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MODULE VII : HORTICULTURE

ORGANIC VEGETABLE PRODUCTION

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1. Introduction

In the early seventies, many farmers and agricultural scientists were convinced that agricultural production without external input of production factors like synthetic fertilizers and pesticides would not be feasible. The misuse of the pesticides led to a grat disturbance of the natural biological balance. Chemical fertilizers led to changes plant physiology, soil texture and chemistry. All these factors resulted in highly susceptible plants, appearance of new pests due to the great reduction in their natural enemies and the great increase in concentrations of toxic substances in human food chain. Organic farming as an alternative to conventional developed agricultural practice was not taken seriously.

In recent years, global awareness of health and environmental issues has been growing, and sustainability has become the key word in discussions on economic development, particularly in relations to developing countries. The ever growing number of health and environmentally concerned consumers, mainly in industrialized countries of Western Europe, North America, Japan and Australia, is at the root of this development. The international community is becoming more and more conscious of these issues, and government policies in industrialized as well as developing countries increasingly encourage organic and other forms of sustainable agriculture.

2.Concepts of organic agriculture

The concept of organic farming is based on holistic viewpoint, meaning that nature is perceived to be more than just the separate individual elements into which it may be split. Its principles are bound to ecology, a science concerned with the interrelationship of living organisms and their environments. In practical terms, this means that organic farmers obtain their inspiration and learn from natural eco-systems. Farmers try to imitate at farm level basic characteristics of relevant eco-systems, for instance by working towards the maximal use of recycling of on-farm resources (fodder, manure, organic waste, etc…).

Organic farming differs from industrialized agriculture that in the latter, biological systems are to a larger extend replaced by technical systems. For instance, the diversified rotation of crops, with its biological significance, is often supplanted by mono-cultural practices giving rise to the need to use pesticides and artificial fertilizers.

In organic farming, the aim is to support and strengthen biological processes without recourse to technical remedies such as synthetic fertilizers and pesticides and the genetic modification of organisms; hence, the approach to the control of weeds , pets, and diseases is primarily preventive.

Organic farming is based on the enhancement of the structure and the fertility of the soil, a balanced choice of crops, and the implementation of diversified crop rotation systems. The number of animals kept on the farm and the available land area are correlated so that farm units can cover their need for feed and oil nutrients from within the system.

Among its key characteristics are the use of organic materials to maintain organic matter and nutrients in the soil (including green manure), nitrogen-fixing plants, pest resistant plant varieties, soil management techniques such as mulching and the use of fallow periods, various cropping systems (including intercropping) and agro-forestry. Agro-forestry consists of land-use systems in which woody perennials are grown in association with crops and/or livestock. Organic farming gives the consideration to animal welfare and the use of manual, mechanical and thermic weeding.

Organic fields accommodate a greater variety of plants, animals and microorganisms. The organic agro-ecosystem is thus more resistant to stress and disturbance. Enhanced microbial activity improves the utilization of the available energy and resources.

Healthy ecosystems, well adapted to the site conditions, are distinguished by species diversity. The element cycles and food structures are closed and the nutrients are bound biologically. Ecosystem theory is in accordance with the principles of the organic farming: the closed nutrient cycle on the farm level. Organic land management allows development of a relatively rich weed flora as compared to conventional system. In conventional farming, weeds are considered competitive to the crops and are eliminated by herbicides and dense crop stands. In organic systems, however, some of the "accompanying plant" of a crop are desired and considered useful.

Organic farming merges traditional and respectful views of nature with modern scientific insights. It encompasses several farming methods and approaches.
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The concept of organic farming also covers economic and social aspects of agricultural production, local as well as global. Organic farming is an investment in my future.

Biodynamic agriculture (a contracted translation of the German *biologisch-dynamische landwirtschaft*) is yet an other approach: it is based on anthroposophy and the ideas formulated in the 1920's by the Austrian Rudolf Steiner. The maintenance and furtherance of life-processes in the soil, and in nature in general, as well as the harnessing of cosmic energy and other influences from the sun, the stars, the moon and other planets, are basic principles. Biodynamic agriculture advocates the combination of animal husbandry and crop production (mixed farming) and it uses compost and biodynamic preparations (naturally occurring plant, animal and mineral materials which are combined in specific recipes) in order to vitalize the soil and to enable it to transmit this vitality to plants, and subsequently to animals and human beings. Sowing, cultivation and harvesting are timed according to cosmic rhythms.

3.Characteristics of Vegetable Crops

3.1. Introduction

In many countries, vegetables plat a very important role in the human diet, supplying some of the things in which other food materials are deficient. They are important in neutralizing the acid substances produced in the course of digestion of meats, cheese, and other foods. They are of value as roughage, which promotes digestion and helps to prevent constipation. They are important sources of mineral elements needed by the body. They are valuable sources in vitamins. Most of the vegetables are poor in fats. Some vegetables are also rich in proteins (died seeds of beans and peas) or in carbohydrates (potatoes, sweet potatoes and carrots). The per capita consumption of vegetables had increased markedly during the last decades overall the world.

Although vegetable growing may appear dynamic, glamorous, and lucrative in some respects, it is highly competitive, speculative endeavor. Hard work, skillful management, expensive machines, and special skills and aptitudes are required for success.

Vegetable growing is one of the major branches of horticulture. Vegetable growing may be grouped into different divisions, based on the objects sought and the methods employed in producing and in disposing of the crops: home gardening, commercial production, production for processing, vegetable forcing (controlled environment), and vegetable seed production

3.2. Classification of vegetables

There are four general methods of vegetable classification:

- Botanical classification

Class, family, genus, species, subspecies, or botanical variety to which vegetable crop plants belong and the common names.

- Classification based on hardiness: adaptation to heat and cold

vegetables vary considerably in their temperature requirements; some need relatively cool temperatures while others need warm temperatures for best development.

Based on the temperature that the plants withstand, vegetables are often classified as hardy, semi hardy (half hardy), tender and very tender. Those classed are as hardy will endure ordinary frost and low temperature injury, while those classed as tender would be killed. The terms cool-season and warm season crops are also used to suggest conditions under which the crops thrive best. This system of classification is of some value in connection with planting time.

Cool season crops		Warm season crops	
Hardy	Half hardy	Tender	Very tender
Asparagus	Beet	Beans	Cucumber
Broccoli	Carrot		Eggplant
Brussel sprouts	Cauliflower	Tomato	Muskmelon
Cabbage	celery		Okra
Garlic	Artichoke		Pepper
Kohlrabi	Endive		Pumpkin
Leek	Lettuce		Squash
Mustard	Potato		Sweet potato
Onion			Watermelon
Parsley			
Peas			
Radish			
Spinach			
Turnip			

- Classification based on parts used as food (edible plant part)
* Crops grown for their leaves (eaten raw or cooked) as Brussels sprout, cabbage, endive, lettuce, and beet and turnip green……
* Crops grown for their petioles as celery
* Crops grown for their bulbs as garlic, leek, onion and shallots
* Crops grown for their stems as asparagus and kohlrabi
* Crops grown for their tubers as potato
* Crops grown for their roots as beet, carrot, radish, turnip, sweet potatoes
* Crops grown for their flower clusters as broccoli, cauliflower and artichoke
* Crops grown for their fruits as melon, watermelon, pepper, tomatoes, eggplant, okra, pumpkin, squash, beans, peas ….
* Crops grown for their seeds as peas, sweet corn, beans….

- Classification based on method of culture
All those crops that have similar cultural requirements are grouped together. This system combines some parts of the other three methods as perennial crops, salad crops, cole crops, root crops, bulb crops…….

3.3. Economic differences between vegetable and fruit growing

The requirements of horticultural crops are considerably different from those of field crops or livestock farming. There are also several essential differences between the vegetable and fruit industries:

- Vegetable production does not ordinarily involve a long time investment as does orchard, and the vegetable grower is not bound to produce the same crop each year.
- Many vegetable areas, particularly those in the process of development and exploitation, lack the stability of the orchard district which wax methodically developed over a period of years. Getting into fruit growing is a slow process, and getting out mat be even slower.
- Since the problem of financing a vegetable crop is largely an annual one, tenants can be used, whereas few orchardists are willing to turn over their growing or bearing trees to temporary operators.
- Co-operative effort and organization are somewhat difficult among vegetable producers than fruit growers. Orchardists have years for making permanent plans and perfecting an organization, whereas vegetable “deals” come and go frequently.
- Vegetable farming may be promoted and financed by dealers or commission men, and production is determined accordingly. Fruit growers are usually more independent and more able to secure long term credit.
- The acreage and resulting production of vegetable crops are flexible, responding easily to promotion, enthusiasm, or price outlook, whereas the fruit industry is slowly adjustable.
- Vegetable crops may be grown by farmers with limited experience, and as a result, frequent failures occur. If the fruit grower develops his own orchard, he is likely to be acquainted with the industry by the time his trees start bearing.

From the contrasts mentioned, one may infer that the vegetable farming in generally unstable and comparatively undesirable. This is not necessarily the case, as many permanent, well organized, vegetable producing areas have been established throughout many countries.

3.4. Climatic and soil requirements

Climate is the most important factor in determining the regions of production of vegetables. The climatic factors that are important are: temperature, rainfall and atmospheric humidity. Of these, temperature is most important in determining the broad localization of vegetable growing. Rainfall is of great importance when irrigation is not practiced, and atmospheric humidity is important with many crops. In the production of many kinds of vegetable seeds, absence of rain, or relatively light rainfall, and low humidity during ripening, harvesting, and curing of the seeds are very important.

The character of the soil usually is an important factor in localizing vegetable growing within a region having suitable climate for the crop or crops to be grown. The soil, however, does not determine the broad general region of production, because soils of similar characteristics are found in nearly all regions of the country.

