control agents are introduced (once or several times) to provide control for a certain period and they are expected to reproduce.

A description from around the 1770s describes how the Arabs used a particular red ant species to control other ants that damaged date palms. Beneficial ants were actively introduced to the orchards. The technique survived the centuries (up to the introduction of DDT that is) and its use has been extended to control caterpillars, too.

While inoculation is the introduction of a small number of individuals of the biological control agent, *Inundative Biological Control* is the introduction of vast numbers of individuals, most often reared for the purpose. This over all approach is common when the biological control agent cannot survive the entire year, or can not achieve densities high enough to regulate the pest population.

For modern examples of species used in inundative biological control, see (2.4).
As opposed to the method described above, where the agro-ecosystem is manipulated by introducing beneficial organisms, *Conservation Biological Control* works with those already present and manipulates their environment to maintain them and help them in regulating pest densities. Conserving natural enemies is often one of the most important factors in increasing the impact of biological control on pest populations.
The first and often most crucial step is to identify natural enemies that might contribute to pest regulation. Those relying on biological control should learn to distinguish between pests and beneficial insects and mites.
Another important requirement is to reduce pesticide application to the minimum possible. Most pesticides kill predators and parasitoids along with pests and quite often natural enemies are more susceptible than pests to commonly used insecticides. This means that we should forget about "spraying according to the calendar" when applying biological control and use chemicals only when pest populations are otherwise uncontrollable and they are likely to cause damage, i.e. when population levels exceed established economic thresholds. Even in such cases as these, pesticides must be used selectively. There are several insecticides that are toxic only to specific pests and less toxic or even harmless to beneficial organisms. A good example is the toxin of the bacterium Bacillus thuringiensis, commonly known as BT toxin, which kills only caterpillars, selected beetles, or certain mosquito and aphid larvae. (See 2.4 for further details). The method of application may also make a difference. It is useful to provide shelter for beneficials by leaving some areas unsprayed.
Beneficial organisms may need shelter not only for hiding from chemical treatments but also for overwintering. For this purpose, try to maintain standing crops, weed stands, crop residues, uncultivated field edges that provide ground cover (always bearing in mind of course that pests may also use these for overwintering or, in the case of for example some aphids, for reproduction). Studies show that natural enemies migrate to cultivated fields from uncultivated field edges, woodlots, hedges, etc. in the spring. However, if we manage

to attract natural enemies to our field, we might destroy or repel them when harvesting our crop. Where applicable, strip cutting or reduced cultivation (leaving the stubble for the winter) may mitigate this problem. (Again, such a practice may be a double edged sword. For example, while encouraging natural enemies reduced tillage may also contribute to the spreading stalk borers and corn borers in corn. As mentioned before, the application of any biological control method assumes the through knowledge of the biology of pests and beneficial organisms in a given system and should be based on an informed decision.)
Non-crop plants also provide pollen, nectar or alternative prey for predators or parasitoids.
Seed mixes of flowering plants intended to attract and nourish beneficial insects are sold at garden centers and through mail order catalogs. The presence of flowering weeds in and around fields may also favor natural enemies.
To replace nectar and pollen, essential for some species to lay eggs, we may also try to use artificial foods to boost natural enemies, with special regard to lacewings, certain ladybirds and syrphid flies. Artificial insect food contains yeast, whey proteins, and sugars.
As we have seen, the various methods of conservation biological control should be used with care. Our ultimate goal is not to have as many natural enemies as possible but to earn our living by producing a yield in acceptable quantity and quality.

2.4 Natural Enemies

2.4.1 Natural Enemies of Insects

Arthropod Natural Enemies - Predators and Parasitoids (Generalists and Specialists)
An organism that feeds on another organism is its natural enemy, if the prey is an agricultural pest, then the natural enemy is called a beneficial organism. Beneficial organisms are most widely used against insect pests and mites, usually the exploited enemies of arthropods are also arthropods. In this context, there are two types of enemies: parasitoids and predators. Parasitoids search for other insects for the purposes of reproduction: they will lay their eggs in, on or near the host and it is their larvae that will feed on the prey item, in this case called the

“host”, consuming it totally or almost totally from inside. As opposed to true parasites, parasitoids eventually kill their host. Predators on the other hand attack their prey for food. They kill several preys during their lives, however, as their reproduction is not directly linked to the pest species their numerical response to pest outbreaks is delayed.

Parasitoids, even the ones considered polyphagous have a rather narrow host range whereas predators tend to be generalists; though there are exceptions of course to both cases. For the purposes of biological control, specialists are usually preferred over generalists as the former group shows a strong numerical response to pest outbreaks and they are not disoriented by cues from non-target host or prey species. They are indeed often used as intermediate treatment, quite similar to the way we use chemicals. After pest numbers are reduced they usually die out (especially in protected cultivation) and in the case of a new outbreak, they have to be introduced again. Generalists on the other hand are also able to survive when the targeted pest species is not available, feeding on other prey items. This way they are available in case another pest outbreak occurs but they may perform effective control only if their opportunistic feeding habits that allow them to rapidly exploit a food resource. In the simplest species-poor ecosystems, for example in greenhouses, specialist parasitoids are usually more effective, whereas in a field situation, where the food-web is far more complex a generalist might be more successful.

Practical examples

Convergent Lady Beetle (*Hippodamia convergens*)

One of the most common ladybird species in North America. Both the larva and the adult feed on aphids. They got their name for their habit of aggregating for overwintering in amazing quantities. Instead of rearing them, the beetles are usually collected from their overwintering sites and sold for gardeners and large scale farmers, in the USA as well as in Europe. They are also used outdoors but they have a large dispersal capacity (i.e. they tend to fly away from the site to be protected) so they should be released early in the morning or in the evening when they move slower. They reproduce only if aphids are plenty.

Harlequin ladybug (*Harmonia axyridis*)

A rather effective biocontrol agent of aphids, with 3-4 generations a

year. Both adults and larvae voraciously feed on aphids. They are used both in arable fields and protected cultivation. Indeed, the species is so successful that it became a pest itself, invading Europe and North America and outcompeting indigenous species at a frightening speed. When lacking aphids, the beetles feed on grape and reduce the quality of must with their bitter body fluids.

Green lacewings (*Chrysopa carnea, Chrysoperla rufilabris*)

They are available for purchase and release as biocontrol agents against aphids (’aphid lions’). They have peculiar eggs, located on the top of fine stalks, that keep them out of the reach of other predators or parasitids. The adults feed mainly on nectar or aphid honeydew. The female cannot lay eggs without some food source, so artificial food sources or flowering edges should be applied. They are used in protected cultivation as well as for field crops.

Aphidoletes aphidimyza

This is a predatory midge whose larvae feed on over 70 species of aphids. The species is used in protected cultivation (though there are promising results concenring field releases) and is particularly important for the protection of long term vegetables.

Phytoseiulus persimilis

It is a predatory mite species, widely reared and used against herbivorous mites, with special regard to the two-spotted mite (*Tetranychus urticae*). It was one of the first beneficial arthropods to be commercialised. Both adults and nymphs are predators. They are able to utilise the webs made by herbivorous mites to reach their prey. *P. persimilis* is used in protected cultivation, for the protection of vegetables and ornamental plants. Special blowers are also available to spread the tiny mites over the area top be protected.

Amblyseius swirskii, A. cucumeris, etc.

These predatory mites are mainly used against thrips and whiteflies in greenhouses, consuming smaller larvae and eggs. They cannot attack large larvae so they should be released in sufficient numbers to prevent the development of later larval phases. A. swirskii, a species discovered for biocontrol only fairly recently, has the added value of not going under diapause with the shortening days so they may also be used in the fall or the winter (at too low temparetues they may go dormant though).

<u>*Orius laevigatus*</u>

This predatory bug has been efficiently used since the 1990s against various thrips species (especially *Frankinella occidentalis*, the western flower thrips). All its larval stages as well as the adults feed on thrips by sucking out their body fluids. Adults are able to fly, thus disperse quickly and find new prey items easily. *Orius* species are known to "overkill", meaning that at a high prey density they kill more than they eat. When provided with pollen to eat, adults are able to survive without prey for a longer time, hence the species may also be used as a preventive treatment.

Parasitoids

<u>*Encarsia formosa*</u>

This tiny aphelinid wasp is an emblematic parasitoid, being used for several decades in Europe and America in the glasshouse control of whiteflies. It was one of the first species to be mass reared successfully. Females lay their eggs into whitefly nymphs and both genders perform host feeding, i.e. they also feed on their host by sucking its body fluids. It is often applied with the "pest-in-fist" method, meaning that first some hosts are released (at very low densities) to provide food and an opportunity to reproduce for the parasitoids introduced later. Sometimes it is used in combination with *Eretmocerus eremicus*.

<u>*Trichogramma* species</u>

These are the most widely used parasitoids worldwide; the most popular species in Europe is *T. brassicae*. They are extremely small, with adults not growing larger than 0.7 mm. They lay their eggs on the eggs of various butterfly species and the larvae will feed on the emerging caterpillars. A special advantage of *Trichogramma* parasitism is that the caterpillars attacked stop feeding, i.e. they do not damage crops any more. However, as the females do not attack the caterpillars themselves, they are not useful when the infestation level is already high. This species is also used for outdoors releases.

<u>*Aphelinus abdominalis, Aphidius colemani, Aphidius ervi*</u>

These parasitic wasps are examples of aphid parasitoids that characteristically turn infested aphids into "mummies". They lay their eggs into their hosts (*A. abdominalis* is also able to lay eggs in winged aphids!) and larvae develop inside the aphid, eating it up from inside and leaving only the dried cuticle. Adult parasitoids may also feed on

the hosts instead of ovipositing.

<u>*Diglyphus isaea, Dacnusa sibirica*</u>

These parasitoid wasps attack the larvae of leafminers. These pests are very hard to reach and usually only systemic insecticides are effective against them. *D. isaea* is an ectoparasite, it means that females lay their eggs not into but onto the host and its larvae consume the host from the outside. *D. sibirica*, similarly to other parasitoids described in previous sections, lay its eggs into the host, thus this insect is called an entoparasite. *D. isaea* has the advantage of being able to build up a large population quite fast. In addition to laying its eggs into leafminer larvae, it also performs host feeding.

Nematodes

Nematodes are usually considered pests. Many species are pathogenic to humans or animals or damage agricultural crops. However, a small group of nematodes are considered beneficial, being the parasites of insects. They are called entomopathogenic nematodes and they have a great potential as biocontrol agents, being highly specific and not posing any risk whatsoever to humans or non-target animal species. They are suitable for mass rearing and, unlike most beneficial arthropods, they may be applied by using standard agricultural equipment, including sprayers and irrigation systems.

Nine families of nematodes (*Allantonematidae, Diplogasteridae, Heterorhabditidae, Mermithidae, Neotylenchidae, Rhabditidae, Sphaerulariidae, Steinernematidae* and *Tetradonematidae*) include species that attack insects by sterilising them or altering their development. They rarely kill their hosts directly, except for the two species considered exploitable both biologically and economically: *Steinernematidae* and *Heterorhabditidae*.

The infective juvenile forms of these species seek insect hosts and enter them via body openings or through the thin areas of the cuticle. Once inside, they release a symbiotic bacterium (*Xenorhabdus* for *Steinernematidae*, *Photorhabdus* for *Heterorhabditidae*) that reproduces readily in the guts of insects, causing rapid death by liquefying the insect from inside. The nematodes eat the bacteria and the liquid tissues and mature into adults, producing new juveniles. From one attacked insect thousands of them emerge. In fact, nematodes themselves only serve as a needle that injects the bacteria where they are needed.

Nematodes are sensitive to draught, so the soil should be sufficiently wet when they are applied. Also, exposure to direct sunlight should be avoided so application should be scheduled to early in the morning or to the evening. As these nematodes are strictly soil dwelling species, the targeted pests are those that damage the root system, for example armyworms (*Noctuidae*), the corn rootworm (*Diabrotica* spp.), root weevils, etc.

Fungi

In the very diverse group of fungi, some species are specialised to attack insects. These are called entomopathogenic fungi. They have a great potential as biocontrol agents as they are harmless to other animals or humans and kill the targeted pest readily. As they are sold in the form of spores, their application is compatible with standard agricultural equipment, like spray rigs. Usually they can maintain high persistence in the growing season though in most cases the fungi population cannot survive the winter at a rate high enough to provide control the following year.

Most species that can be used in practice against insects belong to the class *Hyphomycetes*. Some of these species are already commercialised. A wide range of pest species may be controlled by using them, including thrips, whiteflies, aphids, caterpillars, weevils, grasshoppers, ants, Colorado potato beetle, and mealybugs. The most widely used entomopathogenic species are *Beauveria bassiana* and *Verticillium lecanii*.

Another very promising group is *Entomophthorales* (their name means "insect destroyer" in Greek). They tend to be more host specific, for example, Erynia neoaphidis only attacks aphids. They are not available yet in commercial form, due to difficulties with mass rearing.

Entomopathogenic fungi spread with spores. These spores infect the host when the insect comes in contact with them on plants, in the soil, even in the air. Spores stick to the cuticle of the host and penetrate its body, often at joints or other points where the cuticle is thinner. Once inside, the fungus grows in all the body cavities and consumes body tissues, often producing toxins, too, to outcompete other fungi species. Once the insect dies, the fungus penetrates the cuticle again to get to the

surface of the body of the host and starts producing spores. This is why insects killed by fungi often look "fluffy" with fungus growth. Spores may be carried passively by the wind, rain, etc. but Entomophthorales species for example actively eject spores that increases the spread of fungi in aggregated groups of insects, like aphids. The spores of most beneficial fungi cannot persist for more than a season without coming in contact with a suitable host.

