Organic FARMING HANDBOOK

Erasmus+

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CONTENT

Introduction to the training manual

This handbook is part of an educational package aiming at the training of farmers of North Macedonia, Serbia, Croatia and Bulgaria. It has been developed within the framework of the projectOrganic agriculture innovative platform.

Organic Agriculture Innovation Platform is a project funded by the European Commission's Erasmus+ Programme (Key Action 2 - KA 204 - Strategic partnerships for adult education) and it brings organizations from different countries partnering together to develop new innovative resources to the benefit of the citizens, more specifically farmers, adult education providers and local CSOs working in the field of agriculture and environment. Educating adults about organic food production is the focus of this partnership project. Forum CSRD (North Macedonia) is the lead organization partnering with Serbia Organica (Serbia), Eko Zadar (Croatia), Bulgarian School of Politica "Dimitry Panitza" (Bulgaria), Macedonia Export (North Macedonia) and Good Earth (North Macedonia).

Modern agriculture in the world characterizesa great use of the non-renewable energy per product unit, a strong dependence from weather conditions which influences on quantity and quality of the plant yield and danger from the global change of environment and its degradation. In the coming period, negative consequences of the technical and technological development, above all, the use of agro-chemicals in the future agricultural development requires many adjustments in the use of natural, biological, technical and human resources.

The need for the healthier environemnt and many negativities caused by the current conventional agriculture have led to a numerous alternative trends of the future agricultural development, amongst which is organic agriculture. Organic agriculture is the movement in the agriculture based on the ecological principles, therefore many alterations of all agro-technical, pomo-technical and zoo-technical measures, use of apropriate species and breeds are necessary. This approach needs to be followed by the hollistic approach to life and development, as well as to the activities that should be adjuste to the agro and zoo-technical measures, varieties/breeds and all the other elements of the agricultural system to satisfy current, and future human needs and desires.

Organic agriculture popularly is defined as the agriculture that is not using fertilizers and pesticides. However, it is beyond that. According to the definition of the Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labeling of organic products organic production is an overall system of farm management and food production that combines good agricultural practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards and a production method in line with the preference of certain consumers for products produced using natural substances. Modifications in production technologies of interesting plants and animals require more subtle approach in organic agriculture. Possibilities of streaming agriculture toward sustainable development systems should be observed in the framework of the transition to market economy and from the aspect of technical, technological and economic possibilites. In that sense, setting these systems, especially quality and more diversified agricultural products, should be prioritized.

On the other hand, agronomic and economic flexibility of organic productionshould bring in a certain social function byovercoming gaps between rural and urban population, as well as by diminishing differences between producers and consumers. In that sense a great potential of the climate and soil characteristics for organic production should be used, not to forget all the available resources for development of organic livestock, having in mind large areas under pastures in the region. Development of the organic production is unimaginable without appropraite legislative framework, which should address safety in this area and secured market placement with appropriate certificates in hand, on domestic as well as on foregin markets.

This manual is writen mainly for trainers who would like to teach potential producers how to convert to organic production, and here they will find guideliness how to do it. They will find answers on: what organic production is, what is needed to convert to organic production, what is management of organic farm, how does system of control and certification look like, how to get organic product.

The main goal of this manual is to collect and outline importance of various modifications that need to be made in the future based on numerous postulates that are valid in thisabove all popular course of agriculture, and scientific results in one place.There is still not enough literature for trained people who would use it in that sense, from extension services in the field to individuals who would deal with it in practice.

Aware that our producers know little about the organic agriculture, we have tried to simplify some of the basic facts about this interesting agricultural production. Moreover, the significance of the scientific and advisory services should not be overlooked, they should be trained to work in the field, so that kowledge in this area would be conveyed in the shortest possible way to interested producers.

We hope this manual will partially fill this gap and besides general information, provide to all interested beneficiaries many specific knowledge about this type of agriculture that will serve them in their further work.

Authors

Aims and scope

This handbook is developed to improve quality and availability of didactic material on organic agriculture in North Macedonia, Serbia, Croatia and Bulgaria. It offers a resources basis for trainers with the idea of encouraging individual adaptation and further development of the material according to the needs. This material can be used as a guide and source book to implement training programmes. It will help develop training the structure of training course or workshop and provide material and ideas for its organisation.

It is anticipated that trainers and trainees already have some agricultural background and that the training activities will focus on aspect specifically relevant to organic agriculture. However, it does not provide in-depth practical know-how management of specific crops or animals. The handbook addresses trainers and resources persons who are engaged in training activities on organic agriculture. It can be used to facilitate training for trainers and extension workers, but also directly for farmers interested in learning about organic agriculture. The main focus is on crop production, although animal husbandry is covered in one chapter.

Training on organic agriculture can address a wide range of participants. For some of them the knowledge provided in the handbook will be too basic and the trainers will have to consult the recommended readings to get more detailed information and knowledge. For others the provided topics and ideas are already too scientific or the language too complicated, such that trainers may need to simplify the theory and use local examples for illustration.

The main focus of the handbook is on small farmers in the countries covered by the project North Macedonia, Serbia, Croatia and Bulgaria. This region includes various types of crops and farming systems. Therefore the handbook addresses mostly topics of general relevance but provides examples from different countries.

Training approach

Training manual is based on a training approach combining lectures, illustrations and demonstrations, and active participation of trainees. A balanced mix of these elements allows understanding of organic agriculture through listening, seeing, experience sharing and trying. It is assumed that participants can contribute to the program of the training based on their background and experience. Therefore, interactive elements and practical exposure (field visits) in the course are highly encouraged and the manual will aid their implementation.

Structure

The handbook is divided in 13 sections: an introduction containing recommendations on the didactic and organizational aspects of the training program, the 11 core chapters dealing with the basic topics of organic farming (principles of ecology and agroecology, soil management and plant nutrition, organic pest and disease management, organic production of arable crops and vegetable as well as fruit and viticulture, animal husbandry, traceability and certification in organic farming, multifunctionality in organic farming). Final section of the handbook represents an Annex containing work material and a list of sources. Each chapter starts with a brief introduction to the topic followed by several subchapters containing brief theory paragraphs.

Organizing training course

Steps for preparing training course

The following questions should help you to prepare a successful training program:

1. What is your target group?

The effect of the training will depend of whether you address right group of people in the right way. Therefore, you should first consider your target group: To whom do you want to address the training? How can you make sure that these people are participating? What is their motivation to participate?

Also, think of what is the maximum number of participants you can handle in the training. The more participatory training is, the less participants can be admitted. In case you have to select from a larger group of participants, you should think about the selection procedure and criteria.

2. What are the objectives of the training?

Once the target group is clear, the next step is to define what you want to achieve with the training. Which kind of knowledge, awareness and skills do you want to develop among the participants? Is it the same as what the participants want to learn? During the training, especially towards the end of a course, you should check whether these objectives have been reached. The participant's opinion can be assessed with simple evaluation or feedback methods.

3. Which topics should be covered?

Next you should think about the topics must be tackled in order to achieve the training objectives. Arrange the topics in a logical order so as to help the participants find their way through the training. Is it possible to include the participant's expectations and wishes?

When selecting the topics you want to cover in a specific session, first think about what is your main message and what are the important points the participants must know. Do not try to be complete but relevant. The participants will not keep more than a few points per session in their memory. Therefore, repeate your main points time and again and structure your session around them. Use illustrative examples to reinforce your main points.

4. Which training methods should be used?

How can selected topics and lessons learnt be most efficiently transferred to the participants? Speech is an important method of transferring knowledge, but people learn more efficiently if they not only hear but also see, feel, experience and discover new things. A sound mix of different training methods can therefore help to make the training more effective and interesting. For many topics, the trainer will not have readymade solution at hand, but ideas and solutions can be developed together with the participants. Find ways in which participants can contribute their own experience and interact in the training. Also, think of other resource persons who can cover certain topics.

Developing a training schedule

When planning a training schedule, keep the following points in mind:

- Participants will not listen to you more than 20 minutes.
- Break the monotony with visual material, exercises, stories, contribution of participants, ice breakers and jokes.
- Plan for sufficient time and stick to the timing you have promised.
- If possible avoid lectures or presentations directly after the lunch. Schedule exercises, games and excursions instead to make the participants move.

Through planning of topics and their timing in the available training period is must. A template for a planning sheet and an example for a two-days training schedule are given in Annex. Schedules should be presented in the beginning of the training and adapted according to the feedback of the participants.

CHAPTER 1: | INTRODUCTION

1.1 Principles of Ecology and Agroecology

Ecology is the study of the relationships between living organisms, including humans, and their physical environment; it seeks to understand the vital connections between plants and animals and the world around them. Ecology also provides information about the benefits of ecosystems and how we can use Earth's resources in ways that leave the environment healthy for future generations. Ecologists study these relationships among organisms and habitats of many different sizes, ranging from the study of microscopic bacteria to the complex interactions between the thousands of plant, animal, and other communities found in nature.

The many specialties within ecology, such as marine, vegetation, and agroecology, provide us with information to better understand the world around us. This information also can help us improve our environment, manage our natural resources, and protect human health. The following example illustrate just the way that ecological knowledge has positively influenced our lives: biological control is a technique that uses the natural enemies and predators of pests to control damage to crops. It is based in part on knowing the ecology of pests, which is used to understand when and where they are the most vulnerable to their enemies. Biological control alleviates crop damage by insects, saves money, and decreases problem associated with pesticides.

Agroecology is the field of the applied ecology, linked to the general ecology. Agroecological science is defined as the application of the ecological principles and concepts in forming and management of sustainable agroecosystems. The idea of the agroecology is to use alternative directions in agroecosystems' development, which will be less dependent on the agrochemicals and energy uptake, emphasizing perplexity of the agricultural systems. Ecological relationship and mutual activity between biological components sustains soil fertility, productivity and crop protection. In search for re-establishing ecological principles in agricultural production producers neglected key point in organic agricultural development: strong understanding of the nature of the agroecosystems and running of their principles. Agroecology has grown into the discipline providing basic ecological principles - how to observe, educate and manage agroecosystems to make them more productive, provide preservation of the natural resources but on the same time to be culturally acceptable and economically justified.

Agroecosystems are communities of plants and animals in interaction with physical and chemical external factors man has modified for food production, with other products for mass industrial use (fiber, fuel and other material). Space used for agricultural production is a complex system where completely natural ecological processes can be found: cycle of matter, relationship predator/prey, competition, symbiosis and succession. Agroecosystems can improve productivity and become sustainable with less negative environmental impact, social condition with lower external investments.

Setting such system is based on application of following ecological principles:

- Improving cycle of matter, optimization of available nutrients and their balanced flow;
- Providing favorable soil parameters for plant growth, especially increase of organic matter and of biological soil activity;
- Efficient use of available solar energy, conservation of water resources and suitable soil characteristics by covering larger area with plants;
- Increase of species and genotypes in agroecosystems in time and space;
- Increase of useful biological relationship and synergies between components of agrobiodiversity aimed at promotion of the core ecological processes.

The most important goal of agroecological approach is fitting of the agroecosystem in the natural surrounding, which will imitate structure and function of the natural ecosystems. Agroecology provides knowledge and methodology needed for agricultural development, that should on one hand be acceptable for environment, and on the other hand should be highly productive and economically viable. It opens door to the new concept in agriculture alleviating distance between knowledge gaining and its application in practice. It respects and valorize local farmers' empirical knowledge and uses it to achieve sustainability in agriculture. Ecological methods and principles are needed to determine if specific agricultural practice, inputs or managerial decisions are sustainable in order to provide foundation for functioning and selection of managerial strategy of agroecosystems in longer period of time. Leading agroecological principles that should be respected in successful transition from conventional to organic systems are following:

- Cycle of matter, with emphasized use of natural processes as nitrogen fixation and mycorrhiza;
- Use of renewable energy instead of non-renewable (solar, wind, biomass);
- Elimination of external inputs that can be harmful for the environment or for the health of farmers, workers and consumers;
- If some material needs to be used, it is better to use biodegradable than synthetic;
- Control of pests, weeds and diseases instead of their elimination;
- Renewal of natural biological interactions on farm instead of their reduction and simplification;
- Adjusting sowing and spatial distribution of crops to physical limitations on farm;
- Adjusting biological and genetic potential of crops and livestock to ecological conditions on farm, and not the other way around;
- Focus is on protection of soil, water, saving and rational use of energy and biological resources;
- Introduce the idea of the long-term production sustainability in the overall layout and strategy of the agroecosystem management (farm).

Focus on certain principles can vary, still altogether they contribute to conversion processes. For many farmers fast transition from conventional to organic systems is not even possible nor practical. Processes which are leading to organic farm establishment require longer period of time to show effect. There are three different levels of transition:

1. Increase of efficacy of conventional agrotechnical activities with the goal of decreasing use of expensive and harmful inputs for environment;

2. Replacing conventional inputs and agrotehniques by alternative and organic;

3. Re-designing agroecosystems in a way where they can operate based on the new set of ecological processes.

1.2. Ecological infrastructures

Control of pests and disease is of fundamental importance on an organic holding, as well as control of soil degradation and micro-climates unsuitable for crop cultivation. The development of side elements among the organic farmers was highly encouraged. The creation of hedgerows, rows of trees, grass strips, buffer strips, ponds, haystacks, farm woodlandand any other permanent vegetable form in the agricultural landscape, is indicated by the expression “ecological infrastructure” and is of great importance exactly for the prevention of damages due to weather conditions and crop pests.

Typologies of ecological structures

Every holding conducted with organic methods should carefully evaluate any possible alternative and select the ecological infrastructures that best suit its environment.

The elements that can be possibly introduced are:

- Groves, that is clumps of at least thirty trees or shrubs (e.g.: birch, cherry tree, hawthorn, and euonymus);
- Rows of trees planted 2-3 m apart (e.g.: poplar);
- Wooded strips, made up of forest trees 5-7 m apart (e.g.: alder, maple tree, birch, walnut-tree and laburnum);
- Tall windbreaks made up of forest trees and shrub species (e.g.: beech, oak, hazel and hornbeam);
- Small windbreaks (e.g.: maple tree, hawthorn and seabuckthorn);
- Grass strips to be left natural. These strips should neither be tilled nor fertilized, but just mowed. For maximum results, they should be at least 2 m wide.
- Also grass crops, cover crops and permanent meadows contribute to creating ecological infrastructures.

Main functions of ecological infrastructures.

The contribution that hedgerows and trees give consists essentially in the increase of the global equilibrium of the ecosystem in the holding. Through the different specific actions that are produced, this translates into a potential increase of production.

The main functions are summed up in the following paragraphs.

Wind-breaking action and improvement of the micro-climate

This is the best known function, commonly explained in agronomy texts. Hedgerows must maintain a wind sieving capacity of 30-40%, in order to balance the wind passing over the barrier and the wind going through it.

Windbreaks produce three important results:

- decrease of evapotranspiration, which translates into lower hydric stress to crops and lower energy and water consumption;
- mechanical protection against the beating effect of the wind which may beat down crops or in other ways damage them;
- protection of leaves against the abrasive action that could be produced to the photosynthetic system by particles of sand and dust carried by the wind, especially in the fields near the coastal areas;
- the mitigation of the wind force favours also anemophilous pollination and carbon dioxide exchange near the plant, with consequent higher intensity of photosynthesis.

Natural woodland as protection barrier on blackberry orchard in organic farm Tasic, Korbevac village, Serbia (photo S. Oljaca)

In warm climates, the windbreak action, as already stated above, allows water saving and reduces evapotranspiration even by 25%. In cold climates, it has a beneficial action as it increases temperatures.

The temperature may increase by 1-2°C (both night and day) and even by 4-5°C if the prevailing wind is particularly cold. This temperature increase, due to the infrastructures that reduce wind speed and force, beneficially affects the yield of crops and livestock.

Some of the species most widely used as windbreaks are: oak, privet, viburnum, hazel and boxwood.

Ecological infrastructure in organic farm Kenjeres, Male pijace village, Serbia (photo S. Oljaca)

Protection against external agents

In many parcels located near busy motorways or bordering on parcels belonging to conventional operators who do not take the organic choice of their neighbour into much consideration, or who are quite unable to manage chemical treatments, it is necessary to protect the crops from drift contamination which might have destructive repercussions on product certifications.

If ecological infrastructures are made up, for example, of dense and well-arranged hedgerows, they can act as barriers, or at least as filters, and can remarkably reduce the undesired agents. It has been noticed that the same mechanism acts as protection of crops against wind-borne and insect-borne diseases, for example the spores of fungi diseases or the viruses brought by aphids. For herbaceous crops, it may be sufficient to plant hedgerows made up of shrub species as cornel, hazel, sloe, rose, bramble, hawthorn and dogwood. Instead, for arboreal species, the hedgerows should not be smaller than the production crop. In this case, the operator could choose varieties of the same cultivated species, which could be interesting for their pollinating capacity.

The hedgerows also provided better shelter for the livestock which took shelter on the leeward side of the well-furnished areas during wet and windy weather.

Soil protection

This function is of fundamental importance for sloping parcels where, often, the explanations of arboreal species to conquer few meters of arable land, has exposed the soil to destructive erosion processes. On sloping land the ecological infrastructures help control and purify the water, especially in the autumn and winter seasons, when rainfall is particularly heavy. It is a fact that with rainfall exceeding 50 mm, every hectare of bare land may lose up to 3.5 tonnes of good soil!

The presence of wooded strips, hedgerows or simple grass strips slows down water runoff and facilitates penetration into the ground, thus preventing erosion. Moreover, the nutrients in the soil, which would otherwise be washed away by rain, are absorbed by the same plants constituting the ecological infrastructure. In this way, fertilizer waste and groundwater pollution are avoided. A stabilizing function can be effectively performed by any species (also productive ones). If, however, landslide is to be feared, it is necessary to plant colonizing species such as false acacia, rush, rock rose, berberry, broom and laburnum.

Maintenance of the biological balance

The diversity of plant species in a hedgerow may be a perfect habitat for several species of birds, reptiles, small mammals and insects. Hedgerows are an important source of cover for birds and small animals and provide corridors for the movement of wild-life throughout the agricultural landscape. However, to achieve this objective successfully biodiversity within the hedgerow is important. The combination of earth bank and ditch provides an environment for wetland and dryland fauna. A season long supply of fruits and seeds as a source of food for animals and birds is also important. An unbroken hedgerow provides a corridor for the dispersal of some insect species throughout the countryside.

It is true that some of these organisms may be harmful to crops, but it is also true that as many are beneficial either directly (for example pollinators) or indirectly (parasites or predators of destructive species).

It is important to form as complex a system as possible, rich in animal and plant species interacting among themselves and preventing one from prevailing over the others. All this will ensure long-lasting stability to the ecosystem and, consequently, to agricultural productions.

Shelters for beneficial insects in organic farm Prem, Kaindorf, Austria (photo S. Oljaca)

Other specific functions

It is a serious mistake to consider ecological infrastructures, whether hedgerows, trees or grass strips, just a loss. Actually, the same may include fruit bearing species, and hedgerows may be designed with specific productive or ornamental purposes. In this way, not only the ecosystem is balanced and protected, which is itself economically valid, but it is also possible to obtain added revenue.

Some hedgerows worth mentioning are:

Melliferous hedgerow. Its main purpose is bee feeding, therefore it is important to utilize species that mature at different times, thus producing a prolonged flowering which is added to the flowering of the adjacent crop. The most widely used species are: maple tree, cherry tree, wild rose, different types of bramble, lavender, etc.

Buffer zone with mixture of melliferous plants in experimental field of Tamis Institute, Pancevo, Serbia (photo S. Oljaca)

- Aromatic hedgerow. It is made up of species which can be used by for herbal, culinary and honey production purposes. Some of the most well-known species are: rosemary, thyme, privet, lavender, sage, mint, etc.
- Small fruits hedgerow. The purpose of this hedgerow is the production of small fruits either for direct consumption or for the preparation of jams and liqueurs. The most widely used species for this type of hedgerow are: blackberry, raspberry, currant and blueberry, to which it is possible to add walnut-tree, sour cherry tree, wild rose, burnet, hazel, arbutus, and all those species whose fruits are processed in order to obtain products that may enhance and complete the range offered by farms and holiday farms.
- Ornamental hedgerow. Near the central office, outlet, alleys leading to fields in an organic farm, it is certainly nice to plant hedgerows having a purely ornamental purpose. Evergreen species which flower at different times are selected for this type of hedgerows, in order to enjoy constant flowering.
- Conservation hedgerow. One of the tasks of organic farms should be preventing the extinction of plants and species in the territory and therefore preserving also the species that are not so interesting from the economic point of view, but very important for their genetic patrimony. As biodiversity is an absolute value that agriculture must protect, the conservation of old-time species and varieties must find a place in small portions of the holding.

"Hedonistic" function

Lastly, it is not possible to disregard the beneficial impact of ecological infrastructures on the landscape. They make the rural environment more attractive, indeed. A flat plain without vertical elements, swept by winter winds, is surely not the most enjoyable place where to live, or spend a vacation or just a week-end. This consideration is by no means unimportant in case of holiday farms, educational farms or direct-sale farms.

In this regard, the role of ecological infrastructures is fundamental both for attracting consumers and for keeping them.

Medicinal plants also for ornamental purposes in organic farm Prem, Kaindorf, Austria (photo S. Oljaca)

Introduction of infrastructures into the holding

The target for ecological infrastructure as a percentage of the farm area is usualy five per cent. As already stated before, every farm must select the opportunities that best meet the requirements of the territory where it is located, bearing in mind the following considerations:

- Ecological infrastructures must not be considered a loss and a hindrance to the transit of agricultural implements. However, they must neither take away too much space to crops nor complicate the ordinary agricultural practices.

- Desired effects are to be evaluated and priorities identified. It is necessary to evaluate for each single case whether it is more important to reduce the wind speed or increase the presence of beneficial organisms such as artificial nests for birds or insects, reduce water runoff or protect the crops from pollution.

- Hedgerows and trees should be planted in harmony with the farm context and possibly with the landscape outside the farm (existing hedgerows, groves, water courses, ponds, permanent meadows, etc.).

- Species that are native to the region should be selected and the greatest possible number should be planted. They would take root more easily and the global effect of the infrastructure would improve. Hedgerows just made up of one species should be avoided.

- As regards grass strips, everything is simpler: just leave it to nature. In this way, the most adapted species will become established and over the years they will create the most natural patterns.

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CHAPTER 2: | CONVERSION TO ORGANIC FARMING

Many factors encourage farmers to start the transition process: increased energy costs, lower profits from conventional farming techniques, development of new cultivation systems, increasing environmental awareness of consumers and producers, new and stronger market for alternative farming and processing products.