3.4.1. Open field crops

Vegetables may be grown in different seasons (autumn, winter, spring and summer) depending on their climatic requirements. Cultivar adaptation is also very important.

3.4.2. Protected cultivation

In the Mediterranean region, protected cultivation has gained a popular reputation among horticultural activities. Protected cultivation includes the production in greenhouses (single or multi-span tunnels) and low plastic tunnels. Production of out of season crops under greenhouse conditions can be realized from November to June when the demand (local market and export) for fresh vegetables and the prices are high. Most of them are located on the coast and/or microclimatic areas where the climatic conditions are favorable for protected cultivation without any additional heating. Recently, he protected cultivation has been integrated into the organic farming in many different Mediterranean countries.

3.4.2.1. Low tunnels

They are used for a short time (2-4 months) in order to help crops start faster in winter and spring seasons. They are quite often associated with mulching.

They slightly improve the temperature and allow a better plant growth and earlier production as compared to open field conditions.

As soon as solar radiation intensifies during the day, the air temperature under the tunnels increases fast and **Ventilation** becomes necessary. It has to be managed properly and may require a lot of labor. It can be achieved through perforations or by rolling up the film.

The Polyethylene films (with about 100 microns of thickness) are the most used.

3.4.2.2. Greenhouses

The most used greenhouses are the single span plastic houses (walk in tunnels) with about un area of 500 m2. Multi-span greenhouses are also used with plastic or glass cover in some cases (mainly south European countries). They offer better conditions than low tunnels for plant growth and development: bigger space and volume, higher temperature, better ventilation, better pest and disease control.… Consequently, the yield is higher and the production quality is better. However, their cost is higher than the small tunnels. Farmers are using greenhouses mainly for high value crops such us tomato, cucumber, melon, and pepper.

The main problems for Mediterranean greenhouses are:

- poor greenhouse structure,
- poor quality of plastic film
- low temperatures in winter in some areas: heating for 1 to 3 months,
- high temperature during the daytime, even in springtime: insufficient ventilation through 3-4 months,
- high humidity during night,
- poor resistance against wind,
- poor water quality and water shortage,
- poor fastening and stretching of the film

4. Plant growth and development

Many authors distinguish sharply between growth, development and cell differentiation. In their sense, **growth** merely implies cell division and cell enlargement processes, while the sequence of structural and functional changes that occur during the life cycle of an organism is regarded as **development**. This involves progression of the organism from small and simple to large and complex. According to these authors, **differentiation** is the acquisition of a determined structure and function in the course of development; it is only a component of development though often used as a synonym.

The production of a crop is usually more successful if the grower understands the nature of the plant and its growth and development.

Growth and development of vegetables depend upon several factors:

- Climate: temperature, photoperiod (light), rainfall, wind, frost….
- Soil: physical, chemical and biological characteristics
- Crop: species and cultivars, tolerance or resistance to pests
- Cultural practices: soil preparation, sowing, nursery management, planting, fertilization, irrigation, insect and disease control, weed control, and other production techniques.

The growth and development stages of vegetable plants are mainly germination, vegetative growth, flowering, fruit set, fruit development and growth, fruit ripening, bulb and tuber formation.

4.1.Germination

A seed is a dormant undeveloped plant. It contains its own food supply and is protected by a seed coat. The cost of most vegetable seed is a small part of the cost of producing the edible vegetable product and considerable care should be taken in purchasing the seed. Good vegetable seeds are clean, disease-free, and viable (vitality) and produce plants typical of the cultivar listed on the seed packet.

Some vegetable seeds do have a natural dormancy period as eggplant, lettuce, potato tuber, onion bulb.

When a seed receives the proper amount of air, water, and light and heat, it will begin to grow. Some germination will usually occur over a wide range of each of these of factors.

Germination of a seed involves four phases:

- the absorption of water,
- the formation of enzyme systems and the breakdown of the food reserves,
- the growth of the new root and shoot, and
- the growth of the seedling up to the time it has emerged from the soil.

Vegetable seeds should be planted at a depth equal to about four times the diameter of the seed.

4.2. Vegetative growth

Once the seedling has emerged from the soil, it is capable of continuous and uninterrupted growth until flowering. During this period of growth when the plant cannot readily be induced to flower, it is considered to be **juvenile**. Specific environmental conditions are also required (such as day length or temperature) for some to flower.

There are a number of advantages of the plant for having a period of **rapid vegetative growth**. The plant can be better compete with weeds and other plants if it is large. It maintains its competitive position and is able to receive more sunlight by growing rapidly. As a result, the plant will have more food produced from photosynthesis, and a large plant with more food reserve will produce a higher yield of the edible part. By maintaining a vegetative condition, the food reserve of beet, carrot, onion and radish is used to produce the edible part.

When these plants flower, however, the food reserves is used to produce flowers and seeds. These plants are not capable of developing the edible part and also producing flowers and seeds. In those vegetables in which fruit is desired, a larger plant can withstand the stresses of flowering much easier than a small plant. A small plant often produces seed and then dies.

A buildup of food materials occurs in the leaves during vegetative growth, and these materials are used in flowering process. In many plants, once flowering begins, vegetative growth stops and no more food accumulates. After flowering and fruit set, the plant often stops growing; but if the fruits is removed, the plant continues to grow and produce new flowers and fruits, as occurs in pepper and beans. Often vegetative and reproductive growth.

Vegetative growth is influenced by the environment. Vegetable plants require an optimal range of temperature for optimal vegetative growth. Pungency of onion and radish develops rapidly at high temperature. The amount of solids and starch of potato tubers is also affected by temperature.

4.3. Flowering

4.3. 1. Introduction

The farmer is interested in producing two types of vegetables:

- those in which the edible part is the flower bud, fruit, or seed, and
- those in which the edible part is the leaf, root, stem or petiole.

The plants in the latter group may, however, produce flowers instead of a satisfactory edible part.

Once the plant has reached a certain developmental stage (basic stage of vegetative growth) and the plant has overcome juvenility and when certain environmental conditions have been met, the plant will flower.

Many environmental conditions affect flowering. Temperature, light, water and nutrition play a vital role. The actual environmental conditions that promote flowering do not have to be present during the flowering process.

Flower induction depends on species:

- In some species, it will occur after the juvenile stage without exposure to particular environmental conditions (photoperiod, temperature)
- In other species, the exposure to certain environmental conditions is necessary.
    - The flowering stimulus is efficient only after the juvenile stage (photoperiod, temperature).
    - The flowering stimulus is efficient at any growth stage (Temperature).

4.3.2.Temperature

Temperature is one critical environmental factor that affects flowering.

- Many vegetables are induced to flower by low temperatures, particularly biennial and perennial plants. The induction to flower by low temperature is called vernalization. Biennial plants normally grow one year, are induced to flower during the winter, and flower the next year. They may, however, be induced to flower the first year; if this happens, the plant does not produce satisfactory edible plant part. As the plants become older, they respond more easily to low temperature flower induction. The vernalization requires cold temperature, growing point or bud, water, oxygen, and a food reserve.

Broccoli and cauliflower require very little chilling for vernalization. The farmer can transplant these plants when they are small and do not have enough food reserve fo vernalization to occur or can transplant them as larger plants after the soil temperatures have warmed up. If the plants receive a cold treatment and have enough food reserve, they will flower and produce a head so early that it will be very small.

Carrot varieties are highly variable in their vernalization response. The large root of carrot is easily vernalized at 15°C to induce it to flower.

Onions are vernalized if they undergo 2 weeks at 5 –10°C. Onions sets are normally stored at mower temperatures; during this storage, the sets are vernalized, and if they planted immediately they would flower and would not form a bulb. However, the sets can be converted back to their origin nonflowering condition by high temperature. Exposing the sets to 26°C for 2 or 3 weeks will devernalize the sets, and they will form bulbs instead of flowers. Most farmers do not need to be concerned with converting onion sets back to non flowering condition. In case of low temperatures conditions after planting (5-10°C) and in order to ensure that onion bulbs rather than flowers are produced, medium-sized sets about 1-1.5 cm in diameter should be selected for use as dry onions or bulbs. These sets are small enough that, even if they are exposed to low temperatures when planted, the sets do not have enough food reserve to become vernalized. The larger sets will be vernalized and should be used to produce green onions.

Beets, cabbage, and celery may also be vernalized by cold temperature. To prevent this, it is best to plant beets when the temperature is warming up rapidly (in the spring) and the seedling does not have enough food reserve to bevernalized and the cold temperatures do no remain long enough. Small transplants with low food reserves or larger plants planted late will produce satisfactory heads instead of flowers.

- Some, as spinach and lettuce are induced to flower at high temperatures.

4.3. 3. Light

A large number of vegetables respond to the variation in the length of the light and dark periods, or day lengths.

- Some vegetables initiate flowers during long days (more than 12 hours of light) such as radish, lettuce, spinach, potato and beets.

- Other vegetables initiate flowers during short days, such as some gourds and beans.

- Still other vegetables, such as tomatoes and peppers, produce flowers under long or short days.

As a result, different cultivars of vegetables are grown in the temperate region from Mediterranean or tropical regions. Some types of vegetables are adapted to short days and, if grown under long day conditions, the plants will grow vegetatively but will not flower.

Thus, vegetable species are classified as neutral, short or long day plants.

4.3.4. Nutrition

When some vegetables are given a large amount of nitrogen fertilizer, the plants produce large amounts of vegetative growth but few flowers and fruits. This is particularly a problem when large amounts of manure are applied to a garden.