Similar to nematodes, fungi are also sensitive to dry conditions and direct exposure to sunlight. As environmental factors greatly influence their spreading, outbreaks that can reduce pest numbers after application are sporadic in time and patchy in space, limiting their effectiveness. Their environmental needs may create problems in protected cultivation as they correspond to those of several plant pathogenic fungi, the grey mould *Botrytis cinerea* in particular.

Bacteria and viruses

Sometimes they are discussed together with nematodes and fungi, collectively they are called "microbial insecticides". Most viruses or bacteria (or bacterial toxins) used as biocontrol agents are specific to their hosts, present no risk to humans or wildlife and most of them will not harm beneficial insects either. Their greatest advantage is that they can be used in combination with traditional chemical control as insecticides do not harm them. As their residues do not present health hazard, they can be applied even when the crop is ready to be harvested. If they manage to become established, their impact may extend to several seasons.

The bacteria used in biological pest control belong to the genus Bacillus. They are commonly found in soil and they have to be eaten to be effective. The most widely used species is *Bacillus thuringiensis* (BT). Under the right conditions, the species produces a spore and an endotoxin, the latter in the form of a crystal. When consumed and digested by the insect, the toxin is activated by the enzymes in the digestive track. Whether the toxin will actually poison the insect or not depends on the presence of susceptible receptors in the insect's gut, hence the selectivity of various *B. thuringienses* strains. If the toxin attaches to the specific receptor, it destroys the gut tissue and gut contents enter the body cavity. The insect dies within 2-3 days.

The strain of B. thuringiensis that was used first in biological control was *B. thuringinses var. kurstaki* whose toxin only kills caterpillars. The toxin of the strain *B. thuringiensis aizawai* is used against wax moth larvae in bee hives. The toxin of *B. thuringiensis israelensis* specifically kills *Diptera*; it is particularly often used against mosquitoes. *B. thuringiensis var. tenebrinonis* is used against beetles.
B. thuringiensis does not cause epidemics that would be effective enough to control pest populations and a few days after the application it is not effective any more. This is why it is applied rather like a synthetic insecticide, in repeated treatments. (The bacteria are reared in huge fermentation tanks.) As it has to be eaten to be effective, it should be sprayed on plant parts which the targeted herbivorous species consumes. BT products should be applied early in the morning or in the evening as they are sensitive to ultraviolet radiation.
Another way of exploiting BT toxins is to incorporate the genes responsible for its production into the genome of plants so that the plant themselves can produce the toxin. This application, however, does not belong to the topic of biological control.
Other bacteria species frequently used in biological control are *(Paeni)bacillus sphaericus* and *(Paeni)bacillus popillae*. They are mostly used against grubs, with specific regard to the larvae of the Japanese beetle, *Popillia japonica*, for example on lawns. They cannot be reared in tanks but on live hosts only. On the other hand they are able to reproduce in nature quickly enough to provide effective control and may produce spores that survive to the next season. Thus, the treatment does not have to be repeated every year.
Viruses may effectively control insect pests as they cause quickly spreading yet very much specific epidemics that effect usually only a single genus or one species only. The group most often used in biological control is nuclear polyhedrosis viruses. These viruses, just like bacteria, has to be eaten first by the insect for effective control. The symptoms they cause are particularly spectacular in the case of caterpillars, whose insides become liquefied as a result of the infestation. Infested caterpillars climb up high on plants and die there erupting. Still clinging to the plant, dead caterpillars spread virus particles for days. Naturally occurring epidemics, however, are not likely to effectively control pests as they happen only when the pest

population had reached its peak density and by that time pests have usually caused economic damage.
Viral insecticides have been less popular than bacterial products as viruses can only be reared in living hosts and, being very specific, a given virus cannot be applied against a wide range of pests. Most often they are used in forestry.
Microbial insecticides may be combined with other methods. Grasshoppers in the 1900s were controlled by poisoned baits made of bran. Bran remained as the bait but chemical insecticides have been replaced by the spores of the pathogenic fungus *Nosema locustae*.

Plants

Surprising as it may seem, plants may also be used as crop protection agents in controlling pest populations. The role of plants as pollen and nectar providers as well as sheltering structural elements have been discussed under 2.3, in the section about Conservation Biological Control. Non-crop plants or second crops, however, may have other functions in agro-ecosystems, too. When crops are grown together (intercropping, mixed cropping, etc.) generally pests are found in lower numbers though in higher diversity, while the numbers of beneficial arthropods (individual numbers and/or species richness) is usually higher, when compared to monocrops. Mixed cultures are characterised by plant competition. It does not only affect plants but it may also alter the plant-related signals that determine the behavior of herbivores and natural enemies. Interplant competition may change, for example, the cues that mediate the colonization of herbivores, smaller plants may represent smaller targets for passively dispersing herbivores, changing plant traits may result in lower nutritional quality that hinders the development of noxious organisms and may promote the beneficial actions of natural enemies.
Mixing crops may disorient herbivores regardless of the impact of competition on plants, too. For example, thrips and aphids seem to be able to spot their host plant more successfully in front of a bare, "soil-colored" background. Olfactory cues may also be confused, though it is debated at the moment, whether the odours of plants simply mix, thus creating a confusing situation for herbivores or plants take up root exudates from each other, i.e. their chemical composition itself changes.

Another way to confuse the orientation of herbivores is using attractive plants that distract pests from the other plant. Pests then can be managed on this second plant with reduced risk. Practical implementation may be problematic as the attractive plant should provide a strong enough cue to attract pests at a local level but it must not attract pests into the system at a regional level.

We may also use repellent plants that are supposed to deter herbivores from their host plants. There is a wide range of such plants recommended by various books and internet sites, yet the effectiveness of such practices has not been fully proven as yet. The list of potentially repellent plants include for example catnip (aphids, Colorado potato beetle) tansy (flea beetles), nasturtium (Colorado potato beetle – but it attracts aphids!), anise (aphids), coriander (Colorado potato beetle, mites, carrot fly), garlic (Colorado potato beetle, Japanese beetle, aphids) and even tomato (asparagus beetle).

Another concept regarding the orientation of herbivores in intercropped system is described as the "flypaper" theory. According to it, "plankton" organisms, whose independent movement and dispersion is limited, such as thrips and aphids, may starve if they arrive on non-host plants. The theories that more or less summarize the notions above are the resource concentration hypothesis and the disruptive plant hypothesis. According to the resource concentration hypothesis, visual and chemical interference in mixed systems hinders herbivores in finding their host plants, provoke them to leave host plants (also motivates herbivores to leave host plants faster, fly in a more straight line and to larger distances and prevents them from finding the next host plant. According to the disruptive plant hypothesis, second plants prevent herbivores from finding their food and change their normal behavior on the host plants. Both theories involve "plant appearance", stating that host plants in diverse cultures are "less apparent" than in monocultures. The significance of plant appearance is obvious when considering that the original evolutionary strategy of cultivated plant species was rather the less energy- and resource demanding "hiding" among other plants than producing toxins, digestion inhibitors, repellent chemicals, etc.

Obviously, care should be taken when combining plants. Too strong competition reduces yields, while it may also reduce the efficiency

of plant defense mechanisms. Other disadvantages of too fierce competition may include the following: herbivores may compensate for lower nutritional quality with higher consumption, the higher activity of certain virus vectors may result in increased infestation levels and altered plant-related cues may also disorientate natural enemies.

2.4.2. Natural Enemies of Plant Pathogens

Fungal Diseases

Fungal diseases are among the most important factors that causes serious yiled losses in agricultural crops year after year. Biological methods against them include include hyperparasitism, predation, antibiosis, cross protection, competition for site and nutrient and induced resistance. Their common characteristic is their great potential and their often unpredictable efficiency under various environmental conditions.

A number of products are already available, but just like in any other field of biological control, a more thorough understanding is needed regarding the complex relationship between plants, pathogens and their environment.

Application methods are similar to those discussed for insects. Biological control agents may be applied in an inoculative fashion, when relatively small populations are applied and microorganisms are expected to reproduce on site, for example benign (atoxigenic) *Aspergillus flavus* strains are applied this way to outcompete the aflatoxin-producing strains in cotton. *Trichoderma harzianum* and *Pseudomonas fluorescens,* on the other hand, are typically applied inundatively, in large densities, for example for seed treatment against soil born pathogens. Other species for successful inundative application are *P. putida, P. aerofaciens, Burkholderia cepacia, Bacillus subtillis, B. Polymyxa* and *B. cerrues*, against the pathogens *Rhizoctonia solani, Fusarium moxysporium, F. solani, Verticillium dahliae, Gaummannomuces graminis*, in cotton, sugar beet, wheat, rice and various vegetables. Some details and further practical examples can be found below, where the modes of action are discussed.

The most effective microorganisms that have been studied for their biocontrol potential antagonize plant pathogens by employing several modes of actions. Antagonism may manifest in the form of aggressive colonisation (for example certain bacteria colonise roots in a way that it suppresses the activity of pathogenous fungi) but more characteristically it takes the following forms.

Mycoparasitism. Pathogenous fungi are directly attacked by a specific biocontrol agent (a hyperparasite). Hyperparasites are generally classified into four groups: hypoviruses, facultative parasites, obligate bacterial pathogens and predators. An example of hypoviruses is CHV1 that causes hypovirulence in the pathogen of chestnut blight, Cryphonectria parasitica. The virus was the cue to the biological control of this devastating disease. As for fungal hyperparasites, several studies were conducted with promising species that attack powdery mildew (for example *Acremonium alternatum, Acrodontium crateriforme*) or sclerotinia rot (for example *Coniothyrium minitans*). *Pythium oligandrum* is already used commercially against various dieseases, for example verticillium wilt.

As opposed to hyperparasitation, predation between fungi is less species-specific, hence its results may be less predictable. Some biocontrol agents exhibit predatory behavior only when deprived of nutrients, for example *Trichoderm*a fungi (*T. harzianum*), widely used against soil born pathogens also in the form of seed treatment, start producing chitinase enzyme to penetrate the cell walls of other fungi (pathogenous *Pythium* species, *Phytophtora*, *Rhizoctonia, Fusarium*, etc.) under such circumstances.

Antibiosis. In some cases, the relative importance of antibiotic production by biocontrol bacteria has been demonstrated. For example, the biocontrol agent *Bacillus cereus* UW85 produces antibiotics that play an important role in the control of Phytophtora root rot in alfalfa. Some plant growth promoting rhizobacteria belonging to *Bacillus, Streptomyces*, and *Stenotrophomonas* spp. also produce antibiotics (for further details see the section 'eliciting host plant defense').

Metabolite production. Beside antibiotics, antagonists may produce other substances that can interfere with pathogen growth and other activities. Often these substances are enzymes that break down polymeric compounds. For example, the potential biocontrol agent *Serratia marcescens* (which, by the way, also causes the pink colouration of tile grouts in bathrooms) appears to rely on such metabolites. Also, *S. plymuthica* C48, a rhizobacterium strain currently being developed

into a commercial product, inhibits spore germination and germ-tube elongation in Botrytis cinerea.

Competition. It is generally believed that competition between pathogens and non-pathogens is an important factor in the biological control of fungi, especially in the case of soil born pathogens. Enterobacter cloacae for example outcompetes *Pythium ultimatum* around the roots of seedlings by effectively catabolising nutrients before its competitor.

Eliciting host plant defense. The natural defense mechanisms of plants may be induced or conditioned by chemical or other stimuli presented by non-pathogenes. It is called induced systemic resistance (ISR) as opposed to systemic acquired resistance (SAR) that develops when the plant has successfully defended itself against some pathogen. The phenotypic reactions are similar both for ISR and SAR: cell walls are strengthened and various substances are produced that help the plant in fighting pathogens, including the so called pathogenesis-related (PR) proteins that damage pathogens in various ways, antibiotics, etc. Depending on the stimulus, the induction of the defense mechanisms may be local or systemic. Stimulating self defense in plants is a difficult task as a thorough knowledge of biochemical pathways – that often behave in a mutually antagonistic manner - is a prerequisite. Some *Pseudomonas* and *Trichoderma* strains used in biological control are known for inducing strong replies in their hosts that enhance self defense in colonised plants. Plant growth promoting rhizobacteria (PGPR) that colonize the root system of plants and encourage plant growth also elicit such responses, against for example antrachnose (*Colletotrichum* spp.) or soft rot (*Erwinia carotovora*). PGPR strains are being commercialised now (for example for seed treatment). They occur in the soil naturally, too, and the application of organic manure or compost promotes them effectively.