Despite the fact that they often receive lower yields and profits, especially in the conversion period, many farmers persist respecting the economic and environmental benefits over a longer period of time. The economic benefit of this method of production is that in addition to higher product prices, significant savings are achieved in alternative, ecological methods of production. On organic farms, the consumption of matter and part of the energy comes from the resources of the farms themselves (fertilizers, alternative plant protection products, solar energy, wind energy).

Conversion to farm management on ecological principles leads to a whole series of ecological changes in the system. As the use of synthetic agrochemicals is reduced or completely eliminated, nutrients and biomass are recycled within the system, and the structure and functions on the farm are also changing. The whole process and mutual relations are transformed, starting from the basic structure of the soil, the content of organic matter, as well as the diversity and activities of soil organisms. Major changes also occur in the activities and interrelationships between populations of weeds, insects, and pathogens, as well as in the balance between beneficial and harmful organisms. Finally, the dynamics and circulation of matter, energy efficiency and productivity on the farm are greatly influenced. Tracking and measuring changes that occur during the conversion process can help the farmer assess the success of the conversion process.

The farmer who chooses organic methods for his production, must from the very start create the best agronomic conditions and pursue marketing and communication strategies aimed at the promotion of his products and of his human and natural resources as well.

Some of the technical solutions proposed at this stage in order to attain objectives are investments that the operator makes to maintain and replenish soil fertility and improve his enterprise's specific equipment and organization. At this stage, the operator has to face high costs and high risks because the change in cultivation techniques might entail lower yields and consequently lower income. Moreover, he is aware that the products of the first conversion year cannot be certified and that it is not easy to place them on the market and obtain the reasonable price. Nevertheless, he has to comply with the production rules laid down in regulations since the very start.

Conversion is, therefore, a challenging technical phase that may prove decisive for final success. The regulations in all European countries governing organic farming requires any farm wishing to adopt organic methods to comply with a conversion phase. Two years' conversion period is required before sowing annual herbaceous crops and three years' conversion period before harvesting perennial crops. The certification body can lengthen or shorten this period, based on the history of the farm supported by documentation. In no case may conversion last less than one year. Often the conversion phase ends on completion of the cultivation cycle following notification.

From a technical point of view, conversion is the period when a holding, formerly managed with conventional methods, lays the foundations for a correct and profitable application of organic farming methods. Thus interpreted, conversion involves times that can hardly match the ones laid down in the regulations and required by the certification body. Different holdings certainly require different times. Therefore, we can define as "bureaucratic conversion" the one that allows products to be marketed as from organic farming and "agronomic conversion" the one aiming at optimizing organic methods on the farm from a technical and economical point of view.

Briefly, an operator subjected to a certification system will have to profit from contributions and marketing opportunities offered by a product that has been certified. However, he should be aware that conversion will not end with certification but will continue, in a constant endeavour to find more and more effective agronomic practices that may produce good and healthy products in a well-balanced ecosystem.

2.1. Conversion process

Area to be converted

The farmer must carefully assess potentials and drawbacks of the holding, in order to define times and modes for "agronomic conversion". The regulation contemplates the possibility for a holding to convert only one portion of its agricultural area, but prohibits parallel production, that is growing the same crop varieties and rearing the same animal species with different methods. This is one point that deserves careful evaluation, if the farmer's region has not introduced more restrictive rules. The option of running a holding with both conventional and in-conversion fields entails a number of drawbacks for management, marketing and control system, which often carry some risk. Actually many operators choose to limit risks in order to verify the feasibility of the organic method before fully switching to organic.

If partial conversion is chosen, the areas dedicated to organic farming should not be too small, because long rotations would excessively subdivide fields, the productions obtained would be too small to check market response and it would be too difficult to rationalize work to improve efficiency. Also the decision to convert marginal areas to organic farming and maintain the most fertile fields conventional is very risky. Marginal and neglected fields are often loaded with weeds and it can be big problem into the future. The several specific conditions of holding and territory to be taken into consideration for a careful assessment of technical options and implementation times are many, and all potentially decisive.

2.2. Conversion planning

The purpose of a conversion plan is to guide operators in the first conversion years towards the minimum goals to be achieved. A conversion plan conveys a picture of the holding, analyzing and cross-examining all acquired data with the objective of defining the technical solutions to be adopted.

When organizing work, discussing with operators and advisors, defining actions, it is essential to underline that organic farming is a method and not just replacing the chemical fertilizers and active principles used up to that moment with the substances listed in annexes of regulation. If this concept is not well understood, failure is most likely to occur. Converting a holding to organic farming means setting off to improve the organic fertility of the soil and the equilibrium of the ecosystem on the farm. Once attained, these objectives can produce valid and profitable results.

Assessment

The elements assessed in order to determine conversion modes and times, are the "picture" of the initial situation on the farm. This picture may come handy also later on, when evaluating the work done. For this reason, it is important to give precise descriptions and carefully estimate the influence that these elements may have on immediate and future results and consequently on priority of action and investment.

The elements to be carefully evaluated are:

Field history – it is important to gather, for each field, exhaustive information about agronomic practices, problems and yields, namely:

- rotations and crop sequences in the last four, five years;
- type of fertilizers, herbicides, soil disinfecting products, application rates and methods;
- soil tillage;
- the most problematic weeds and correlation with crops and pedoclimatic circumstances;
- main diseases;
- any other specific problem historically recorded;
- average yields of crops;
- varieties utilized and their adaptation to microclimate.

The evaluation of the above data will help the farmer to define agronomic options and consequently will help him to elaborate an appropriate cultivation plan (rotations, crop sequence, crop location, cultivation techniques) that may prevent the occurrence of problems.

Initial soil properties – The farmer's experience is always the most important factor to rely on. Then, soil tests may be useful to identify some problems that deserve careful consideration because they may be the cause of unsuccessful crops or ineffective fertilizers. Initial soil tests are also important because they are a reference for the farmer and enable him to assess work done and goals attained, especially as far as organic matter is concerned. If no soils tests are available on the farm, and not even the percentage of organic matter is known, it is necessary to have the soil tested, otherwise it will be difficult to calculate the humic balance for a good fertilizing plan. Balance of humus is a strategic data that enables the farmer to calibrate cultivation plan and fertilization rates to soil potentials, thus successfully practicing the organic farming method.

Social-environmental situation - A farmer tackling conversion should know the environment where the holding is located and other organic holdings in the area, because in this way he would be able to exchange information and receive useful hints and would not feel a pioneer. He should also gather information about points of sale or agents that sell outputs or supply services of interest to organic farmers and he should become acquainted with traders who may buy his products. It is also useful for the growers who are not self-reliant to know third-party operators or processors in the area, their equipment, expertise and willingness to perform any operations that may be needed.

Farmer's awareness and know-how – These elements play a key role in the definition of times and methods for introducing innovations on the farm and of technical support needed. They are crucial when the farmer has to choose whether to convert the whole farm, or just a part of it and spread the potential risk over a longer time.

The farmer's motivation is a determining factor for success both when switching to organic farming and when adopting innovative solutions that disrupt habits and convictions. Obviously, if a farmer is not persuaded with, or has not fully "digested", a proposed initiative, this initiative is not likely to succeed. This is true also for the persons in charge of operations, especially outside the farm such as third-party processors, who rather pursue their own interests than the farm's.

Equipment present on the farm. Willingness to invest – The time required for implementing agronomic options depends not only on the farmer's conviction, as stated above, but also on the availability of the necessary inputs and equipment on the farm and in the territory. Also the willingness to invest money on the farm has an influence on implementation times.

From the following examples it clearly appears that if specific equipment is missing on the farm, the operator should choose alternative solutions to prevent failure.

The operator should not:

- plan piling up organic matter compost, if no adequate space and no turning tools are available;
- plan the use of fertilizers, if no suitable harrows are available for incorporation into the soil;
- buy powder fertilizers, if no cylindrical spreader is available;
- include green manure crops in rotations, if no choppers and no adequate implements for shallow ploughing-in are available.

Expert advisors will certainly suggest temporary alternative solutions that on the one hand will convince the farmer that the operations are practicable and are worth investing money, and on the other hand will not excessively delay important technical decisions.

Constraints – Some restraints of organizational or environmental nature may heavily affect technical options and may require even more careful consideration of actions to be taken to attain objectives. The ones most frequently found are:

- environmental and political restraints: motor-ways or pollution sources in the vicinity, no services available in the area;

Regional policies, definition of priority areas where organic farming is promoted, no premiums awarded by regional plans to key crops, measures not implemented, undifferentiated premiums to simpler and less controlled farming;

- former obligations: acceptance of less restrictive agri-environmental measures and impossibility to pass to more restrictive ones; contracts in force; rented land;
- family disputes about options, entailing lack of serenity in options and higher competitiveness regarding production results;
- short-term or expiring rents, which reduce certainty about land possession and do not allow long-term investments and access to community premiums.

Definition of a conversion plan

All the information gathered will, after due consideration, help the farmer to define a conversion plan that will include the technical solutions that he deems best for his holding, namely:

1. *Fertilization*, evenly balanced, organic, based on balance of humus.

2. *Rotation*, satisfying:

   a) agronomic requirements - soil fertility and health;

   - soil erosion protection;
   - weed control;
   - pest and disease control;

   b) economic requirements

   - market appreciation;
   - premiums and incentives.

3. *Intercropping*, to exploit the plants synergic action in relation to nutrients, pest and disease control, quality and environment.

4. *Selection of varieties*, to adapt to the agricultural ecosystem and obtain nutritional, organoleptic and technical qualities in the final product.

5. *Introduction* of hedgerows and trees, to favour biodiversity, farm ecosystem balance and landscape.

A conversion plan is also useful to highlight the fact that in organic farming no action is an end in itself. The actions will be effective only if the equilibrium of soil and ecosystem is respected. Conversion times and modes for an agricultural crop production are in fact correlated with a rotation plan, because to a rotation plan are connected balance of humus and fertilization, selection of varieties and seed treatments, weed control, soil tillage, soil cover and intervention times. All these operations have in their turn various technical implications that are interlinked with the fertility of the soil.

During the plan implementation stage, all actions carried out (or derogations) and the consequent results must be accurately recorded. Only through careful examination of soil response it will be possible to check whether conversion is being complied with and the choice made was a good one, or some improvements and amendments are necessary in order to attain objectives.

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CHAPTER 3. | SOIL MANAGEMENT

3.1. The characteristics of soil and soil organic matter

Organic agriculture uses a variety of methods for soil cultivation to conserve and improve soil structure, soil fertility and increase organic matter content. There are many methods and principles, but it is essential to recognize importance of the long term soil fertility. Applied practices should increase organic matter and humus, protect from erosion, decline loss of nutrients and maintain healthy and diversified soil life. Well planned crop rotation satisfies all these conditions.

Soil organic matter is broken up into three different categories: "living", "dead", and the "very dead". Living component encompasses all functional group of organisms in soil: plants, animals and microorganisms. Dead component makes plant residues, decomposing roots, dead organisms and metabolites of soil microorganisms, while the very dead component is what we call soil humus, result of decomposing. Organic producers should thrive to increase content of all three soil organic matter components. Soil tillage in organic production increases organic matter content and biological soil activity. This is achieved by crop rotation, composting, use of green manure and cover crops. Introduction of the four-year and the five-year crop rotation plan with grasses and legumes on meadows and pastures, fallow land, is a great way to increase and maintain organic matter. Also, soils with high percentage of organic matter do not always have high fertility rate. Peat bog soils for example, are completely made out of organic matter but are poor with nutrients. Also, soils rich in organic matter do not always have the most desirable biological activity. Over moisture in these soils creates anaerobic environment unsuitable for decomposition of organic matter, and organisms provoking plant disease here multiply. Soils need to be properly tilled for organic matter to lead to the increase of nutrients available for plants, improved soil structure and increase of nutrients' reserve.

Amount of soil organic matter depends on soil type and type of tillage. Sandy soils in their essential form can have 1% of the organic matter, while humus soils even up to 30% of the organic matter. Usually the content of organic matter is between 3 - 6%.

3.2. Soil management, cultivation and analysis

In organic soil management are used methods that are minimizing soil erosion, increasing organic matter and intensifying diverse life in soil. Synthetic fertilizers are not used in organic production, so organic producers increase soil fertility specifically through:

- careful planning of crop rotation,
- increasing microbial diversity of soil with organic fertilizers,
- reducing practices on soil which are harmful for soil biogenity,
- avoiding tillage on erosion prone slopes,
- sequence sowing (sowing legumes and other crops one after the other),
- avoiding overgrazing,
- no synthetic soluble fertilizers and pesticides, both can be harmful for soil microorganisms, and when used too long, contribute to soil degradation.

In organic agriculture, activity of micro and macroflora and fauna is very important, especially of the earthworms. Setting up a suitable habitat is the first step to improve biological characteristic of the soil, which long-term results in increase of soil quality and productivity. This means that reduced tillage systems should be used as they less deteriorate soils and secure longer period of its rest (setting up a wider crop rotation, intercropping, using quality composted fertilizers). Tendency is to minimize soils' turning and mixing during ploughing. Harvest residues should be integrated in the soil at 8 cm depth, where living soil organisms can decompose it. Part of these residues remains on the surface to diminish soil erosion.

Conservation tillage: (Reduced tillage, Mulch tillage, Partial width tillage, No tillage), crop residues as mulch remain on the top or in the surface layer to protect from soil erosion, deflation and strong evapotranspiration, thus depleting soil degradation. Improved physical characteristics of the soil and the constant increase in organic matter in conservation tillage increases biological diversity of soil.

Conservation tillage systems:

Reduced tillage, is every type of cultivation without inverting soil and when 30% of its surface is covered with crop residue (Figure 1).
Mulch tillage, is tillage system in which residue is partially incorporated using chisels, sweeps, field cultivators, providing fine tilth and soil cutting, with 30% of plant residues on surface (Figure 2).
Partial width tillage, immediately prior sowing narrow strips foreseen for sowing are tilled, up to 1/3 of total surface(Strip tillage, Figure 3).
No tillage (Figure 4), direct seeding machine (no-till planter) removes crop residues and provide a layer of fine tilth in the planting rows up to 5 cm.

Reduced tillage (photo: Ugrenović, 2016)

Partial width tillage - strip till (photo: Ugrenović, 2014)

Mulch tillage (photo: Ugrenović, 2012)

Direct sowing - No till (photo: Ugrenović, 2012)

Analysis of soil fertility – Organic production system emphasizes importance of soil preservation, therefore fertilization differs from approach in conventional production, instead of direct application of soluble fertilizers, focus in organic farming is on the conservation of natural fertility. We can monitor soil fertility through results of the soil analysis, which is also useful in the process of control and certification of organic production. Within systematic soil fertility control, following parameters are checked: pH, lime content, humus, total nitrogen, available forms of phosphorus and potassium. Furthermore analysis can show content of Ca, Mg, Fe, Mn, Cu, Zn, B and S. Analysis can determine if the content of heavy metals is complied to the maximum allowed content set in the law (Official Gazette of RS No 23/94) and consequently if the soil is suitable for organic farming.

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CHAPTER 4. | SOIL FERTILITY AND PLANT NUTRITION

4.1. Crop rotation, green manures, catch crops, cover crops

Crop rotation

Crop rotation is a planned system of plant production where crops and surface are defined for longer period of time. Plant species are sequentially planted in time and space. In organic field crop production, crop rotation is seen as an important phytosanitary measure that reduces the diseases, pests and weeds. In all field crop production systems, strong crop rotations are applied with a significant share of annual and perennial legumes and their mixtures with grasses to enrich the soil with nitrogen and provide enough roughage for livestock on a farm.

Due to its complex and manifold positive effects on soil and yields, crop rotation in organic production is returning to basic principles in times when agriculture was based on methods applied in organic farming nowadays. Share of legumes and grasses in such crop rotations is huge (20-40%), either as setting pastures and meadows on some part of fields, or annual and perennial legumes. In this type of crop rotation focus is on activating and preservation of natural fertility of soil, and less on plant nutrition, as opposed to intensive conventional production. One of the precondition for successful management of organic crop production is by introducing cover crops in rotation. Benefits for soil and main crop are manifold: erosion control, increase in organic matter content, management of soil moisture, water quality protection, weeds and pests control, etc. Planning of such crop rotation is done parallel for the main and the cover crops.

Soil productivity increases by implementation of wide-row crop rotation without ploughing, with inclusion of more plant species. Crops that leave on the field less remains (brassicas) should be sown in combination with grains. Available content of nitrogen for plants can be increased by rotation of grains or oleaceus plants with legumes and forage crops. Symbiotic nitrogen from legumes can persist for some time, depending of legumes involved. Pay attention that symbiotic nitrogen fixation in legumes depends on mycorrhiza providing phosphorus, needed for absorption of nitrogen and Rhisobium responsible for nitrogen fixation. Legumes grow well on biological active soil, creating even better biological soil activity.

After several years of cultivation of perennial fodder crops, soil gets better structure, better biological activity, organic matter is higher, is enriched with in nitrogen in comparison to monoculture crops. Legumes with strong and deep root system (alfalfa) in the crop rotation increase softness of the soil and nitrogen content. Intercropping in crop rotation intensify agrobiodiversity, leading to better biological diversity in soil. Such soil is more resistant to drought, extensive utilization, with less tillage and less nutrients.

In comparison to monoculture crops, crops in crop rotation are less damaged by diseases and pests. Cultivation of the same crop or the crops prone to same disease on the same place over the years, results in spreading plant diseases and pests and their piling in the soil. Crop rotation interrupts life cycle of pests. For example, population of click beetles (Elateridae) reach their peak of ability to damage grains is in the following year, therefore is needed to grow oat or flax as part of the next year crop rotation. Susceptibility to diseases should be considered in planning crop rotation. For example, crops prone to same diseases should not be sown one after another (Table 1), like crops prone to white mold, require 4-5 year crop rotation period.

Table 1. Possible crop diseases appearing in crop rotation

Crop	Possibility of diseases and its development*	Not to grow after	Reason
Barley, wheat	1 2 3	Barley, wheat Maize Winter rye	Leaf diseases, Common root rot Scab Ergot of rye
Flax	1 1	Sugar beet, peas, lenticels Flax	Rhizoctonia root rot Rhizoctonia root rot
Rye	1	Rye, wheat, barley	Ergot
Canolaand mustard	1 2	Canola, mustard, beans Sunflower, soybeans, lenticels	White mold, Rhizoctonia root rot White mold
Sunflower	1 1 2	Sunflower, soybeans, beans Canola, field mustard Lenticels	White mold , black rust White mold White mold
Peas, beans	1 2 2 1	Peas, beans Sugar beet Alfalfa, flax, lenticels, beans Sunflower, lenticels, canola, field mustard, beans, mustard	Bacteriosis Rhizoctonia root rot Fusarium, Pythium White mold
*Ranking potential of appearance of disease and its development: 1- strong, 2 –moderate, 3 – weak			

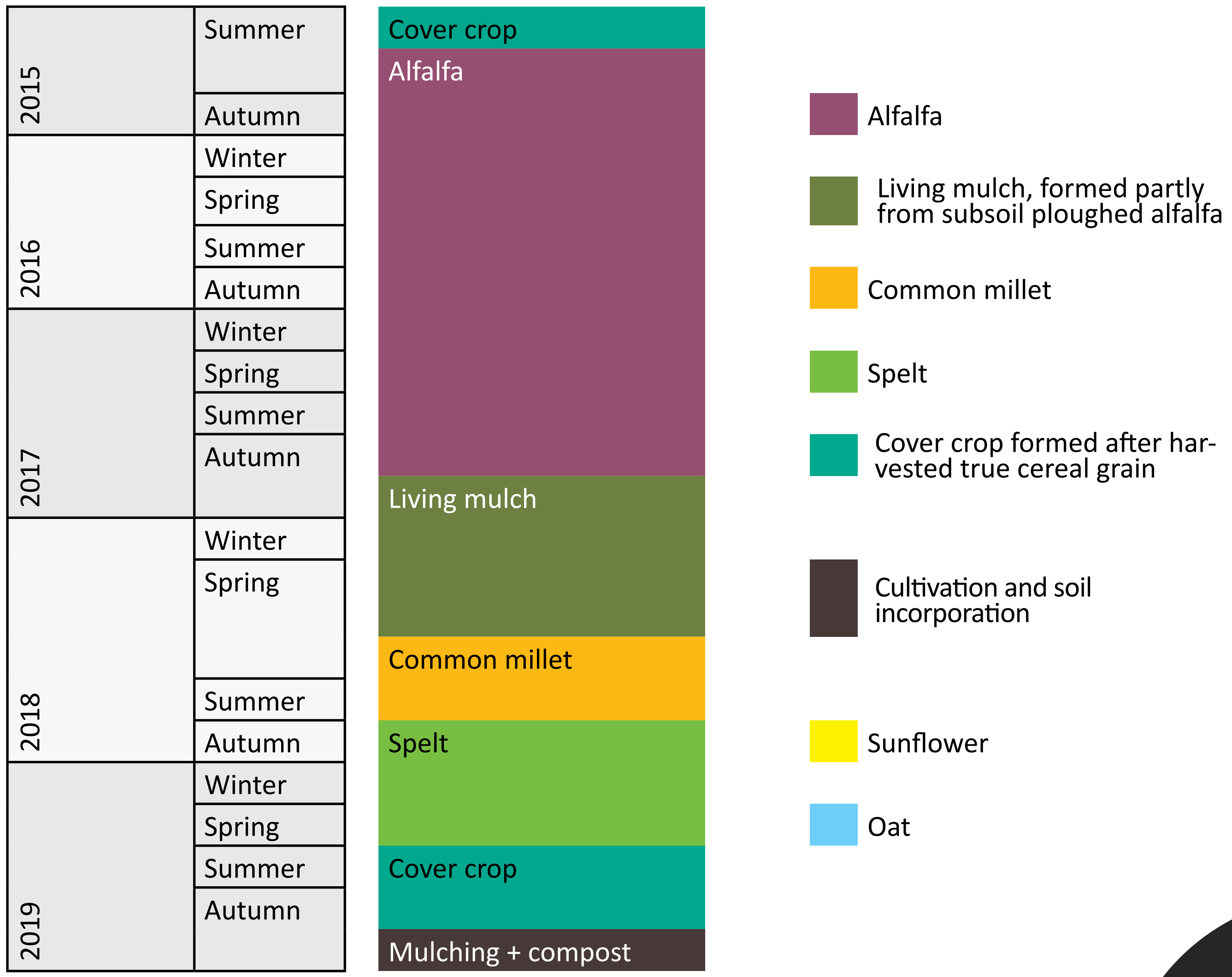
Pests struggle to find host crops in intercropping systems which lessen problems in some extent. Establishing habitats for predators and parasitoids with perennial legumes enables better pest control. Alfalfa attracts many beneficial organisms able to destroy pests in neighboring field. Intercropping of soybeans and corn resulted in lower infection rate.