4.3.5. Flower types

Most vegetables, of which the edible part is the fruit or seed, produce complete flowers (containing all parts of flowers) and perfect flowers (containing both male and female parts) : hermaphrodite plants

Some vegetables, however, have separate flowers:

- on the same plant as:

* cucumber, squash, pumpkin, most varieties of water melon and few varieties of muskmelon: separate male and female flowers: monoecious plants
* Most varieties of muskmelon and few varieties of watermelon: separate perfect and male flowers: andro-monoecious plants

- on different plants as asparagus and spinach: male and female plants : dioecious plants

4.4. Fruit set

4.4.1. Pollination

The changes that mark the transition of the flower into a young fruit are called fruit set.
- Peas, beans, and some other legumes are already pollinated when the flowers emerge.
- In others like tomato, the flowers are self pollinated but must be shaken lightly by the wind to ensure pollination.
- Beets and spinach are pollinated by airborne pollen, and crossing between cultivars readily occurs.
- Most vegetables are pollinated by insect-borne pollen, including those given in the following list.

Asparagus	Broccoli	Brussels sprouts		Cabbage	Carrot
Cauliflower	Celery	Cucumber		Eggplant	Gherkin
Gourds	Kohlrabi	Muskmelon		Onion	Parsley
Pepper	Pumpkin	Radish	Squash	Turnip	Watermelon

Farmers cannot control the flight path of insects. Bees and other insects from other farms may pollinate your farm. If seed is to be saved from your plants (seed production) the various cultivars of the same species should be well separated from each other by at least 400 m. Pollination allows seed production and also prevents the flower or young fruit from falling off the plant.

In vegetables with separate male and female flowers, bees or some other insects must transfer the pollen from the male to the female. Commercial seeds of these plants are produced in isolated areas where no other cultivar is grown.

In cultivars which cross-pollinate each other within a same species, the cross-pollination does not affect the shape, color, or taste of the fruit presently produced.

However, if the seed from these fruits is saved and planted next year, a vast array of colors, shapes, sizes, and tastes of fruits will be produced.

Within the *Cucurbita* genus, some species will also sometimes cross-pollinate with another species, although only a few seeds are usually produced. Thus, cultivars in the species *pepo* and *maxima* will sometimes cross with *moshata.*

4.4.2. Parthenocarpy

Some vegetables can have fruit without the production of seeds, and this is called parthenocarpy. Fruit development by this means can occur:

- without any pollination,
- with pollination but without fertilization
- by pollination and fertilization but the embryo aborts

Parthenocarpic fruit produced without pollination occasionally occurs naturally with tomato, pepper, pumpkin and cucumbers. There are several cultivars of cucumbers for greenhouse production that produce fruit without pollination. Most of these cultivars will produce seed if grown outdoors and pollinated.

Fruit development with pollination but without fertilization can occur in tomato. Below 15°C, pollination of the flower can occur, but the pollen tube does not grow so that fertilization does not occur.

Production of parthenocarpic fruit by embryo abortion occurs in seedless watermelons. Although no seeds are produced, the fruit still contains small seed coats, which are sometimes confused with true sedds.

4.5. fruit development

The control of fruit development is extremely complex. Many growth hormones are involved, and there is considerable competition among various growth substances. It is obvious that fruits that contain a large amount of food material must obtain this from the rest of the plant. The seeds in the developing fruit produce new growth substances that induce the production of a conducting system between the fruit and the plant. Usually this conducting system is among certain leaves nearest the developing fruit. In peas and cucumbers, about 80% of the sugar is provided by the leaves nearest the fruit. When the fruit is removed, very little sugar moves out to the rest of the plant. Thus, old leaves fall off or be shaded by new growth without any yield reduction. These old leaves are not providing much food mateial to the new, developing fruit anyway. When the food material is being rapidly transported to the fruit, a nutrient deficiency sometimes occurs in the leaves because of this rapid transport.

Without the production of growth hormones by the developing seed, the fruit usually falls off. In cucumber, however, if two flowers at the same node are pollinated at the same time, both fruits develop simultaneously. If there is one day difference in pollination, the one pollinated first develops first. The other fruit remains small and does not develop until the first fruit is developed or picked. Sometimes the food material may move from the second fruit into the first fruit, causing the latter pollinated fruit to fall off the plant.

Fruit may stop growing without falling off the plant. If the young developing fruit is removed, other fruits continue to grow. In okra, if the old fruit is allowed to mature and remain on the plant, yield is drastically reduced. In tomato, it normally takes about 45 days to go from pollination to incipient color (just turning red).

Fruit size depends upon:

- the number of leaves,
- the amount of sunlight received by leaves,
- an ample supply of water,
- the right temperature, and
- the competition between fruit.

The plant has only so much food material available for the developing fruit. If the plant is large and has ample food, it is capable of producing more and larger fruit than a small plant.

If a tomato transplant is planted with a small fruit on the plant, the fruit will be small. This plant cannot grow vegetatively and develop an adequate-sized fruit at the same time. The plant will use the available energy to produce this fruit and will have limited energy for new growth and additional fruit. Fruit on a tomato transplant should be removed before planting.

The cucumber plants is capable of producing many medium-sized fruits or few large fruits. However, total weight of the fruits produced by the same plant is about the same.

4.6. Fruit ripening

When fruit has reached its maximum size, it is mature. A tomato fruit beginning to turn red is mature and will not increase further in size and may be picked. Ripening of fruit refers to the processes that changes in the mature fruit. The general changes during ripening are:

- softening of the fruit flesh,
- hydrolysis of stored materials into soluble material,
- changes into the pigment content (color) of the fruit,
- changes in flavor, and
- changes in respiration.

During ripening, cell walls are broken down, making the fruit soft. Various insoluble starches are converted to sugar. Ripe bell peppers are sweeter than green ones due to this increased sugar.

Most farmers consider a fruit ripe when it has changed to a characteristic color. Tomato and bell pepper become red. Winter squash turns light yellow or orange, starting at the areas which was in contact with the ground. Usually, this color is due to new pigments being synthesized. In summer beets, there is a high sugar content and a small amount of color. In the autumn, under cooler temperatures, the red color increases greatly; as less photosynthesis is occurring, the sugar content declines.

During ripening, various flavor components appear. Sweetness and acidity are often important in flavor, and sugar usually accumulates during ripening and acid levels decline.

Color development and softening of tomato fruit, for example, are greatly influenced by temperature. At high temperature (30°C), the fruit becomes soft but color development is slow. The fruit becomes partially colored or becomes orangish instead of red in color and is soft. Tomato fruit should be exposed to temperatures in the 20°C to produce a red, firm fruit. This can be achieved by picking the fruit at the first appearance of red color and allowing the fruit to ripen in the light in an air-conditioned house or another cooler place.

During ripening, the formation and release of ethylene occur. Once ethylene is formed, it induces more of itself, and the ripening changes occur more rapidly. To hasten ripening, fruit such as tomato can be placed in a “fruit-ripening-bowl” or another closed container with a few holes for air exchange. Little ethylene will be lost, and fruit will be induced to ripen faster. Some air exchange is needed because the ripening changes require a large amount of energy and oxygen is needed to allow the fruit to increase respiration.

4.7. Bulb and tuber formation

4.7.1. Tuberization

A tuber is an inflated stem produced by a swelling type of growth. This tuber has a number of buds, called “eyes” in potatoes.

The initiation of tuber involves the arresting of the stolon apical growth and stimulation of cell division, cell expansion and starch accumulation. There is great evidence that the tuberization stimulus is hormonal.

Tuber formation is a short day process. Potato cultivars have various critical photoperiods so they produce tubers over a wide range of day lengths. Tuber induction is also favored by low temperature, high radiation and low nutrient supply (mainly nitrogen).

High yields of tubers are obtained by a good vegetative growth during the first part of the season and an optimal photosynthesis.

4.7.2. Bulbing

Bulb development in the onion plant which is the swelling of leaf bases (sheaths). Bulb formation is a long day process. onion cultivars have various critical photoperiods so they produce tubers over a wide range of day lengths.

Moreover, there is an interaction between daylength and temperature. For given daylength, high temperatures accelerate bulb formation, while at lower temperatures, longer days are needed to obtain the same effect.

Bulb formation is generally accompanied by carbohydrate accumulation. The onset of bulbing results from the accumulation of sugars in all parts of he plant; large quantities of soil nitrates tend to delay bulb formation and reduce yield.

The developmental physiology and the morphological and histological changes that occur during bulb development led to the speculation of the existence of a bulbing hormone. It was suggested that bulbing was controlled by a growth substance originating in either the leaves or apex as a result of long day conditions.

High yields of bulbs are obtained by a good vegetative growth and an optimal photosynthesis.

4.8. Examples of crops growth and development (to be developed in lecture)

4.8.1. Potato

4.8.2. Oignon

4.8.3. Cucurbits

4.8.4. Strawberry

4.8.5. Artichock

4.8.6. Asparagus

4.8.7. Tomato

4.8.8. Pepper

5.Organic vegetable farming

Successful vegetable farms are not accidental. They are the results of planning, constant care, and the will to make things grow. Among the many things a vegetable farm may offer toward a satisfying experience are fresh air, exercise, sunshine, knowledge, supplemental income, mental therapy, and fresh food, rich in vitamins and minerals, harvested at the best stage of maturity.

Organic farming differs from "conventional" farming mainly in the areas of fertilization and pest control. The organic gardener prefers to use natural and organic materials and methods, and avoids using practices and synthetic chemicals that may be detrimental to his health or environment.

5.1.Conversion to organic agriculture

5.1.1.Introduction

Conversion means a process of developing a viable and sustainable agro-ecosystem. It is recommended that the whole farm, including livestock, should be converted according to the organic rules over a period of time which is defined by the certification body.

If a farm unit is not converted all at once, it should be done on a field by field basis, whereby full organic standards are followed from the start of conversion of the relevant fields. The area of land managed to the full standards will therefore progressively increase.

5.1.2.Conversion requirements

It is essential that the farmer has got a clear plan of how to proceed with the conversion. This plan must be assessed in the field annually by the inspector and updated if necessary. Such a plan must include:

- history of fields (crops, fertilization, pets management),
- existing situation and deviation from standards,
- a plan for progressive conversion,
- aspects, which must be changed during the conversion period (e.g. crop rotation, manure management, pest management, environmental conditions) including time limits.