2.4.3 Natural Enemies of Weeds

Many dangerous weed species are not indigenous to the region where they compromise yields. The local herbivore community has not adapted to their presence in many cases, allowing these plants to spread freely. For example in Hungary, about half of the species of the "most wanted" list of weeds are invasive. This is why classical

biological control is a relatively popular study field in biological weed control.
The best known success story of classical biological weed control is St John's wort, also known as "Klamath" weed (*Hypericum perforatum*), a European species mildly toxic to sheep and cattle that infested American meadows at the beginning of the 20th century. Two beetle species, native to the same region as the plant, were introduced in the USA, *Chrysolina quadrigemina* and its close relative, *C. hyperici*. The beetles solved the problem is less than 10 years, saving millions of dollars for Californian agriculture. Another successful biocontrol intervention was the use of a rust species, Puccinia chondrillina against the originally Mediterranean skeleton weed (*Chondrilla juncaea*) in Australia. However, the very same fungus in the United States was not as effective.
The results of introducing an alien species in a given ecosystem are rather unpredictable. An evaluation that analysed worldwide data up to 1985 showed that only 25% of the cases yielded any success whatsoever and "any" success is not enough to comply with all four criteria of a successful biological weed control agent: establishment (survival in the field after introduction), biological success (consumption or other destruction of the targeted plants), host impact (decrease of weed reproduction and/or biomass in situ) and control success (reduced herbicide use, etc.).
The introduction of natural enemies is not always intentional. The only widely known European success story of classical biological weed control is about such an unintentional introduction: the rust species *Puccinia lagenophorae* is native to Australia and it was unknown in Europe before the 1960s when it was reported from the UK and France on groundsel (*Senecio vulgaris*). Though the fungus does not kill the weed, it reduces its competitiveness significantly. It is evaluated currently as a biocontrol agent against various *Senecio* species.
Being somewhat more predictable and compatible with traditional agricultural machinery, bioherbicides, i.e. inundative and inoculative applications of microbial weed control agents would be preferred to classical biological control in everyday agricultural practice, yet there are only a few products available. The majority of research

and commercial products are linked to the USA. Most of the work done focused on organisms for the foliar treatment of weeds (for example *Phytophtora palmivora*, various strains of *Colletotrichum gloeosporioides*). There are numerous potential weed biocontrol agents under evaluation, for example *Ascochyta caulina* against the common lambsquarters (*Chenopodium album*), or *Alternaria destruens* for the control of dodder (*Cuscuta* sp.)
Soil micro-organisms, though having a great potential, are often overlooked. Another important field of weed management is the reduction of the seed bank in the soil, but since the possibilities to do so are only just being currently investigated, there are no commercial products available. In addition to pathogens, insects may also play an important role in this case, seed weevils and ground beetles have a particularly great potential. The combination of various natural enemies is also a promising field of research, for example the seed feeding insect *Niesthrea louisianica* facilitated the seed penetration of *Fusarium* pathogens in the case of velvetleaf (*Abutilon theophrasti*).

2.5. Other Methods of Biological Control

Attractants

Infochemicals - Infochemicals play an important role in the biology of many insect species. The understanding of interactions between plants, herbivores and beneficial organisms at the level of infochemicals resulted in products that can be used in biological control.
Chemical information is regarded as a key factor mediating behavioural and ecological
interactions between insects and plants and between insects themselves and, more surprisingly, also between plants.
The chemicals that carry information between members of the same species are called pheromones. Sex pheromones are produced by either sex (usually by the female though) to attract the opposite sex for mating. Aggregation pheromones are produced by both sexes (mostly the males) and attract conspecifics regardless of gender, resulting in aggregations to utilise food sources or for mating. Alarm pheromones warn of some danger and repel conspecifics, oviposition deterring pheromones are used by females to mark locations where they have laid eggs, so that other females do not lay in the same place.

The chemicals that mediate interactions between members of different species are called allelochemicals. Marking the interacting species as 'Species 1' and 'Species 2', allelochemicals may be categorised as follows:

- Allomones are produced by Species 1 and the reaction of Species 2 to the chemical is favourable for Species 1. Chemicals produced by herbivores to deter natural enemies fall into this category.
- Kairomones are produced by Species 1 and the reaction of species 2 to the chemical is favourable for Species 2 but not for Species 1. A well known example is carbon dioxide, emitted by humans and received as a feeding attractant by female mosquitoes but of course plant-produced chemicals that attract herbivores are also considered kairomones.
- Synomones are produced by Species 1 and the reaction of Species 2 to the chemical is favourable for both species.

The best known application of infochemicals is the use of pheromones. Pheromones are applied either as a tool for monitoring pest populations or as an agent directly aimed at manipulating pests. Most often artificially produced pheromones are used as their quality is guaranteed and they are available in sufficient volumes.

Several pheromone-baited trap types are available for monitoring, and they usually but not exclusively contain some kind of sex pheromone. The most frequently used are the delta trap and the funnel trap but designs are ample. Pheromone traps are extremely useful at very low pest densities, where other methods are unfeasible to detect specimens. They are essential in projects when the first appearance of dangerous exotic pests is to be monitored. Pheromone traps are also used to determine first emergence or population peaks. Efficient as they are, the interpretation of the catches of these traps requires care and attention of course, as environmental factors (rain, temperature, wind speed and direction, etc.) influence their performance. Pheromones may also be combined with plant kairomones for increased effectiveness, for example the pine weevil *Pissodes nemorensis* reacts to traps with its own aggregation pheromone only if it is presented together with odours from the host plant.

A direct pest management application of pheromone traps is to "trap out" populations.

The idea behind this is placing out as many traps as to substantially reduce the pest population. Both aggregation and sex pheromones are suitable for the purpose. When sex pheromones are used, care should be taken to place out traps early enough to prevent mating. Mass trapping has been applied to control for example bark beetles, the codling moth, the apple maggot, the Japanese beetle. Results, however, are controversial. First of all, to adequately reduce pest populations, a large number of very efficient traps are needed, otherwise trap capacity will not suffice. Second, removal by trapping can only be successful if the pest population is low enough and immigration into the trapping zone is minimal, otherwise we might end up with the unwanted result of alluring all the pests of the region into the area to be protected.

Another direct application method of pheromones is the disruption of mating. Obviously, this method applies sex pheromones. In theory, if the air in the given area is sufficiently saturated with sex pheromones, males will be unable to follow chemical cues to find females. The method is not widely used but it has been successfully applied against the oriental fruit moth, pink bollworm in cotton, grape berry worm, tomato pinworm and some forestry pests. Again, the immigration from other areas by pests following the irresistible lure might cause problems.

The common advantages of the direct methods listed above are that they are highly species-specific, harmless to other living organisms and usually relatively cheap.

Infochemicals may be also used to promote the effectiveness of parasitoids and predators, by means of enhancing their searching efficiency (attracting them to the plants or arresting them there), host utilisation or reproductive capacity. Field applications are scarce as yet but the topic has a rich and diverse literature.

<u>Visual Lures - </u>Visual lures used in pest management fall into 3 categories: lights, coloured objects and shapes or silhouettes standing out against some background.

Hundreds of species of moths, beetles, flies, and other insects are attracted to artificial light, among them there are also several pest species, for example European corn borer, codling moth, cabbage looper, many cutworms and armyworms or the diamondback moth. As pheromones are cheaper, light trapping is not as popular any more as it used to be, though it is still a useful method of monitoring flying insects. The wavelength of light should be adjusted according the sensitivity of different species. Light tarps are not suitable for mass trapping.

Coloured sticky traps are used to monitor various pests. For example, aphids and whitefly are attracted to yellow, maggot flies to red and thrips to blue. Yellow sticky cards or plastic cups are widely used in mass trapping programs to control whiteflies (only the winged adult forms) in greenhouses. The mass trapping of apple maggots is still in the experimental phase, its success being limited by the immense number of traps required and delicate timing.

Botanical Insecticides

While reducing the targeted pest populations, pesticides should break down quickly, preferably leaving minimal or no residuals and should not pose a hazard to human health or wildlife. Synthetic pesticides do not always comply with these criteria so more and more attention is given to natural extracts. Plant extracts, though having various modes of actions, have some common traits: they break down fast, they work fast, they are selective and they are usually not toxic to plants or mammals (there are exceptions of course). Non-plant products, such as oils, insecticide soaps, sulfur, etc. share more or less the same characteristics but they may be toxic to sensitive crops or ornamentals.

Plant extracts

Limonene, linalool

They are colourless substances having a strong odour of oranges. They are found in the peel of citrus fruits. Limonene and linalool are used as contact nerve toxins, though their mode of action is not fully understood. They appear to stimulate the sensory nerves and the central nervous system, resulting in the overstimulation of motor nerves. These substances are used against a number of insects including mealybugs, mites, aphids and scale insects. Some studies indicated limonene to be a possible kairomone for the beneficial predator Harmonia axyridis.

Neem

Neem oil is the extract of the fruit and seed of the neem tree, Azadirachta indica and as such, one of the most important commercially available biological pest control products. At least two components of the rather

complex substance have insecticidal effect (azadirachtin and salannin) but neem oil appears to be effective in controlling some fungal pathogens, too, for example powdery mildew. As an insecticide, neem oil is a feeding deterrent (when sprayed on plants, they repel herbivores) and a growth regulator (when the larvae of insects get in contact with it, they cannot mould into the next instar and die). It is used against an extremely wide range of insects, for example mealy bugs, the beet armyworm, aphids, the cabbage worm, thrips, whiteflies, mites, fungus gnats, beetles, moth larvae, mushroom flies, leafminers, caterpillars, locusts, nematodes and the Japanese beetle.

Pyrethrum

The pest control effect of the ground flowers of a daisy species (*Chrysanthemum cinerariaefolium*) had been known by the Arabs well before the Middle Ages and the knowledge was first brought to Europe by the crusaders. The information, however, was lost and pyrethrum, as it was known later, had to be rediscovered. The flower was traded along the Silk Route from China and eventually was grown in the Dalmatian region. French soldiers were reported to have used the crushed flower to control fleas and body lice during the Napoleonic Wars. In modern times, most of the world's pyrethrum crop is grown in Kenya but synthetic pyrethroids are also widely used. Pyrethrins interrupt the normal transmission of nerve impulses in insects, resulting in immediate paralysis. Insects are able to metabolyse pyrethrins thus recovering from the poisoning. To prevent this, most products containing pyrethrins also contain a synergist, piperonyl butoxide (PBO). Without PBO, the effectiveness of pyrethrins is greatly reduced. Pyrethrins have a low toxicity to mammals but cats are highly sensitive to it. They are used against a broad range of insects, for example earwigs, leaf miners, beetles, aphids and spider mites.

Rotenone

Rotenone, an extract of the tropical legumes *Lonchocarpus* and *Derris*, is used against insects feeding on leaves, such as aphids, the asparagus beetle, the bean leaf beetle, the Colorado potato beetle, the cucumber beetle, flea beetles, the strawberry leaf beetle, caterpillars, and also against parasites like fleas and lice. Rotenone is a powerful inhibitor of cellular respiration and acts as a contact and stomach poison. In pure form, it is more toxic than malathion, the most commonly used and very effective organophosphate insecticide. It is extremely toxic to fish.

<u>Ryania</u>

This extract is produced from the South American *Ryania speciosa*. It is a slowly working stomach poison, yet insects consuming it stop feeding soon so they are unable to cause more economic damage. It is used mostly against caterpillars, either in itself, or in combination with pyrethrins and rotenone. PBO may be used as a synergist also in this case. Ryania is reported to be most effective in hot weather. The exact mode of action is unknown.

<u>Sabadilla</u>

Sabadilla, a contact poison effective against a broad range of insects including squash bugs, harlequin bugs, thrips, caterpillars, leaf hoppers and stink bugs, comes from the seeds of the tropical lily *Schoenocaulon officinale*. Its alkaloids act as nerve poisons. When used, care should be taken to protect bees as sabadilla is highly toxic to them. The dust of seeds has very low toxicity to mammals, but the purified alkaloids are in range with the most toxic synthetic insecticides.

Soaps and oils

The Chinese used soap as a pest control agent already by 1100 AD while the Romans treated trees with oil and ash as early as 350 BC. (It is true though that the same Romans controlled locusts by sending naked women to run around the garden barefoot with their hair down. There is no evidence as to the effectiveness of this program but gardening must have been quite entertaining those days nonetheless.)

<u>Horticultural oil</u>

'Dormant' and 'summer' horticultural oils are different in the time of their application: heavy, unrefined dormant oils may only be used before the active growing season while summer oils may also be used on leaves.

Oils block the breathing holes of insects and prevent gas exchange through egg membranes (this is why oils were traditionally used early in the spring, to kill overwintering insect eggs). Some oils have antifeedant properties. Oils are most effective against small, resting or slow-moving, soft-bodied insects (aphids, scales, leafhopper nymphs,

whiteflies). Oils have to cover the target insect, they do not work if the insect arrives later to the treated area.

<u>Insecticidal soap</u>

These special soaps are made of plant oils, for example from cottonseed, olive, palm, coconut or animal fat. Though they have been used for decades, their mode of action is still unclear. They are thought to disrupt the cuticula of insects but toxicity is also suspected. They are only effective against soft-bodied insects (aphids, scales, psyllids, whiteflies, mealybugs, thrips, spider mites).

Mineral insecticides

<u>Diatomaceous Earth</u>

This is a non-toxic insecticide, composed of the fossilised shells of ancient *Diatoma* algae. It absorbs the lipids from the wax of insect exoskeleton, erodes the cuticula and eventually insects dry out. It is used against millipedes, soft bodied insects such as aphids but also against slugs (as slugs prefer wet habitats, the effectiveness of diatomaceous earth is rather limited). Sometimes it is combined with pyrethrins. It is widely used for insect control in grain storing facilities.

<u>**Sulfur**</u>

Sulfur is one of the oldest pesticides, even mentioned by Homer some 3,000 years ago. Most often it is used against pathogens, for example against powdery mildews, rusts, fruit rots, but some arthropods, mites in particular, are also sensitive to it. Sulfur is not toxic to mammals but in dry weather it may scorch plants.

<u>Bordeaux mixture</u>

Originally, the Bordeaux mixture was used against the most dangerous of pests, humans. In France, vine growers used it to deter thieves, as the mixture, well visible on grapes, has a very bitter taste. Later it was discovered that it is effective against the dreaded vine disease, downy mildew.

Bordeaux mixture is a mixture of copper sulfate and hydrated lime. Its mode of action relies on the effect copper ions have on fungal enzymes. Affected spores do not germinate. Thus, the mixture should be used to prevent the development of fungal diseases, when the disease has onset, it is not effective any more.

2.5 Mechanical Tools

Mechanical Weed Management

Surprising as it may seem, row planting and seeding that facilitates mechanised weed control started only around the 1750s, after Jethro Tull had invented his seed planter. Nonetheless, mechanical weed control by manual means (hand weeding, hoeing, etc.) had been performed by farmers already for millennia before that (chemical weed control is a relatively new development).