Crop rotation planning

Crop rotation is one of the most powerful weapons organic farmer has against weeds and in maintaining soil fertility, thus has high priority in this plant production system. Crop rotation in organic farming should be diversified as much as possible. Crops with deep root system (alfalfa) should switch crops with shallow root system (grains) to maintain structure and drainage. It is desirable to switch legumes (nitrogen fixation) with heavy nitrogen feeders, crops with bigger root biomass with crops with less, bigger consumers with smaller, etc. Recommendation is to include cover crops with different characteristics and pasture crop rotation involving legumes.

Key to good crop rotation is in diversification of rotating crops, belonging to different plant groups, sown in different time and with different nutritional demands, etc. It is important to understand principles of crop rotation to be able to adjust it to your farm conditions. Crop rotation on one successful farm for sure will not work on another, because every farm is unique. However, successful crop rotation (Scheme 1) can give ideas and models adjustable to the needs of other farms.

Scheme 1. Example of crop rotation on organic farm without livestock and with alfalfa



2020	Winter	
	Spring	Sunflower
	Summer	
	Autumn	Oat
2021	Winter	
	Spring	
	Summer	Cover crop
	Autumn	Alfalfa

Planning of crop rotation requires estimation of following:

- economic value of production,
- importance as feed for livestock,
- role in building organic matter in soil,
- cover crops – soil erosion control,
- rising or depletion of nutrients,
- ability to compete with weeds and their suppression,
- pest tolerance,
- need for human labor in production.

Legumes used as the livestock feed can provide other benefits as well. They can be used as hay, roughage or for seed production, but they are also contributing to weed and pest control, building nitrogen in soil for succeeding crops, improving soil structure. Buckwheat could be used for grain production, but is also included in the crop rotation to control weeds, and is used as the green manure for phosphorus accumulation and food for the bees. Winter rye is produced for its grains and huge quantities of straw for bedding and compost, and in the crop rotation control weeds and builds up organic matter in soil.

Example: Five-field crop rotation on organic farm without livestock, is modeled with alfalfa inclusion (Scheme 1). Alfalfa should be cultivated for two years, which is suitable as total surface is faster enriched with nitrogen and free from weeds for the next crop. It means that alfalfa will be in the same field every five years, and meanwhile in the middle of that period, field is fertilized with farm compost. Alfalfa yield can be up to 52 t ha-1 green biomass, i.e. 12,6 t ha-1 dry matter on annual level. Part of this biomass can be used for compost production to maintain soil fertility on farm. Due to alfalfa seed production which is providing economic sustainability, suggested technology sustains soil fertility in natural and sustainable way.

Significance of vegetable crop rotation

Vegetable crop rotation has important biological impact: it maintains balance of nitrogen in soil, stabilizes active matter in the soil, reduces loss of nutrients by runoff water, maintains microbiological soil activity and reduces weeds and pests. Ground of the vegetable production presents solid vegetable, and if the farm has the possibility, can apply field crops-vegetables and field crops-fodder crops-vegetable crops crop rotation by including green manure, fodder crops and grain cereals which will help to control diseases, pests (white clover...) and weeds (spelt, rye, triticale) efficiently. However, if cultivated crops require more nitrogen (fruit-bearing vegetables, brassicas, potato, squash), then in the crop rotation should be at least 25% of legumes with vegetation period longer than three months (French bean, lenticels, fava bean, and as a successive crop alfalfa, Crimson clover or clover). In practice, content and size of the crop rotation vary from many factors: whether vegetables will be sold on the green markets (different species, varieties) or processed on the farm, perhaps vegetables will be used as a raw material for processing industry, or as a propagation material.

Economic significance of correct implementation of the crop rotation mainly comes from the negative consequences of vegetable conventional production where crop rotation is lacking. Vegetables in monoculture and tiredness of soil long-term influence to yield decrease and directly to the farm income. Poorly planned crop rotation in vegetable production results in more weeds, due to the wrong selection of species (some crops in vegetation can cover soils with their biomass), and due to the appearance of rhizome weeds. Therefore, farmer needs to spend resources to eliminate weeds manually and mechanically. Correct crop rotation in combination with cover crops reduces labor work, not only in weeding, but also in the inter-row cultivation.

Planning vegetable crop rotation

Crop rotation is usually planned for several years (3-7). In planning successive plant production and in selection of crops, farmer complies crop rotation with available farm resources. It is important to rationally use soil resources, to fertilize vegetables with products of natural origin (taking into consideration plants' needs). Sowing and harvesting as labor intensive activities should be well planned to comply with other work on the farm. Production in greenhouses is especially demanding as it adds costs for heating as well.

It is essential to cultivate cash crops with market demand and which producer knows how to grow (has enough experience and knowledge). For selected crops, producer has to have appropriate machinery and equipment and to fully respect times of plant propagation, planting, harvesting, washing, sorting, packing, etc. Farm should have enough workers and labor costs need to be calculated in the farm income. If everything above is applied, farmer can expect profit.

Every producer plans crop rotation in compliance to the agro ecological conditions, soil parameters, irrigation possibility and set production goals. Though it may seem otherwise, to make a good crop rotation plan is not easy. Producer plans crops sequencing in time and space and periods when soil rests. Moreover, producer needs to select species, resistant variety, fertilizers, adequate soil preparation, set deadline for sowing and planting, harvesting, etc. In order to make proper crop rotation, one should know which crops were grown previously and on which fields. Farmer divides production field in the several plots and in the Field book plans future crop production.

Vegetables are divided into several categories, one is according to their resistance to monoculture and soil exhaustion. Low sensitivity to monoculture has leek, celery, lettuce and pepper, medium sensitivity has tomato, cabbage, cauliflower, carrot, and peas, and high sensitivity has parsley and beet root. The most sensitive species to soil exhaustion are brassicas (cabbage, cauliflower, broccoli), spinach, beet root, chard and beans, further less or no sensitivity at all has lettuce and fruit-bearing vegetables (tomato, pepper).

Vegetables are categorized according to fertilization demand. For organic vegetable production is specific application of the clean vegetables crop rotation where three groups of vegetables shifts:

- I group in the crop rotation – species fertilized abundantly with manure (2-6 kg/m2): potato, late cabbage varieties, kale, broccoli, cauliflower, Brussels sprout, pepper, tomato, eggplant, sweet corn, celery, leek, cucumbers, melon and watermelon;
- II group in the crop rotation – species with less need for fertilization (1,5-2,5 kg/m^2), are using extended effect of manure decomposition (organic fertilizers have adverse influence on product quality): carrot, parsley, parsnip, early varieties of cabbage, kohlrabi, onion, garlic, lettuce, spinach, chard, beet root, red radish (alternatively);
- III group in the crop rotation – species enriching soils with nitrogen, and species which are not fertilized with manure as they are low users: peas, French beans, beans, fava beans, various lettuce, rocket, radish, corn salad, curly parsley, chicory, endive.

When crop rotation is planned, one should keep in mind that legumes and root vegetables do not stand manure. When vegetables from these three groups change in time and space they make a three-filed crop rotation system. In the three-field crop rotation, crops in the I group always come in the first field, crops in the II group take the second field, and vegetables in the III group come to the third field (Scheme 2). Their shifting make three-year cycle of vegetable production (Table 2).

Scheme 2. Rotation of field within three years

	First field	Second field	Third field
1. year	I group	II group	III group
2. year	II group	III group	I group
3. year	III group	I group	II group

Table 2. Sequencing of vegetables in the three-year crop rotation

Year	I field	II field	III field
year	Fruit-bearing vegetables, leek, brassicas	Carrot, parsley, parsnip, beet root, onion, garlic	Legumes
year	Carrot, parsley, parsnip, beet root, onion, garlic	Legumes	Fruit-bearing vegetables, leek, brassicas
year	Legumes	Fruit-bearing vegetables, leek, brassicas	Carrot, parsley, parsnip, beet root, , garlic

Crop rotation in greenhouses is also applied and is obligatory measure ofharmful organisms control in such specific production conditions. In order to use all the production fields throughout the year, intensive vegetable crop rotation is applied (change of 2-3 species on the same field during the year), which is based on the three-field vegetable crop rotation. During one vegetation period or a year, farmer on the same field continuously or in the same time (intercropping) cultivates more vegetables species. It means that after harvesting of one crop, the other one is sown, and even third, if conditions allow it. Intensive crop rotation is possible due to the different vegetables' vegetation, difference in heat requirements and resistance to low temperatures (kale, Brussels sprout, leek...). Therefore, we distinguish main vegetables species and according to them are planned preceding and successive crops.

Main crops (the longest vegetation or the highest yield) are:

- carrot, parsley, parsnip, celery...
- pea, French bean (bush and climbing), bean...
- chard, beet root...
- leek, garlic, onion;
- broccoli, red and white cabbage, cauliflower, Brussels sprout, kohlrabi, kale…
- cucumber, pumpkin, zucchini, melon, watermelon…
- sweetcorn;
- tomato, pepper, potato, eggplant…

Crop rotation and field rotation depends on the vegetables' biological characteristics, so peas uccessfully grows after numerous varieties, and for some varieties preceding crop selection is limited. Selection of preceding crops depends from the need for tillage, nutrients, water and as the most important factor, resistance to diseases and pests (Table 3).

Table 3. Preceding crops selection

	Good preceding crop	Satisfactory preceding crop
Pea	Cucumber, cabbage, tomato, wheat, onion, carrot	Melon, watermelon, potato
Onion, spring onion	Pea, wheat, perennial grasses	Carrot, cabbage,
Carrot, celery, parsley	Pea, wheat, perennial grasses	Cabbage, tomato, pepper
Cucumber, melon, watermel-on, squash	Legumes, perennial grasses	Basics
Basics	Legumes, perennial grasses	Pepper, Tomato
Tomato Pepper	Pea, onion, perennial grasses, wheat	Cabbage, carrot

Poor preceding crop:

- before tomatoes not to grow: tomato, potato, pepper, spinach, cucumber, eggplant;
- before basics not to grow: basics, cucumber, squash;
- before root vegetables not to grow: carrot, celery, parsnip, parsley;
- before pea not to grow: pea and French bean;
- before cucumber and watermelon not to grow: cucumber, melon, watermelon, squash, tomato, pepper;
- before alliums not to grow: onion, garlic, leek, radish.

In intensive crop rotation, we differentiate:

- first crops (preceding crops)–usually early or winter variety (lettuce, red radish, pea, early potato, early carrot, spring onion, spinach),
- successive crops – produced after the main crop (lettuce, spinach, spring onion, French bean, pea, radish…),
- intercrops – lettuce, garlic, (spring onion and with smaller bulbs), red radish, chives, spinach, garden orache.

Table 4. Examples of intensive crop rotation

Field	First crop	Main crop	Successive
1	Lettuce	Tomato	Garlic
2	Onion and carrot	Red radish and spinach	
3	Pea	Beet root	Lettuce
4	Parsley		Pea

In the first example of the intensive crop rotation (Table 4), as the first crop in the early spring lettuce is sown, in April is transplanted tomato as the main crop, and as the successive crop is planted garlic. In the second example onion and carrot are grown from the spring time until the summer as the main crops, and the radishes and spinach as the successive crops until the winter. In the third example pea is sown early in the spring. After its harvest, a beet root is sown, followed by winter lettuce. In the last example parsley is sown in spring, after which is sown winter pea.

Furthermore, to plan production it is important to be familiar with the plant taxonomy. Similarities or differences between vegetable groups derive from its affiliation to the same plant families: similar growing conditions (soil, heat, water, sunlight), sensitivity to certain diseases, presence of pests specific for certain plant family (the flea beetle attacks brassicas, radish and rocket), need for certain nutrients (French bean, pea, cauliflower are Molybdenum sensitive), interactions between certain vegetables (allelopathic interactions).

In the vegetable crop rotation should not be grown species from the same botanical families in a row, since they are sensitive to the same diseases and pests. Essential is to respect the time gap between sowing or planting crops from the same botanical family! The time gap should be at least three years, but it is desirable to keep it up to five years, specifically for tomato, eggplant, pepper, cucumber, root vegetables (parsley, celery, carrot, parsnip), as well as for alliums (onion, garlic, leek). Practically, on one plot pepper, tomato, eggplant, potato or tobacco should not be grown together for longer period of time nor combined in the crop rotation. For above mentioned crops good preceding are beans, French bean, pea, onion, as well ascorn, grains, sunflower, sugar beet.

Botanical vegetables' classification:

- Alliums (Alliaceae): (Allium cepa L.), garlic (Allium sativum L.), leek (Allium porum L.), chives (Allium schoenoprasum L.);
- Umbelliferae(Apiaceae):carrot (Daucus carota L.), parsley (Petroselinum hortense L.), parsnip (Pastinaca sativa L.), celery (Apium graveolens L.), fennel (Foeniculum vulgare L.);
- Brassicas (Brassicaceae): cabbage (Brassica oleracea L. var. capitata), cauliflower (Brassica oleracea L. var. botrytis), broccoli (Brassica oleracea L. var. italica), kale (Brassica oleracea L. var. sabauda), tree kale (Brassica oleracea L. var. acephala D. C.), Brussels sprout (Brassica oleracea L. var. gemmifera), kohlrabi (Brassica oleracea L. var. gogylodes), rocket (Eruca sativa, Mill.), radish (Raphanus sativus var. major L.), radishes (Raphanus sativus var. sativus L.), horseradish (Armoracia rusticana L.);
- Compositae (Asteraceae): lettuce (Lactuca sativa L.), endive (Cichorium endivia L.), chicory (Cichorium intybus L.), salsify (Tragopogon porrfolius), Spanish salsify (Scorzonera hispanica),artichoke (Cynara scolymus L.), cardoon (Cynara cardunculus L.), Jerusalem artichoke (Helianthus tuberosus L. fam.);
- Chenopodiaceae (Chenopodiaceae): spinach (Spinacea oleracea L.), chard (Beta vulgaris ssp. cicla L.), beet root (Beta vulgaris L. ssp. esculenta), garden orache (Atriplex hortensis L.);
- Cucurbits(Cucurbitaceae): watermelon (Citrullus vulgaris L.), melon (Cucumis melo L.), cucumber (Cucumis sativus L.), squash (Cucurbita sp. L.), zucchini (Cucurbita pepo L.);
- Pods (Fabaceae): pea (Pisum sativum L.), French bean (Phaseolus vulgaris L.), bean (Phaseolus vulgaris),fava bean (Vicia faba L.);
- Nightshade family (Solanaceae): tomato (Solanum lycopersicum L.), pepper (Capsicum annuum L.), eggplant (Solanum melongena L.), potato (Solanum tuberosum ssp. tuberosum L.), physalis (Physalis sp. L.);
- Grasses (Poaceae) – sweetcorn (Zea mays var. sacharata);
- Perennial crops:familyMalvaceae – okra (Hibiscus esculentus L.); family Valerianaceae – corn salad (Valerianella locusta L.); family Asparaginaceae – asparagus(Asparagus officinalis L); family Convolvulaceae – sweet potato (Ipomea batatas L. fam.); family Polygonaceae - rhubarb (Rheum rhabarbarum L.).

If farm produces perennial vegetables species, they are then separated from others. Asparagus, rhubarb, chives as well as many other plants are produced on the separated fourth plot for the green manure.

When planning the crop rotation look after following principles of crops' sequencing:

- deep-root crops with shallow-root crops (root species with legumes or fruit-bearing and root vegetables) to maintain good structure, aeration and drainage of soil;
- narrow row spacing with high density with wider row spacing produced crops (hoed crops);
- legumes with heavy nitrogen feeders (brassicas, squash, sweetcorn…);
- crops that form more biomass with those with less biomass (vining vegetables with alliums);
- big water consumers (pepper, cabbage, cucumber, tomato…) with more water tolerant (pea, potato…).
- to change leafy and root varieties and grains to diminish weeds;
- to avoid sowing or planting of crops prone to diseases;
- to apply mixed sowing and planting;
- to grow cover crops.

When planning the crop rotation take into consideration as well:

- abundance of water-loving vegetables (pepper, tomato, cabbage, cucumber…);
- abundance of perennial legumes (alfalfa, white and red clover);
- abundance of crops which improve soil structure;
- specificities of certain crops' cultivation with trellis, their shading, pruning, etc.

Green manure

Green manure presents any crop in crop rotation system, incorporated into the soil to increase organic matter, nitrogen and other nutrients. Green manure can have other purpose like: erosion protection as a soil cover, adoption of available nutrients from soil and protection of soil from erosion reducing their depletion by water runoff (catch crops), intersect life of pests, weeds and diseases, suppressing weeds with high density and shading. Green manure have many functions on farm. Goals, shading manner and use of green manure presents part of cover crop technology therefore are described in more details in this handbook.

Cover crops

Cover crops are applied as a biotechnological measure in systems of ecological agriculture. They can be defined as crops not grown for commercial purposes, with multiple role in crop rotation. Different ways of introduction of cover crops in the crop rotation provides multiple benefits for the main crop and soil: protection of the soil surface from erosion, increase in organic matter content, management of soil moisture, protection of water quality, control of weeds and pests, etc. One of the core principles of organic production is conservation of natural soil fertility, therefore application of the cover crops production system is a basic precondition for its successful management. Management of practices in organic production: crop rotation plan, species and variety selection, cultivation type, sowing methods, crop management, way of harvesting, are done parallel for main and cover crop. Production of main crops is adjusted to application of this technology with possibility of sequential cropping (subsequent, stubble, winter crops), intercropping and protective cover crops.

Role of cover crops and their effects

Soil erosion control -Establishing cover crops with high biomass production can effectively protect soil against erosion, especially in the part of the season when the soil is bare. Plant cover crops splice soil particles with their roots, while the above-ground biomass prevents fine particles of soil surface from being flushed away by water or carried off by wind. Dense perennial crops improve the retention and absorption of water by the soil, and reduce run-off, whereas the above-ground parts of the plants reduce the impact of the rain drops. After the destruction of the cover crops, the dry above-ground biomass forms mulch on the soil surface, which also provides the protection against soil erosion. Grasses and grass mixtures provide the best protection against erosion, and winter grains or winter brassicas are suitable for covering the soil during the winter.

Increasing the organic matter content - Cover crops leave plant residues thus causing the increase of organic matter in the soil. The increase depends on the amount of the biomass formed in a cover crop and the ratio of carbon between nitrogen in plant residues(C:N ratio, Table 5). This ratio depends on plant species and the time of the year when the cover crops are destroyed. Plant residues of cover crop with a low ratio of C:N – legumes (Fabaceae), are decomposed faster than those with a high ratio – grasses (Poaceae). Thanks to their powerful roots, plants from the grass family accumulate nutrients, especially nitrogen, that remains in the soil after the harvest. However, these nutrients become available to plants rather slowly, so that grass cover crops have more effect on the increase of organic matter in the soil. On the other hand, plant residues of legumes are rapidly degraded in the soil due to their lower C:N ratio, therefore less increasing the content of organic matter in the soil than grass cover crops. For the degradation of plant residues in which the C:N ratio is above 30, the microorganisms consume additional nitrogen (nitrogen immobilization), creating a temporary shortage of this element for the next crop. The pairing of different plant species from different families (grasses and legumes) in cover crops can reduce the C:N ratio, and thus accelerate decomposition of the total biomass produced. Knowing the individual characteristics of the species in cover crops, the processes in the soil can be directed towards the set goal, whether we need organic matter or available nitrogen for the next crop.

Table 5. Carbon and nitrogen ration (C:N) in plant residues

Organic matter	C:N ratio
Young rye plants	14:1
Mature rye plant	40.1
Maize stems	60:1
Hairy vetch	10:1 to 15:1
Crimson clover	15:1
Sawdust	200:1

Enhancement of soil structure –Plant roots in cover crops bind soil particles, during their decomposition in the soil, organic molecules are released, and, also, fungal networks are formed. The best effects to enhance soil structure are achieved by the establishment of cover crops that form a strong hairy root system, such as grass species. The roots of these species bind and can also penetrate into the soil. Species with spindly, parsnip-like root (brassicas) penetrate into deeper layers of the soil, thus making it possible for the following crop roots to easily penetrate into those deeper layers, where they make use of water and nutrients. Plant species with strong root systems can also be used in mitigating soil compaction. It was noted that crops such as corn, sorghum, Sudan grass, common milletrelieve the effects of compaction. Cover crops that grow in winter are suitable for breaking compact layers in the soil, because they can penetrate through those layers when they are softened with plenty of water during this period (which is less likely in summer).

In the course of decomposition, cover crops with a low C:N ratio will release large amounts of organic molecules, such as polysaccharides, which enhance soil structure. That is the reason why the soil is soft in the spring after a crop of legumes. This effect is expected to last only as long as there are biodegradable residues. Cover crops with a high C:N ratio will have a slower release of polysaccharides, which brings about slower soil structure enhancement than in cover crops with a low C:N ratio.

In a symbiotic relationship with the majority of grown plant species (excluding brassicas) live mycorrhizal fungi. The plants provide these fungi with energy, and the fungi extend the zone of the root system, can help the absorption of water and nutrients such as phosphorus. Mycorrhizas settle the cells of root tops, so, as the root is growing, they are dying, on which occasion, glomalin is being released. It is this rejected glycoprotein that contributes to a better soil structure. The practices that stimulate the creation of mycorrhizas, and hence, the creation of glomalin itself, include: the implementation of conservation cultivation, continuous occupation of soil with the living root systems where mycorrhizas can settle, as well as the avoidance of excessive phosphorus fertilization. Therefore, the establishment of cover crops at the time of the year when soil is without the main crop positively affects the formation of mycorrhiza populations.

Fixation of atmospheric nitrogen -It is well known that a large number of plant species live in different symbiotic relationships with microorganisms. This group of plants belongs to all annual and perennial legumes, as well as many other species (mostly grains), with nitrogen fixing microorganisms (bacteria or fungi) developed on the roots. Soil nitrogen fixing bacteria (Rhizobiaceae) are located on the roots of legumes (Fabaceae), which bind atmospheric nitrogen into compounds available to plants, hence reducing the need for additional nutrition of crops with mineral nitrogen nutrients. The intensity of nitrogen fixation depends on the agroecological and soil conditions. In the soils with low nitrogen content, nitrogen fixation is significantly higher. To ensure the fixation of nitrogen, plant seeds are treated with biological products contain in gmicroorganism cultures in order to start symbiotic processes quickly. These symbiotic communities are particularly useful in a cover crop. Red clover, white clover, peas and sainfoin are especially suitable as cover crops in spring and summer, with the accent on importance of several annual lupinus species. In the more arid regions (the majority of Balkan peninsula) white lupinus as the drought tolerant, is the most appropriate. For winter sowing are appropriate Crimson clover, hairy vetch and winter peas. The hairy vetch from early March onwards, secured 2 kg of nitrogen per day, and was proved to increase the yield of corn to such an extent that it justified the use of cover crops. Winter peas, vetch and alfalfa in a cover crop can provide up to 100% of nitrogen for the next crop of potato. In intercrops, legumes transfer significant amounts of nitrogen to the main crop and these values range from 30 to 50% of the total fixation. Also, the adoption of cover crops can reduce losses of nitrogen in the soil and thus preserve it for the next crop. As legume plant residues decompose quickly in the soil and release large amounts of nitrogen, in wet springs, it can cause its leaching into the deeper layers of the ground. This should be considered in the management of such cover crops. These occurrences can be prevented by establishing cover crops with mixed legumes and grasses, which allows a slower decomposition of plant remains.