If the whole farm does not get converted, the part of the farm which is included in the conversion must:

- have fixed demarcation to the conventionally farmed parts,
- be inspectable,
- have separate accounting,
- have strict division of responsibility between organic and non organic aprts of the farm, where more than on person manages the farm,
- clean machinery thoroughly between use on organically and non-organically managed fields,
- not have parallel production,
- Have different spraying equipment used for pesticides on un-converted areas from equipment for permitted substances used on certifies areas.

The inspection must be carried out on the whole farm during conversion.

5.1.3.Length of conversion period

The time which passes between the start of organic management and certification of crops is known as the conversion period.

The concern about chemical residues stemming from previous use of the land and tha wish to establish an organic ecology before certification takes place, make for a certain time.

The conversion period is estimated at 2 years for annual crops and three years for perennial crops. This period can be reduced or extended by the certification body depending on the farm situation.

Certification body may allow plant products to be sold as “produce in process of conversion to organic agriculture” one year after the start of conversion.

5.1.4. Practical obstacles and constraints to conversion in Mediterranean countries

As organic agriculture seems fairly similar to many traditional farming systems in developing countries, conversion from these traditional systems and certification may appear to be an obvious thing to aspire. However, certification is costly and for subsistence farmers with small marketable surpluses, it may not be economically feasible. Additionally, many smallholder production systems cause soil degradation and are not environmentally sustainable.

The adoption of organic farming techniques may also be constrained by the lack of know-how and the absence of training and extension facilities. Furthermore, expertise on local farming conditions is a basic requirement and outsiders, while they may be conversant with the principle of organic farming, may not have this expertise. Research into these conditions is essential to organic farming: for instance, a certain cropping system may be preferable in one area, whereas in another area the threat of a certain pest would dictate a different approach.

Uncertainties about ownership and access to land are real obstacles to conversion. Farmers have to be sure that they will be able to benefit from investing, for example, in improved soil fertility in order to want to make such investment. Different access to credit is another factor often impeding initiatives and the implementation of conversion projects.

Some farmers do have access to financial resources and are more likely to consider conversion. However, they also have to contend with marketing constraints. The market for organic products is still comparatively small and is mainly concentrated in European Union, the United States an Japan, making access to both market information and the markets themselves difficult. The length of the conversion period, normally two to three years, is also a barrier, as products usually cannot be sold as organic during this period.

These are some of impediments to conversion by smallholders. However, the issue is wider and more complex. Take the question of external costs of high-input conventional farming. These costs, which take such forms as for instance the pollution of drinking water and reduced bio-diversity, are not reflected in the market prices of these products of wider and more complex. Take the question of external costs of high-input conventional farming; if they were, these products would perhaps be less price competitive. Furthermore, some enterprises have an interest in promoting the inputs on which these conventional systems are based, and stimulate activities promoting their use, including technical research.

Individual smallholders are usually advised to join or to form cooperatives or other farmers' groups in order to overcome some of the problems described above, create the required critical mass, build the necessary infrastructure (primary processing and packing facilities), cut costs and improved market access.

5.2. Production techniques

5.2.1 Soil management

5.2.1.1. General aspects

The soil is characterized by its physical, chemical and biological aspects.
The best soils for growing vegetables are well drained, fairly deep, and relatively high in organic matter.

The soil is a life natural body. The biological activity of the soil depends on the availability of nutrients and energy supplied by soil organic matter and crop and live stock residues. Natural soil fertility provides the current growing crops with nutrients available by the activity of soil microorganisms.

The organic concept is that : feed the soil, the soil will feed the plant and healthy soil will give healthy plant.

Creating healthy soil rely on considering soil as a living entity, an ecosystem containing a wide variety of different flora and fauna. The main components of soil ecosystem can thus be categorized as living organisms, organic matter, minerals, water and air, all of witch are required for soil efficient function.

Since organic fertilizer and soil conditioning materials are slow working in general, they should be mixed into the soil some weeks ahead of planting and the soil thoroughly prepared for the seed or transplants.

5.2.1.2. Soil fertility and fertilization

5.2.1.2.1. Introduction

The first significant fact is that most commercial chemical fertilizers kill a large portion of the microbiotic life in the top 15 cm of the soil.They drive out the earthworms and most of the other creatures in the soil that normally live there. The soil becomes just a medium for holding up the plants, and the plants become totally dependent on man's continued application of fertilizer to keep them healthy.

The primary source of food for my farm is compost. My compost is free. Chemical fertilizers are not free, and their cost will rise significantly in the next decade. The time it takes me to make my compost and apply it once a year is about the same as the time it takes to go and buy the fertilizer and spread it appropriately throughout the growing season. I get as good or even better productivity in my crops; I save valuable time; and in the long run (over five years) I save money. That is a good business deal, and that is why I am an organic gardener.

Soil is the habitat for plants, animals and microorganisms. As plants build up organic matter, soil animals feed on them and their debris, while microbes decompose the complex organic compounds to their mineral components and CO_2. The living soil is a criteria for soil fertility, because the activity of soil organisms renders available the elements in plant residues and organic debris entering the soil. Part of this material however remains in the soil and contributes to its stabilization by humus build up.
The microbial biomass as a proportion of the total soil organic matter pool indicates soil organic matter quality with respect to its role in supporting soil microorganisms.
Microbial biomass and enzyme activities were closely related to soil acidity and soil organic matter content.

Mineralization of plant residues is the most important activity carried out by soil organisms. Microorganisms in organic soils are not only mineralizing more actively, but also that they contribute to the build up of stable soil organic matter.

Microbes have activities with important functions in the soil; soil enzymes indicate these functions. The total acidity of microorganisms can be estimated by measuring the activity of a living cell-associated enzyme such as dehydrogenase. This enzyme play an important role in the respiratory pathway. Proteases in soil, where most organic N is protein, cleave protein compounds. Phosphatases cleave phosphorus compounds and thus provide a link between the plant and the stock of organic phosphorus in the soil. In soils of organic crops, soil enzyme activities were markedly higher than in the conventional soils.

Organic crops profit from root symbioses and are better able to exploit the soil.
A major part of the soil microbial biomass is composed of fungi. Important representatives of the soil fungi are mycorrhizae that build up a symbiosis between fungus and plant. Both the plant and the fungus profit from this symbiosis: the plant gets nutrients acquired by the fungus and the fungus receive assimilates from the plant in exchange. Micorrhizae enlarge the rooting zone and can enter small pores in the soil, mobilize nutrients and carry them to the plants. Recently it was shown that mycorrhizae are able to colonize different plants at the same time and may therefore serve as a bridge between them. Moreover nitrogen bound in decaying roots may be saved from leaching. Last but not least, mycorrhizae play a role in soil aggregate stability.
Even when soil is inoculated with active mycorrhizae, colonization is enhanced in organic soil.

Eartworms work hand in hand with fungi, bacteria and numerous other microorganisms in soil. In organically managed soil, the activity of these organisms is higher. Thus, nutrients are recycled faster and soil structure is improved.
Earthworms react positively to organic fertilization, a factor which must also be taken into account.

Organic soil management improves soil structure by increasing soil activity, thus reducing the risk of erosion. The build up of soil fertility is an important goal of sustainable land use.

Organic matter has a positive effect on the development and stability of soil structure. Silty and loamy soils profit from organic matter by enhanced aggregate structure. Organic matter is adsorbed to the charged surfaces of clay minerals. The negative charge decreases with increasing particle size. Silt is very susceptible to erosion since it is not charged, but organic matter layers on the silt surface may favor aggregates with silt too.
Prudent use of heavy machinery that may lead to soil compaction is required to maintain soil structure. Fertilization and protection strategies must also be designed in such a way that soil biological processes leading to a better soil structure are supported.

Organically grown crops do not reach the crop yield of conventional systems that are minerally fertilized and protected by synthetic chemicals. An average crop yield reduction of 20% has to be accepted.

- The strategies of fertilization and plant protection are the main differences between organic and conventional systems, whereas crop rotation and soil tillage were almost identical.
- Considering that the input of fertilizers was almost 50% lower than in the organic system, the average yield reduction of 20% appears to be reasonable. Nutrient in the soil appear to be utilized to a higher extent as supported by root symbioses with rhizobia and mycorrhize.

Organically grown crops may exhibit higher deficits in nutrients than conventional crops. Stocks of the most important plant nutrients should be analyzed regularly.
Organically grown crops use less fossil energy than conventional crops.

Fertilization in organic systems has a positive effect on the content of organic matter and helps to ovoid soil acidification.
Soil organic matter and the pH markedly affect soil structure and biological activity and plant growth. . In soils that were not fertilized with manure the decrease in soil organic matter was higher than in manured soils. Utilization of composted manure has positive effects on soil pH and organic matter.

Soil fertility is a critical issue in organic vegetable production. Given the **high demand of vegetables or nutrients and the nature of arid land soils** (sandy with low fertility), the management of soil fertility in Mediterranean countries is often a complicated task. This management should meet the nutrients needs of the crops and improve the soil fertility itself over long period of time. Farmers rely on different nutrient sources : **organic matter** (animal manure, compost, green manure, crop residues , organic fertilizers) and **natural mineral fertilizers** as complementary means.
A good strategy should integrate all the means available at local level. The cheapest means which improve soil fertility and ensure sustainable nutrition of the crops will be chosen. Before implementing any of these means, one should start with **soil analys**is in order a clear picture about the soil nutrient status.