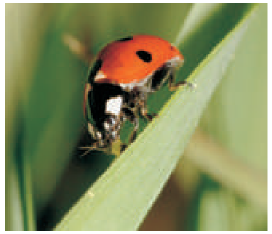
Mechanical weed control may be a viable and cost effective alternative to costly and toxic herbicides.

Cultivators are the tools most often used for mechanical weed control. Their effectiveness is influenced by a number of factors, the most important ones being cultivation, depth, soil moisture and not the least the experience of the operator. Too shallow cultivation spares weeds while too deep cultivation may damage the crop, too. Cultivation on wet soils may result in the formation of clods, in addition weeds may survive the intervention.

Timing is crucial. Cultivators may be applied in pre-emergent or post-emergent weed control and the growth stage of both the crop and the targeted weeds need to be considered. The more runs needed, the less cost efficient mechanical weed control is (fuel and labour costs, etc.). In addition to classic cultivator types, modern tools such as flex-tine harrows, finger weeders (for in-row weed control) and torsion weeders are also available.

Bug Vacuums

Field vacuuming, applied for the purposes of insect control, is a relatively new concept in organic cropping systems. Though heavily promoted, it has not been widely used as yet. Field vacuums suck pests from the crop and crush them. They are not yet a commercial success but some references recommend them for the control of lygus bugs in strawberry. Their disadvantages include frequent treading of the field, high initial costs and the spreading of spores of fungal diseases.



Ladybeetle eating an aphid. Hans Smid www.bugsinthepicture.com

The predatory mite, Pheitoseiulus persimilis. Hans Smid www.bugsinthepicture.com

Harmonia axyridis, invasive harlequin ladybird. Nina Fatouros www.bugsinthepicture.com

The solitary parasitoid wasp Cotesia rubecula, parasitizing on the 1st instar larva of the small cabbage white, Pieris rapae. Hans Smid www.bugsinthepicture.com

Aphids in parsley (photo A. Enamorado)

Aphids in salads (photo A. Enamorado)

Pheromone trap (photo I. Manolov)

VI. ENVIRONMENTAL MEASURES

1. Introduction

Council Regulation (EC) No 1182/2007 of 26 September 2007, laying down specific rules as regards the fruit and vegetable sector, amending Directives 2001/112/EC and 2001/113/EC and Regulations (EEC) No 827/68, (EC) No 2200/96, (EC) No 2201/96, (EC) No 2826/2000, (EC) No 1782/2003 and (EC) No 318/2006 and repealing Regulation (EC) No 2202/96, stipulates that operational programmes must include two or more environmental actions or at least 10% of the expenditure under operational programmes must cover environmental actions.

That Regulation also provides that producer organisations must have the objective of the use of environmentally sound cultivation practices, production techniques and waste management practices, in particular to protect the quality of water, soil and landscape, and preserve or encourage biodiversity.

Producer organisations must also effectively enable their members to obtain technical assistance in using environmentally sound cultivation practices.

2. Environmental actions

The environmental actions have been grouped together according to the main objective to which they contribute, and seven sets of actions have been established. These sets have been established with a view to assessing the actions and making them more effective, as they can be evaluated using the same indicators.

Furthermore, the four priority areas for action established under the Sixth Environment Action Programme were taken into account.

The sets are as follows:

2. 1. Actions aimed at improving or maintaining soil quality

2.1.1. Combat the erosion: There are certain areas, which are at high risk of erosion due to their geographical location, height and rainfall pattern.

Therefore, the objective of this action is the protection and conservationof the soil in those situations through the installation of features designed to reduce washout of those products and the

subsequent erosion.
Installing traditional features and systems used in crop growing: low walls, terraces, hedges and similar.

2. 2. Actions aimed at improving or maintaining water quality

2.2.1. Use of solarisation or biosolarisation tehcniques. Solarisation is a technique which consists of using a plastic covering and solar radiation in order effect an increase in temperature and humidity thereby disinfecting the soil.
Beneath the plastic, the temperature of the uppermost layer of soil climbs to 50ºC or more during the hottest hours of the day. Under those conditions, soil pathogens are quite significantly reduced in number and become less parasitic.
Therefore, this technique provides an alternative to using soil disinfectants, thus avoiding water and soil quality deterioration. This action clearly contributes to the main objective of improving and maintaining water quality.
Biosolarisation is a technique that consists of a combination of the solarisation yet described and the biofumigation.
Biofumigation can be described as the action that certain volatile substances, resulting from organic matter degradation, exert on soil pathogens or on land – based sources. To this aim, additional organic soil conditioner is required.
These two combined techniques provide an alternative to using soil disinfectants, thus avoiding water and soil quality deterioration.

2.2.2. Equipment for and/or improvements in water purification and water recycling.
Given that water is scarce in countries like Spain, maintaining water quality must be considered a main objective, so water purification must be encouraged in order to achieve a level of water quality above that required by the law and, furthermore, the installation of any system which would allow water to be re-used for other purposes should be encouraged.

2.3. Actions aimed at the sustainable use of water resources

2.3.1. Improvement of irrigation systems and replacement of existing systems with more efficient systems (modernisation of irrigated areas)
Rainfall in most of Spain (as well as in the Mediterranean countries) is low and irregular, which can give rise to problems associated with drought. As a result of the water shortage, there is a high risk of desertification in certain areas. In addition, different economic sectors compete fiercely to use that water.
Therefore, one of the main objectives of the environmental actions in our country is to make more efficient use of the available water resources.
Given that irrigation is used in virtually all agricultural districts and that almost 75% of water resources are consumed in this way, it is essential that infrastructures are improved in order to manage water resources properly.
Thus, the aim of improving those infrastructures is to save water (with help of new technology) and, therefore, to allow the holdings and producer organisations concerned to irrigate more efficiently and save water using new technology.
Water savings will under no circumstances be used to extend irrigable areas.
Undertake one of the two following commitments:

- Replacing flood irrigation systems with drip irrigation or sprinkler irrigation systems or with any other system which allows this water saving;
- or Replacing any irrigation system with a drip irrigation system or with any other highly efficient micro -irrigation system (e.g. low pressure sprinklers above foliage or below foliage, drip nozzles, spray lines) or recirculating multilayer hydroponics systems which allows this water saving.
- To improve the existing systems in order to achieve a minimum water saving of 25% without changing the irrigation system.

2.3.2. Use shade covers technique on reservoirs to slow down the evaporation of water resources.

Commitments are:

- Placing shade covers on the irrigation dams or small reservoirs.
- Executing the development works and perimeter works to anchor the structure (shade cover) on the irrigation dam or small reservoir.
- If the shade cover used is plastic but not biodegradable, commitment of removing the plastic from the ground after use and hand it over to an authorised waste management company for recovery or incineration.

2.4. Actions aimed at maintaining natural habitat and biodiversity

2.4.1. Organic production: Organic production systems do not use synthetic chemical fertilisers, pesticides or plant protection products to combat plant disease and invasive species, neither do they use methods which cause soil quality, or environmental conditions in general, to deteriorate.

Stopping the use of those synthetic products will contribute directly to improving the quality of water and soil resources and therefore help to protect certain species and to maintain natural habitat and biodiversity. Moreover, cutting down the use of synthetic products and, therefore, reducing the manufacturing of those products, will also result in a drop in greenhouse gas emissions.

The objective of this action is, therefore, to encourage farming practices which make less use of chemical products. In particular, the amount of land used for organic production will be used as an impact indicator. The amount of land used for organic production by producer organisations is anticipated to increase significantly throughout Europe.

Another indicator will be the estimated change in mineral fertiliser consumption by type of fertiliser (N and P2O5).

2.4.2. Integrated production: The objective of the action is to reduce soil and water contamination by encouraging the adoption of plant production methods which make maximum use of resources and natural production techniques.

The action will make it possible to reduce soil and water pollution by cutting down the use of fertilisers, herbicides and plant protection products, which in the long-term guarantees sustainable agriculture and the protection of natural resources.

In addition, using biological control methods has a direct impact on biodiversity by introducing fauna which are beneficial to production and reducing the risk of ecosystems becoming unbalanced.

The objective of this action is, therefore, to encourage farming practices which make demonstrably less use of chemicals. In particular, the impact of the action will be indicated by the amount of land used for integrated production compared with the initial area under crops. It is anticipated that the amount of land used by producer organisations for integrated production will grow significantly throughout Europe.

Another indicator will be the estimated change in mineral fertiliser consumption by type of fertiliser (N and P2O5).

Commitment:

- Use of traps, bait-traps, natural predators, pheromones, vegetal extracts, micro-organisms, repellent plants, and/ or any other plan protection material excluding chemical products friendly with the environment connected with the use of organic production techniques.

  The aim of this action is to reduce contaminant effects through the promotion of the replacement of certain pesticides dangerous for the environment by more friendly ones or the reduction of the number of treatments.

  Therefore, contaminant effects on soil and water will be reduced and, consequently, a long-term sustainable agriculture and natural resources protection will be achieved.

  Moreover, these biological control techniques have a direct effect on biodiversity. On the one hand, they allow the existence of wildlife reserves which causes benefits on agricultural productions. On the other hand, they reduce the risk of ecosystem imbalance.

  So, the purpose of this action is to promote cultural practices which involve a verifiable reduction on the use of chemical products.

Specifically, surface where these alternative products have been uses will be taken as an impact indicator.

- Use of farming techniques whereby crops are pollinated by bees
  This measure aims to use the most effective pollinating insects, such as bees and bumblebees in order to achieve natural pollination of fruit and vegetables and of other crops in areas where those fruit and vegetables are grown.
  This will enable the conservation and recovery of the biodiversity of native flora in agricultural systems within the production areas.
  There is a wide range of natural habitats in Europe thanks to its varied climate, the contrasting types of substrate and soil and its geographical location. Much of Spain's rich, natural vegetation benefits particularly from being pollinated by bees and bumblebees that, despite not being the only pollinating insects, are extraordinarily active pollinators. Setting up beehives in these areas, therefore, contributes very significantly to the conservation of the aforementioned plant biodiversity.

- Horticultural grafting to reduce the use of chemicals
  Nematodes and fungi in the soil have a very significant impact on vegetable crops, causing production levels to fall very substantially or even making farming impossible in some areas.
  For that reason, various treatments are carried out to combat them. The treatments are based mainly on using generic soil disinfectants and other specific chemicals targeting a particular type of fungus or nematode.
  There is now the option of grafting scions of commercial plant varieties onto rootstocks, which are resistant to attack by nematodes and fungi in the soil.
  By using horticultural grafting as a solution, it is possible to reduce substantially the need to treat with plant protection products, which has a very positive impact on the environment.
  So far, research has successfully developed, for a range of products, grafted plants which are resistant to several nematodes and other soil pathogens.

Generally speaking, for all crops, it is possible to achieve a substantial reduction in the use of generic soil disinfectants such as metam-potassium and metam-sodium

- Use of the bagging technique on cultures as physical barrier against plagues to reduce the use of chemical products.
  The fruit fly *(Ceratitis capitata*) is a highly extended plague in Spain because of the weather conditions. This plague seriously affects to a number of species, especially those with soft flesh as peaches.
  To control this plague chemical products as phosphorous containing *(Metil Clorpirifos)* and pyrethroids (*Deltametrin, Lambda Cihalotrin, Efotenprox*) are used, with the consequent contaminant effect on soil and water.
  An alternative to chemical products is the use of physical barriers to prevent fruit fly attack, such as the bagging of each peach with paraffin paper. Thus, chemical treatments against this plague are highly reduced with a clear environmental effect.
  Commitment to remove the paper after use and manage it in a environmentally friendly way.

2.5. Actions aimed at climate change mitigation

2.5.1. Renewable energy installations (wind and solar)

Contributing to the mitigation of climate change must be (and is) a fundamental objective for the farming sector, just as it is for the other economic sectors. Therefore, actions to cut CO2 emissions must be encouraged.

Commitments:

- To install renewable energy systems with the capacity to generate an amount of energy not exceeding the amount required by the producer organisation and/or its members for the production of fruit and vegetables.
- In case the energy system is owned by a PO' member, the maximum capacity of the system will be equivalent to the electricity consumption needed for the production of fruits and vegetables of that member in its holding.

2.5.2. Use of means of production which are more energy efficient.
To replace a means of production with a new system, with an equal capacity, which is at least 25%2 of energy saving. However, if it can be shown that the improvements to the existing systems bring additional environmental benefits (i.e. reduction in emission of air pollutant, use of renewable energy), the minimum energy saving required will be 10%.

2.5.3. Cogeneration [combined production of heat and power] using fruit and vegetable waste from production, processing, product preparation for marketing and/or marketing.

The EU encourages the installation and operation of electrical cogeneration plants in order to save energy and combat climate change. Cogeneration allows the simultaneous production of heat and electricity in the same plant and using just one "fuel" source. According to this principle, heat energy that would otherwise be wasted can be used, which makes for much greater energy efficiency.

In addition, if waste material is used as a source of primary energy instead of natural gas, the benefit to the environment is multiplied because, using waste material as an energy source would bring about a reduction both in the emission of waste and in the use of fossil fuels.

Commitments:

- To install systems which produce energy by means of cogeneration (combined production of heat and power) using fruit and vegetable waste produced by the producer organisation or its members during the producing, processing, product preparation for marketing and or marketing process.
- The systems installed must have a capacity to generate an amount of energy not exceeding the amount required by the producer organisation and/or its members for the production of fruit and vegetables.

2.5.4 Using rail or maritime transport as compared to road transport.
Transporting fruit and vegetables for sale is a very important issue in Spain, which is a major exporter. Road transport uses the most energy, therefore depleting fossil fuels and producing more CO2 emissions, thus contributing to the greenhouse effect.

For that reason, and in keeping with the objective of mitigating climate change, the replacement of road freight transport with short sea shipping or rail transport or with a combination of modes of transport should be encouraged. The aim is to keep road journeys as short as possible.