Soil moisture management – Cover crops consume water, and after their decomposition prevent evapotranspiration of soil moisture. Also, biomass of the plants and the shredded plant residues prevent surface water run-off and improve its absorption into the soil. These positive effects of the utilization of cover crops are expressed fully only if crop residues are left on the soil surface as mulch, while the effect is minor when the crop residues are incorporated in the soil. Mulch is particularly needed in the main crops if the previous crop has not left any residues (corn silage). Cover crop stubble may retain the snow, especially if it is left in different altitudinal zones.

To avoid most of the problems with the lack of water in spring, cover crops should be destroyed at least two weeks before planting of the main crop, which will prevent water loss.

On the other hand on flooded soils, mulch formed from cover crops residues prevent soil from drying and makes production of the main crop difficult. In such situations, the destruction of the cover crop should be delayed, as living cover crops consume water, and may result in the decrease of moisture excess in the soil. Good examples of cover crops are: grass cover crops, rye, which increases organic matter and conserve moisture, sorghum and Sudan grass, whose roots penetrate deeply into the ground and favorably affect the physical properties of the soil, as well as ryegrass, which, in the case of over moist soil, stabilizes inter row space in crops, perennial plantations, on the headlands of agricultural lots and non-agricultural areas. Fodder radish forms a large root, and thus allows the easy infiltration of water into the soil. Xerophyte leguminous plants, yellow lentils and alfalfa utilize water efficiently, and, in cover crops, they conserve soil moisture better than on bare uncultivated soil.

Control of weeds and harmful organisms -Cover crops suppress weeds, reduce damages from diseases, insects and nemathodes, with different mechanisms. Cover crops suppress weeds physically or due to their allelopathic effect. The physical activity is about competitive relations which can manifest as plant shading, resulting in a change in light frequency crops which prevents weed seeds from germinating, or as a mechanical suppression of weed by high-coverage crops (crops of small grains, buckwheat and brassicas). Allelopathic effect is linked with root secretions, which may have a natural herbicidal effect on the weeds. These natural processes can have a negative effect on the main crop (rye, corn), and therefore be taken into consideration.

The introduction of bioactive plants - "plant friends" - can be successfully performed in the biocontrol of cropping systems. They can repel harmful insects (pyrethrum, yarrow), or attract beneficial predators and parasitoids(fennel, cumin, dill, mint, buckwheat), and, in this way, the number of insect pests can be reduced below a level of harmfulness. Cover crops can create a negative environment for diseases, especially those based on mustard or phacelia which are capable of producing compounds that reduce pest populations of nematodes.

Selection and management of cover crops

The reasons and goals for cover crop establishment must be determined prior to the establishment. Manifestation of the use of cover crops and the strength of their effects depends on the site and the season, but a properly set cover crop will almost always achieve at least two or three positive effects. To start with the advantages which certain cover crops allow, the goals should be reduced to one or two primary and several secondary goals. Goals could be: to provide nitrogen, to manage organic matter, to enhance soil structure, to reduce soil erosion, to conserve soil moisture, to provide weed control, to establish biocontrol of harmful organisms and others.

Apart from their benefits, cover crops bear some potential disadvantages (increased seed costs, the increase in the amount of labor, the competition with main crops for soil moisture and nutrients, potential attraction to certain harmful organisms, etc.), which further limits their applicability. When choosing and setting up a cover crop management plan, one should start from setting crop rotations for a longer term, and, for each lot, possible rotational crops should be pointed out, as well as the terms of the sowing and the harvesting of the main crop. It is also necessary to take into consideration some issues such as: local agroecological conditions (the amount of rainfall, the occurrence of early autumn and late spring frosts etc.), main crop needs, system of production (organic or integral, irrigation or no irrigation, conservation or classic processing) etc. In the scope of the abovementioned facts, it is necessary to find time and space for production of cover crops, to determine plant species, as well as the technological model that will meet the objectives.

Table 6. The plant varieties most commonly used in cover crops

Family Species	Impact within a Cover Crop	
Grass (Poaceae)	Barley (Hordeum vulgare) Rye (Secale cereale) Oats (Avena sativa) Triticale Wheat (Triticum sp)	- Erosion prevention - Nutrient adoption from the soil - Increase in organic matter content in the soil - Weed control - Allelopathic action
	Sorghum(Sorghum bicolor sp)	- Erosion prevention - Nutrient adoption from the soil - Increase in organic matter content in the soil - Weed and nematode control
	Annual Ryegrass (Lolium multiflorum)	- Erosion prevention - Soil structure and drainage improvement
		- Increase in organic matter content in the soil - Weed control
(Polygonaceae)	Buckwheat (Fagopyrum esculentum Moench.)	- Weed control - Stimulation of biocontrol - Allelopathic action - Attraction of beneficial insects - Soil structure improvement
Legumes (Fabaceae)	Hairy vetch (Vicia villosa Roth) Woollypod vetch (Vicia villosa ssp. Dasy carpa) Field peas (Pisum sativum subsp. arvense) Lupinus (Lupinus sp) Crimson Clover (TrifoliumincarnatumL) Cowpeas (Vigna unguiculata)	- Fixation of atmospheric nitrogen - Soil structure improvement - Weed suppression
	Medics (Medicago sp.) Red Clover (Trifolium pretense) White clover (Trifolium repens) Subterranean clovers (Trifolium subterraneum) Berseem clover (Trifolium alexandrinum) Yellow sweetclover (Melilotus officinalis)	- Fixation of atmospheric nitrogen - Soil structure improvement - Weed suppression - Erosion prevention - Beneficial insect habitat
Brassicas (Brassicaceae)	White Mustard (Sinapsis alba L) Rapeseed (Brassica napus L. em. Metzg. var. napus)	- Nutrient adoption from the soil - Increase in organic matter content in the soil - Soil structure improvement - Erosion prevention - Biocontrol of soil pests - Weed control
	Forage radish (Raphanus sativus L) Rapini (Brassica raparapifera) Forage beet (Beta vulgaris L. ssp. vulgaris convar. Crassa Alef.)	- Nutrient adoption from the soil - Increase in organic matter content in the soil - Improvement of the physical characteristics of the soil - Biocontrol of soil pests

According to sowing time, cover crops can be established as intercrops (subsequent, stubble, winter), and, in wide-row crops, they can be sowed in inter-row space as intercrops. Cover crops can be established as annual or perennial crops.

Cover crops as subsequent or preceding crop - Cover crops should be established during the period between two main crops, in order to cover the soil surface with biomass throughout the year. After the harvest of the main crop at the beginning and during summer, fast-growing plant species (buckwheat, sorghum, Sudan grass, etc.) are usually used for cover crop to prevent erosion, provide weed control and manage organic matter. Sowing in summer in conditions without irrigation may cause a problem with the lack of moisture for germination of cover crops. The required amount of rainfall should be 100 to 125 mm, what makes cultivation of succeeding crops in the most parts of Balkan questionable due to frequent summer droughts. Therefore, it is more suitable to cultivate subsequent and winter cover crops.

Oat grown itself as the cover crop (photo: Ugrenović, 2016).

When sowing cover crops in late summer and early autumn, when the soil is not occupied with main crops, varieties of winter plants are used. These belong to the grass family, legumes or brassicas and they are used for their resistance to low temperatures.

Before the planting of the main crop, cover crop plants form root sand a significant amount of above-ground biomass. The advantages of such crops are reflected in the enhancement of the soil structure, protecting it from erosion during the winter, reducing nitrate loss and adding organic matter. A destruction of cover crops (Figure 2 and 3) is performed two to three weeks before the planting the main crop, using a roller crimper for cover crops, as well as wood chippers. The delayed destruction during dry springs leads to the risk of losing soil moisture planned for the next crop by the cover crop.

Destroyed cover crops form a layer of crop residue on the soil surface (mulch), which preserves soil moisture and increases water infiltration from precipitation, thus creating favorable conditions for the establishment of the main crop. In such circumstances, the implementation of direct drilling (no till) or partial treatment (strip till) and planting, creates the base of the main crop and the mulch, which will be formed later to prevent weeds and keep soil moisture.

Destruction of mustard cover crop (photo: Ugrenović, 2019)

Cover crops in intercropping -Intercropping represents the growing of two or more crops together in which have a positive competitive ratio (facilitation), and the goal is to increase productivity per unit area. In intercropping, crop yields are often individually slightly lower than when there is one main crop, but their total combined yield is higher. Also, the combination of small grains with legumes provides a higher yield of protein when there is one crop of small grains. In addition to their productive and protective functions with a certain group of plants, intercrops also affect the environment, and thus perform the function of cover crops. In intercrops, soil coverage is better and therefore reduced impact on erosion. If the combined species have complementary needs, i.e. they equally efficiently use resources (sunlight, water, nutrients), then, there is less of it left for weeds to use. Legumes can provide nitrogen for other plant species in intercropping. Stubble of two crops have a more balanced nutrient composition than in a single crop – more favorable C:N. In intercrops, problems with pests are reduced because the pests have difficulties locating and navigating through the crop. In addition to these beneficial effects, intercropping leads to an increase in farm production diversity, as well as to an increase in production safety, because adverse conditions will always affect one crop more than the other, so the one that is less endangered will provide the desired yield.

In intercrops, the crops that are usually combined are generically related to one another (cereals with legumes or cereals with broadleaf crops), which leads to greater manifestation of beneficial effects. For that purpose, plant species tolerant to shade are frequently used, such as white clover, annual ryegrass, rye, hairy vetch, crimson clover, red clover, sweet clover and others.

A cover-cropping combination of two or more plant species, mixed intercropping is often more effective than single cover crops based on only one plant species. By using the differences in biological and morphological characteristics of various plant species, for example, by combining the advantages of grasses and legumes, the objectives set for production of cover crops can be achieved. Legumes in a cover crop with grasses receive a support which allows them to get more sunlight and higher nitrogen fixation.

Intercrops oat and mustard (photo: Ugrenović, 2019)

Intercrops can be grown in alternate rows (e. g. rapeseed and barley, corn and soybeans), with the same or different spacing. One way is growing intercrops in alternating strip (strip-intercropping) with customized width for mechanical cultivation, which allows sowing, cultivating and harvesting every single crop separately. Intercropping with cover crops may be performed by subsequent under sowing of a second crop with the existing one, in sequential or delayed sowing of a second crop with the existing one as an example of the so-called delayed intercropping (relay intercropping). Red clover or alfalfa can be sown together with winter wheat in the spring, and grass species with perennial legume crops in the autumn, which enhances coverage of the soil and provides nitrogen.
Perennial cover crops - Perennial plant species of legume and grass family and mixtures of these are suitable to improve fertility and increase organic matter content in the soil. In several years soil quality can be improved significantly. One of the characteristics of previously mentioned cover crops is that the aboveground biomass forms a living mulch, in which main crop is sown in strips. If it consists of legumes, nitrogen can be transferred to the main crop, and provided for a future crop.

The practice of cover cropping imposes certain problems, such as: labor intensification, the best time to destroy one crop is not the best for another, needless amounts of plant residues. The advantages of the use of intercropped cover crops usually outweigh the shortcomings, but it takes careful management to prevent problems.

Intercropping in organic vegetables production

In organic production system, important biotechnical measure is intercropping of vegetables and other species, along with careful selection of varieties and well adapted crop rotation. Intercropping is appropriate for plants that are competing for sunlight, moist and nutrients.

Between plants exist specific allelopathic interactions also.

Advantage of intercropping is:

- soil is not evenly exhausted;
- yield increase (harvesting index >1) per production unit (space and nutrients are used better);
- less plant diseases;
- less pests;
- more beneficial organisms – predators;
- shade for shade-tolerant crops;
- suppression of weeds.

Crops successfully grown in intercropping can be tall and short plants, with long or short vegetation, plants with similar habitat (heat, moist and sunlight tolerance), plant with deep and shallow root, with more or less biomass, and the most important is that those are species that grow well next to each other.

Types of intercropping:

- mixed intercropping – seeds are mixed before sowing;
- row intercropping – growing different crops on the same field with distinct row arrangement;
- strip intercropping – growing different crops simultaneously on the same field in strips wide enough to permit independent cultivation;
- relay intercropping – growing different crops simultaneously on the same field, where the second crop is planted after the first crop has reached its reproductive stage of growth but before it is ready for harvest.

In companion planting, every vegetable group has three companions: a friendly companion, a bad neighbor and a neutral companion (Table 7). Interactions between friendly companions boost growth and development of vegetables and repel harmful insects, thus protecting neighboring plants.

Table 7. Good neighbors

Vegetables	Interact well
Garlic	carrot, tomato, beet root
Chard	radish, red radish, carrot, French beans
French beans, five beans	Beet root, cabbage, carrot, cauliflower, squash, sweetcorn, tomato
Onion	Beet root, cabbage, carrot, lettuce, potato, strawberry, tomato
Celery	French beans, cabbage, leek, onion, tomato
Beet root	Cabbage, kohlrabi
Pea	Carrot, lettuce, red radish, spinach, sweetcorn, tomato
Cabbage	Tomato, celery, French beans, beet root, onion, marigold, African marigold, chamomile
Cucumber	French beans, broccoli, celery, Chinese cabbage, lettuce, pea, radish, tomato, dill
Potato	French beans, cabbage, lettuce, onion, red radish, beans, sweetcorn
Sweetcorn	French beans, cabbage, leek, watermelon, cucumber, squash
Carrot	Onion, garlic, leek, marigold
Pepper	Carrot, onion, basil, garden orache, pigweed
Tomato	Asparagus, cabbage, carrot, onion, spinach, parsley, pea, basil, dande-lion
Beans	Corn, celery, tomato, melon, carrot, cucumber
Radish, red radish	French beans, cabbage, cauliflower, cucumber, lettuce, pea, squash, tomato
Lettuce	Beet root, cabbage, pea, radish, onion, spinach
Spinach	Eggplant, cabbage, celery, onion, pea, lettuce
Squash	French beans, radish, sweetcorn

Crops that do not get along: celery and carrots; parsley and potato; onion and French beans and beans; garlic and French beans, peas or beans; tomato and potato or peas; cucumbers and red radish; potato and tomato, celery or peas, etc.

Well know is the example of positive effects of growing “Three sisters” together – climbing beans, squash and corn. The corn makes favorable microclimate (retain moisture in the soil) and provides a structure for the beans to climb, while beans fix the nitrogen in the soil, and squash with its large leaves spreads along the ground making shade, blocking weeds and acting as a living mulch. Another good example of intercropping is carrot and onion. Carrot repels the onion fly (Delia antiqua), and the onion repels the carrot fly (Psila rosae).

Onion and carrot in intercropping system (photo: Dreamstime.com 2017)

Some plants just have undesirable effects on vegetables. Dill, therefore will not grow well next to potato; and onion, chives and garlic have adverse effect on growth of beans and the French beans. Pepper grown next to tomato is less vigorous. Also, there are plant attractants, they attract pest: African marigold attracts snails, fava beans and Indian cress attracts aphids, wild cabbage attracts crucifer flea beetle (Phyllotreta cruciferae) protecting brassicas, etc.

Friendly plants can be flowering plants (marigold (Calendula officinalis), African marigold, Indian cress (Tropaeolum majus), fennel…), herbs and medicinal plants (garlic, basil, borage). Beneficial species used in organic vegetable production for flower belts – habitats of beneficial insects (ladybirds, common green lacewing Chrysoperla carnea, parasitic wasp, etc.), predators which are integral part of biological and integral plan protection.

Good neighbors:

- garlic and strawberry (garlic protects strawberry from grey mold (Botrytis cinerea);
- broccoli and Indian cress (against aphids);
- potato and pyrethrum (Chrysanthemum cinerariifolium) repels potato beetle;
- horseradish and potato (repels potato beetle, increases resistance to diseases);
- cucumber and cabbage and broccoli (against crucifer flea beetle);
- cabbage and white clover (repels cabbage whitefly);
- cabbage and celery (cabbage protects celery from rust, and celery repels cabbage butterfly (Pieris sp.);
- cabbage, tomato and onion (tomato protects cabbage from diamondback moth (Plutella maculipennis);
- cabbage and tomato, celery and basil (repel cabbage butterfly Pieris sp.);
- cabbage and red and white clover (against cabbage whitefly (Aleyrodes proletella) and cabbage butterfly (Pieris sp.));
- dandelion reduces fusarium on tomato (Fusarium oxysporum f.sp. lycopersici);
- carrot and marigold, potato and marigold (against nematodes);

- tomato and tobacco with cabbage (alleviates attacks of diamondback moth and repels crucifer flea beetle);
- tomato and African marigold (repels pests in soil);
- beans and red poppy in potato (reduces potato beetle (Leptinotarsa decemlineata));
- lettuce and red radish (lettuce protects red radish from crucifer flea beetle);

Crops that can grow together: sweetcorn and lupine, celery and cabbage, French beans and red radish, beet root or radish; pepper and spinach; carrot and leek; watermelon and sweetcorn; red radish and pea; tomato and spinach, etc.

4.2. Organic fertilization, compost, animal manure

Organic fertilizers which are used in organic production have to be organically produced or to have a certificate that they do not contain antibiotics residues, heavy metals and other harmful material. It is forbidden to use fertilizers from intensive, i.e. industrial production. In order to increase area under organic production Ministry of Agriculture, Water Management and Forestry of the Republic of Serbia designated Working group for creating and updating annually List of plant protection agents and List of fertilizers and soil enhancer allowed for use in organic production. Great part of agents on the lists are fabricated organic fertilizers based on compost, manure, vermicompost and similar. Still, the biggest share of organic fertilizers used in organic production originates from primary production from agricultural holdings. First of all mature manure, compost, vermicompost and other less available fertilizers are in question.

The goal of application of organic fertilizers in organic production is soil fertility increase, improvement of biological characteristics and of soil structure. According to the rules, these fertilizers should come from own farm. If that is not the case, and in order to distribute surplus fertilizers from organic production, producer applying methods of organic production can give this surplus to other producer based on the written agreement or other equally valid document. Essence of organic production is balanced relationship of plant and livestock production. Only in this manner is possible to get enough certified fertilizers for the plant production and enough for the livestock feed.

Total amount of fertilizers used in organic production, manure mostly, dry manure and dehydrated poultry fertilizers and composted animal excrements, including poultry fertilizers, composted manure and liquid animal excrements, cannot exceed 170 kg of nitrogen per ha per year, due to possible soil pollution and water pollution by nitrates.

Besides above mentioned, in organic plant production can be used appropriate treatments based on microorganisms for improvement of soil or availability of nutrients in the soil or crops, suitable products based on oil or microorganisms for compost activation, as well as biodynamic products.

Law on organic production (Official Gazette RS, No. 30/2010) defines management of the entire production. During the control of the authorized control organization, administrative check is obliging, and documentation need to be available in any time. Control comprise check of production area (cadastre plots), species, quantity and date of plant protection and fertilizers application, documented with proofs for their utilization necessity. Law on organic production prescribe that organic production administration should be kept apart from conventional.

Compost

Composting is biochemical process where organic matter is completely decomposed by the microorganisms. Microbiological degradation results in compost, CO2, heat and water. The most frequently composted material is plant waste and animal remains deriving from garden, kitchen, backyard, industry, like vegetable waste, fruit, leaves, stems, cut grass, old hay, ashes, paper, food scraps, etc. Also, leaves and green material of plants are richer in nutrients than brown material (wooden material, cardboard). Suitable ratio C:N should be 25:1, if this is not the case, one might get worthless mass of dark-yellowish (more C) up to greenish (more N) color. Composter should be free from tuberous rhizome weeds, ill plants and other industrial household waste. It is especially difficult to get rid of weed seeds and pathogens that can endure maximum temperatures during biodegrading. Therefore, recommendation is to avoid putting weeds in the composter, otherwise to look that only seedless weeds are put. If such plants get into the composter, weeds might spread when mature compost is applied. For example, giant ragweed (Ambrosia trifida) easily reproduce by seeds – one plant can produce up to 150.000 seeds, able to germinate even up to 40 years! Also, when adding material into compost, first add in less percentage slowly degradable like leaves of willow, poplar, platanus, walnut, needles and branches of confers plants, and so on.

Composting in compost heap is done on place protected from wind and strong sun, approachable in different weather conditions. Also concrete and stone blocks should be avoided as they do not allow microorganisms, earthworms and other beneficial “creatures” to degrade the composting heap. Composting can be done in open space or in boxes specially made for it (composter).

Selection of location and composter building

Dimensions of composting heap are different, it depends first of all from composting material and utilization of the compost. Dimensions of composter in open space and smaller surface are usually 2 m width and 1,5 m height. Layer of soil of 10 cm should be removed and filled out with branches and stems to improve drainage. Composting on open space is not so popular anymore, mostly due to the presence of pests in soil which can significantly diminish fertilizer's quality, but also due to external conditions, above all, high temperatures. The other way of composting is "over" composter mostly of different shapes (rectangular, quadrant, round), of different sizes and made of different material (wood, tin, brick and wire). Every composter contains openings for air flow needed for microorganisms to breathe, otherwise heap would rot very soon. Composter in one average garden is 2mx2mx2mx2m. Composting will speed up if the layer of old compost is put on a drainage level as it would initiate faster degradation of organic matter.

Composter built within project "ABC of Better Me" implemented by the National Association for organic production "Serbia Organica" and Novak Djokovic Foundation (photo: Filipovic, 2018)

Before the composting, it is necessary to break down material to smaller pieces not bigger than 5,0 cm. Then heap needs to be prepared: in case if it is dryer it needs moisturizing and vice versa, to dry with some of structural materials. During the decomposition, temperature reaches (in the middle of the heap) 70°C which lasts about 1-1,5 months. Heap needs occasional turning and to be covered again several times during biodegradation, with the goal of renewal of microflora activity. In that period are most actives fungus, bacteria and collembola, that after the cooling on temperature of 25°C that role is overtaken by earthworms and other insects. In some cases finalization of decomposition can be after six months, still the best compost is the one gained after a year when the heap is totally decomposed.