5.2.1.2.2. Benefits from adding organic material:

Organic matter has several benefits :

1. Improves tilth, condition, and structure of soil.
2. Improves ability of soil to hold water.
3. Improves ability of soil to hold nutrients.
4. Improves "buffering" capacity of soil; that is, keeps soil from "over-reacting".
5. Supports the soil's microbiological activity (or the life of the soil).
6. Contributes nutrients, both minor and major.
7. Releases nutrients slowly.
8. Acids arising from the decomposition of the organic matter help to convert insoluble natural additives such as ground rock into plant-usable forms.
9. Helps vegetables survive stress, as from nematodes.
10. Helps dispose of organic waste products

Under suitable conditions, the organic matter is decomposed by micro-organisms such as fungi, algae, bacteria, molds, and earthworms. In the process, insoluble and unavailable (to plants) nutrients, such as nitrogen, are gradually changed into simple usable products.

For example, *nitrogen* is converted from the unusable organic forms to a usable inorganic form through the process called nitrification. Thus, nitrification is the breakdown of protein (organic nitrogen) into ammonia and then nitrate. Some of the organic matter becomes part of the soil humus.

5.2.1.2.3. Animal manures

Where animal manures are available, they are probably the best source of fertilizer and organic matter for the organic gardener. Use manure which has been aged for at least 30 days, or composted.

Manures vary greatly in their content of fertilizing nutrients. The composition varies according to:

- type, age, and condition of animal;
- the kind of feed used;
- the age and degree of rotting of the manure;
- the moisture content of the manure; and
- the kind and amount of litter or bedding mixed in the manure.

Animal manures also provide most of the micro-nutrients needed. Some manure products are composted, rehydrated or mixed with plant litter to enhance their fertility.

Manure is not always a complete well-balanced fertilizer. It is advantageous to broadcast a complete organic fertilizer or ground rock phosphate and potash in addition to the manures.

5.2.1.2.4. Composts

Composting is well accepted by vegetable growers as one of the best ways to improve soil fertility and unsure crop rotation. Composting is an efficient way to recycle crop residues, animal manure and green crops. Besides tits nutritional value, compost has also a sanutary value ; the increase of temperature above 50°C during composting process kill a wide range of pathogens.

Acceptable manure-like organic fertilizer (artificial manure) may be obtained through the process of *composting*. Simply put, *compost* is made by alternating layers of organic materials, such as leaves and kitchen table refuse, with manure, topsoil, lime, organic fertilizer, water, and air, in such a manner that it decomposes, combines, and artificial manure. Most anything organic, but most popular materials are natural materials. Natural and organic fertilizers may be added to the compost pile.

The *compost* pile is made of convenient size, usually 2m large, 1.5m high and 20-30m long. The top should be left flat or with a slight depression in the center to catch rain or added water. Too much water eliminates air and slows the decay process.

Compost will begin to heat after 2 or 3 days. Keep it moist, but not too wet, and do not disturb for a while.

After 3 to 4 weeks, fork it over, mixing the parts to obtain uniformity.

Compost for the farm should be ready from 2 months to 1 year, depending on the time of year, type of materials added, and skill of the composter. When the compost is broken down into a homogenous mixture, and no composed leaves or other material may be seen, it is ready for use.

Since compost is artificial manure, it should be used much as you would manure. Broadcast it over the entire garden three weeks or more before planting. Or if you have only a small quantity of compost, it may be mixed into the soil along each planting furrow or at each hill site.

5.2.1.2.5. Green manure

The green manure crop is a crop which should be incorporated in the soil before maturity in order to increase the soil organic matter and improve the soil fertility by protecting the structure and stimulating the microorganisms activities, thus, the humus mineralization.

The green manure should be introduced in crop rotation. At least, a two-three months growing period is necessary.

The incorporation of the green manure should be done at the flowering stage. The following crop should be planted at 2- 3 weeks later.

It is recommended to grow legumes (leguminous plants) because of nitrogen fixation capacity.

5.2.1.2.6. Crop residues

Crop residues can be all kind of plant products left after the harvest. Vegetable species produce a huge amount of biomasse beside the fruits. These residues offer a good opportunity to be recyceld and improve the level of soil organic matter.

Crop residues can be incorporated directly into the soil or composted with other products (manure, straw…). The degradation of the incorprated residues need appropriate temperature and humidity.

5.2.1.2.7. Application rules of organic matter

- Crops which prefer the fresh manure in big/medium quantity (in the beginning of the rotation): leek, eggplant, bell pepper, cucumber, squash, pumpkin, muskmelon and tomato.
- Crops which prefer the young compost (less than three months) in big quantity (in the beginning of the rotation): cabbage, spinach, (applied long time before sowing) and celery.

- Crops which prefer the mature (old) compost (more than six months) in big quantity (in the beginning of the rotation): potato
- Crops which prefer the young compost (less than three months) in medium quantity (plants at the second or third place in the rotation): Brussels sprout, turnip, radish, strawberry, artichoke and fennel.
- Crops which prefer the mature (old) compost in medium quantity (plants at the second or third place in the rotation): lettuce, chicory, bean, cauliflower, and carrot (low requirements).
- Crops which prefer the mature (old) compost in big quantity (plants at the end of the rotation): red beet
- Plants which prefer very old compost in very small quantity (plants at the end of the rotation): peas, garlic, onion and shallot.
- Plants which do not like big quantity of nitrogen: Brussels sprout, chicory, tomato, red beet, garlic, onion, and shallot.

5.2.1.2.8. Natural and organic fertilizers

Natural and organic materials which yield plant nutrients upon decomposition are often available for purchase either separately or in combination. These materials may be applied to the farm separately or combined, used in the compost pile, or mixed with manure.

These include both the organic materials derived from plants and animals, plus the natural deposits of rocks and minerals.

The natural deposits (Rocks, Sands, Shells, etc.) are usually not easily obtained in today's modern agriculture; however, where available they represent sources of mainly potash, phosphorus, and lime (calcium and magnesium) for organic farms.

Phosphorus

Rock phosphates are natural deposits of phosphate in combination with calcium. The material as dug from the earth is very hard and yields its phosphorus very slowly. When finely ground and with impurities removed, the powdery material is only slightly soluble in water, but may be beneficial to plants in subsequent seasons following application. The reaction of phosphate rock with acids from decaying organic matter in the garden or compost tend to make the phosphorus available to garden plants. Collodial phosphate is also available and widely used.

Broadcast the material over the soil surface and work into the topsoil at least three weeks before planting. Manure or other organic fertilizer should be added at this time. Since the materials are so slowly decomposed, side dressings are seldom beneficial.

Potash

Potassium is widely distributed in nature, occurring in rocks, soils, tissues of plants and animals, and water of seas and lakes.

In farming practice, materials such as wood ashes, tobacco stems, seaweed, potash salts, and ground rock potash are used alone, in combinations with other materials yielding other nutrients, mixed with manure, or in compost piles.

Since the potash bearing materials vary so much in composition and rate of decomposition, specific application rates must be determined for each material and its combinations.

Micro-nutrients

An advantage for using organic materials as fertilizers is that they contain many of the elements also needed by the plants in addition to N, P, and K (for example, manganese in manure).

Besides the general amounts of micronutrients found in most organic materials, certain ones are concentrated into such naturally occurring materials as gypsum (calcium and sulfur), marl (calcium), dolomite (Calcium and magnesium), limestone (calcium), basic slag (iron, calcium, manganese and magnesium), and finely ground borosilicates.

Lime

Reducing the acidity of the soil is the primary purpose for using lime in the garden. However, liming materials also provide nutrients for plant use. Calcium and magnesium are the two elements most commonly provided by lime. Gypsum is used where more calcium is needed without raising the pH.

Natural deposits of lime which, an organic farmer might use, are limestone, dolomite, shell, and marl. All these forms must be finely ground to provide maximum benefit to the soil and plants. Dolomite is preferred due to its content of both calcium and magnesium.

Apply lime well in advance of the planting date, preferably 2 to 3 months before the garden is planted. Mix well with the soil and keep moist for best reaction. Application closer to planting time is permissible, but its benefits are delayed.

5.2.1.2.9. Foliar fertilizers

The foliar fertilizers are used when soil fertilization cannot solve the problem. One should note the normal and natural mineral nutrition of a plant is the root.

In vegetable crops, the mineral deficiencies are shown in the following cases:

- conversion phase mainly after many ears of intensive practices,
- fertilization error,
- use of organic method not adapted to soil and region climate.

5.2.1.2.10. Other methods allowing to improve the fertilization:

- Crop rotation:

Crop rotation allow the restitution of part of the soil nutrients exported by the crops. Crop rotation is easily achieved in open field crops but it is difficult to manage crop rotation under protected cultivation.

The crop rotation should include at least 20% of annual meadows with legumes. The meadow allows a high level of fertility because of its high content of humus.

The vegetable crops with high nutrition requirements, such as cabbage, can be grown immediately after an annual meadow. The vegetable crops with low nutrition requirements can be gown at the end of the rotation.

In long term, growing vegetable crops is possible only if the rotation includes sufficient meadows: artificial meadows, fallow, green manure…

- Soil preparation and hoeing:

A good soil preparation allows an adequate plant rooting. The hoeing done during the crop growing allows a good soil aeration in order to stimulate the microorganisms activities. This will permit the nitrogen mobilization and its availability to he plant.

Each hoeing allow, in the average, the mineralization of 15-25 kg of nitrogen per hectare.

The hoeing loosens the shallow layer of the soil, improves gases exchanges with soil at reduces water evaporation, thus reduces the need for irrigation.

- Crop association

Crop association has beneficial effects when it is practiced. One may use bean/tomato, bean/zucchini in order to let the tomato or zucchini crop take advantage of the nitrogen fixing capacity of the bean. Non legume species can also be associated (zucchini/tomato, cucumber/pepper) in order to increase the land use and diversify the production.

5.2.2. Nursery management

Vegetable crops are usually propagated but direct seeding (legumes, cucurbitaceous) and seedling transplants.

When direct seeding is used, more the one seed (usually tow) are sown.

Seedling production in the nursery is a common practice. Many growers produce their own seedlings on their farms. Others purchase certified or non treated material from specialized nurseries.