2.6. Actions aimed at waste reduction

The issue of waste production affects all sections of society. The difference in the farming sector is that it produces such a wide range of waste material, some of which are hazardous, such as packaging and plant protection products, and others which are very bulky, such as vegetable waste, plastic greenhouse sheeting or manure and liquid manure.

Therefore, one of the environmental objectives must focus on eliminating and managing waste more effectively in order to prevent harmful effects on environmental systems, natural resources and the landscape, to eradicate or reduce nuisance to those living in the area in question and to reduce contamination of natural resources such as water, soil and air.

2.6.1. Collection of waste, packaging, plastics, chemical consumables (lubricants, etc.)

Install waste collection systems or contract waste collection services to collect packaging and waste from products other than fertilisers and plant protection products. The aforementioned waste must be managed in a way which is environmentally friendly.

2.6.2. Environmental management of recyclable and reusable empty product packaging - Use recyclable wooden or cardboard or reusable plastic packaging.

2.6.3. Use of biodegradable thread on holdings. - Thread commonly used to plant staking in greenhouses is made of synthetic material, such as propylene fibre.
Removing the thread from the ground is quite difficult. For this reason, the generated wastes remain on the ground or even are attached in it. Thus, this kind of thread must be promoted.
Use biodegradable thread.

2.6.4. Use of oxo-biodegradable and biodegradable plastics on holdings. In traditional farming, the most commonly used plastics are linear lowdensity polyethylene (LLDPE), low-density polyethylene (LDPE) and, for certain crops, ethylene vinyl acetate (EVA) copolymers.
Widespread use of those materials is causing gradual soil contamination as materials, which degrade very slowly, are repeatedly incorporated into the soil.
Therefore, the use of eco-friendly materials, such as oxo-biodegradable and biodegradable plastics, must be encouraged.
Biodegradable plastics are degradable through the action of microorganisms (bacteria, fungi or other biological agents) under aerobic or anaerobic conditions, which occur naturally in nature, producing water and CO2, methane and other waste products, which are non-toxic to the environment. Use oxo-biodegradable and biodegradable plastics.

2.6.5. Recovery of waste generated during production, processing, product preparation for marketing and/or marketing - Adequate and eco-friendly management of the waste generated during production, processing, product preparation for marketing and/or marketing must be encouraged in order to avoid the risk of that waste being left on holdings, thereby damaging the landscape and possibly causing the spread of pests and disease.
We must, therefore, encourage techniques such as composting and, in any event, upgrade landfill sites to enable them to operate under the best possible conditions.

2.6.6. Biogas obtained using fruit and vegetable waste from production or processing - One of these environmentally friendly managements is to use waste to obtain biogas. The systems installed must have a capacity to generate an amount of energy not exceeding the amount required by the producer organisations and/or its members for the production of fruit and vegetables.

2.7. Other environmental actions - environmental training and awareness courses; qualified staff, in addition to the staff involved in other environmental actions costed on a flat-rate basis, intended to improve or maintain a high level of environmental protection; costs of analysis, consultancy and auditing; actions to avoid GMOs contamination.

VII. WATER MANAGEMENT

Water management ın general

Water management in agriculture is a critical evaluation of the benefits, costs and impacts of the past 50 years of water development, the water management challenges communities face today and the solutions people developed around the world.

Will there be enough water to grow enough food? Yes. If...The question is, is there enough land, water and human capacity to produce food for a growing population over the next 50 years? Or will we run out of water? It is possible to produce the food-but it is probable that today's food production and environmental trend, if continued, will lead to crises in many parts of the world. Only if we act to improve water use in agriculture, will we meet the fresh water challenges facing humankind over the coming 50 years?

50 years ago the world had fewer than half as many people as it has today. They were not as whealthy. They consumed fewer calories, ate less meat and thus required less water to produce their food. The pressure they inflicted on the environment was lower. They took a third of the water from the rivers that we take now.

Today the competition of scarce water resources in many places is intense. Many river basins do not have enough water to meet all the demands or even enough water for their rivers to reach the sea. Further appropriation of water for human use is not possible because the limits have been reached and in many cases breached. Basins are effectively "closed" with no possibility of using more water. The lack of water is thus a constraint to producing food for hundreds of millions of people. Agriculture is central in meeting this challenge because the production of food and other agricultural products takes 70 % of the fresh water withdrawals from rivers and groundwater. Without better water management in agriculture the millennium development goals for poverty, hunger and sustainable environment can not be met. Without further improvements in water productivity of major shifts in production patterns the amount of water consumed by evapotranspiration in agriculture will increase by 70%-90% by 2050. The total amount of water evaporated in crop production would

amount to 12.000-13.500 cubic kilometres almost doubling the 7.130 cubic kilometres of today.

In the early years, much effort went into building check dams and bunds to stop the soil erosion in the barren land. The water which improved vastly is once again under the threat of saline contamination of aquifers. Efforts are being made to re-charge and achieve a water balance, through: awareness and outreach programs to neighbouring villages; extensive water harvesting through check dams and bunding; as well as waste water treatment.

Most people are wasteful of water and treat access to plentiful water as a right. They think little about our water consumption and less about reducing our use. Despite recent improvements in awareness of water sustainability, there is still very little recycling of grey water (water used in the home, excluding water used in the toilet, which is black water). But in reality the fresh water resources of Planet Earth are a rare and enormously valuable resource.

Of all the water on earth, 97% is in the oceans, 2% is contained in glaciers and only 1% is on land. Of the 1% on land, 97% is below the surface, as groundwater, and more than half of that is out of reach.

Of the global reserves of fresh water, 0.06% is in soil moisture, 0.3% is in lakes, 0.03% is in rivers and 0.03% is in the atmosphere as water vapour. Only 11.39% of global freshwater is accessible, non-saline water.

Of the liquid fresh water found at the surface, 30% is in lakes in Africa, 25% in lakes in North America, 18% is in Lake Baykal (Russia) and 27% is in smaller lakes and rivers elsewhere in the world. Rivers are really insignificant in global terms. They carry only 1,200 km3 compared with 125,000km3 in fresh water in lakes and inland seas.

Irrigated agriculture

In the past half century there have been massive investments in large scale public surface irrigation infrastructure as part of efforts to increase world staple food production and ensure food self-sufficiency. Irrigation water was essential to achieve the gains from high yielding fertilizer-responsive crop varieties.

Especially in recent years, an increasingly common form of irrigation

is the drip irrigation system. This is the most suitable system of irrigation systems.
In Drip system, roots of plants are watered drop by drop with the help of pipes laid in the region. Thus, the water passes directly into the soil without any evaporation and with less water the best yield is achieved. Drought and global warming in recent years, has increased the importance of irrigation to be made consciously. (http://tr.wikipedia.org/wiki/Sulama)
Irrigation, encourages development of species and varieties, and provides efficiency. It is also effective in the development of buds, it reduces the loss. However, it has a negative impact during the blooming period, it causes an increase in fruit size. Irrigation techniques, vary both acording to the species and varieties and to the methods of tillage.
In organic agriculture irrigation, water should be applied properly, in a way not to accumulate in the root zone which and will not cause any root decay, additionally, proper planting techniques and irrigation frequency should be applied.
In organic production, keel irrigation techniques can not be used in the agricultural fields. The plant's water plan is prepared according to the amount of water to be consumed. Water meter placed in the land and water is used as measured according to the schedule of irrigation.
Furrow irrigation is allowed in cases of necessity under the supervision of inspection and certification company.
In a heavy clay soil with defective drainage, low permeability rate, drainage system should be used for irrigation.

Water use in organic farms

There is ample anecdotal evidence and some experimental evidence that organic farms use less water than conventional farms. Anecdotal evidence from many growers, especially irrigation users, indicates that organic growers apply water less often than their non-organic neighbours. It is reasonable to assume that this is largely due to increased soil moisture storage in soils well supplied with organic matter, and to common cultural practices on organic farms, such as use of mulch. Mulch may directly limit evaporation from the soil surface and prevents soil from forming a water-resistant crust, but also allows plant roots to more effectively use the top five centimetres of soil,

by keeping them cool and protected from bright light. Better water use on organic farms may also be due in part to greater awareness of water management issues by organic farmers, including plant requirements and irrigation programming, and a greater willingness to directly observe soil moisture, or to use remote sensing devices to help manage irrigation.
We may also reasonably speculate that avoidance of very-soluble fertilisers and long-lasting pesticides on organic farms cause organic growers to contribute less to off-farm water quality issues than their conventional neighbours. Again we could assume that significant awareness of environmental impacts, combined with (at least) annual inspection of environmental performance indicators on certified farms will ensure that the most unsustainable practices do not occur on organic farms and that most organic growers are not causing major water quality issues downstream

Water use by plants

Vegetation transpires at least 100 times more water per annum than is present in the plant as biological water. This figure varies greatly with different plant types, according to their specific adaptations for preserving water. For instance, drought-adapted plants have a much greater capacity to close down stomata (pores on the leaf surface) to limit transpiration. Plants are therefore a type of water pump. They move large volumes of water because they use it as a medium to extract dissolved nutrients, and as an evaporative cooling mechanism – a room with plants will always feel cooler. A plant with a large leaf area, such as a mature apple tree, is therefore capable of removing many tonnes of soil water during the growing season.
Plants have many different adaptations to help them obtain, and conserve moisture. A grape vine, for instance, may put down water-seeking roots to a depth of 40metres. Sometimes, there are roots 50 mm across nearly 50 metres below the surface. Presumably they are seeking groundwater at the level of the river or below, still nearly 10 metres lower, but the trees on the surface are less than 15metres tall.
While plants may have deep roots for survival, they will generally prefer to seek water at or near the soil surface, where air and nutrients are readily available. If there is not a continual input of water into

soil, plant roots will dry out the soil around their main feeding roots. Some of this water can be replaced by capillary action (water seeping upwards through the soil pores), but there is always a tension between the two forces of gravity (pulling water down) and capillarity (pulling water up).

Irrigation is also an important factor in terms of disease control in organic agriculture. Selection of irrigation system (mini-sprinkler, drip, furrow), irrigation time and irrigation ranges should provide enough the water needs of the product. Over-irrigation facilitates the development of soil borne pathogenic fungi. Sprinkler irrigation system should not be preferred against many leaf diseases. Because sprinkler irrigation encourages the development of leaf diseases and distribution of the pathogen. Therefore, drip irrigation and irrigation system from the bottom should be preferred.

Drip irrigation: Drip irrigation, also known as trickle irrigation or microirrigation is an irrigation method which minimizes the use of water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters.

Water sprinkler: In sprinkler or overhead irrigation, water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns.

Rain gun: Rainguns are similar to water sprinkler, except that they generally operate at very high pressures and flows.

Direct water irrigation: In surface irrigation systems water moves over and across the land by simple gravity flow in order to wet it and to infiltrate into the soil.

Irrigation is giving water required to be met by natural means to the plants in the soil in different ways so that they can continue their growth and vital activity.

Flood irrigation is the oldest and still the most common type of irrigation. Flood irrigation has two advantages. It is easy to manage (low technology) and most of, or the entire root zone, of the plant is watered. However flood irrigation is wasteful of water and is the major cause of environmental damage. The reason for the wastefulness and damage caused by flood irrigation is the same. Unless the irrigation

bays are very short and the delivery time for water is also very short (i.e. there is very good pressure) the water at the start of the irrigation bay will have infiltrated below the main root zone of the plant (and therefore be effectively wasted, or unrecoverable by the crop) before water has reached the end of the bay. Flood irrigation can be slightly improved by delivering water in surges, so that the wetting front has time to cause soil to expand and pore spaces seal, thereby minimising soakage at the start of the bay.

Sprinkler systems can be much more efficient, depending on irrigation timing and management. Short irrigation cycles, especially during the hot part of the day, result in 80% of water being lost to evaporation or by blowing away on the wind. It is probable that 40% of all water applied to lawns is lost to evaporation, even accounting for nighttime irrigation. Very long irrigations cause water to soak past the root zone. Remember too, that even after the system is turned off, water will continue to soak through the soil profile.

Drip irrigation is now considered much more efficient than all systems. One significant advantage is restriction of water to weeds in the inter-row area. The main limitation on efficiency of drippers is the narrow zone of distribution of water, which results in plants having very restricted root zones. There may also be increased salinity at the margin of the wetted rim. Drippers are also sometimes mismanaged, by having a long duration of operation and inadequate frequency of irrigation.

However, the implementation of the various methods of irrigation depends on certain conditions. Traditional surface irrigation methods can be only be applied, if the land has been leveled. In addition, plenty of water and the quality, must be suitable for irrigation.

Is irrigation not used in regions with scarce water or in where the water is saline?

Of course, it is not an obstacle that the water is problematic in these regions, if the climate and the land are suitable for cultivation in high economic value. Plants with high value, provide high income. In order to achieve this, a new irrigation method has been developed that eliminates the problems of the water. The name of this new method is becoming increasingly popular in the world is drip irrigation. Drip irrigation, also known as trickle irrigation or microirrigation is an irrigation method which minimizes the use of water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. Drip irrigation is actually an expensive irrigation system. However, since it requires less labor and allows automatic watering it is applied for the greenhouses and in planting of high economic value products especially in initial investment stages. The droppers are the heart of the irrigation system. They are made of plastic and mounted on the pipes called lateral pipes with the diameter between 12 and 32 centimeters. The drippers drop the water to the soil in a rate that few liters of water is dropped per hour.

A successful solution to bio-organic agriculture means ensuring optimal plant nutrition while restoring the soil and its micro-organisms to their natural state. With synthetic fertilizer, pesticides and herbicides prohibited, compost and other organic and natural nutrient sources play a key role. Nevertheless, using natural nitrogen sources for fertilization in the irrigation system requires special attention, such as proper filtration and maintenance as well as periodical flushing of the drip system to avoid potential clogging.