Shredding plant material before adding it to composter (photo: Filipovic, 2013)

Manual adding plant material to composting place (photo: Filipovic, 2014)

Care of compost includes mixing, cold-fogging, health control and nurturing during composting. As mentioned earlier, heap needs turning for several times during composting for equal degrading of all parts of compost. Turning is extremely important as it aerates heap and provides air for normal activity of microorganisms. Forks, shovels and similar tools are used for turning. With every turning temperature will decrease and then increase again since biothermic processes of decomposing reactivate. Cold-fogging is done in case of over dried compost when mold is evident. If the heap is not over hydrated, it is possible to revive it by adding fresh material, manure, vermicompost, etc. Cold-fogging provides water to microorganisms that cannot survive too long in dried compost. Health control has to be periodically carried out as it can be deteriorated due to high moisture suitable for intense development of pathogens.

Cold-fogging of the compost heap (photo: Filipović, 2017)

In that case a structural material is added and stone derived flour, which neutralizes odor created by the over moisture and the pathogen presence.

Added flour and sand improve physical-mechanical characteristics of compost, and ease up later handling and application. Mature manure is often added to increase nitrogen content of compost. Plant-based teas are added to boost activity of microorganisms during composting. The most commonly used are herbs, medicinal and aromatic plants, and many vegetables. Also are used flowering plants and weeds. For that purpose is mostly used liquid spraying to treat organic waste which is preventing infections and pests to occur on the compost heap. Botanical teas influence faster and more quality mineralization of organic waste via stimulation of microbial activity. Moreover, the quality of future compost will improve, as every plant used in certain level has certain amount of micro and macroelements necessary for growth and plant development. Some of these plants can be cultivated or autochtonous, while abroad botanical teas made out of them can be found as the final product, available online, in different hypermarkets, agricultural shops or specialized stores for organic production. In organic and biodynamic production the most widely used medicinal and aromatic plants' species for this purpose are: stinging nettle (Urtica dioica L.), comfrey (Symphytum officinale Wallwort), dandelion stinging nettle (Urtica dioica L.), comfrey (Symphytum officinale Wallwort), dandelion (Taraxacum officinalis Weber), garlic (Allium sativum L.), horsetail (Equisetum arvense L.), tansy (Tanacetum vulgare L.), yarrow (Achillea millefolium L.), pot marigold (Calendula officinalis L.), valerian (Valeriana officinalis L.), marigolds (Tagetes sp.) and burdock (Arctium lappa L.). For example, in compost preparation, stinging nettle is frequently present as the raw material, and is also a significant component in making compost teas that inhibit microbiological activities in compost.

Nettle in the most suitable phase for composting (photo: Filipovic, 2019)

In order to prevent high insolation, strong wind and rainfall, a layer of soil from meadow or garden, or any other natural material (hay, straw, etc.) should be added. Around the composting place is desirable to grow tall plants (sunflower, corn, etc.) or some of the crops with large leaves (squash, zucchini, etc.). If composting started in autumn, during winter well prepared compost should be covered with layer of straw to preserve temperature in the middle, and prevent microorganisms to abandon compost and return to the soil.

Improvised composter (photo: Filipovic, 2018)

Compost resembles to mature manure, due to its crumble structure, dark brown, homogenous and pleasant odor of soil. Mature compost is consisted of microorganisms and invertebrates, their skeleton and decomposition products, as well as of non-degradable organic matter. Based on our experience, when composting is finalized, compost heap reduces for one third. Moist content in the mature compost is below 40%, on average pH is neutral (mostly depends on composting waste), and carbon toward nitrogen ratio (C:N) is in that moment about 8 (10):1. Active matter content is similar to the ones in the manure, the most frequently contains nitrogen 0,3-0,5%, phosphorus 0,2%, potassium 0,2-0,3% and calcium around 0,6%, which is changeable according to the content of composted material. Before the use, compost should be disinfected on this way usually: in an old barrel a fire should be set as well as the dish with water. On top of this dish is placed an iron net, with the layer of 10-15 cm of compost. In the moment when the vapor passes compost layer, sterilization is finished. This high-quality organic fertilizer is multi-purposeful, mainly is used as a substrate in nursery, vegetable, flower, mushroom production, and so on.

Just before sowing or planting fertilizer is used, in quantity of 3 – 6 kg/m2 with effect up to three years. Compost is put near the soil surface (up to 5 cm depth). Compost is suitable to make substrate mixes, preparation of sowing layer, plant transplantation and as cover layer of seeds.

Solid manure

Manure is mix of animal excrements and plant material (animal bedding). Manure quality depends of type of livestock, bedding and manure age. After 3-4 months manure is usually semi-ready, and after 6-8 months completely aged (Figure 4.12). In the process of aging phosphorus acid and humus material are bonded, which is valuable characteristic for fertility, physical features, water capacity, aeration and soil temperature. Horse and sheep manure have more dry matter, more nitrogen, phosphorus and potassium, thus are more appropriate for heavier and cold soils. Cattle and pig manure have more water, they are colder and more acid, hence decomposes slowly. This is why they are more suitable for sandy soils. Fresh and semi-ready manure are incorporated into the soil before the autumn cultivation, and aged can be used in the spring and summer, right before sowing or planting.

Aged cow manure (photo: Filipovic, 2012)

In organic production on larger area, aged manure is incorporated into the soil during the autumn soil cultivation, in organic garden on the contrary is manure distributing equally on the surface with forks and partly incorporates into the upper sowing soil layer. The most of the manure remains as mulch on the soil surface (1-4 kg per m2). Manure fertilization can be done in the rows and holes. This is rational way of fertilization, still nutrients distribution is uneven. On average 1 t of manure contains 10 kg of nitrogen, 5 kg of phosphorous and about 10 kg of potassium. Effect of manure lasts for several years (up to five), during which plants are able to use nutrients. Manure quantity for use depend on soil fertility, species and cultivation model. Lighter soils are fertilized every 2-3 years, while heavier every 4-6 years, depending on crop rotation. Usually 3-4 kg/ m2 of fertilizers is used in accordance to crop rotation, and soils lacking humus 5-8 kg/ m2. It means that 15-20 kg of manure on 10 m2 provides around 3,5 kg of organic matter, 80-100 g of nitrogen, 40-50 g of phosphorous and 100-130 g of potassium, and decomposing time is 2-3 years. Maximum allowed nitrogen quantity cannot exceed 170 kg/ha, in one year. In the first year 20-35% of nitrogen is used from manure, 20-35% phosphorous and around 65% of potassium.

Manure and compost have many weed seeds digested by livestock. Weeds' seed has highly expressed life capability enabling it to maintain germination energy even under unfavorable life conditions. Straw bedding can also contain large number of weeds' seed. This is why well aged manure is recommended to use as significant weeds seeds are destroyed by the high temperature (above 80°C) created during ageing. During storage manure losses dry matter (10-50%), nitrogen (20-60%), and somewhat phosphorous and potassium (5-20%).

Vermicompost

Vermicompostis is a type of organic fertilizer, product of decomposition process of various species of worms. Californian red wigglers or California's red hybrids are created at the Berkeley University in California during hybridization of different worms during 50s in the last century. This hybrid fosters biomass creation and substrate exploitation.

A day old worms are white and look more like lice until they are one week. From that day worms get pink color which stays for 15 days. Dark red color appears after three months and stays for the end of worms' life cycle. Worms lifespan is around 2 years. Full growth is reached in 10 month of life. Worms are rarely over 5 cm. If they are longer that this and able to survive up to 50°C, they are taken for experimental purposes, to breed new worms, for industrial waste decomposing. Production does not require expensive equipment, and is possible to produce it almost everywhere, in open space (concrete, wooden or wire container) and indoors (garage, balcony or basement). Basic unit for vermicompost is vermiculture. One batch should have 100.000 individuals (adults, juvenile, cocoon), out of which 20.000 to 30.000 are reproductive worms. Usually batch is 100x200x25 cm and as such more volume is needed for feeding, manure handling and finished humus. If it would be expressed in kilograms, in one kilogram there are 5000 worms, which means on average in 20 kilograms is one vermiculture. One standard vermiculture every 100 days is ready to be split to the new ones.

First aim of worms cultivation is humus production, the most refined, the best quality organic fertilizer for all plants' species. Worms digest manure, eating some, but most of it is turned into the humus.

The second goal of vremiculture is for "meat". Science found out that worms' meat contains 67% of proteins. Worms' meat represents suitable high protein food for chickens, fish or pigs as fresh or processed into protein flour. Pigs are given live worms, and in poultry feed worms are preventing cannibalism.

The third goal is fixing some of the problems of human beings environment. This type of worm with some technological alteration, is used for decomposition of feces, waste from big livestock farms, numerous industries and sewage network. Humus produced in this way is not suitable for utilization in agriculture due high percentage of heavy metals (led and mercury), therefore can be used only for stimulation of flower and grassland in industrial zones, also outside of industrial zones on grassland, with special chemical fertilizers and with special mixture.

For worms production is the most appropriate aged manure. For vermicompost every aged manure is good, except of poultry which contains many proteins, making it “hot”. Besides manure, all materials for composting can be used. It is important to avoid materials worms do not stand like coniferous needles, nut leaves, certain aromatic plants and so on. Also, worms eat organic waste in combination with manure, and those are fruit and vegetables waste, hay and leaves, organic food scraps, food industry waste, and as a treat they like the most card boards, with accent on pH to be controlled. The best ground for worms is mixed bovine and horse fertilizers and rabbits feces. Fresh and semi-ready manure is not suitable. In fresh manure worms die due to high temperature of 90°C during fermentation, while worms rarely enter into the semi-ready manure. In Serbia is mainly used mixture of bovine and horse manure, and pH always should be controlled, i.e. acidity that can arouse in mixtures.

Temperature mustn’t go beyond 25 °C. Pigs, chickens, sheep and rabbits manure in Serbia is not used as they need special preparatory technology, even if mixtures are found, in all manure, except pigs, sawdust is used and this type of humus is used for flower production. Rarely is found in agriculture. The first few months, worms will be dying due to acid pH, and it takes a lot of time for worm to adapt.

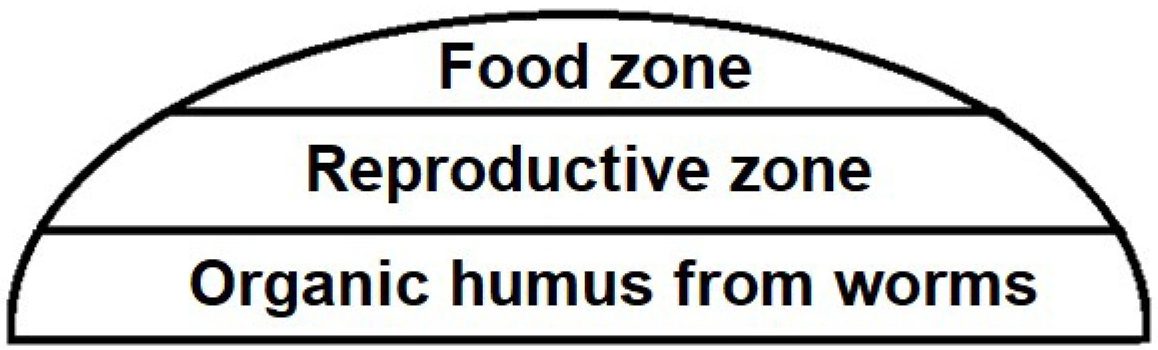
Vermicompost needs to be settle on place protected from wind. Vibration and quivering disturb worms’ normal growth and development. For successful worms production it is necessary to provide optimal agroecological conditions. Above all appropriate pH, temperature and substrate moisture.

pH value- worms are sensitive to substrate acidity. Substrate, food for worms, should be neutral 6,5 – 7,5 pH. If the pH is lower, calcium carbonate ($CaCO_3$) should be added, on the other hand if pH is higher, peat and dry paper should be added, all with the aim of balancing pH of vermiculture.

Temperature – optimum temperature of the substrate is from 20 - 25°C. If the temperature is lower or higher, can be lethal for worms. If the temperature is below 5°C, a thicker layer of organic waste (10 cm thick), should be put. Temperature below 0°C is lethal for worms. Worms preserve during winter in cocoon stadium, enduring extremely low temperatures. Higher temperature (30°C and more), are also unfavorable for worm growth, thus temperature needs to be lowered (spraying water, shading from direct sun).

Moisture – the most adequate moisture for growth and development of worms is 80%. Moisture can be checked manually, pressing manure by hand. If five to six drops of water comes out, manure is moist enough. However, if the moisture is higher or lower, worms abandon batch to search more suitable conditions. More often occurs less moisture, that is regulated by watering.

Before we take batch into the bed, we need to prepare manure according to above mentioned conditions. Prepared manure should be spread all over the prepared soil in the layer of 15 cm in summer, and 25 cm thick when it is colder. In the early winter, on the top of the existing layer should be added at least 20 cm of manure as the frost barrier, if it is not provided otherwise. Every seventh day we put new layer to the bedding. Routine must be respected. Worm from the layer they have already transferred into the humus, naturally switch to the new one. However, by the end of the seventh day, we do not add manure, but wait for two more days. Then we add a new layer of 5 cm manure in the middle of the bed of 40 cm width and across entire bed. Since the food has arrived two days later, hungry worms will run to the new layer. This procedure we repeat after seven days, and in 16 days in the top layer will be 96% of worms, adults and juvenile. A part of belt 40 cm wide is taken with forks into specially prepared containers. Collected worms form base for the new batch which can be sold or used to expand own farm. Just then vermicompost (humus) can be harvested and stored in a sunny, windy place where will humidity reduce to the level suitable for further processing. This fertilizer is just between base and food, taking 15 to 20 cm, black color and its full maturity reaches one year after rearing vermiculture.



Small farm will always follow this pattern, while bigger farms will use special mechanical separator, dividing humus from worms. This humus is still not for use. It will undergo drying, disinfection and enrichment with nutrients which are lacking according to the lab analysis. Agrochemical analysis of vermicompost are done at the very beginning and at the end of the production cycle. This is necessary to get the proper insight into the vermicompost's quality. After analysis vermicompost can then be used, packed and sold.

Vermicompost is usually collected twice per year, in March-April, and September-October. Worm in favorable conditions produce more than 8 batches annually. Each batch gives 1 m^3 of vermicompost. Vermicompost cannot be less than 6 months, and more than 24 months old, and cleared from impurities. Worms in production process do not eat and do not process just manure and other organic materials, they process vermicompost (humus) they themselves produces, meaning they are processing own feces.

The only worm's disease is metabolism disorder due to malnutrition, which we called protein poisoning. Protein poisoning is result of improper diet, after which substrate or worms food is acidified. Calcium carbonate (CaCO3) is then added to balance pH in batches.

Enemies of Californian red worms are divided into two groups: direct and indirect enemies. Direct enemies are animals that eat worms like pigs, mice, birds, poultry, frogs, mole, centipede and snakes. Indirect enemies disturb life, diet and reproduction of worms by its presence. Those are ants, earwig, and so on. In this group we can add human beings who can decimate or even destroy worms with careless handling during production.

Vermicompost is rich in humus (up to 25%), poor in mineral nitrogen (1 to 1,5%), but contains a lot of phosphorus (up to 2400 mg/100 g of soil) and potassium (up to 1400 mg/100 g soil), as well as significant microelements (Zn, Cu, Mn, Fe). Agrochemical analysis of vermicompost and of soil where it will be applied needs to be done before application. Vermicompost is used in mixture with soil, for poor soils mixture ratio is one part of vermicompost and ten parts of soil, while for fertile soils mixture ratio is 1:6. These mixtures are used for plant propagation and vegetables, in gardens and indoor production. Vermicompost is used in 0,2 to 5 kg/m2 as fertilizer. Humus is rich in enzymes, and its maturity depends on moisture and balance between carbon and nitrogen. According to certain authors, one ton of average vermicompost (humus) replaces five tons of manure.

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CHAPTER 5. | DISEASE AND PEST MANAGEMENT IN ORGANIC PRODUCTION

The intensive use of synthetic pesticides in conventional production has a strong and negative impact on the environment, quality of food, and also on human and animal health. By limiting the usage of synthetic pesticides, a direct effect is achieved on reducing the content of their residues in agricultural products.

According to the EU regulations for organic production, as well as our own regional legislation that is in accordance with EU legislation, they do not allow the use of synthetic pesticides, fertilizers, plant growth regulators, and genetically modified organisms (GMO) in organic production.

As the use of synthetic products for the control of pests, diseases and weeds, is forbidden in organic production, the implementation of preventative protection measures is of particular importance. These measures include: appropriate soil management, use of domestic and indigenous varieties that have an advanced level of adaptation to the existing ecological conditions with a natural immunity for defense, as well as cultivation of intermediate and combined crops. Monoculture cultivation can be a significant source of infection, a cause of many diseases and pests, and a factor for intensive weeding. For this reason, regarding the control of pests and diseases in organic production, as well as in weed control, the introduction of crop rotation is a very important and necessary phytosanitary measure.

Prohibited use of pesticides in organic production contributes to the emergence of more virulent attacks of pests and pathogens in organic plants compared to conventional ones, causing the formation of induced defense compounds, which protect the plants from disease or pests.

To reduce the possibilities for plant diseases, pest attacks and weed development, organic farmers should always give priority to genetically resistant varieties (indigenous varieties and local populations) when choosing plant varieties. Through a long period of time, these varieties have adapted to local conditions of production and have acquired adequate immunity to harmful external influences in the production process.

Plant protection in organic production includes the employment of specialized techniques which are based on preventive measures for the good health of plants and soil (agrotechnical and hygiene measures) and on measures for direct protection against diseases, pests and weeds (biological, chemical and physical) that provide plant protection to the economic threshold of harmfulness.

5.1. Preventive measures for pest control

As the use of pest-controlling pesticides within organic production is completely excluded, there is a greater likelihood for the occurrence of a series of negative effects to appear within production. Therefore, pest control in organic production is of paramount importance, and is a sensitive topic that needs to be overseen carefully and professionally. Preventive measures for pest control are: appropriate agrotechnical and hygienic measures, physic-mechanical and biochemical measures (use of some organic and inorganic natural substances).

The implementation of the hygienic measures in organic production is vital for plant protection. These measures include: the hygiene of the producers (clothes, shoes, gloves, etc.), the hygiene of the mechanization (cleaning and disinfection) and removing the affected parts of the plants or removing the whole plant. It is crucial to remember that disease-carriers, i.e. pests, are easily transmitted. For example, before entering a plastic greenhouse, it is necessary to install barriers with disinfectant, and diseased plants need to be burned in a designated area intended for that purpose. At the same time, hygiene measures reduce the risk of microbial contamination and other possible infections.

Preventive and agrotechnical measures are: selection of plot, selection of resistant and indigenous varieties, selection of quality planting and seed material, introduction of crop rotation, as well as proper appropriate soil fertilisation.

Tillage

In the case when tillage is carried out improperly, it can affect a number of degradative processes in the soil (structural disturbance, erosion, reduction of humus content, disturbance in the process of water circulation, nitrogen and other elements). In addition, the disruption of the physical environment is the main reason for the reduction of the number of meso and micro fauna, which contribute to the reduced biological activity in the soil that is necessary in the organic production system.

An important role in the systems of organic production is given to various conservation systems of tillage that must be adapted to the requirements of cultivated plants and soil properties. Conservation processing systems include reducing or completely excluding the number and intensity of soil tillage operations, by retaining part or all of the biomass on the soil surface. The impact of these systems is significant on the balance of water, air, heat, and biological regime of the soil, as well as on increasing the content of organic matter and the positive processes of formation and preservation of soil structure.

Protective tillage, e.g. with chisel plows, is an acceptable variant in organic production in order to reduce soil resistance during tillage and achieve significant energy savings. Of particular importance is the use of chisel plows in perennial plantations and vineyards. For the soils with worse mechanical composition, the use of a vertical tillage machine is recommended.

The soil tillage system adapts to the type of cultivated crop, the crop rotation, the soil type, the quantity and to the way of applying the organic fertilizers. The goal is to maintain the biogenicity of the soil during the entire vegetation period, maintaining a favorable water-air regime, accumulation of moisture reserves and separation of excess water from the soil, good rooting of plants, etc. Particular attention should be given to the exchange of gases in the surface layer of the soil and in the crop. Cultivation measures and digging around the root enable the presence of a sufficient amount of oxygen for “breathing” of the root and for the normal conduction of energy processes, which create conditions for greater activity of aerobic microorganisms.

In the technological process of plant production, the basic tillage during autumn presents the beginning of the soil preparation for sowing the next crop. The function of autumn cultivation is to create a favorable soil structure in conditions of alternating humidity and temperatures of the soil. However, if it is planned to grow a mid-autumn crop, then it is acceptable to perform the basic cultivation of the soil in February or March, before the beginning of the vegetation.

The pre-planting tillage of agricultural areas is performed at a depth of approximately 5-10 cm in order to create optimal conditions for quality sowing or planting. The task of pre-sowing tillage is to remove any soil unevenness created by the basic tillage, to prevent the formation of soil crust, to provide a favorable structure of the topsoil for fast and uniform germination of plants, to destroy the weeds that are in the initial growth phase and prevent water loss through evaporation. Timely and quality performance of all planned operations in soil preparation will contribute to increasing the biological and physical maturity of the soil.

The basic tillage of the soil is performed in autumn by plowing and using different types of plows, usually at a depth of about 20 cm. For plants with a deep and developed root system (alfalfa, corn, etc.) the plowing depth is slightly higher compared to the species that have a less developed and shallower root system. The use of disk plows is recommended for heavy soils or for those with worse mechanical composition. Due to the tendency for minimal soil mixing, and in accordance to the depth of the profile and condition of the plots, the most favourable tools and machines for use in organic production are: chisel plows, light-weight and spike rakes, seed sowing machines, etc.

Pre-sowing tillage

In order to select the most favorable soil cultivation system in our agroecological conditions, it is necessary to analyze the climatic characteristics of the area, soil properties, specific requirements of crops, crop rotation, fertilisation method, and the technical equipment of the farm. When planning the soil cultivation, the effect on the activity of the biological phase in the soil should always be taken into account. Each stage of the soil cultivation must be planned. Optimal agrotechnical deadlines, the appropriate depth, and the use of appropriate machinery must be taken into account. In organic farming it is often necessary to use specific tools or adapt pre-existing tools to the needs of the production process, using the experiences gained in conventional farming.

Use of indigenous varieties

Indigenous varieties and local populations are especially important in organic production because they have an advanced level of adaptation to existing environmental conditions (climate, soil), biotic factors (pests, pathogens) and organic production technology.

The use of indigenous, old, and local populations in organic production is one method to increase the genetic divergence of cultivated plants and their advancement. Their specific adaptation to local conditions is a result of the spontaneous selection made by farmers for generations. Namely, due to long-term exposure to the most aggressive pathogens, there is a decline of non-resistant plant species. In that way groups of resistant plants are separated, and these plants have a created resistance to the dominant pathogens. By sowing the seeds of such plants, farmers produce improved offspring that create natural immunity to defend against disease and pests. Indigenous varieties and local populations, in addition to having an abundance of pest and disease-resistant genes, also have genes for the quality of agricultural products that are permanently disappearing in our region due to the use of commercial variety genotypes and hybrids.