The use of seedling as propagating materiel offers several advantages compared to direct seeding. It allows a better control of the growth at the post germination stage and therefore production of uniform and vigorous plants. The following precautions should be taken when establishing nursery in order to ensure the production of good quality seedlings :

- The nursery should be separated from the rest of the crops. Appropriate tunnels or greenhouses are recommended.
- The main doors and side-openings should be covered with a mesh (10x20) to ovoid insect entrance such as white flies m aphids and others.
- The soil should be covered with a black plastic to ovoid weed emergence and the direct contact of the seeding trays with the soil. The trays should be placed on a support, or a table.

Grafting is becoming a popular and widely accepted technique among vegetable growers. Grafting is performed when the rootstock and the stock have appropriate ages (3-5 weeks). Temperature and humidity are critical factors for the graft union. Several grafting techniques have been used for vegetables. Grafting allows to control soil pest and diseases, rapid growth, early production and high yield. Commercial rootstocks tolerant to nematodes, fungi (Fusarirum , Phytophthora, Verticilium), bacteria (Pseudomonas solanacearum, Pyrenochaeta lycopersici) have been released by several companies.

5.2.3. Cultural practices

Many horticultural practices require the presence of permanent labor on the farm and have to be undertaken daily in order to improve the yield and the quality and reduce the impact of pest and diseases.

- Training

Training is a critical operation for vegetables grown under protected cultivation. It considerably affects the plant growth, yield and health status of the crop. Training improves nutrient and hormone translocation within the plant and increase neat photosynthesis. We may train plants on simple (tomato), or two stems (muskmelon) that support the plant in upward position and prevent the fruit from infection that may arise from soil pathogens.

- Leaf and bud pruning

Few weeks after planting, the basal leaves of tomato plants should be pruned in order to improve the air movement and ventilation under protected cultivation and reduce humidity and diseases (Phytophthora, Botrytis). Lateral buds (branches) are also pruned because they negatively affect fruit loading.

- Ventilation under protected cultivation

Air movement inside low tunnels or greenhouses is a critical factor for plant growth, pollination, fruit quality, and pest and disease dissemination. Ventilation management should be seriously undertaken. It is difficult to achieve good ventilation under low and walk in tunnels. Multi-span greenhouses may offer better ventilation.

5.2.4. Insect and disease control

Pests and diseases may have serious threat and may cause catastrophic damages to the crops if appropriate sanitary measures are not taken. The control of pests and diseases is probably the most challenging task that organic vegetable growers are facing. The challenge is presented by successive and continual cropping and the year-around climate moderation that protect and harbor pests as well as the crop itself. Thus, a clear strategy should be implemented.

5.2.4.1.Preventive measures

The preventive approach is the key point in growing organic vegetables. The preventive measures include all aspects which favor a development of vigorous and healthy plant and reduce pest damage and physiological disorders.

5.2.4.1.1. Sanitary measures on the farm

- Preventing disease contamination by equipment used in infested plots. The knife used in pruning or harvesting (to prevent virus contamination) should be disinfected by alcohol 70%,
- Cleaning the seedling boxes with hot water (with pressure) in order to prevent seed diseases,
- Incorporating plant rests in the compost
- Using only healthy seedlings

5.2.4.1.2. Choice of species and varieties adapted to soil and climatic conditions

- **Choice of species:**
  - Try experiments on a small scale,
  - Look for local and reliable references during many years,
  - Choose the vegetable crops, the best adapted to the region (soil and climatic conditions.
- **Choice of varieties:**
  - Choose local and national seeds and varieties better than the imported hybrids if we have an equivalent quality,
  - Never use genetic modified seeds,
  - Market adaptation: quality, aspect, taste, storage and transport adaptation, yield,
  - Adaptation to farm conditions and cultural practices,
  - Be informed about disease and pest resistance of new varieties.

5.2.4.1.3. Suppression of disease and pest transmission

- Tissue culture
- Seed treatment with authorized products
- Thermal treatment

5.2.4.1.4. Soil maintenance and fertilization

A good soil fertility is a perquisite for vigorous plants which resist to pest and diseases. Soil analysis should be done for macro and minor nutrients.

Some nutrient deficiencies or excess may affect the plant health. The nitrogen excess favors aphid development, Botrytis, Rhizoctonia, Salad necrosis….

5.2.4.1.5. Fungi biology and insect cycle

A good knowledge about fungi biology and insect cycle is important to know the conditions (temperature, humidity) which are favorable for their development. Thus, the farmer will take this information into consideration in order to prevent pest and disease development.

5.2.4.1.6. Rotation

Crop rotation is the most efficient system to control nematods, soil pathogens and many insects.

The objective of crop rotation is to dissociate the development of the soil pathogen population from the growth of the host plant, by introducing crops which are not susceptible or inhibit the pathogen growth.

We may recommend four year rotation in vegetable crops.

In potato crop, bacteria and golden nematod may stay in the soil for 7-8 years.

5.2.4.1.7. Choice of the site

A favorite climate and good soil conditions favor a good development of roots and a rapid growth of the crop. So, we should take into consideration the regional conditions (average temperature, rainfall) and local (risk of early or late frost). We should plant only vegetables well adapted to local conditions, soil pH and type.

5.2.4.1.8. Sowing and planting dates

In spring season, it is recommended to sow or plant in open field only when the soil is sufficiently warmed up.

An early or late crop is grown depending on the importance of pests and diseases.

5.2.4.1.9. Crop system and plant density

A reduced density allows a reduction of healthy risks: salad rots, mildew in radish, Alternaria in carrots.

Using longer distance between plants and rows and growing on hills will reduce humidity and diseases.

It is recommended to:

- plant rather than sow
- plant on hills to let leaves dry rapidly
- choose a low density (longer distance between plants and rows).

5.2.4.1.10. Crop association

It is recommended to introduce various crops. Examples of associations:

- Cabbage-tomato: the tomato repels the cabbage butterflies
- Celery, onion and potato repel also the cabbage butterflies
- Carrot-leek: the carrot repels le leek moth
- Some aromatic plants (thyme, rosemary, salvia) planted at the edges of the field allow to repel aphids and cabbage butterflies.

5.2.4.1.11. Climate control

In protected cultivation, the climate control is an important factor. The greenhouse ventilation is necessary to reduce the excess of humidity and limit the development of fungal diseases, mainly in cool period with poor light: Botrytis, Cladosporium, Blight and mildew.

During dry and hot period, the humidification favors predators and parasitoids and limits the activities of correspondent pests: Orius against thrips, Phytoseilus against red mites.

5.2.4.1.12. Irrigation

The irrigation reduces the development of pests such as thrips and aphids.

When we irrigate in the morning, the plants and the soil will dry rapidly; this will reduce the fungal diseases.

The drip irrigation system is recommended mainly for susceptible crops to fungal diseases.

During germination, we should water efficiently to get a rapid growth in the field.

5.2.4.1.13. Ploughing and hoeing

Ploughing the soil allows to reduce the gray worms (Agrotis), the larvae and eggs of slowcoach.

A well prepared seed bed allows a rapid emergence and reduces disease risks and slowcoach population.

A good soil preparation favors a good rooting and limits the health prblesm.

The hoeing favors the nutrient mobilization and the plant development because of a good soil aeration.

5.2.4.1.14. Soil disinfection : water vapor and solarization

The **water vapor** disinfection is recommended when the soil is highly infested (nematods).

The **solarization** is a simple technique and is efficient against many soil born diseases and nematodes and preserves the soil useful microflora. The soil solarization involves placing a clear polyethylene plastic sheet cover on soil that is moist and well tilled for about 6 – 8 weeks. Soil solarization should be practiced during period of high solar radiation to be most effective. In-coming radiation is trapped under the clear plastic by the « greenhouse effect » which increases the soil temperature.

5.2.4.1.15. Green manure crop

The incorporated green manure in the hallow soil layer gives organic substances which have a favorable affect on plant growth and pest resistance.

5.2.4.1.16. Trapping

Trapping allows to evaluate the populations of pests and natural enemies and the period of predator release.

Insect traps are useful tools to detect the presence of insects and determine their population level and location. Sticky cards should be placed in several locations (one card: 6 cm x 20 cm per 1000 m2) to trap leafminer, thrips and aphids. Yellow card are used to trap a wide range of pests, blue cards are restricted to thrips.

5.2.4.1.17. Preservation of predators

The hedges constitute not only wind breaks but also natural refuges for useful insects (natural enemies) and birds. The flowers are good sources of food (nectar and pollen) for many natural enemies.

The floral zones can be done along the roads (ways), around the plots and between greenhouses. The diversity of species allows to have long flowering period and attracts many useful insects.

5.2.4.1.18. Preparation of a favorable environment

It is recommended to:

- divide the plots in sub-plots in order to limit the damage of pests with slow movements.
- Leave strips of wild land to let predators finding their plant hosts to lay eggs.

4.2.4.2.Curative measures

5.2.4.2.1. Biological control

- Monitoring.

A good strategy with a careful monitoring of pests and timely release of their predators discard the risk of economic damage to the crop. Several insect predators and parasites are currently available in the market and are used by vegetable growers.

Monitoring is a key operation in biological control. It consists of checking plants systematically for the presence of pests. A careful monitoring can be achieved by insect traps, plant inspection and the use of indicator plants.

- Plant inspection

Plant inspection as often as possible (at least twice a week) is important in detecting pests and diseases in their early stage before they spread through the crop. Suspect plants should be examined at the lower and upper part and in both sides of the leaves.

- Predator release

In protected cultivation, the release of predators is efficient when the natural enemies are absent, insufficient or late. The following rules have to be undertaken :

- Check the quality of predators and parasites at their reception
- Distribute them as uniform as possible
- A good crop management in order to ovoid plant stresses
- Ovoid the use of some authorized products such as rotenone and pyrethrins which are toxic for some predators. Thus, it is recommended to avoid generalized treatments and use localized ones.