Dealing with clogging:

One of the major problems affecting the efficiency of organic agriculture irrigation is the creation of bacterial slime and lime scale, which can decrease flow rate and clog the dripper. This problem was resolved by providing suitable disinfestation to enable the free flow of nutrient-enriched water through the pipes.

Using compost:

Composting is vital for organic production. It efficiently treats and stabilises fresh organic material, destroys weed seeds and pathogenic microbes, reduces the volume of organic waste and prevents environmental pollution. Adding compost to the soil improves its physical characteristics, aerates heavy and clay soils, improves the water retention capacity of light and sandy soils, stimulates the development of biomass, reduces the carbon/nitrogen ratio and provides the soil with humic elements.

When used in compost preparation, low-volume irrigation technology, either micro-sprinklers or drip-lines, is extremely effective in preventing nutrient leaching and resulting environmental contamination.

Advantages related to the use of drip irrigation and organics

- Ensures accurate irrigation and Nutrigation
- Reduces weeds
- Activates compost as the main source of nutrients
- Saves water, reduces runoffs
- Maintains the correct water and air balance in the soil
- Prevents diseases; drip irrigation keeps leaves and fruit dry-Economizes on manpower costs and minimizes hands-on involvement

Subsurface irrigation is increasing in popularity and has several theoretical and practical advantages, especially now that new pipe designs have been developed, with holes that do not easily become blocked. It is possible to operate subsurface irrigation for very short intervals, because the pipe is already located within the root zone, so effective delivery of water starts immediately. Other advantages are: there are no surface pipes to tangle equipment, there are no evaporation losses, no water is present at the surface to encourage weeds and irrigation can occur simultaneously with other management activities on the surface (eg pruning, harvesting etc). The main disadvantage of this system is that it is prone to mismanagement, as it occurs almost entirely out of view of the operator. Water is most effectively delivered in subsurface irrigation if it is delivered at high flow rates, in short bursts, to encourage lateral distribution rather than deep penetration.

The water used in irrigation of organic crop production should not cause environmental pollution. Industrial and urban waste water and drainage water from the drainage system can not be used in organic agriculture. Where necessary, the suitability of the water is decided by an authorized body in the controls. Irrigation should not lead degradation in the structure of soil and erosion.

Organic fruit growing is the main training for the healthy plant, therefore it is very important to give water at any time, at any amount that the plant needs.

Irrigation gains efficiency in fruit types and varieties, also encourages vegetative growth. It is effective in segregation and development of buds. It reduces the breakdown of fruits. As irrigation techniques change according to the species and varieties they also vary according to the methods of soil management.
Irrigation of orchards, should be made in a way that water will not accumulate in the root zone of trees, which causes root decays in the end. Drip irrigation and mini-spring irrigation systems are the most appropriate methods for orchards.

Table 1. Water requirements of plants

Berries, pome fruit, stone fruit	3 megalitre per Ha
Summer veg	1 megalitre per Ha
Winter veg	0.6 megalitre per Ha
Perennial flowers	0.6 megalitre per Ha
Annual flowers	1 megalitre per Ha
Nut trees	0.6 megalitre per Ha
Grapes	1.5 megalitre per Ha

Table 2. Minimum infiltration rates for different soils

Soil type	**minimum infiltration rate (mm per hour)**
Deep sands, aggregated silts	more than 20
Deep sandy loams	10 to 20
Clay loams, shallow sandy loams, soils	
low in organic matter	5 to 10
Sodic clay soils	less than 1

Drip irrigation in vegetable field
(photo I. Manolov)

Drip irrigation in greenhouse
(photo I. Manolov)

Drip irrigation system in orchards
(photo I. Manolov)

Irrigation on potato crop
(photo A. Enamorado)

Water reservoir in olive plantation
(photo A. Enamorado)

Water reservoir
(photo A. Eanmorado)

VIII. CERTIFICATION

Introduction

The certification of organic products is an important and mandatory procedure for a product to be treated and sold as an "organic" one. This procedure is applying by the relative bodies called "Inspection Bodies" or "Certification Bodies". During the last ten years the organic certification demand presents a significant increase in European and in Global level as well. The main goal and aim of this procedure is the assurance quality of the products and the commercial promotion.
The new EU Regulations regarding to Organic Agriculture establish that the organic inspection system provided for in Regulations (EC) No 834/2007 and 889/2008 shall be implemented in accordance with Regulation (EC) No 882/2004 on official food and feed controls (OFFC regulation).
According to these revised EU Regulations on Organic Agriculture, the competent authorities of each country – member of EU member assume the sole responsibility for ensuring that products marketed as organic are in fact organic products. They "may delegate certain control tasks" to one or more control bodies. These "private" control bodies must be accredited according to EN 45011.

From Conventional to Organic Agriculture

The concerned people in order to join to the Control and Certification System of organic products initially have to select the Inspection Body for Organic products and after that have to:

- submit to the Inspection Body or to the component Authority an application form accompanied by a statutory declaration in which will be bound for the law enforcement
- sign a cooperation Convention with the Certification Organization
- inform the beginning of their activity on organic farming, giving information for their cultivations, the cultivation methods etc.
- organic farms, have to spend a conversional period before sell their products as organic.

The Certification Process

Organic Certification is a process of certification for organic products' producers and other agricultural products as well, including seed suppliers, organic food processors, organic retailers and special restaurants with organic food. As it was expected the basic requirements are different to each country and in general frame a set of standards which are in relevance with production, storage, processing, packaging and shipping can involve the followings:

- Avoidance of pesticides and other chemical inputs, irradiation, genetically modified organisms etc.
- Usage of "clear" farms concerning the chemical inputs the last three years at least.
- Segregation of organic and conventional products.
- Maintenance of production and sales records.
- Undergoing periodic on-site inspections.

Goods that are producing and selling as organic with the obligatory labels and logos, follow a severe process that must be in a full compliance. For the products and the cultivations as well in order to be marketed organic, a conversion of at least two years period must be undergone by the conversional farmers, as it is mentioned above. In the case that a farmer cultivates at the same time in conventional and organic way, he/she must separate these two operations clearly through every stage of production.

Both organic farmers and processors must apply and respect with continuity and consequence the EU regulations. For the insurance of their compliance with the EU regulations, inspection bodies or authorities carry out inspections. After these inspections a certification is given to them who are qualified for, and only these people have the right to label their products as organic.

For a farm in order to be certified as organic, the farmer must change totally his/her cultivation methods and to engage in various new activities, in addition to normal farming operations:

- ***Study:***
  The organic standards, in order to know very well what is legal and illegal concerning to his/her obligations regarding to the regulations.

- ***Compliance:***
  Concerning to farm facilities and cultivation methods that must comply with the organic standards.
- ***Documentation:***
  Organic farmers and processors should keep a record of documents relative to the organic farming.
- ***Planning:***
  A written annual production plan must be submitted to the relevant bodies. This plan involves details about seed sources, field and crop locations, fertilization and pest control activities, harvest methods, storage locations and so on.
- ***Inspection:***
  Annual on-farm inspections are an obligatory procedure in the frame of organic farming. A representative of the Certification Body has the role of the inspector.
- ***Fee:***
  Every year organic farmers pay the inspection body for the certification process a fee which is different for each country and is depending on the organization and the size of the organic cultivated area as well.
- ***Specific Analysis:***
  Furthermore, short-notice or surprise inspections can be carried out and specific water and soil analysis may be requested.

As it is mentioned above, for the primary organic agricultural certification the soil must meet basic requirements of being free and clear from use of prohibited substances (synthetic chemicals, etc) for a number of years. A conventional farm must adhere to organic standards for this period, often, two to three years. This is known as being in *transition*. Transitional crops are not considered fully organic.

Certification for operations other than farms is similar. The focus is on ingredients and other inputs, and processing and handling conditions. A transport company would be required to detail the use and maintenance of its vehicles, storage facilities, containers, and so forth. A restaurant would have its premises inspected and its suppliers verified as certified organic.

Inspections

To ensure the farmers' compliance on organic farming with European and National legislation is very important to be checked at least on an annual basis, as they are apart of the chain of the organic production circle.

This process is supervised by each EU Member State, which is responsible for establishing an inspection system with competent authorities to ensure adherence to the obligations established in the organic Regulation.

After the completed conversion phase organic operators are keeping on to be amenable to annual inspections which are consisted of:

- Inspection of purchase and sale invoices, livestock and medication, accounting books or records
- Possible sampling
- Inspection of animal welfare conditions (in and out-door)
- Inspection of warehouses, fields, orchards, greenhouses and pastures

Extra inspections and unwarned inspections may be come about by inspectors where it is necessary. Each EU Member State has established an inspection system and designated a number of public authorities and/or approved private inspection bodies to carry out the inspection and certification of organic production according to its needs.

Non – Compliance

In case that an organic farmer is not in a full compliance with the regulations' and inspection's requirements and obligations the component certification body has the right to exclude the products from the organic market. When irregularities come on surface in a single part of the total production, then the inspection body has to ensure that the obligatory organic label and logo is not bearing anymore to this specific part of production. If organic operators are not complied with all the obligations the certification and the right to sell their products as organic can be canceled.

Labeling

Organic products can be identified by signs bearing on their markings

(labels) and the Product Certificate accompanying them. From July 2010 the organic logo is obligatory for all organic products in each country – member of European Union.

The first logo for organic agriculture was created at the end of '90s and it wasn't an obligation for organic products.

After the decision of E.U. (2007) that European organic products must have a visible common compulsory logo, they had the idea to organize a design competition on an EU level in order to choose the best logo for organic products. This competition took place from March to July of 2009 and could participate students from all EU country – members. The ten best proposals went to the next stage which was the online voting from 06.12.2009 to 31.01.2010. Finally, after this procedure the winner was a German student named Dušan Milenković whose design proposal in title "Euro-Leaf" took almost 63% of the summary votes. After these, the final and compulsory logo for organic products was accepted.

For labeling and promotion – advertising of organic products should be included the following information gradually from 1st of July 2010 to 1st of July 2012:

- The new EU organic farming logo
- The new approval code of the Agricultural Products Certification and Supervision Organization, next to the EU logo
- The phrase "PRODUCT OF ORGANIC AGRICULTURE" in combination with the trade name of the product.
- The phrase "PRODUCT OF ORGANIC AGRICULTURE UNDER CONVERTION" only for products of crop production that their cultivation is in a conversion period in combination with the trade name of the product.
- The origin of the ingredients of the product (e.g. EU Agriculture, non-EU Agriculture or the country of origin), under the new European code of the Agricultural Products Certification and Supervision Organization
- For manufactured products the phrase "X% of the agricultural ingredients are organic" if only the percentage of components of organic origin is at least 70% and the other ingredients are those allowed by EU legislation.

Inspection and Certification Bodies

Each EU Member – State has determined a number of public or private bodies in order to carry out inspections and certifications. All these inspection bodies are acting under the supervision of the component central Government Authorities of each Member – State or in a close cooperation with them. Every year each Member – State submits a report to the EU Commission relating to this inspection or collaboration.

The private inspection bodies must meet the next specific requirements:

- They have to be accredited under the EU's General requirements for bodies operating product certification systems
- They have to be approved by the Member – State's competent authority
- They have to be objective and fair to all the operators during their inspection procedures

Code numbers of control bodies and control authorities

Whenever the EU organic logo is used on the product, it always has to be accompanied by the code number of the control body or authority to which the operator who has carried out the most recent production or preparation operation is subject.

The general format of the code number is AB-CDE-999, where AB is the ISO code of the country where the control takes place, CDE is a term establishing a link with the organic production, such as "bio" or "org" or "eko" and 999 is a reference number.

Member States attribute a code number to each organic control body and authority they have approved to operate on their territory. You should find this code number on every organic label. The code number is a sign that the product you are buying has been inspected by the control body or authority which guarantees it was produced or processed in accordance with the organic Regulation.

On imported products, it is an obligation to mention the code number of the control body or authority only if the EU organic logo is used. The European Commission is in charge of attribution of code numbers to control bodies and authorities performing inspections outside the EU.

EU Organic Farming Logo
(1st version, 1990 2010)

EU Organic Farming Logo

General idea for the design of EU Organic Farming Logo (2nd version, 2010)

European label for organic products (new one on the left bottle and old one on the right bottle (photo I. Manolov)

IX. ORGANIC FOOD RETAIL

Global market

According to Organic Monitor, the global market for organic food and drink is recovering from the repercussions of the economic crisis. Single-digit market growth was observed for the first time in 2009 because of the economic slowdown reducing industry investment and consumer spending power.

Organic food and drink sales expanded by roughly five percent to 40 billion Euros in 2009. Global revenues have increased over three-fold from 13 billion Euros in 2000 and double-digit growth rates were observed each year, except in 2009. Healthy growth rates are envisaged to restart as consumer spending power rises and as more countries come out of economic recession.

The countries with the largest markets are the US, Germany, and France; the highest per capita consumption is Denmark, Switzerland, and Austria

European market

As of the end of 2009, 9,3 million hectares of agricultural land in Europe were managed

organically by more than 250.000 farms. In Europe, 1,9 percent of the agricultural area, and in the European Union 4,7 percent of the agricultural area is organic. Twenty-five percent of the world's organic land is in Europe. Compared to 2008, organic land increased by nearly one million hectares. The country with the largest organic agricultural area is Spain (1,6 million hectares).

There are five countries now in Europe with more than ten percent organic agricultural land: Liechtenstein (26,9%), Austria (18,5%), Sweden (12,6%), Switzerland (10.8%), and Estonia (10.5%).