Use of crop rotation, combined and intermediate crops

The symbiotic way of growing and companion planting of plants have a series of positive effects in agriculture, and in organic production, represent the basis of biological methods for soil reparation and preventive measures to regulate and protect against pests, diseases and weeds in cultivated plants.

The introduction of crop rotation in appropriate crop rotation schemes, plays a key role in achieving the goals of organic farming. In order to achieve optimal mutual interaction of the crops and increase the efficiency in the crop rotation, the cultivation of common and intermediate crops is of great importance.

The role of crop rotation and the cultivation of combined and intermediate crops is seen in the following:

- providing sufficient nutrients in the soil and minimising their loss;
- self-sustaining nitrogen supply by growing legumes;
- reduction and preventive control of the presence of weeds, diseases and pests;
- maintaining the level of organic matter in the soil and repairing the soil structure;
- providing sufficient feed for livestock;
- providing profitable production in the existing conditions.

The compilation of the crop rotation scheme in organic production is preceded by an analysis of the most important aspects of its application, which include:

- soil fertility;
- microbiological activity, including fauna and mycorrhiza;
- balance of nutrients and their availability for rotating crops;
- labor and mechanisation needs;
- economic justification of the sowing structure;
- efficient use of resources;
- analysis of the most common weeds, diseases and pests;
- sustainability of the production system;
- impact on the environment and biodiversity;
- climatic indicators, etc.

In the crop rotation schemes of the organic crop rotation, there is a need for an increased share of legumes due to the new positive impact on the soil structure and on the balance of nutrients, especially on providing the soil with the necessary amounts of nitrogen.

- The following basic principles should be considered when planning the crop rotation:
- the crops with shallow roots should be planted after crops with a deep root system;
- crops with a large root system, i.e. root mass to be replaced with crops with a small root mass;
- crops with a sensitivity to weeds should be planted after crops that prevent the development of weeds;
- the crops that have high needs for nitrogen are planted after crops that bind or fix the nitrogen, and in that way, it remains deposited in the soil.

With proper crop rotation it is possible to significantly reduce the occurrence of weeds, diseases and some pests. A significant reduction in the occurrence of weeds, diseases and some pests is possible to achieve with a proper crop rotation. It is highly recommended that the crop rotation be at least a four-field rotation. When compiling the crop rotation scheme, it is necessary to give importance to the ratio of the individual groups of plants, but also the period between re-sowing of the same crop on the same plot. Recommended intervals between re-sowing of certain crops in the rotation are: 5-6 years for red clover, potato and alfalfa, 4-5 years for peas, beans, fodder and sugar beet, 3-4 years for corn, oats, wheat and barley, 2-3 years for soy and rye.

Deviation from these principles of crop rotation can contribute to the occurrence of problems with weeds, diseases and pests, which will inevitably contribute to reduced yields.

Planned rotations of crops in organic production can be adjusted because there is a need for possible corrections during their application.

Examples of crop rotations

I rotation	II rotation	III rotation	IV rotation
2-3 years grass mixture (red clover or alfalfa)	2-3 years legumes -grass mixture	peas or beans	wheat
wheat/green manure	wheat	wheat/green manure	wheat, rye or autumn barley/green manure
potatoes	rye	oats or rye	wheat, rye or autumn barley/green manure
wheat	grainy legumes (soybeans, peas)/ green manure	potatoes	corn or peas / oats
rye	wheat	autumn cereals or mixture of grainy legumes	rye with red clover

Crop rotation in organic production

The combination of crops increases the biological diversity, as well as the efficiency in crop rotation. Cultivated crops on the same plot should encourage each other to grow and thus affect the increase of biomass production and yield, better utilization of resources, reduction of damage from diseases, pests and weeds, and the stability of the system.

The combination of cereals and herbaceous plants has proven to be the best in organic agriculture in terms of utilization of basic resources (water, nutrients, light, heat). There are many possibilities for combining crops, such as: autumn wheat and soybeans, legume cover crops and corn, wheat and soybeans, corn and soybeans, corn and beans, spring barley and red clover, oats and geraniums, corn and pumpkin, onions and carrots, tomatoes and cabbage, peppers and basil, etc. Apart from different types of crops, it is possible to combine different varieties from the same crop.

Intercropping presents growing a crop next to the main crop of the production plot (e.g. beans, peas, clover, etc. in an orchard or vineyard). The main goal of the cultivation of the intercrops is not the yield, but the protection of the agroecosystem, reducing the use of fertilizers and plant protection products, and increasing biodiversity. According to some authors, up to 35-40 t/ha of green mass and 100-200 kg/ha of fixed nitrogen can be introduced by plowing the intercrops into the soil. Proper selection of suitable intercrops improves the efficiency of crop rotation and soil structure, therefore these crops are also an important part of organic production.

However, it is crucial that the method of growing the combined and intermediate crops must be determined by an expert, because improper and unprofessional cultivation compromises the supply of nutrients to the cultivated plants, disturbs the water regime of the soil or eventually these plants may appear as weeds in some of the cultivated crops.

Raising eco-corridors

Additional preventive protection of cultivated crops in organic production can be achieved by raising eco-corridors or barriers with useful plants, which have a protective function for cultivated crops. Eco-corridors are placed along the edges of the plot or around the cultivated plants. Plants that form eco-corridors with their biochemical characteristics stimulate the growth of cultivated plants or may have a repulsive effect on pathogens, pests and weeds. These plants can also be a habitat for some beneficial insects (predators), such as: phacelia (Phacelia tanacetifolia), pot marigold (Calendula officinalis), fennel (Foeniculum vulgare), aromatic or spicy plants, buckwheat (Fagopyrum esculentum), garden nasturtium (Tropaeolum majus), etc. or varieties of plants that attract pests such as the garden nasturtium (Tropaeolum majus), broad bean (Vicia faba) or sunflower that attracts aphids and many others.

Physic-mechanical measures for plant protection in organic production include collection and burning of eggs and caterpillars of insects, as well as infected plants. These protective measures also include setting up barriers or obstacles to prevent or reduce pest damage. Foil is often used as a barrier to mulch the soil and for covering the plants. Barriers of various dry matters (ash, silicon, diatomaceous earth) disperse around plants and injure insects or act as a repellent. For example, ash and diatomaceous earth prevent cabbage fly from laying eggs in the soil. Good protection against cabbage fly can also be mulching the soil with a proper hydro isolation terry paper.

An effective way to deal with harmful insects is to set traps that can reduce the number of insects to a low level. Colored and sticky traps can be used on which insects simply stick. Yellow-orange traps attract carrot fly, and yellow-white traps attract flies and aphids. Sticky pheromone hunting traps “confuse” insects, males lose orientation and are unable to find females for mating. To control aphids, light yellow dishes with water are used, where soap or detergent can be added. Food baits are used to attract snails by pouring beer or yeast into a shallow container and buryingit in the soil. Attracted by the smell, the snails drown in these traps.

Biochemical measures for plant protection in organic production are measures where various organic and inorganic substances from nature are used.

Diatomaceous earth is a sharp powder obtained from the remains of shells and algae and is used as an insecticide. It is used to treat plants together with potassium soap against caterpillars. Insecticidal soaps are special solutions of fatty acids that paralyze and kill aphids (Aphididae), mites (Dermatophagoides pteronyssinus) and whiteflies. Sulphur is used to eradicate mites and fleas. In the attempt to control nematodes (Nematoda), products derived from the crushed lithic coating of shells and crabs are being used. These increase the populations of specific fungi that destroy nematodes.

Finely ground stone flour is also used in plant protection. At the beginning of the vegetation, the plants are pollinated every 8-10 days, while grown plants are pollinated every 2-3 weeks. For spraying, 0,5-2% aqueous solution of stone flour is used, in which algae extract and flour are often added, and in that way, foliar fertilization of the plants is performed at the same time. The stone flour makes the surface of the leaf and the fruit solid, so the insects cannot penetrate into the plant. A vast number of plant protection products have been developed on the basis of stone flour.

5.2. Biological measures for plant protection

Biological measures for plant protection is in fact the utilisation of living organisms - plants, insects, animals and microorganisms (fungi, bacteria, viruses), and the chemical compounds they create, as well as other organic and inorganic matter from nature (plant extracts).

Encouragement of natural regulatory mechanisms and introduction or implementation of permitted products (biological and natural pesticides) are the two bases of biological protection in organic agriculture. These protection measures are most effective with slower-growing insect populations, as sensitive varieties of insect populations grow explosively and have an adverse effect the stability of the biological protection system. In recent times, there is a growing interest in the exploitation of microorganisms in the protection against diseases, pests and weeds.

The natural enemies of plant pests are beneficial insects that can be: parasites and predators. Predators immediately kill their prey and feed on it, while the parasites live at the expense of other organisms, either on them - ectoparasites, or in them - endoparasites. Insects appear as predators from almost all orders that include pests, but not all have the same importance in regulating the number of harmful insects. Insects from the following orders are most commonly used in biological control: Dermaptera - earwig, Orthoptera - orthopterans, Thysanoptera - thrips, Hemiptera - true bugs, Coleoptera - beetles, Neuroptera - net-winged insects, Diptera - two winged and Hymenoptera - hymenopterans.

Some insects are both harmful and beneficial (phytophagous and zoophagous) and often the damage they cause is greater than their benefit as predators. The best example of this is the European earwig (Forficula auricularia), which is a pest in fruit growing, but is also a significant predator of aphids, mites, and eggs of other harmful insects in the fruit growing process. It is similar with the representatives of the order Thysanoptera, which are mainly phytophagous, but some representatives of this order can be predators of mites and small insects. The most famous predator of the order of Orthoptera is the mantis (Mantis religiosa), which feeds on various insects and can eat up to 30 true bugs during the day.

The presence of a beneficial insect is an indicator that nature is not polluted, and at the same time they destroy pests that attack cultivated plants. For example, the ladybug (Coccinellidae) destroys aphids, which prevents some viral diseases (e.g. fading of peppers and cucumbers). Some wasps of the order Hymenoptera (fam. Ichneumonidae) lays eggs on aphids (one wasp can destroy more than 1000 aphids). The European cockchafer (Melontha melontha) and its larvae feed on harmful larvae, caterpillars and insects, while the spider destroys flies and mosquitoes. The European earwig (Forficula auricularia) feeds on aphids at night, some species of mites feed on red spider, etc.

For beneficial insects, the cultivation of beneficial plants that attract these insects is essential. Beneficial plants that attract these beneficial insects include: marigold (Tagetes), garden cosmos (Cosmos bipinnatus), dill (Anethum graveolens), sunflower, fennel, (Foeniculum vulgare), buckwheat (Fagopyrum esculentum) as well as hedge bindweed (Calystegia sepium) and garden angelica (Angelica archangelica) attract ladybugs, yarrow attracts wasps, bees and ichneumonids, etc.

Review of some predators and parasites

pests	predators and parasites
aphids	ladybug, raspberry gall fly (Lasioptera rubi Heeger), aphid lion larva (Chrysoperla carnea), ladybug larva, parasitic wasps
white aphids	parasitic wasps, predatory true bugs
California flower thrips	mites, flower bugs of the genus Orius
red spider	predatory mites, flies, ladybug larva
leaf miners	parasitic wasps
owlet moths	parasitic wasps
flies larvae	nematodes, parasitic wasps
Colorado potato beetle	true bugs
garden flies	nematodes
mole cricket	nematodes
snails of the genus Limax	nematodes

Biological pesticides are plant protection products that are prepared on the basis of microorganisms - viruses, bacteria, fungi and plant extracts.

Substances secreted by bacteria and fungi can affect the growth and health of plants, or compete with harmful organisms. Fungi are used to control harmful insects and nematodes, or as antagonists in fighting other harmful fungi.

From the metabolic products of the fungus Strobilurus tenacellus effective fungicides Strobilurin are extracted, the fungus Verticillium lecanii is used to control aphids, Beauveria bassianato for the control of Colorado potato beetle (Leptinotarsa decemlineata), certain aphids and other pests, Coniothyrium minitrans for the control of fungi that appear in lettuce and other vegetables, Paecilomyces lilacinus for the control of nematodes, etc.

Bacteria are the most commonly used microorganisms for the preparation of biological pesticides. The most widely used is the bacteria Bacillus, whose products have been used for 40 years in plant protection. Products of this bacteria are particularly harmful to leaf-eating insects, primarily caterpillars of various butterflies and other beetles from the Coleoptera order, such as the Colorado potato beetle. For example, Bacillus thuringiensis var. tenebrionis is used to suppress caterpillar of beetles from the Coleoptera order, while Bacillus thuringiensis var. kurstaki is used to suppress butterfly caterpillars. Different strains of the bacteria Bacillus suptilis are used to control pathogenic fungi in the soil and to control bacteria and fungi that cause various diseases such as: grey mould, powdery mildew, rust on plants, leaf spot, etc.

The metabolism of the terrestrial bacteria Saccharopolyspora spinosa produces the substance spinosyn which is used as basis of the product “Spinosad”. This product has a high insecticidal effect and is used against caterpillars, larvae of the order Diptera and many other insects.

Plant protection products prepared on the basis of viruses are also used in organic production, but to achieve satisfactory results they need to be reused several times and often in combination with other protective measures. This is because these products have a slow effect, high dependence on climatic conditions, photo-lability and have a short-term effect.

Natural pesticides obtained by plant extraction can also be very effective in biological control. One of the first extracted natural insecticides is pyrethrin, which is obtained by extracting the flower of the plant pyrethrum (Tanacetum cinerariifolium). It is used in the protection of various crops, especially vegetables grown in a protected area, because pyrethrin is unstable to light. This insecticide can also be used to control insects in households and warehouses.

Ryania is an insecticidal alkaloid which is obtained from the plant Ryania speciose, and used as a contact and stomach poison against caterpillars of butterflies and moths. Rothenone is a powerful insecticide used against insect bites and is derived from the root of the legume Derris elliptica, which grows in Southeast Asia and some Pacific islands. Strong insecticides are the so-called "neem extracts" which are extracted from the seeds and other parts of the tree Azadirachta indica which grows in Asia, Africa and Australia. These natural pesticides in small concentrations, up to 1% act on aphids, whiteflies, caterpillars, and etc. while in high concentrations up to 70% are used to suppress various plant diseases (downy mildew, powdery mildew, rust on plants, grey mould, etc.)

In biological control of plant health, small animals such as frogs, hedgehogs, bats, and certain birds - great tit, woodpeckers, turkeys and guineafowl destroy Colorado potato beetle. A pair of great tits (Parus major) collects up to 300 - 350 different caterpillars per day to feed their young.

5.3. Natural products for pest control

Natural plant protection products used in organic production can be bactericidal, fungicidal, or aid in a variety of ways to reduce the attack of pests and the spread of some diseases. Their use additionally helps maintain good health condition of the plants, which creates greater immunity of the plants. These products are usually applied foliar - through the leaf or by watering the soil near the root. Many natural remedies can also be prepared in households.

One of the ways to reduce pest attacks is to grow some plants that with their biochemical properties have a positive effect on the growth of cultivated plants, and repel some pests. The environment in which a crop is grown is also home to many other organisms in which most of them are beneficial. Russian farmers have long sown chamomile (Matricaria chamomilla) among grain, believing it improves grain growth. Today it is confirmed that only one plant of chamomile protects an area of 1 m² to prevent an appearance of grindal worms (Enchytraeus buchholzi). Chamomile positively affects all plants and crops, so it should be sown wherever conditions allow. Pot marigold (Calendula officinalis) can be used to control white worms, because white worms escape from the evaporations of the root of pot marigold. It is especially useful when grown in symbiosis with carrots. In addition, marigold is a medicinal plant and its flower can be dried and used for tea.

The plant garden nasturtium (Tropaeolum majus) has an extremely high percentage of antibiotics, and can be used as a food, both fresh and as a salad. This plant is an annual creeper that can reach a length of 2 m. Two such plants sown next to a fruit tree and wrapped around it greatly suppress the aphids. Plants attacked by aphids are best to be sprayed with a prepared porridge of crushed leaves of this plant.

Some vegetables are also good for plant protection. For example, garlic is a deterrent for the white worm, while planted between the rows of strawberries helps the strawberries to be tight. Horseradish planted at the ends of the potato plantation will help to obtain healthier tubers, and planted next to the cherry prevents the appearance of Monilinia that causes rot.

Cumin planted near the potato plantation will improve the taste of the potato, while the taste of the tomatoes will improve the parsley planted near the plantation. Parsley also has a positive effect against some parasites in leeks. Lily of the valley (Convallaria majalis) along with raspberries or currants will increase the immunity of these plants. Many other preparations as well as extracts can also be prepared, and some of them can already be purchased as ready-made products. In organic production, plants whose substances have a nematocidal effect are also used: marigold (Tagetes), garden nasturtium (Tropaeolum majus), pot marigold (Calendula officinalis), beet (Brassica), white mustard (Sinapis alba). Also, the oils of some plants, such as the ethereal oil thymol have a good effect in suppressing nematodes (Nematoda).

Chamomile in cereals

Marigold (Tagetes)

Natural pest protection products in organic production are usually prepared as:

- Tea made from fresh or dried parts of plants that are steamed with boiling water and left for about 15 minutes, after which it is strained and cooled.

- Stew is prepared with chopped parts of certain plants that are poured with cold water and left for a few hours. Then the stew is boiled for 15-30 minutes, cooled, filtered and the liquid is used for treatments.

- Fermented extracts are prepared by soaking fresh or dried plant parts in cold water and leaving them open until boiling. This content is occasionally stirred for 7-12 days. Fermentation is complete when the plant parts have fallen to the bottom of the pot and the liquid is clear. Before the treatment of the plants, this extract must be diluted with water (1 part of the extract and 20 to 50 parts of water).

- For the preparation of macerates or preparations for plant protection, some types of vegetables are used, wild plants, aromatic, medicinal and spice plants.

Application of some home plant protection products

disease / pest	natural protection product
spiders	tea from above ground parts of potatoes
mites (Dermatophagoides pteronyssinus)	pyrethrum tea (Tanacetum cinerariifolium)
insects	onion and garlic tea, pepper stew, marigold macerate (Tagetes)
onion fly (Helomyza lurida)	garden rhubarb tea (Rheum), fermented garlic extract
owlet moths (Noctuidae)	wormwood stew, edible burdock macerate (Arctium lappa), fermented garden nasturtium extract (Tropaeolum majus)
cabbage root fly (Chortophila brassicae)	wormwood stew, tomato macerate
cabbage caterpillar (Pieris brassicae) small cabbage white (Pieris rapae)	tomato stew, edible burdock macerate (Arctium lappa)
caterpillar larvae	lawn daisy macerate (Bellis perennis)
aphids (Aphididae)	nettle macerate, fermented wormwood extract, fermented garden nasturtium extract (Tropaeolum majus) dandelion tea (Taraxacum officinale), pyrethrum tea (Tanacetum cinerariifolium)
nematodes (Nematoda)	fermented pot marigold extract (Calendula officinalis) and fermented marigold extract (Tagetes)
downy mildew	onion tea
grey mould (Botrytis sp.)	common yarrow stew (Achillea millefolium), onion tea
rust on plants (Phragmidium spp.)	common yarrow stew and tea (Achillea millefolium), field horsetail stew (Equisetum arvense)
powdery mildew	field horsetail stew (Equisetum arvense), garlic tea

Recipes for some teas, stews, macerates and extracts

Teas:

- Onion tea (Allium cepa) - this tea acts against insects, stains, downy mildew, etc. It is prepared with 200 gr of dried leaves of onion bulb that are poured over hot water (40oC) and left to stand for 4-5 days and then it is filtered. With this solution the plants are sprayed three times at intervals of 5 days. From a bucket half-filled with the leaves of onion bulbs,10 l of boiled water can be poured, and after a day to strain and dilute the resulting amount with double the amount of water.

- Dandelion tea (Taraxacum officinale) - this tea is used to suppress the aphids. It is prepared with 300 gr of chopped root or 400 gr of fresh leaf of the plant, which is poured with 10 l of hot water (40oC), and filtered after 1-2 hours. Dandelion root should be stored in a cool place (in the basement) until use.

- Garlic tea (Allium sativum) - used against pests and powdery mildew. It is prepared by pouring 700 g of garlic with 10 l of boiling water, then covering it and leaving it to stand, and then straining it. Diluted (1:3 parts water) it can be used for spraying the cucumber against the downy mildew and in undiluted form it is also used for direct soil treatment.

- Chamomile tea (Matricaria chamomilla) - one tablespoon of dried chamomile flower is poured with 1 l of boiled water and the dish is covered and left to stand for up to 30 minutes. It is then filtered and used to disinfect the seeds.

Stews:

- Tomato stew (Solanum lycopersicum) - used against cabbage butterflies (Pieris brassicae, Pieris rapae). It is prepared with 4 kg of fresh, healthy, above ground parts of the plant and the root of the tomato, which are poured with 10 l of water and thus boiled at a moderate temperature for 30 minutes. Then the broth is cooled and strained. Before spraying, dilute with double the amount of water and add potassium soap (40 gr per 10 l).

- Pepper stew (Capsicum annuum) - used against various insects. It is prepared with 100 gr of finely chopped fruits of hot pepper that are poured with 1 l of water. The stew is boiled in a closed enamel dish in which it will then stand for two days. The soup is filtered and stored in a closed container in a dark place. For spraying against insects, take 100 g of the stew and dissolve it in 10 l of water by adding 40 gr of potassium soap.

- Field horsetail stew (Equisetum arvense) - used against powdery mildew and rust. One kilogram of fresh above ground part or 150 gr of dried plant washed in August, when the content of silicic acid is at the highest point, is poured with 10 l of water and after 24 hours it is boiled for 30 minutes. Then cool, strain and dilute with water in a ratio of 1: 5 before use. The plants are treated every 2-3 weeks, and in severe attacks every three days. Spray the plants and the soil next to the plants in sunny weather.

Macerates:

- Garlic macerate (Allium sativum) - used against downy mildew. It is prepared with 30-40 gr of garlic, which is ground and immersed in 10 l of water. Stir well and leave for 24 hours, then strain. With this solution the plants are sprayed every 10-15 days.

- Nettle macerate (Urtica dioica) - used against aphids (it is also an excellent fertilizer). One kilogram of nettle is poured with 10 l of water and left to stand for 24 hours, then filtered. With this solution the plants are sprayed once a week, and in case of a stronger attack every three days.

- Marigold macerate (Tagetes) - used against aphids. Half a bucket of dried plant parts of stinking roger in the flower stage is poured with 10 l of water and is left for two days. Then strain and add 40 gr of potassium soap.