A mesh screen (insect proof) should be used to cover the doors and the openings in order to ovoid or delay the introduction of pests and the escape of predators and parasites.

The predators and parasites need some time to their multiplication and adaptation. So, their use on long cycle crops is more recommended than short cycle crops.

The most of parasites have a high specificity; their effect is limited to the first larvae stages or to one stage.Example : Encarcia famosa against the white fly – Trialeurodes vaporariorum

The predators may have effects in general on all pest stages. Example: Phytoseilus persimili is predator mite against Tetranychus urticae.

5.2.4.2.2. **Authorized products**

The used products are natural substances synthesized from bacteria, fungi, viruses, protozoa and nematodes.

5.2.4.2.2.1. Application techniques

These products are efficient only if they are in direct contact with the pest or pathogen. A succeful treatement needs a total cover of the plant and mainly the lower leaf surface.

- Crop with a high density : use at least 400 L of solution per Ha with a high pressure.
- Crop with a low density: sue less amount of solution with lower pressure.

5.2.4.2.2.2. Insecticides

- **Bacillus thuringiensis :**

This product is efficient against larvae of butterflies. Noctuids and moth (the damaging stage of these pests) and does not effect on eggs or adult stage. It causes the death of larvae one to two days after the treatment but the feeding of the larvae is stopped few hours after the treatment. The young larvae are very sensitive to this product. Its efficience will remain for eight days. A 20°C of temperature is favorable for the treatment.

- **Pyrethrin :**

It is efficient against aphids and some flies and used on crops and during storage.

- **Rotenone**

It is efficient against aphids, white flies, thrips, mites, larvae…..

- **Mix of pyrethrin and rotenone**

This product is efficient against the previous pests.

- **Soap :**

It is efficient against thrips. The soap spray, usually, kills the insects in less than one hour, but it does not have a residual effect. It kills the insects which are on the plants during spraying but not the insects which will come six hours later. The use of soap is compatible with an other method of biological control.

5.2.4.2.2.3. Fungicides

- **Copper:** copper hydroxide, copper oxichloride, copper sulfate, cuprous oxide

It is efficient against Phytopthora (late blight), Pseudoperonospera (downy mildew) and Bacteria of many vegetable crops. The copper has a preventive effect which remains about three weeks.

- **Sulfur:**

It is efficient against powdery mildew (oïdium) and mites of many vegetable crops. The sulfur has a preventive effect and it can be used as repellant. (Wetted -with water : 0.5 – 1 kg / hl. Powder : 30 – 40 kg / ha).

5.2.4.2.3. Bio-technical control

The bio-technical control is based on the use of traps of repellants, pheromones ….to control the population level of insects. Some pheromones are specific to certain insects.

5.2.4.2.4. Use of plant traps

Nematocide plants (tagete) are used to control nematodes. It is recommanded to use plants as a par of the rotation system.

5.2.4.2.5. Conclusion

Plant protection precautions aim to protect the plants instead of curing. Primarily available plant growing conditions should be provided in order to prevent the incidence of pest and disease problems.

During periods when infestations of various pests are high, control by natural means becomes very difficult. However, the following practices will help to reduce losses without use of chemical pesticides.

1. Plant resistant varieties.
2. Plant seed from disease-free plants.
3. Select pest-free transplants.
4. Use a mulch; vegetables touching the soil may rot.
5. Clean up crop refuse early.
6. Keep out weeds which harbor insects and diseases.
7. Water in morning so plants are not wet at night.
8. Dispose of severely diseased plants before they contaminate others.
9. Some insects, like cabbage worms, may be killed by spraying with natural preparations such as *Bacillus thuringiensis*.
10. Use an adequate rotation .
11. Many organic farmers use sprays and other preparations containing naturally occurring materials. Pyrethrin and rotenone are examples of natural poisons from plant parts. These give some control to some insects under certain conditions.
12. Natural predators should be encouraged wherever possible; however, predators raised in captivity, can be also released into the farm area.
13. Insecticidal soaps, made from fatty acids tend to work well for some insects under average conditions.
14. Insect traps, baited with phermone lures, work well in some instances. Many of these have sticky adhesives to catch insects.
15. Solar fumigation is effective in reducing some soil-borne problems such as nematodes.
16. Solarization is effective in reducing fungi and nematodes problems

Organic management promotes the development of earthworms and above ground arthropods, thus improving the growth conditions of the crop. More abundant predators help to control harmful organisms (pests).

Epigaeic arthropods that live above ground, like carabids, ataphilinids and spiders, are considered sensitive indicators for the evaluation of site quality. Some species are recognized as important predators, who feed on other insects and especially on the highly abundant pest populations.

Earthworms are well known for their sensitivity to pesticides. The biomass of earthworms in the organic system was 30 – 40% higher than in the conventional systems, their density even 50-80% higher.

Pests
In terms of pets problems, abundant number of plant hosts is available and the relatively warm atmosphere and humid environment (in some season or under greenhouse) favors tremendously the rapid multiplication and spread of pest and diseases.

The most important pests causing problems to vegetable crops are:

- whitefly (*Trialeurodes vaporariorum, Bemicia tabaci*)
- red spider mite (*Tetranychus urticae, T.cinnabarinus*)
- aphids (*Macrosiphum euphoribae, Mysus persicae, Apfis gossypii*)
- leaf miner (*Liriomyza spp*)

Diseases
Low temperature and high relative humidity, especially under plastic houses and tunnels, cause fungal and bacterial diseases which result in severe crop losses. These pathogens can be the causal organisms of:

- root and collar root diseases:
  - damping-off: *Pythium* spp., *Phytophthora* spp., *Rhizoctonia solani*;
  - corcky root: *Pyrenochaeta lycopersici*;
  - basal stem rot: *Phytophthora* spp., etc,
- wilt diseases (*Verticillium dahliae, Fusarium oxysporium* f. sp. *Lycopersici*),
- foliage diseases:
  - grey mould: *Botrytis cinerea*,
  - powdery mildew: *Leveillula taurica, Erysiphe cichoracearum*,
  - downy mildew: *Pseudoperonospora cubensis, Phytophthora cubensis*,
  - leaf mould: *Cladosporium fulvum*,
  - bacterial spot: *Pseudomonas syringae* sub spp., etc)
- viral diseases:
  - tomato yellow leaf curl virus,
  - zucchini yellow mosaic virus,
  - cucumber mosaic virus, etc)
  -

control

It is evident that for proper management one has to be able to identify the pest and disease problem at its various stages and forms of development. Monitoring of the problem is very important to start biological control and/or apply any natural product. Integrated management is a tool to control pest and disease via saving money on pesticides, reducing worker and consumer exposure to health hazards and protecting the environment for future generations.

Yellow sticky traps are excellent supplements to inspect pests on plants. It is possible to follow the population trends as well. Yellow sticky traps are useful tools to monitor aphids, whiteflies, leafminers and thrips. Blue ones are mainly used to monitor thrips Sticky traps should be considered as an integral part of pest management strategies. There are some natural enemies that could be used successfully during the growing period .

Some pests and their natural enemies (Voest, 1985, Hanafi, 1997)

Pest	Natural enemy
Whitefly	*Encarsia formosa, Verticillium lecanii, Macrolophus* sp., *Cyrtopeltis tenius*
Red spider mite	*Phytoseiulus persimilis*
Aphid	*Coccinella septempunctata, Chrysoperla carnea, Verticillium lecani, Aphidoletes aphidimyza, Aphidius* spp.,
Leafminer	*Dacnusa sibirica, Opius pallipes, Diglyphus isae*
Thrips	*Amblyseius cucumeris, A. degenerans, Orius* spp.

The use of insect nets by covering the ventilations and entrances is also very effective as it prevents the pest entrance into the greenhouse.

Non-chemical alternatives also include the use of reflective mulches to repel or attract away vectors from crops, barrier crops, means of crop hygiene such as rouging and isolation, and use of times or places when vectors are rare.

In order to be able to reduce disease incidence and have a profitable and sound production, it is essential to disinfect the soil. Among the soil disinfection methods, soil solarization is accepted to be the most easy and environmentally friendly one. It is an hydrothermal disinfection method basing on covering the water saturated soil with a transparent polyethylene sheet and thus, increasing the soil temperature by the solar energy. Solarization results in some physical, chemical and biological changes that favor plant health and growth while having a deleterious effect on weeds, diseases and pests.

Grafting of sensitive cultivars on resistant rootstocks is also very effective to protect the plants against some nematodes and diseases.
It should not be forgotten that all sanitation practices and diversification of production is essential.

5.2.5. Weed control

The primary purpose of cultivation is to control weeds. Weeds are easy to control when they are small. Shallow cultivation is advised in order to reduce damage to the root system. Careful management of weed population during the production of organic vegetable crops is necessary for a successful farming operation.

The primary aim of all organic vegetable producers should be to create favorable conditions for crop production while providing unfavorable ones for weeds.

5.2.5.1. Preventive measures

5.2.5.1.1. Rotation

An appropriate crop rotation is an efficient way to reduce weed growth. Certain weeds are common in some crops than in others. A good rotation for weed control usually includes strong competitive crops.

5.2.5.1.2. False seeding

Soil is prepared and irrigated. Two to three weeks later, when weeds emerge (less than 2 cm high), the soil is harrowed (hoeing). 24 to 48 hours later, sowing or planting is done. Sometimes, if weeds are very dense, this operation is repeated one more time.

5.2.5.1.3. Cleaning at the field edges (borders)

The hedges may help stopping the weed seeds brought by the wind. The field edges should be maintained clean (weed free). It is important to crush the weeds at the field edges before bolting and seeding.