Sales of organic products were approximately 18.400 million Euros in 2009. The market grew at smaller rates than in previous years even though some countries like France and Sweden showed strong growth. The largest market for organic products in 2009 was Germany with a turnover of 5.800 million Euros, followed by France (3.041 million Euros), UK (2.065 million Euros) and Italy (1.970 million Euros)

As a portion of the total market share, the highest levels have been reached in Denmark, Austria and Switzerland, with five percent or more for organic products.

KEY POINT

Strong growth (5-30+%) in most countries,including new EU members

Conventional supermarkets emphasize "quality products" and "green issues"

Discounters selling large amounts thanks to low prices and expanding consumer base.

Organic supermarkets growing fastest.

Small but smart: specialization is the trick

The highest per capita spending is also in these countries. While the organic land has expanded rapidly in many new EU member states as well as in candidate and potential EU candidate countries, consumption levels have remained very low in these countries (less than 1%).

Support for organic farming in the European Union and neighboring countries includes grants under rural development programs, legal protection, and the European as well as national action plans. An updated overview of European action plans shows that currently 26 action plans (including regional action plans) are in place.

A major development in 2010 was the launch of the new European logo for organic food.

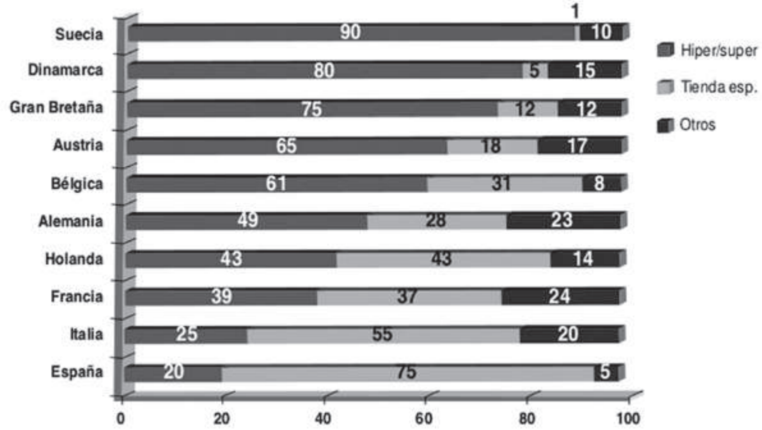
The European consumers

The popularity of organic products is growing right across the EU as more and more people are waking up to the benefits of organic food and farming.

Consumers can choose from an ever expanding range of organically certified produce: from fresh organic fruits, vegetables and meats, to organic processed goods, convenience meals and beverages – and even organic health and beauty products – all available from a growing number of convenient shopping outlets.

People who purchase organic food care about where their food comes from and how it is produced. They care about its authenticity, as well as animal welfare and the environment. Many of them also prefer local products to food which has been transported across long distances.

As a result, more and more consumers are choosing to buy organic food directly from the farm where it was produced, buying from their local farm shops or roadside stalls, or visiting one of the many



farmers' markets that are regularly held in towns and cities across the EU. Here, they can meet the farmers face-to-face and find out more about how organic farmers build soil fertility without using artificial fertilizers, or control pest and diseases without reliance on artificial insecticides and herbicides.

But those cases where there is not a **local farm** shop **or farmer' market** near you, then you have the chance to buy your fresh organic produce and provisions from the many organic shops that you will find both rural and metropolitan areas which specialize in supplying organic, natural and local foods – and nothing else.

Diversity of organic channels 'multi-streams'

Supermarkets and hypermarkets

Discounters

Independent food shops

Health and Natural food shops

Organic shops and supermarkets

Specialised shops: butchers, bakers, natural body care shops, natural textile boutiques

Farm shops

Farmers' markets

Box schemes

On-line shopping

These shops range from independent local retail outlets found in many villages and cities, to the newly emerging **specialist organic retail chains** – like Natura Si in Italy, Organic Farma Zdrowia in Poland, or Planet Organic in the United Kingdom. In 2008, specialist organic retailers accounted for well over 50% of all organic retail sales in several Member States, including Spain (75%), Poland (73%), Greece (58%) and Italy (55%). Consumers can also now find specialist organic butchers and bakers in many EU countries, all offering their customers a wonderful range of delicious local and organic artisan produce.

There are also many **web based home delivery** services or box schemes that are now available and where you can have a box of fresh, seasonal vegetables and fruits – and often a range of fresh meats and other organic groceries – delivered directly to your door or to a local collection point, saving you time and money – and reducing transport. United Kingdom is a country with many companies web based on box schemes businesses.

We all know that **supermarkets** offer today's busy consumers choice, quality and – above all – convenience when it comes to shopping.

In 2008, the main supermarkets accounted for well over 50% of all organic retail sales in many Member States, including Denmark (80%), the United Kingdom (75%), Slovenia (78%) and Belgium (61%). Most of the major supermarkets in the EU now stock a wide range of organic fresh fruit, vegetables and meats. And if you look closely you will find an ever-increasing range of processed organic goods and convenience foods on most shelves – as well as in the refrigerated sections.

Many **Restaurants and catering** services are now choosing to source fresh and authentic organic ingredients for their menus – including organically produced beverages.

Over the past few years an increasing number of new establishments have opened in many Member States which serve nothing but organic food – such as the Bio Café franchise in the Czech Republic – while many others are choosing to serve organic and local options as part of their menus.

A growing number of school and hospital canteens right across the EU are now providing their students with an organic menu. In Italy, for example, over 650 schools served organic meals to their students last year, while several high profile companies across the EU are now choosing to provide organic foods in their cafeterias.

Different regional development;

Italy, Spain, France and Belgium: specialized shops and direct marketing growing faster than conventional trade. In Italy, around 1 mill organic meals a day are served in public catering.

Germany: strong growth in discounters and conventional trade, organic supermarkets. In Germany around 90% of the German households bought at least one organic product per year. Extreme growth in discounters, who are using organic food to give their business a significantboost – private brands

Switzerland: organic supermarkets struggling. Market experiencing some difficulties but Swiss consumers continue to be the biggest spenders in Europe at €103 per person in one year.

UK: conventional trade growing fast, but direct markets and specialized shops even faster. 65% consumers buy organics - affluent society, shoppers less concerned with cost than about quality, changing attitudes to food, affected by factors such as celebrity, chefs and fears about obesity, and climate chang concerns. Conventional retail: 76% market share, expanding range of organics, Fair trade, ethical food.

CZ: fast growth of conventional trade – supermarkets and drugstores

Austria: small organic shops struggling, supermarkets growing fast

Latest Trends in the European market for organic product are:

- Organic supermarkets moving to new markets
- UK Supermarkets develop "green and sustainable" initiatives to win a more educated
- and environmentally aware consumer base.
- Renewable energy, composting, recycling, compostable packaging, reducing carbon emissions, recycled plastic, local sourcing, Fair trade, organics, no GMO, no trans-fats.....
- In the well develop countries, supermarkets are repositioning towards to "high quality" instead of "best price", organic food a key point.
- Worldwide, private labels' share of consumer packaged-goods sales is expected to climb from 14 percent in 2000 to 22 percent in 2010. With private label, retailers reap higher profits and profit margins, gain greater leverage in negotiating with brand manufacturers, build loyalty and sell higher price and margin goods.

- In the newest EU Members, there is a very little domestic market for organic food. Most purchases are done via direct marketing channels.
- Fresh fruit and vegetables represent 40% of the sales and growth 8,4% annually. Milk products, cereals bread, convenience food, frozen food and baby food represent 60% of the sales and growth a 36% annually

Market economy mechanisms

One of the main obstacles for further growth of the market for organic products appears to be the high consumer price. The price premium for organic products differs very much from country to country and from product to product. The typical price premium that consumers have to pay is about 30–60 %. The typical farm-gate price premium is at the same level but with an even greater variation. As the price that farmers receive is normally only a smaller part of the final price, a study showed that the processing and retail sectors receive an extra premium when selling organic products, due the have to make profit on a low level rotation product.

There is no precise information available about the relation between prices and the underlying costs. However, there are a number of obvious reasons for higher costs.

In the distribution chain, the reasons why costs are higher at the combined wholesale, processing and retail level are:

- Higher purchase price of raw materials;
- Higher operational cost on the supply chain, due they need a bigger number of grower due the low availability of quantities from the growers;
- More problems with continuity of supply;
- Higher costs for cleaning and separation in non-dedicated wholesale and processing units;
- Lack of economies of scale;
- Higher transport costs and small volumes of through put leading to high distribution costs per unit;
- More unsold products and wastage;
- Cost of inspection and certification.

At farm level the main reasons for higher costs include generally lower crop productivity and yields, lower animal stocking density leading to higher production costs, additional costs for labour input, as well as a lower grade of intensive specialisation at the farm level and costs for inspection and certification.

In order to reduce the price of the final product it is important to develop approaches which can reduce costs, without affecting the correct application of organic farming standards. In the distribution chain, an ongoing trend is direct delivery from the farmer to the consumer. Such a system can also strengthen the link between farmers and consumers, which falls within the basic ideas of organic farming.

A new marketing trend have been developing by the chains, offering product with 75% of the volume or weight that the same product in conventional for the same price or just a small difference.

Organic sales through supermarkets are, however, the fastest-growing distribution channel in most markets. For consumers buying organic produce in supermarkets, environmental considerations are thought to be less important, compared to consumers buying produce in specialised organic shops. This lends some support to the expectation of decreasing price premiums in the years to come. Furthermore, there are also reasons to expect that growth in demand may become more difficult as further increases in sales will depend more on less committed consumers with different perceptions and attitudes and who are more sensitive to prices.

In line with general market economy principles, the organic premium can only be maintained if supply growth is in line with demand. Where this is not the case, the premium will be eroded. There has been a tendency to regard organic markets as unlimited but in reality their potential can only be harvested when growth of supply and demand are balanced. While many countries report strong growth in demand for organic meat and dairy products, for example, a number of instances can be cited where supply has exceeded demand. This has resulted in either a severe reduction in the price difference between organic and conventional products or organic products being sold as conventional products.

It is essential for the future development of the sector that supply and demand grow hand in hand and that the share of organic products becomes large enough to establish a big enough, stable market.

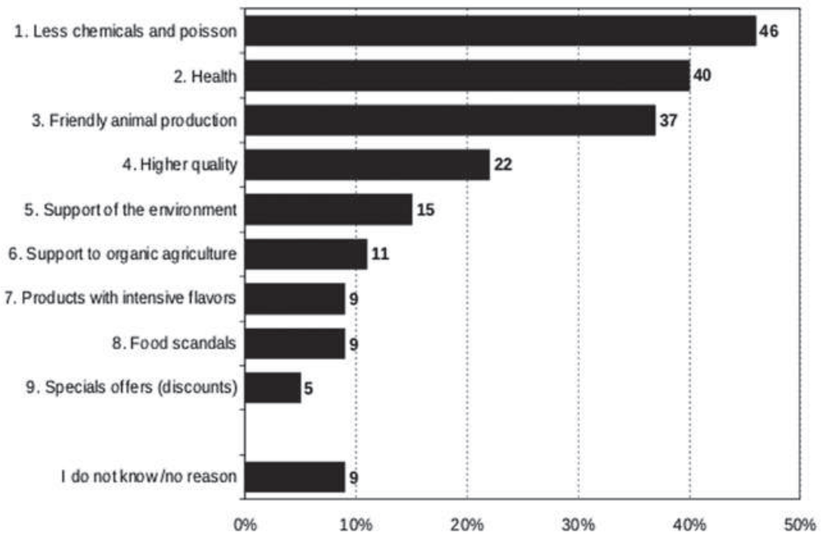
Organic has to be trusted

The European consumer are looking organic products due the are looking mainly for:

- Food safety
- Healthy food
- Friendly production.

So the system has to proof that each single product sold in the market meets the specification for the consumer.

Whether you buy organic fruit at your supermarket or farm shop, or choose a bottle of wine made from organic grapes at your favourite restaurant, you can be confident that it was produced according to strict EU Regulation, aimed at respecting the environment and animal welfare.



Direct selling from the farm (photo I. Manolov)

Small shops where group of producers sell their products (St. Berthold)

Temporary and open markets (photos I. Manolov)

Box (subscription) system of distribution of organic products (photo St. Berthold)

X. VIABILITY OF ORGANIC PRODUCTION

Organic agriculture has triggered a controversial debate in the last decades, most importantly because it shed light on the darker sides of chemical-intensive conventional farming by offering an alternative. By now, there is a strong body of evidence showing that organic farming is more environmentally friendly: potential benefits from organic production arise from improved soil fertility, organic matter content and biological activity; better soil structure and reduced susceptibility to erosion; reduced pollution from nutrient leaching and pesticides; and improved plant and animal biodiversity .

As more and more attention has been put on determining whether organic systems are environmentally better or not, it is not clear whether organic agriculture could be economically attractive enough to trigger wide spread adoption. If organic farming offered a better environmental quality, and potentially healthier foods, but not sufficient economic returns to the majority of farmers, it would obviously remain a luxury way of food production available to a very tiny fraction of farmers. However, the continued growth of organically managed lands worldwide, especially in developing countries, does not support this hypothesis.

The determinants of organic profits are in general very similar to those in conventional farming; only their relative importance may vary. Obviously for the whole farm performance, yields, prices and costs matter most in the calculations, but those are influenced by the following main determinants of profitability:

- Agricultural policy environment: the economic performance in Europe significantly influenced by the support payments for organic farming. These payments on average contributed to 16-24 percent of profits in countries as Germany, Austria, Switzerland and Denmark.
- Market environment: an important aspect of the profitability of organic farms is the opportunity of receiving higher farm gate prices for organically produced goods than for conventionally produced ones. Prices vary between the different marketing channels and the quantities marketed via these sales channels. Organic farm gate prices also have to take into account part of the production that

may be sold at conventional prices. Data from Great Britain and Germany showed that higher prices for organic products accounted for 40-73 percent of profits for arable farms, and 10-48 percent for dairy farms. The incentive effect of market situation and organic prices are generally higher than of support payments.
- Political environment: the market environment is very often influenced by political factors (and vice versa).
- Farmers' management abilities: although hardly measured in economic studies, farmers' experience and decision making abilities are one of the most crucial determinants for profitability. Farm success is often more dependent on the management ability of farmers, especially in the area of marketing, than on site-specific conditions.