Fermented extracts:

- Garlic extract (Allium sativum) or onion extract (Allium cepa) - is used against land pests and to create disease resistance. It is prepared with 30-50 gr of fresh garlic or onion bulb and 10 l of water and left to ferment for three weeks. The extract is then filtered and diluted with water in a ratio of 1:10 and is used to irrigate the soil, however with a ratio of 1:20 it is used for foliar treatment.

- Nettle extract (Urtica dioica) - is prepared with 1kg of fresh or 200 gr of dry nettle with 10 l of water and left in a wooden bowl to ferment for two weeks, with the addition of a handful of stone flour that removes the unpleasant odor. The filtered extract is diluted with water in a ratio of 1:10 and used to fertilize the soil, and in a ratio of 1:20 for foliar plant nutrition and seed disinfection.

- Dandelion extract (Taraxacum officinale) - is prepared with 2 kg of fresh leaves and flowers or 200 gr of dried dandelion soaked in 10 l of water and left to stand for 24 hours, then filtered. Undiluted extract (pure or with the addition of nettle extract or horsetail) is used to fertilize the soil to increase plant resistance.

5.4. Weed control

Weed control in organic production consists of preventive measures and direct control measures within the production technology.

Preventive measures are an important component of the weed control strategy, whose function is to prevent the recovery of seed reserves and other reproductive parts of weeds, in order to prevent them from spreading to crops. Preventive measures to control weeds include: proper treatment of harvest residues and other by-products of primary agriculture (proper use and storage of the stable manure and other organic fertilizers), crop rotation, growing intermediate crops (intercropping), cultivation of combined crops, utilization of allopathic relations, etc.

Since no synthetic herbicides are used in organic farming, weed control begins with the choice of production plot (appropriate location). Soil cultivation is an especially important part of weed control. In addition, effective weed control involves the timely application of appropriate mechanization and proper crop rotation, i.e. the introduction of crop rotation with the simultaneous use of green manure, intermediate crops and cover crops that do not allow weed development.

With appropriate cultivations of the soil, both basic and multiple, before planting or sowing of crops, the growth of weeds is provoked and their mechanical destruction is performed. In dry periods, it is necessary to irrigate in order to provoke faster growth of the weeds and their destruction before the final preparation of the soil for planting or sowing.

Based on the relation between cultivated plants and weeds, i.e. the level of their mutual competition, it is imperative to decide when the best time is to suppress weeds and which machines and tools is will be used. Also, the use of quality stable manure and compost reduces the possibility of weeds spreading through the seeds of these fertilizers.

Different direct weed control measures can be used: mechanical, physical and biological. In organic production, mechanical and physical measures are always preferred, while the use of organic certified bioherbicides is recommended only in cases of more serious conditions.

In the mechanical control of weeds the most important measure is tillage, whether it is a basic or additional soil cultivation, or cultivation of the soil as a component of crop care measures. Also, the measures for mechanical weed control include the sowing of the crops as an extremely crucial and complex agrotechnical measure. The way in which sowing affects the mechanical control of weeds is primarily by choosing good seeds, respecting the optimal sowing dates, and achieving the best density for a particular type of crop. Increasing the distance between the rows, and decreasing the distance into the row by adjusting the approaches of weed destroying machines establishes good control over their emergence. Good soil covering is achieved by quick and even immediate sprouting of the cultivated crops. This increases the competitiveness of the cultivated crops in relation to weeds, and in particular for the crops that are densely laid.

The degree of weeding is significantly reduced by implementing appropriate mechanisation from different types of cultivators, rake tools and mechanized burning of weeds with flame or hot air. In addition, weeds can be destroyed mechanically by cutting the above ground weed plant parts before the crop germinates, then by digging, using different cultivators with working parts in the form of small hoes or combs. Weeds that appear in the planted rows need to be manually dug up and uprooted using a variety of hoes and hand tools.

The most important physical measures to control weeds are: the use of flame to suppress weeds and their reproductive organs, the use of foil or some organic materials that prevent the appearance and growth of weeds, as well as the use of various roofing materials (mulching).

Mulching is a very effective weed control measure that reduces labor costs and successfully prevents weed growth. In organic farming it appears as a common practice especially in vegetable, fruit production, and viticulture. Weeds are much less likely to germinate on mulched surfaces, so weeding is both less probable and more infrequent.

Organic matter, i.e. various crop residues, photodegradable foils and mulch paper are more prevalently used for mulching. These materials can be easily removed from the surfaces or slowly decompose and sink into the soil. These mulching materials can be considered as herbicides that are absolutely non-toxic and harmless to plants, soil, and humans.

Mulching is more commonly performed by scattering large amounts of organic matter (straw, old hay, sawdust, etc.) in the rows where the production takes place. In this manner, the conditions for growth and development of weeds are reduced, the soil moisture and temperature are regulated, and the soil is enriched with organic matter all at the same time. Organic mulch also provides shelter for many beneficial organisms. It is especially useful on heavy, poorly permeable clay soils, or on highly permeable and sandy soils, where water is lost very quickly through the soil into the deeper layers.

After heavy rains organic mulch in a layer of 5-8 cm prevents soil compaction and formation of soil crust while retaining soil moisture. It facilitates the rooting of young, freshly planted plants and ensures better growth in the initial period of development. It protects the plants from the strong sun rays and helps to preserve the oxygen in the soil (aeration).

With the use of photodegradable transparent foils under the influence of sunlight, i.e. solarisation, the soil is heated through these foils, the weed seeds are encouraged to germinate, and then the newly germinated weed seeds suffer from high temperature. This provides excellent conditions for weed control in organic production.

Possibilities for mulching with plant residues

material	basic benefit	time for application	application way
compost	enriches the soil, increases fertility, destroys weeds, warms the soil	during planting and throughout the year	covering one or more times around the plant
mowed grass	enriches the soil with nitrogen and organic matter	during planting and throughout the year	in a layer of 1-4 cm around the plant
mulch paper	well destroys weeds, retains humidity	during planting	The paper is placed and fixed with soil or other type of mulch
pine needles	well weeds, retains humidity	during planting and as winter covering	in a layer of 2-4 cm, not used for plants that do not tolerate acidic soils
straw	enriches the soil, well weeds, cools the soil	during planting and as summer covering	in a layer of 8 cm around the plant, but not touching the plant, the best one is oat straw
sawdust, wood chips and chopped bark	well weeds, cools the soil and и retains water	during planting and throughout the whole year	it is best to compost before use, it is used in a layer of 1-2 cm

Mulching ways

Biological measures for weed control are based on the use of bioherbicides that are essentially chemical compounds produced by living organisms (plants, animals and microorganisms). Phytopathogenic microorganisms used as herbicides must be genetically stable, multiply rapidly and easily, and have a short incubation period to ensure stable weed-wide infection.

Some of the preparations used in the organic production for weed control are made on the basis of corn gluten (for suppression of weeds in the germination phase), and on the basis of apple cider vinegar, clove oil, cinnamon and lemon. Even salt water has been shown to be effective in controlling weeds, but is only effective for annual weeds.

These measures include the use of predators that destroy weeds. The application of bioherbicides is the ultimate measure, to be used only in circumstances where other measures prove to be insufficiently effective.

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CHAPTER 6: | ARABLE CROPS

6.1. Introduction and concepts

Successful organic production of arable crops is carried out on well supplied soil with organic matter, rich in living organisms, with good structure and good water-air properties. In such soils, the fixation of atmospheric nitrogen and the cycle of circulation of substances can take place effectively, including the organic materials from farms and fertilizers that are allowed in organic production.

Production of arable crops is closely related to livestock production where plant products are used, while plant production uses by-products from livestock production. This is the main goal and is especially important for organic farming systems that prefer a closed cycle of organic matter.

In organic production of arable crops, introduction of crop rotation (annual and perennial crops) is very important and is especially emphasized. On the basis of crop rotation rules for alternately changing deep-root (alfalfa) with shallow-root crops (cereals), the crops are expected to preserve soil potential. To maintain soil structure and provide good drainage, legumes (nitrogen fixers) are replaced by crops which are large consumers of nitrogen. Also, crops that develop large biomass of the root system are replaced by crops with a small root system, large water consumers with small water consumers, etc.

The selection of varieties in organic arable crop production should be aimed at selecting adaptable varieties and genotypes that have natural resistance to the external climatic influences, as well as diseases and pests. The seed that is used in production needs to be produced organically or if it is procured from conventional production, it is necessary to prove that the seed has not been treated with chemicals.

The soil cultivation system is adapted to the crop type, crop rotation, soil type and method of fertilization, i.e. the method of application of organic fertilizers. The method of soil cultivation should ensure balance of water, air, heat and biological regime of the soil.

The sowing of arable crops should be performed within the optimal deadlines, with a density that is adapted to the crop itself. In most arable crops, the above ground part of the plants grows more slowly at the beginning of the vegetation, compared to the faster development of the root system.

In order to provide the plants with optimal amount of nutrients during the whole vegetation, and especially in its critical periods, organic fertilizers are used for fertilizing the arable crops. These include stable manure, compost, peat, humus, vermicompost and green manure. Lime, marl (sedimentary rock, soft limestone) or dolomite can be used to enrich the soil with calcium. Among the phosphorus fertilizers: phosphate and bone flour, Thomas phosphate fertilizer, etc. can be used. Also, standard potassium fertilizers, sulphates and chlorides are introduced to supply the soil with potassium. By using some microbiological fertilizers, the soil is provided with the necessary substances, so with the application of the product "phosphorobacterin" (Bacillus megaterium var. phosphaticus) the soil will be provided with phosphorus, while the product "silicobacterina" (Bacillus circulans) will provide the soil with potassium.

As with all other systems of organic production, in the production of organic arable crops, the application of hygiene and crop care measures is of paramount importance in the process. Their regular and proper application provides prevention against weeds, pests and plant diseases.

There are several divisions of arable crops, but the most acceptable is the division according to the use in the economy, made by prof. V. Đorgević (quoted by Vasilevski, 2004), according to which arable crops are divided into the following groups:

1. Cereals - grain starchy plants;
2. Grain legumes;
3. Plants for technical processing:
    a) for oil production;
    b) for hair production;
    c) for the production of sugar, starch and alcohol;
    d) for the production of India rubber;
    e) aromatic, spicy and medicinal plants and
    f) for technical processing (tobacco and hops);
4. Plants for animal feed:
    a) root-tuberous;
    b) grasses and
    c) other plants for animal feed.

6.2. Industrial crops

The most important industrial crops, i.e. crops for technical processing in our region are: sunflower (Helianthus annuus), oilseed rape (Brassica napus), flax (Linum usitatissimum), hemp (Cannabis sativa), sesame (Sesamum indicum), some medicinal plants, aromatic and spice plants (fennel, mint), etc.

Oilseed rape (Brassica napus) is a very suitable crop for growing in organic production. Because it has a well-developed root system and a large above ground biomass, this crop is an important part of the crop rotation, and is an ideal pre-crop for many crops, especially cereals. Good pre-crops for oilseed rape include: potatoes, early vegetables, small grain cereals, etc. Oilseed rape seeds contain up to 49% high quality oil and 18-25% protein, and are used for the production of edible oil, oil for technical purposes in the textile and leather industry, and for the production of paints, varnishes, biodiesel, soaps, etc. This crop is also used to feed livestock, both fresh or canned (silage).

Growing conditions:

Oilseed rape does not tolerate monoculture production and should be returned to the same plot after 5 years. Oilseed rape does not have any special requirements regarding pre-crops, but the most successful oilseed rape production is obtained after pulses, green fodder crops, green manure crops, and especially after clover.

Light sandy-loam soil is the most suitable for the production of oilseed rape, but it can also be successfully grown on deep, fertile, and carbonate soils. The soil should be rich in humus and well-fertilised so that the plant has access to many nutrients. The needs of this crop are similar to those of other arable crops. The soil should not have a pH value lower than 6, and in case the pH value is lower than 6, it is necessary to calcify the soil at least one month before sowing.

Oilseed rape (Brassica napus)

Oil from oilseed rape

Production techniques:

Shallow tillage and soil raking should be done if the soil is too compacted. Basic deep tillage is performed at a depth of 25-30 cm, no later than three weeks before sowing so that the soil tightens naturally.

When manually sowing, holes for the seeds are marked in the soil. Sowing is performed with non-germinated or germinated seeds - shallow in the soil (2-3 cm) or seedlings at a depth of 3 to 5 cm. Sowing can be done by a rowing machine at a distance of 30-40 cm between rows. The most optimal time for sowing oilseed rape in our region is from the end of August to the beginning of September.

In the early stages of plant growth, the soil temperature should be from 12 to 15°C. The warm climate helps the growth and development of oilseed rape, because it is a very sensitive crop to low temperatures. In the case temperature staying between 2 to 4°C lasts longer than 3 days, the yield can be halved. At a temperature of -1°! plants are completely destroyed.

In order to achieve a good yield in organic production of oilseed rape, and in accordance to our agroecological conditions, fertilization with 120-160 kg/ha nitrogen, 80-120 kg/ha phosphorus and 140-180 kg/ha potassium is required. In cases when a crop of the Fabaceae family is a pre-crop of oilseed rape, or if more nitrogen is added during fertilization, vegetation might continue, i.e. increased growth and reduced resistance of oilseed rape during the winter.

Since oilseed rape shares the same diseases with cucumbers it is not recommended to produce oilseed rape or cucumber in the same place for at least 4 to 5 years. Oilseed rape suffers from the common diseases that occur in pumpkins, but the most common diseases that occur are: white mold (Sclerotina sclerotiorum), downy mildew of rape (Peronospora brassicae) and black spot of rape (Alternaria brassicae). Diseases occur most often in the rainy season. In order to control diseases spraying with copper products can help, but it is especially important to apply preventive measures for protection and crop maintenances. The degree of disease incidence during germination can be reduced with good pre-sowing tillage, in order to achieve a lighter soil structure with more abundant fertilization. These measures also help to reduce drooping or rot of the stem caused by the fungi Fusarium and Sclerotinia.

In order to obtain the highest percentage of oil in the fruit, the harvest should be performed at the stage of full maturity of the fruits. This is when the seeds in the fruit turn black and are not yet fully hardened. Harvesting should be done in the morning and at the shortest possible interval. If oilseed rape is grown for green fodder, then it is harvested from the beginning of flowering, which in our agroecological conditions is in the last 10 days of March, until the end of April.

6.3. Cereals and pulses

The most important cereals in our area are: wheat (Triticum sp.), barley (Hordeum vulgare), oats (Avena sativa), rye (Secale cereale), rice (Oryza sativa), triticale (Triticosecale), corn (Zea mays), etc.

Cereals are crops of temperate zone. The biological minimum for germination is 4-5°C, a temperature of 10-12°C is required for the formation of the generative organs and for maturation. High temperatures above 30°C significantly shorten the vegetation period and reduce the yield. These crops are most suitable on fertile and humus soils with a neutral pH reaction (6-7). Soils with a more acidic pH reaction (up to 5,5) can tolerate rye and triticale (5,5-6).

Cereals do not require very deep tillage, but the soil should be supplied with a sufficient amount of readily available nutrients because cereals, in terms of mineral nutrition, have one of the largest demands. Especially as some crops such as wheat, have a root system that develops in the surface layer of the soil and has a low suction power, it is necessary to carry out fertilization in a timely manner and in sufficient quantities. By using green manure from red and white clover, sufficient amounts of nitrogen will be introduced into the soil to achieve the desired yield. For example, to achieve a yield of 4 t/ha wheat uses 100 to 200 kg of pure nitrogen from the soil.

The implementation of preventive measures for protection against diseases, pests and weeds is extremely important in the cereal production. During May, the most common pest of cereals is the cereal leaf beetle (Lema melanopus) which does great damage to the leaves. It mainly attacks oats, barley and wheat. Delayed sowing and the long germination phase can be the cause of certain diseases. Among the diseases of cereals, the most common are the diseases caused by the fungi Tiletia sp. and Fusarium sp.

The cereal harvest must be fast and well organized to reduce yield and quality losses. The highest yield and quality are achieved at the end of the wax maturity of the grain when the moisture in the grain is between 20 and 26%. Among the cereals, barley, triticale, rye, wheat, etc. ripen the fastest. In the plain areas, the harvest is usually carried out in the second half of June.

Due to the good agronomic characteristics and the quality of the grain, the wheat variety spelt (Triticum spelta) is very suitable for cultivation in organic production. The protein content of the grain of this wheat can be quite high (13-15%). Due to its high nutritional value, it finds various use in human nutrition, but it is also used for animal feed. There are winter and spring forms of spelt, but for our region winter forms are more favorable, from which larger and more stable yields are obtained.

This variety of wheat tolerates infertile soils and soils with excessive soil moisture than ordinary wheat. Compared to common wheat, spelt is also more resistant to disease, while due to the higher levels of above ground biomass, it suffocates grasses and broad leaf weeds. Since plants of this variety form a larger crop covering, they protect the soil well during winter from wind and water erosion. The powerful root system allows the plants to use the nutrients from the deeper layers of the soil. These are some of the reasons why this variety of wheat is recommended to be grown in organic production.

Growing conditions:

Spelt is a very adaptable and tolerant culture to adverse external conditions. There are modest needs in terms of climatic and soil conditions. Since it is quite resistant to low temperatures, it can be grown at 1200 m above sea level. In terms of water, spelt have slightly higher needs than common wheat because it develops a larger leaf mass. It tolerates lower pH values well, but thrives well on soils with pH 6,0-7,5.

It is grown in the crop rotation as an alternative crop of winter wheat. Spelt is a good pre-culture for trench crops. Since spelt, barley and wheat attack the same pests, in order to interrupt their life cycles, it is recommended to introduce oats in the crop rotation immediately after harvesting the spelt but before sowing the barley and wheat. It can be sown as a crop with some perennial crops, or as a protected crop.

Production techniques:

The basic tillage depends on the type and humidity of the soil and is performed at 15-25 cm. Since the seeds are sown at a depth not shallower than 3 cm and not deeper than 4 cm, pre-sowing of the soil should be done at a small depth of 6-7 cm, immediately after the basic tillage.

Like ordinary wheat in our agroecological conditions, this variety is sown during October. The optimal number of plants is achieved with 450 to 500 seeds per m^2, i.e. 220 to 250 kg/ha.

Basic fertilization is mainly done through the introduction of large amounts of organic matter through green manure or by plowing crop residues. Depending on the type of green manure, an average of 200 kg of nitrogen per ha is introduced into the soil. As with other types of wheat, in the spring before the onset of intensive plant growth, it is necessary to carry out fertilization. Organic waste material such as stable manure, peat, vermicompost, green manure are used in this fertilization.

In terms of diseases and pests, spelt is susceptible to the same diseases and pests as common wheat, but they are less common in this variety. Due to the relatively good resistance to diseases, by applying the correct crop rotation, this wheat can be successfully grown in organic production without any significant risks. In case of occurrence of some diseases and pests, biological, physical-mechanical and other measures for protection and suppression allowed in the organic production are applied.

Although weeds are a major problem in cereals, due to the large leaf mass of this variety, weeds are less common. The spring crop itself keeps the winter annual weeds under control by suffocating them, and by shading the space it prevents the germination and development of the spring weeds. In case of emergence of weeds in the crop, it is recommended to remove them by weeding tools or machines.

The spelt is harvested when the straw is completely yellow and the grain contains up to 14% moisture. The average grain yield of this variety in organic production is 2000-4000 kg/ha.

Mature classes of spelt (Triticum spelta)

The most important legumes in our area are: lentils (Eruum lens), chickpea (Cicer arietinum), beans (Phaseolus vulgaris), peas (Pisum sativum), soybeans (Glycine max), etc.

These crops belong to the Fabaceae family crops of a moderately warm zone. In the phases of intensive growth, flowering and formation of legumes, legumes have the greatest need for water. Lack of water in these phases will cause falling of the flowers, emergence of seedless legumes that may latter fall off. Peas have the greatest need for water, soybeans, lentils and beans have the most moderate needs, and chickpeas have the least needs for water.

Legumes grow best on neutral soils (pH 6-7), and the main fertilizers are phosphorus and potassium fertilizers. They consume a great deal of calcium from the soil and respond favorably to fertilization with microelements.

Beans (Phaseolus vulgaris) are grown because of the seeds that are rich in protein (23-30%). Due to their nutritional value and different uses, they are one of the most widespread legume crops in the world, which are successfully grown in organic production. Beans are often used in combination with other crops, but most commonly grown with corn. In this combined crop, biological efficiency, crop rotation efficiency and yield per unit area increase.

Growing conditions:

Beans thrive best in deep, fertile and loose soils with a neutral pH reaction. The critical vegetation phase is from the appearance of buds to the ripening. During the flowering phase, beans are particularly sensitive to soil and air drought. At high temperatures when there is a lack of humidity in the air, buds, flowers and even young legumes fall off.

These plants do not tolerate monoculture cultivation and require a 3 year break to grow again on the same soil plot. The vegetation period of beans is up to 120 days and they are therefore suitable as a second crop, after early spring potatoes, cabbage and lettuce. Good pre-crops for beans are: corn, industrial crops and cereals.

Production Techniques:

Beans respond well to deeper plowing, which is performed in autumn at a depth of 30 cm. In the spring, the pre-sowing tillage should be done with the use of light weight and spike rakes and seed sowing machines.

On light soils it is recommended to plant at a depth of 3-6 cm at a temperature of 12-15°C, and on heavier soils the planting depth is lower.

The distance between the rows should not be more than 60 cm, the distance between the plants should be 25 cm. Approximately a week after germination, the soil is easily cultivated to a depth of 5 cm, and the second cultivation is performed when the plants reach a height of 10-15 cm.

Tall bean varieties are grown using a support up to two and a half meters high that is placed in the form of a trellis or with two wooden supports crossed at about 2 m.

Manners of growing beans (Phaseolus vulgaris)

Phosphorus and potassium fertilization are of the greatest importance for beans, 90% of which are required during the flowering phase. They do not tolerate heavy fertilization with stale manure because nitrogen needs are met by up to 80% of nitrogen-fixing microorganisms and 20% by fertilization. The best results are achieved with foliar fertilization every 7-10 days, especially with liquid organic fertilizers and various naturally prepared products, especially in the phase of the first leaves and the phase of flowering.

Beans often suffer from dry root rot of bean (Fusarium solani f. sp. phaseoli), common blight of bean (Xanthomonas axonopodis pv. phaseoli), bacterial wilt (Curtobacterium flaccumfaciens pv. flaccumfaciens) and yellow mosaic (Bean yellow mosaic potyvirus). Therefore, it is useful to preventively spray the plants with common yarrow or onions macerates and with other naturally prepared products. Inter-row tillage and regular irrigation are also necessary.