5.2.5.1.4. Stiffing and suffocating plants as green manure

This technique consists of sowing , at a high density, a crop (ex : green manure) with quick emergence and rapid growth in order to cover the soil before weeds. These weed plants will grow slowly and may be eliminated naturally.

5.2.5.1.5. Transplanting instead of sowing

Direct sowing should be avoided and replaced by transplanting. Transplanted seedlings may grow fast and compete well against weeds.

5.2.5.1.6. Early canopy development

Favoring early canopy development is considered as a good management practice of weed control :

- Select a cultivar with rapid seed germination
- Select a cultivar that quickly forms a canopy over weeds
- Use a maximum number of crop plants (high plant density)
- Use narrow rows for row crops. Mechanical cultivation may require wider rows.

- Delay planting spring crops until soil is warm enough for rapid germination of crop seeds. This delay may also give time to destroy one or two flushes of weed growth before planting the crop.
- Use agronomic practices favorable for rapid growth to the crop, such as proper soil fertility, good seed preparation, proper depth of planting , adequate water and tillage as needed to control weeds.

5.2.5.2. Specific measures

5.2.5.2.1. Solarization

Solar heating the soil using large plastic covers reduces nematodes, soil-born insects, pathogens and **weeds**

5.2.5.2.2. Mulching

A mulch will help to keep weeds from growing if the mulch is thick enough to exclude light.

5.2.5.2.3. Composting of organic matter

Organic matter may be a source of weed seeds (crop residues, fresh manure,…). Thus, composting will allow temperature to increase and eliminate these seeds.

5.2.5.2.4. Filtering of irrigation water

Irrigation water coming through open canals (channels) and dams may contain weed seeds. Water filtering before use may eliminate these weed seeds.

5.2.5.3. Curative measures

5.2.5.3.1. Mechanical cultivation : tilling, hoeing, harrowing et mowing

Hoeing and harrowing lead to loosen the soil and eliminate weeds. Under particular conditions for some crops, this mechanical weeding is not satisfactory.

For slow growth plants, weeds may grow fast and suffocate the crop and mechanical weeding is difficult in this case. It is recommended to grow on clean soil. For rapid growth plants or with large spaced plants, the mechanical weeding is very efficient.

One type of tillage is burial. If all growing points are buried, most annual weeds are killed. Burial is partly effective on weeds with underground stems and roots that are capable of sprouting (couch grass, binweed….). Such perennial must be repeatedly cut off or buried until the underground parts are killed by carbohydrate starvation.

The second method of tillage is the disturbed rooting system. Shallow cultivation equipment such as knives, harrows, finger weeders and rotary hoes is used. This method leads to loosen or cut the root system so the plant dies from desiccation before it can re-establish its roots. This is very effective in hot, dry weather.

Mowing weeds will lead to reduce competition with crop plants and to prevent seed production. Repeated mowing not only prevents seed production of perennial weeds but also may starve the underground parts. The control of perennial weeds requires repeated and frequent cutting. The benefits from mowing is not only weed control, but also undisturbed soil surface. Moreover, the mowed weeds may be used as animal fodder or incorporated in a compost.

5.2.5.3.2. Hand (manual) weeding

Hand weeding (traditional mean) is practiced for certain crops under some conditions and when labor is cheap.

5.2.5.3.3 Thermal (thermic) weeding : flame weeding.

5.2.6. Irrigation

Irrigation practice is of great importance in organic production. Providing the required amounts of water to the appropriate growth stage of the crop will contribute significantly in plant health. The main problems and constraints faced on farm irrigation management are inefficient water use, cost of irrigation systems, quality of irrigation equipment, and salinity. The following factors affect on-farm water management improvement:

- irrigation efficiency and uniformity
- water requirement and irrigation scheduling
- land leveling
- efficient drainage

In irrigating the farm, it is advisable to thoroughly wet the soil once a week unless sufficient rain falls. Thus, the soil will be moistened throughout the root zone. Light sprinklings every day merely tend to wet the surface and encourage shallow root growth. Drip or trickle irrigation is encouraged as a method for conserving water.

Use of organic materials as soil conditioners and fertilizers tends to improve the ability of the soil to retain moisture. Also, a good garden mulch will conserve soil moisture.

Water security is considered a major concern in most of the semi-arid and arid climate countries.

5.2.7. Mulching

A mulch is any material, usually organic, which is spread on the soil surface around the plants. **Organic materials** most commonly used for mulching are leaves, grass clippings, straw, crop residues, green manure or compost. **Living mulch (cover crop)** ca be defined as a crop production technique in which a vegetable crop is planted directly into an established cover crop, or a cover crop is inter planted between vegetable crop rows. **Synthetic materials**, mostly plastic sheeting, have been used quite often in recent years. A plastic mulch is a layer of clear or black plastic film used to cover the soil. Among the benefits of a mulch are:

- conserves soil moisture,
- conserves nutrients,
- reduces soil erosion,
- reduces weed growth,
- provides barrier between fruit and soil, thus reducing soil rot on fruit, and
- moderates the soil temperature.

Apply mulch before or after seeding or transplanting. Roll back the mulch with a rake in order to wet the soil beneath when irrigating, for best results. At the end of the season, the mulch (except plastic) may be removed and composted, or cut into the soil.

5.2.8. Climate control

Insufficient ventilation is one of the most important problems of the greenhouses. Although it is necessary to provide a ratio of roof ventilation to the floor space as 20%, roof ventilation is not taken into consideration at sufficient levels. There is no roof ventilation in most of the plastic houses which makes it difficult to control humidity and temperature. In cases where insufficient ventilation is applied serious disease problems are experienced with pests and diseases.

5.2.9. Fruit setting

In tomato production, the characteristics determining yield are efficient fruit set and the proportion of marketable sized fruits resulting from pollination and fertilization practices. Thus, the number of pollen grains reaching the stigma and the number of pollen tubes reaching the ovary is important. In practice, mechanical aids to stimulate pollination play an important role in increasing fruit set in the greenhouses.

Tomato grown in the greenhouses need to be assisted with pollination, because the pollen does not loosen easily from the stamen. To achieve optimal fruit setting each flower has to be vibrated so that enough pollen grains land on stigma. Since not all the flowers of a truss or a plant open at the same time, it is necessary to vibrate regularly and for the duration of the entire growth season. This can be done with an electric bee, a labor intensive method. In natural surroundings, insects can provide pollination. In the greenhouses, earth bumble bees provide a very good alternative for this task. The natural pollination with the aid of the bumble bees ensure an excellent fruit setting in the greenhouses.

5.2.10. Choice of crops and varieties (seeds, vegetative material and seedlings)

The crop(s) chosen to be grown for sale is an economic and/or personal decision. The potential market should be determined even before deciding what crops to grow and the acreage of each.

Cultivated species and varieties must, as far as possible, be adapted to the soil and climatic conditions and resistant to pests and diseases. In the choice of varieties, the genetic diversity should be maintained. Variety trial results will provide information on adaptability of varieties under a range of environmental conditions. Pest and disease tolerance and resistance is the most economical and effective means of pest management. Yield, horticultural quality, and market acceptability also have to be considered in making variety selection.

The use of genetically modified seeds and transgenic plants are not allowed.

Seed and vegetative propagating material should be obtained from organic production method. This method implies that for seeds and vegetative reproductive material, the mother plant in the case of seeds and the parent plant(s) in the case of vegetative propagating material have been produced in accordance with rules of organic production for at least one generation or, in the case of permanent crops, two growing seasons.

Seeds and vegetative propagating material not obtained by the organic production method may, during a transitional period, be used in so far users the such propagating material can show to the satisfaction of the inspection body or the state authority that they are unable to obtain on the market propagating material for an appropriate variety. In that case, propagating material which is not treated with the unauthorized products must be used, if available in the community market.

Seedlings should be produced in accordance with rules of organic production.

Seedlings not obtained by organic production methods may be used during a transitional period, in so far the following conditions are met:

- the state competent authority has authorized the use after the user or users the such material have demonstrated to the satisfaction of the inspection body or the state authority that they are not able to obtain an appropriate variety on the community market.
- The seedlings have not been treated, since sowing, with any product other than those authorized.
- After planting, the seedlings must have been cultivated in accordance with rules of organic production for a period of at least six weeks before harvesting

5.2.11. Rotation

Rotations must be variable as possible and aim to:

- maintain soil fertility,
- reduce nitrate leaching,
- reduce weed, pest and disease problems.
- Satisfy consumer requirements

It is recommended that specific rotations including legumes are used on farms without animal husbandry.

5.2.12. Growth regulators

Al synthetic products (like growth regulators) are excluded.

5.2.13. Use of plastics

For protected structure coverings, plastic mulches, fleeces, insects netting and silage wrapping, only products based on polyethylene and polypropylene or other polycarbonates are allowed. These must be removed from the soil after use and must not be burned on the farmland. PVC is not allowed for the above mentioned uses.

5.2.14. Environmental conditions

All relevant measures must be taken to minimize pesticide contamination from outside and within the farm by wind drift, drainage and irrigation.

In case of reasonable suspicion of pesticide residues, the certification body must make sure that an analysis of the relevant products, crops, and/or soil quality take place. E.g when the farm units are situated near major sources of pollution.

5.2.15. Landscape

It is recommended that the certification bodies set standards for a minimum percentage of the agricultural area, to be ecologically diversified. These areas should be ecologically managed in a proper way and be linked to each other.

Areas which can be included in this percentage are:

- very extensive grassland such as moorland, reedland or dry land,
- in general all areas which are not under rotation and are not heavily manured:
    - extensive pastures
    - meadows
    - extensive grassland
    - extensive orchards
- hedges, hedgerows, groups of trees and/or bushes and forest lines
- ecologically rich fallow land or arable land (with ni inputs),
- ecologically diversified (extensive) field margins,
- waterways, pools, springs, ditches, wetlands, swamps and other water rich areas which are not used for intensive agriculture or aqua production,

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