Farm managing is very important to get it on control in order to approach to the best possible result. In order to understand a bit better what are the variables that they must be controlled, we provide a list of these ones:

Fixed costs generally include:
- Purchase and/or rental of land.
- Land charges and administrative costs
- Interest on farm-related loans
- Replacement values of machines including depreciation, interest and insurance.

Variable costs make an important differences between organic and conventional systems in a given agroclimatic region in order to consider all relevant variable costs. For instance, weed control in organic agriculture may include manual pick-up or mechanical tillage, plastic mulching and flaming: these costs will not be captured if only herbicide costs are accounted for. Similarly, using transplants (e.g. tomatoes) in organic agriculture but not in conventional systems raises variable costs for organic, so do cover crops, purchased composted manure, legumes, green manure and labour for hand and hoeing costs. These are different costs than what a conventional system may entail with the dominance of fertilizer and pesticide costs.

Generally, variable costs include:
- Ploughing and tillage.
- Irrigation
- Seeds and transplants.
- Fertilizers, manure, mulch.
- Pesticides, herbicides.
- Energy, fuel.
- Labour (operator labour, regular and seasonal hired labour).
- Machine repair and maintenance.
- Renting equipment.
- Cold storage.
- Transport.
- Variable irrigation expenses.
- Other materials (e.g. packing containers for fruits).
- Record keeping.
- Certification costs.

Gross margins and net returns ; Most studies use net income/returns per hectare as a measure of profitability. Net returns are calculated by subtracting total costs from gross revenues. Gross revenues are the average yields per hectare multiplied by the commodity farm-gate price. Other studies use gross margins to measure economic performance; gross margins are calculated by subtracting variable costs from the total farm income.

Main reasons for higher profitability of organic systems ;
- Higher market prices and premiums: even with less yields and higher production costs, organic remained more profitable due to higher market price; even with much higher costs and significantly lower yields, price premium made organic more profitable ; higher prices for organic accounted for 30-60 percent of profits in Germany and Britain for arable farms, and 10-48 percent for dairy farms.
- Lower production costs: lower production costs caused significant difference in net returns even without premiums.
- Aid from the government.

Analyzing some of the top reason, they are;

- ***Production structure.***In most countries, organic farms are on average smaller than conventional farms. Labour use is higher than on comparable conventional farms, but the extent of the higher labour requirements is strongly dependent on the farm type. The majority of the studies evaluated report an increase of labour needs in the range of 10-20 %. While horticultural farms may need more than twice the labour input of conventional farms.
- ***Yields*** In Europe, yields in organic crop production are in general significantly lower than under conventional management. But, these yield differences vary between crops, and partly also between countries and regions analysed. For cereals, the range of observed typical yield ratios is quite narrow for most countries, especially in central and western Europe. Cereal yields are typically 60-70% of those under conventional management. For most countries the studies evaluated show a high variation in both the absolute and the relative yield levels of potatoes. This variation exists within countries, between countries, and for data of different years. Vegetable yields are often just as high as under conventional management. Few data are available on pasture and grassland yields in organic farming, reported values lie in the range of 70-100% of conventional yields, depending on the intensity of use.
- ***Inputs.*** Is depend the country, there is more availability of supplier of input for organic agriculture, so the competition is the main reason why the prices can be significant different between countries in Europe. The biggest supplier concentration of input for organic agriculture in Europe is based in Spain. So it this country, the prices for input are around 40-70 % shipper that other countries as Bulgaria.
- ***Labour cost.*** Is depend the country, the organic agriculture, can afford to invest more money in labour due the costing in some countries are much more lower that in the developed countries in Europe. For example, the labour cost could vary up to ten time between Spain and Bulgaria. And the farm gate price should be the same in both countries. There is also a direct relation between developed countries and inputs; In those countries where the labour

cost is higher, they also use more inputs in order to avoid as much as they can, labour operations.
- ***Efficiency on machinery.*** As the constant rising up on the fuel oil prices, the energy efficiency has to be consider as a big reason for loosing competitiveness. One way how to carry on competitive is to use efficient machinery, so there are reduction of fuel oil consumption and less labour cost. The cost could rise up to twenty cent per kilo more in horticultural crop using a low efficiency system.
- ***Prices.*** An important aspect of the profitability of organic farms is the opportunity of receiving higher farm gate prices for organically produced goods than for conventionally produced ones. Prices vary considerably between the different marketing channels. The realised average organic price depends on the level of these prices and on the quantities market via the respective sales channels. For many products, the calculation of an 'average organic farm gate price' has to take into account that in many cases part of the production still has to be sold at conventional prices. Currently, premium prices are higher than conventional for most crop products. In nearly all countries analysed, average farm gate prices for organically produced were 40-90 % higher than for conventional.
- ***Aid and support from the EU.*** Organic farming methods meet many of the environmental and social concerns of policy makers and the public. When organic farming became legally defined in the EU in 1991, it became possible to support organic farming through agri-environmental and rural support programmes, including the CAP. CAP2 was reformed in 2003 when agricultural production was decoupled from (no longer linked to) subsidy payments through the introduction of a Single Farm Payment (SFP) scheme. Payments are now linked to environmental, food safety and animal welfare standards.

In 2013, the 2003 CAP reform will be fully implemented in all EU Member States. Its effects will depend on how each country chooses to implement the CAP reforms and the type of farm. Organic farms will benefit in countries that opt for full rather than partial decoupling or in countries where the SFP is based on regional payments rather than on historical payments. For example, the reform will benefit organic farms in Denmark and organic dairy farms in southern Germany.

In general, increased first pillar payments contribute to higher levels of total payments to all Western organic farms. For organic farms in new Member States, costs will initially rise from meeting EU standards. However, by 2013, most organic farms in the new States will benefit: farm incomes, should typically rise by 300 per cent in the Czech Republic, by 50-240 per cent in Hungary, by 140-220 per cent in Estonia, by about 50 per cent in Poland and 0-150 per cent in Slovenia.

However, once higher payment rates have been implemented, organic farms in new Member States, particularly in Estonia, Hungary and Poland, are likely to become more vulnerable to policy changes. Enlarging the organic farming sector in new Member States could reduce the price of organic products, but there is also likely to be an increase in demand for organic products, particularly in the old Member States.

Organic Farming Vs Conventional Farming

Generally it is hard to conclude that one system is more profitable than the other – it depends on site and crop specific factors, availability of marketing opportunities, labour availability, agronomic factors, etc. Several variables could impact overall farm performance, thus a multi-disciplinary approach that involves the whole farm and takes into account the management skills and objectives of the farmers is a more favorable option.

Dozens of studies have been analyzed in terms of their research on farm profitability, and though methodological differences prevent us from comparing them systematically, the similarities between the studies from many countries and contexts allow us to draw some general conclusions.

Profitability certainly depends on the crop choice, which of course is determined partly by environmental conditions and partly by the demand for products and available governmental programmes supporting those crops. Selection of the comparison group seems to have a strong influence on profitability. Farm size, farm type, location

are all important factors in selecting the suitable candidate farms for a comparison. The availability of price premiums seem to be a crucial factor in good economic performances of organic systems and in most cases, make organic farms more profitable.

However, as at least a dozen studies showed that price premiums are not always necessary for organic systems to be more profitable than conventional systems. If higher prices are not available to compensate for the organic yield loss, than financial profitability depends entirely on achieving cost reductions. Overall, the complied data suggest that organic agriculture is economically more profitable, and even though yields decrease in developed countries, higher premiums and lower production costs compensate for these losses.

Increased profitability of organic agriculture very much depends on consumer demand, market prices and the availability of premiums. One of the biggest potentials to further improve the profitability of organic farms in developing countries lies in establishing organic markets for staple crops (organic soybeans, wheat, chilies, etc) that are part of the rotation; if these crops could be sold with a premium price, incomes of organic farms would further increase. In developed countries, premiums are most often available, so besides the market prices which farmers are unable to influence, the further reduction of production costs (energy, fuel, feed) and the use of better varieties (in terms of resistance, yield, etc.) could result in an increase of relative profitability in organic farms.

Still to date, organic agriculture faces an unfair competition in the marketplace due to: the current subsidy schemes that favour conventional production; the unequal availability of research and extension services; and the failure to capture the real environmental, social and health externalities in market prices of conventional foods. Besides directing much more research and extension investments into organic agriculture and shifting the bulk of public support from polluting activities to sustainable practices to give an equal footing to profitability studies, such studies need to take the differences in external costs and benefits into account to capture the real and multiple profits of agriculture.

In conclusion:

Absolute yield levels are increasing over time, but at a slower rate than for a comparable conventional system. S. Yield differences relative to the conventional system vary depending on enterprise type, and Iintensity of the conventional system between regions and also, between crops within a region. Therefore, in the case of organic farming there is a need to consider not just modification to agricultural practices, such as the level of input use, or the combination of individual inputs, but also restructuring of the farming system.

Variable input costs, particularly, agrochemicals, are lower. Indeed, quite marked differences between organic and conventional farms can be found in cost structure and organic farms are more labor intensive.

Total production costs per unit for organics is higher than conventional products due to low level use of chemicals but higher cost of fertilization and weed control.

Premium prices for organic crops are available in most the countries and in most the crops. But when the demand in the market is smaller than the current offer of a certain product, the grower, has to sell the production as conventional, in order to protect the tendency on the market for that particular product.

An important aspect of profitability of organic farms is the opportunity to receive higher farm gate prices for organic than for conventional goods. Prices vary considerably between different marketing channels. In the longrun especially, the problem of market failure which can only be addressed if some consumers are prepared to place a higher value on organic food, or if policy makers act to bring about coordinated change through voluntary agreements, regulation or appropriate financial signals.

Gross margins may be similar or higher if premium prices can be obtained, but otherwise they are likely to be lower and individual enterprise gross margins need to be considered in the context the entire farm system because, gross margin comparisons between enter prises with different cost structures can be misleading, particularly where conventional variable costs such as fertilizer and crop protection inputs have been substituted by fixed costs in the organic context.

Labor use is higher, but this is generally related to an increase in the number and range of enterprises on the farm and to the development of new marketing and processing activities, rather than to increases in labor use for specific crop and livestock enterprises.

Food and safety is also a requirement for organic production, so all the growers who want to be providers of the supermarket chain, they have to became minimum Globalgap certified. If they are also packers, and depending of the market, they will have to summit BRC or IFS or other particular food and safety protocol.

Some fixed costs include items such as power repairs, and depreciation of machinery, and capital costs are typically similar between organic and conventional farms, in most counries. Total costs of organic farms are, on average, only slightly lower than when compared with conventional farms.

In terms of Gross Product Income or Income per Hectare, organic agriculture is slightly higher than conventional agriculture. In terms of income per working hour, the productivity of the organic system is still below the best conventional performance.

Organic farming is more profitable than conventional one if there is a high knowledge of growing organically, cost controlled and commercialization on the shortest possible way.

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XII. USEFUL LINKS

Biological control in general:

http://lamar.colostate.edu/~hufbauer/Pages/biologicalcontrol.html
http://www.inhs.illinois.edu/research/biocontrol/introduction/basicdef.html
http://cipm.ncsu.edu/ent/biocontrol/qanda.htm
http://www.syngenta-bioline.co.uk/
http://www.ko ert.com/
http://greenmethods.com/

http://www.bio-bee.com/
http://www.biobest.be/
http://www.ghorganics.com/
http://www.omri.org/
Biological control of insects (predators, parasitoids):
http://www.biocontrol.entomology.cornell.edu/
http://www.biology.ualberta.ca/courses.hp/ent207/lec31-32.htm
http://www.rinconvitova.com/bulletins_product_pdf/Hi odamia_BUL.pdf
http://www.issg.org/database/species/ecology.asp?fr=1&si=668
Beneficial microorganisms:
http://www.invasiveforestinsectandweedbiocontrol.info/resources/documents/pdf-08- 16-bioinsecticides-conceptsanda l.pdf
http://www.entomology.wisc.edu/mbcn/kyf612.html
http://www.biology-online.org/articles/microorganisms-agricultural-development/plant-growth-promoting-rhizobacteria.html
Beneficial nematodes:
http://nematode.unl.edu/wormepns.htm
Biological control of pathogens:
http://www.entomology.wisc.edu/mbcn/fea303.html
Botanical insecticides:
http://landscapeipm.tamu.edu/what-is-ipm/types-of-pest-control/chemical-control/organic/botanical/
Mechanical weed control:
http://www.ewrs.org/et/et_introduction_to_physical_weed_control.asp
Ministry of Rural Development and Food, www.minagric.gr
Agricultural Products Certification and Supervision Organization (OPEGEP), www.agrocert.gr
European Commission, http://epp.eurostat.ec.europa.eu/
Research Institute of Organic Agriculture FiBL, www.fibl.org
International Federation of Organic Agriculture Movements (IFOAM), www.ifoam.org
Bio DIO NET, www.dionet.gr
BIO-HELLAS S.A., www.bio-hellas.gr
QWAYS S.A., www.qways.gr
A-CERT S.A., www.a-cert.org
IRIS, www.irisbio.gr
GREEN CONTROL, www.greencontrol.gr
GMCERT, www.gmcert.gr
QMS-CERT, www.qmscert.gr
TUV HELLAS, www.tuvhellas.gr
FILIKI CERT S.A., www.filikicert.gr
National Printing House www.et.gr
http://www.bioportal.gr