Vegetation periods of beans vary depending upon the variety, and last from 65-140 days. When 2/3 of the legumes have entered the mature phase, and the leaves begin to fall massively, harvesting should begin. Harvesting is performed manually by plucking whole plants or by cutting with a sickle. This yield can provide 1,5-3 t/ha.

6.4. Fodder crops

Fodder crops are used to provide food for livestock and are used in many ways such as: green food, hay, silage, briquettes, etc. These crops establish a direct connection between plant and livestock production. Without them, livestock production cannot be imagined, especially in organic livestock production. Also, the representatives of this group can be grown as second crops. They are excellent pre-crops for many arable crops and vegetables. Fodder crops add a large amount of organic matter in the soil, enrich the soil with nitrogen, limit the surface of the soil covered with weeds, give high production of organic matter, etc.

The most important fodder crops in our region are: alfalfa (Medicago sativa), red clover (Trifolium pretense), sainfoin (Onobrychis sativa) and field pea (Pisum arvense).

Alfalfa (Medicago sativa) is one of the oldest fodder plants. It is a crucial perennial fodder crop that gives high yields up to 25 t/ha. This is due to the biology of this crop, i.e. the ability to regenerate quickly and give 5-6 or more mowing during a single growing season.

Its special significance is that it leaves a large amount of organic matter in the soil, which improves the structure of the soil and enriches the soil with available nitrogen. This makes alfalfa an excellent pre-crop for many cereals, industrial crops and vegetables. The best pre-crops for alfalfa are trench crops such as corn, sugar beet, potatoes, cotton, etc.

Alfalfa cultivation and an alfalfa flower (Medicago sativa)

Growing conditions:

Alfalfa requires warm and moderately humid climates. The optimum temperature for intense growth is 25 to 30°C.

In the early phases young alfalfa plants withstand low temperatures down to -6°C. Well-rooted plants can withstand even lower temperatures. Alfalfa is tolerated even at high temperatures, but at temperatures above 40°C and longer retention of dry conditions, the formation of new buds on the plant is prevented.

Due to the deep root system, alfalfa is very resistant to dry conditions, because the plant can draw water from the deeper soil layers and can therefore survive even in the driest years. However, under such conditions, the yield decreases. The critical moments for water are considered the phases of germination, stem growth and blossoming.

Production techniques:

In early autumn or summer sowing, after harvesting the pre-crop, the surfaces are plowed to a depth of 25-35 cm. The soil is cultivated and raked immediately after deep plowing, which allows the preparation of a good pre-sowing layer. If the sowing is planned to be performed in spring, a deep autumn plowing at 30-40 cm is carried out. During the winter, the surface is left in open furrows, and in early spring the soil raking is made. Before sowing, the soil is cultivated and raked again in order to destroy the weeds.

In order to achieve high production potential and to obtain a large plant mass per unit, it is necessary for the soil to be provided with sufficient nutrients. In the first year, when establishing the alfalfa plantation, it is recommended to fertilize with phosphorus around 250-300 kg/ha, and potassium around 200-300 kg/ha, while nitrogen can be added in small amounts of 30-40 kg/ha, until nitrogen-fixing bacteria are formed at the root. In the following years it is recommended to add about 50-60 kg/ha of phosphorus and about 80 kg/ha of potassium.

In order to be better rooted and to better use nutrients to give higher yields in the following years, alfalfa is best sown as an individual crop. It is best sown by hand, by scattering and in rows. Sowing in rows is done with a rowing machine at a distance of 12-15 cm between the rows. One of the most important operations after sowing is compaction of the crop with a light roller.

For proper development of the young plants of alfalfa, it is necessary to protect the surface from weeds, i.e. to destroy them with proper tillage or earlier mowing. Effective destruction of weeds in newly established alfalfa crops is done by mowing 10 cm in height when the weeds reach 20-25 cm in height. Soil raking is a regular measure applied to alfalfa in the first year. Irrigation is an effective measure for obtaining high yields of alfalfa. Depending on the amount of rain and the type of soil, irrigation is done after each mowing so that the alfalfa can regenerate faster and provide a solid yield.

The mowing period of alfalfa depends on the method of use. It is used for the production of hay, green mass, silage, haylage, alfalfa flour, pallets and seeds. For hay, alfalfa should be mowed when 40% of the plants are in the flowering phase. It is then dried, collected and stored. Alfalfa mowing is done mechanically with silo combines or mowers at a height of 5-6 cm so that the plants can regenerate again. The last mowing should be higher, at 7-8 cm so that the plants can better prepare for winter, without damaging the root collar.

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CHAPTER 7: | VEGETABLE PRODUCTION

7.1. Introduction and concepts

Vegetables are a large group of crops with different chemical compositions and varied requirements in terms of growing conditions. Vegetables are indispensable in the nutrition of people primarily because they are rich in vitamins, minerals, and secondary biologically active substances. Within these contain a group of antioxidants that give vegetables a high value in the prevention of various diseases. That is why it is important for vegetables to be produced in sustainable agricultural systems, and most preferably in the organic production system, without the risks of pesticide residues, synthetic mineral fertilizers, hormones and genetically modified organisms.

In that regard, it is interesting to note that in 2018, results were published, of a three-year comparative research regarding six varieties of peppers that are grown mostly in our region. The same varieties of peppers are grown in organic and conventional production, and provide conclusive proof showing the advantages of peppers grown in organic production. The most remarkable evidence of this study shows that the organic peppers not only provided a greater content of vitamin C and higher antioxidant potential than the peppers grown in the conventional production system, but also about 2 t/ha higher average total yield compared to the total yield of peppers in the conventional production system.

The production of vegetables can be performed outdoors and in all types of protected areas (beds, plastic tunnels, greenhouses), the fruits are used fresh or employed in various processed products. When producing vegetables indoors, energy saving is recommended by using alternative sources for space heating, while the use of PVC foils and hydroponic cultivation are prohibited. Production must be carried out in soil or organic soil mixture.

7.2. Leafy vegetables

The most prominent leafy vegetables in our area are: lettuce (Lactuca sativa), cabbage (Brassica oleracea var. capitate), broccoli (Brassica oleracea var. silvestris), spinach (Spinacia oleracea), chard (Beta vulgaris var. cicla), curly kale (Brassica oleracea var. sabauda), arugula (Eruca sativa), etc.

Cabbage (Brassica oleracea var. capitate) is one of the traditional types of vegetables that has been grown in our region for many centuries. It can be grown in regions with different climatic conditions because it has modest temperature requirements. It tolerates short-term frosts up to -10°C, while the early varieties are somewhat more sensitive and freeze at around -3°C. Temperatures above 25°C negatively affect the growth and development of this crop.

Growing conditions:

The most suitable soil for cabbage production is medium-textured soil, clayey-loamy sandy-loamy soil with good drainage and fast water permeability. The optimal water needs are 70-80% AWC (Available Water Capacity) and 60-80% relative humidity. Good yields are achieved on fertile, humus soils, with a neutral pH reaction (6-7).

Cabbage should be grown in the first place in the crop rotation. It grows well after legumes, cucumbers, potatoes and wheat. It does not tolerate monoculture and should not be planted in the same place for 3-4 years. Cabbage is a good pre-crop for most horticultural crops because it leaves a rich organic matter and soil with little weeds.

Growing cabbage (Brassica oleracea var.capitate)

Production techniques:

To ensure good soil condition, good water utilization, and the prevention of undesirable physiological changes, the soil must be well levelled with the basic tillage to a depth of 30-35 cm. Two-layer plowing and 1-2 additional tillage with disc cultivator and hoeing are recommended.

Cabbage can be produced by direct sowing of seeds, but in our region, it is mostly grown with seedlings. Planting must be done with precision, deep and at an appropriate distance. Usually the plants are transplanted at a distance of 50-70 cm between rows and 30-50 cm in a row. A few days after planting (3-5 days), in the phase of 4-6 true leaves, shallow inter-row tillage of the soil (5-10cm) is done to encourage the formation of additional roots.

Enrichment of the soil with organic matter and improvement of its structure is performed by fertilizing, usually with compost, stable manure, green manure, etc. The optimal dose is 3-5 kg of burnt stable manure per 1 m^2. The recommended dose for nitrogen fertilization is 120-130 kg/ha, with phosphorus (P_2O_5) is 80-100 kg/ha and with potassium (K_2O) 130-140 kg/ha. Potassium is added only if the soil is poor in K_2O and it is added before planting. Of the total planned phosphorus nutrition, 50% of the phosphorus fertilizers are applied before the main tillage and the remaining 50% during the vegetation, while 30% of the total nitrogen is added after planting, and the remaining amount is applied during the vegetation, until 30 days before harvest. The application of fertilizers in the soil should be done by plowing, and soluble forms of organic fertilizers (fish emulsion, seaweed and algae ash, soy derivatives, etc.) are suitable for application through drip systems. To maintain good condition of the plantation, every 5-7 days it should be treated with some of the naturally prepared products, and as a preventive measure, the use of tea from tomato leaves or tomato extract is recommended.

The proper selection of varieties and selection of the appropriate location for production can be a decisive factor for the success of cabbage cultivation and protection against diseases. The appropriate combination of agrotechnical measures can successfully build a strategy for protection against the occurrence and spread of diseases. The most common pests that attack cabbage are: cabbage root fly (Chortophila brassicae), cabbage moth (Plutella maculipennis), cabbage bugs (Eurydema ornata, Eurydema oleraceum), and the most common diseases that occur are black spot of rape (Alternaria brassicae), downy mildew of crucifers (Perenospora parastica) and black rot of cabbage (Xanthomonas campestris pv. campestris). In case of diseases or pests, products based on copper and sulphur, which are permitted for use in organic vegetable production, are applied.

The duration of the cabbage vegetation period depends mostly on the variety itself, but the average period of vegetation is 100-150 days. The average yield of cabbage in our conditions is 25.000-30.000 kg/ha.

It is recommended to harvest cabbage in the cooler hours of the day, preferably in the morning. The cabbage is picked by hand by bending the cabbage head to one side and cutting it as close to the head as possible with a sharp knife. The head must not be removed by breaking or turning because this procedure damages the head and broken stems are also more susceptible to spoilage. Thus, harvested cabbage is placed in baskets or containers with good ventilation and should be taken out of the field immediately.

7.3. Fruit vegetables

The most important fruits vegetables in our area are: tomato (Solanum lycopersicum), pepper (Capsicum annuum), cucumber (Cucumis sativus), eggplant (Solanum melongena), potato (Solanum tuberosum), onion (Allium cepa), garlic (Allium sativum), etc.

Pepper (Capsicum annuum) is grown because of the fruits that are used in the nutrition throughout the whole year in a fresh or a processed state. In the fresh state the peppers are usually harvested in their technological maturity or they are harvested in physiological (botanical) maturity for industrial processing such as: roasted, marinated for various dishes and salads, pickles, cans, such as ground dried red pepper and various other processed foods.

Pepper has a very rich chemical composition of the fruit and therefore has distinct healing properties. Pepper contains vitamins C, E, B, proteins, carbohydrates, sodium, magnesium, etc., and due to the capsaicin content of the pepper, the fruit is used in the pharmaceutical industry.

Growing conditions:

Pepper is a thermophilic crop whose optimal temperature for growth and development is 25°C (± 5-7°C). The minimum temperature at which the vital functions of the pepper cease is -0,3 to -0,5°C, and the maximum temperature is 38°C.

In terms of soil requirements, peppers with neutral to slightly alkaline reaction, i.e. pH 6,0-7,0, are most suitable for pepper. Due to the poorly developed root system which is characterized by relatively weak suction ability, this crop has a great need for water in all phases of vegetation, especially in the phase of formation of the generative organs. To achieve high quality and high volume yields, it is necessary to maintain soil moisture of about 75-80% of AWC and optimal air humidity of 60 to 70%.

Growing pepper (Capsicum annuum)

Production techniques:

Pepper comes first in the crop rotation as the main crop. Perennial legumes, cereals and grasses are considered to be good pre-crops. Pepper is a good pre-crop for many horticultural species, especially root crops and sugar beet.

Seedling production can be realized in a protected area (plastic tunnels, greenhouses,) (25.000 plants/ha - at a distance of 40x90cm) or outdoor (65.000 plants/ha - at a distance of 20x70 cm).

When cultivating the soil, it is mandatory to perform basic tillage, pre-sowing cultivation and one cultivation during the vegetation. The basic tillage consists of deep plowing at a depth of 40-50 cm with careful soil loosening. Later, if the soil is well-structured, plowing with rotary plows (overturning), and in some cases soil raking, is sufficient in pre-planting. Transplantation of plants is performed on a levelled, weed-free fields.

The use of organic fertilizers should be done by putting them into the soil through shallow plowing, to avoid nitrogen loss. Fertilizers should be applied to the soil at least 3-4 months before harvest. Soluble forms of organic fertilizers (fish emulsion, seaweed and algae ash, soybeans derivatives) are suitable for application through drip systems. These irrigation systems are the most recommended in the production, and the flood norm should be (200-300 m²/ha) 15-10 times during the vegetation, with irrigation every 4-5 days.

The most common diseases of pepper are: wilting, powdery mildew, leaf spot, and the most common pests are aphids (Myzus persicae, Macrosiphum euphorbiae, Aphids gossypii). When the first signs of disease or signs of insect attack appear, the plant should be treated immediately with copper limestone, on several occasions, especially after rain and irrigation. Some diseases can be prevented by disinfecting the soil with water vapor, using bioinsecticides, extracts and garlic, onion or common yarrow macerates. For severe attacks of diseases, bio fungicides and copper are used, while against aphids, nettle or pyrethrum (Tanacetum cinerariifolium) and Bacillus thuringiensis based bioinsecticide are used.

Harvesting of peppers, depending on the variety, begins in June for early varieties and lasts until the end of September for autumn varieties. It is carried out several times and usually has 3-5 harvests. Harvesting must be carried out regularly to allow smooth development of newly formed fruits. Yield is a varied characteristic and ranges from 4-5 t/ha in hot peppers varieties, 10-25 t/ha in spicy peppers and 25-50 t/ha in varieties with large fruits.

7.4. Root vegetables

The most important root vegetables in our region are: carrot (Daucus carota), celery (Apium graveolens), beets (Beta vulgaris ssp. vulgaris), radish (Raphanus sativus), etc.

Carrot (Daucus carota) is a root vegetable with mostly orange color that is used in nutrition throughout the year as fresh, but also as a spice, dried, frozen or marinated, and as a juice. Carrots are rich in carbohydrates, balancing substances and beta carotene and are a particularly important vegetable in nutritional terms.

Growing conditions:

Carrots thrive best on light, medium light, and medium heavy structural soils, with an optimum humidity of 70-80% AWC and a neutral pH reaction (6-7). The optimum temperature for growth is 18°C, and for flowering 25°C. They tolerate low temperatures, depending on the variety (from -3 to -10°C). The greatest needs for water are in sprouting and root formation.

Production techniques:

Carrots in the crop rotation are the second crop that is grown after crops that are abundantly fertilized with organic fertilizers (tomato, cabbage, potato). It can be grown on the same plot after 3-4 years to reduce the dangers of carrot fly and nematodes. The sowing of carrots in our conditions is done in February or early March, by direct sowing of seeds, but it can also be produced from container seedlings.

In order to achieve a quality yield, the soil should contain enough nutrients during the entire vegetation. As for all crops, nutrient quantities are determined by soil fertility, but carrots are optimally fertilized with 1-3 kg/m² compost or burnt stable manure. During the vegetation, natural mineral fertilizer, i.e. liquid organic fertilizer or naturally prepared products every 7-10 days are added.

Soil tillage should be done well because this crop germinates and develops very slowly to the phase of formation of three leaves in the rosette. Sprouted and young plants are very tender which allows faster growth of weeds. In that direction, it is necessary to perform basic tillage, then one or more shallow cultivations to provoke the emergence of weeds, and then to destroy them mechanically.

Sowing can be done gradually, in rows whose distance is adjusted to the way in which the inter-row tillage will be performed. Usually the row spacing is 20-30 cm and the distance between the plants is 10-15 cm. With the appearance of the first leaves, inter-row tillage is performed for crop maintenance and mulching of the inter-row space. It is watered every 10-15 days, until 20-25 days before harvesting.

Among the harmful insects in carrots, carrot fly, aphids and nematodes are the most common. The diseases that most often attack this crop are: bacterial soft rot of potato (Erwinia carotovora subsp. carotovora), leaf blight of carrot (Alternaria dauci), powdery mildew of carrot (Erysiphe heracleid), etc. In order to create biological protection, it is necessary to apply hygienic measures, proper crop rotation, growing useful plants (onion, garlic, pot marigold) between or in front of the rows of carrots and creating living conditions for beneficial insects (ladybug). Plant extracts (fermented extracts of garlic and pot marigold) and biological products such as natural pyrethrin (insecticide) and copper-based fungicides are used in plant protection.

Root extraction is done in dry weather, by hand, semi-mechanized or with a combine. Carrots can be successfully stored for 3-6 months in dark rooms at a temperature of 1°C and relative humidity of 85%. The average yield in carrots is 20-60 t/ha.

Carrot plantations (Daucus carota sativus)

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CHAPTER 8: | PERENNIAL CROPS

8.1. Introduction and concepts

In the group of perennial crops, the most important place is taken by fruits and grapevines. These crops are an important part of the human nutrition due to the content of numerous vitamins, minerals and biologically active substances, and especially due to the antioxidants that are necessary to improve general human health. The fruits are used fresh and in various forms of processing (compote, marmalade, jam, syrup, juice, etc.).

In order to achieve the maximum prevention of weeds and pesticides, as well as improvement of human health, it is especially recommended that these products be produced in an organic production system.

In the organic production of perennial crops, it is especially important to remove any risk that would later have a negative impact on the production process. Unlike conventional producers, which, by applying chemicals and fertilizers can repair possible omissions made when choosing a plot to a certain extent, in organic production this is not possible. Therefore, a plan for the entire production should be made carefully, and planned in accordance with the specific agroecological conditions. When choosing varieties, those which are more resistant to diseases and pests, have more modest agrotechnical requirements, and contain high productive potential should be taken into account. When choosing the location, attention should be given to the distance from plots where conventional farming is performed in order to prevent the risk of transferring chemical treatments from these plots to organic plots, through water and air.

By applying preventive and properly performed agrotechnical measures, perennial crops can be successfully grown in organic production. In this regard, the method of soil cultivation should be adapted to the crop that is being grown, to ensure balance of water, air, heat and biological regime of the soil.

Crop rotation in the production of these crops is an important phytosanitary measure in the control of weeds, diseases and pests, as well as the cultivation of intercrops or cover crops in the inter-row space and mulching of the very same area.

The tillage can be done manually and mechanically. Tractors, cultivators and other machinery used in organic production should be of lower volume, and not cause soil compaction, i.e. disruption of its structure.

To maintain balance in the development of the canopy and roots of perennial crops, as well as to regulate fertility, pruning is performed each year. This is usually performed in the spring, but is possible to be done later in the year. The pruning ensures the penetration of light inside the canopy, thus creating conditions for better ripening of the fruits. First the branches that grow towards the inside of the canopy as well as the dry and damaged branches are removed. Then the fruit branches are shortened and thinned and the unnecessary young branches are removed.

Perennial crops do not unconditionally require soils with high nutritional value because such soils rich in nitrogen contribute to a greater increase in vegetative mass at the expense of the development of the fruit tree. Therefore, proper nutrition or fertilization of these crops is an important agrotechnical measure on which the growth and fertility of other crops depend. The most commonly used fertilizers for these crops are: stable manure, compost, vermicompost, green and microbiological fertilizers, as well as biological nitrogen fixation by growing legumes.

8.2. Apple fruit

The most important apple crops grown in our region are: apples (Malus domestica), pear (Pyrus sp.), medlar (Mespilus germanica), quince (Cydonia oblonga), etc.

Apple (Malus domestica) is one of the most prevalently grown fruit crops in our region and in the world. For most countries in our region, the apple is of great economic importance. Depending on the variety, the fruits ripen from early summer until the beginning of winter. The fruit is of great nutritional value and contains various vitamins, minerals, fruit sugars and acids. It is used in fresh condition and in different types of processed products.

Growing conditions:

The soil on which apples are grown should be moderately heavy soil and well drained. As with most fruit crops, neutral or slightly acidic soils with a pH of 6-6,5 are best suited for apples. Any deficiency of nutrients should be corrected before establishment of the plantation based on previously performed agrochemical analysis of the soil layer of 0-30 cm and 30-50 cm.

In general, apples are an adaptable crop to climatic conditions, and there is a different need for heat depending on the variety. However, all varieties of apples are sensitive to lack of light, which appears immediately after flowering and causes the development of smaller fruits, and an increased decline during June. Or if there is a lack of sufficient light before harvest it will affect fruit development and their coloration. The production of quality fruits requires between 1600 and 1800 hours of sunshine per year.

Production techniques:

Before planting, it is necessary to prepare the soil well, in order to create conditions for the development of plants, and the large number of microorganisms that are invaluable in creating a good soil structure and fertility. It is also vital to introduce minerals in the form of which plants can easily absorb them. At least one year before planting the apples, clover should be grown on the plot, in combination with other herbaceous plants.

The intermediate space is mowed, and the plant mass is left to decompose. It is recommended not to mow the entire surface of the plantation at once, but to mow it several times to ensure continuity in the growth of the cover plants. After the third year, mulching of this area can be applied, using the mown grass or some other plant material in a layer with a thickness of 10 cm.

Planting is done in autumn while the soil is still warm. The seedlings should be organically produced, or in case organic seedlings cannot be procured, the use of seedlings that have not been treated with chemicals is allowed. The depth of the planting holes should be 40-60 cm, and their width is determined in a way that will provide enough space in which the root system can spread freely. At least 1,5 l of compost or composted stable manure is added to the planting holes during planting. The seedlings are irrigated immediately after planting, and to prevent the development of weeds, some plant material (straw, hay, etc.) is placed around the seedlings.

The intermediate distance and the distance in the row are determined according to the variety and the needs of the fruit. In organic production, usually an intermediate distance of 3,5-4 m and a distance in the row of 1,2-1,4 m; intermediate distance of 4-4,5 m and distance in the row of 1,6-2,3 m and intermediate distance of 4,5-5 m and distance in the row of 2-3 m is recommended.

Pruning of the entire plantation should be done gradually. Winter pruning reduces the size of the stem, but stimulates growth in subsequent vegetation. Summer pruning reduces the number of twigs that are in critical condition. On diseased branches, pruning is performed at a distance of 30 cm from the area where symptoms of disease are visible. After each pruning the scissors are disinfected in ethyl alcohol, hydrogen or sodium hypochlorite solution.

The fertilization is performed with stable manure, compost, green manure, etc. During the planting, 10-20 l of compost per plant or 10-15 kg of stable manure is used. The stable manure is added in two layers. The first layer of pure stable manure covers the root, and the second layer is added mixed with soil. Especially if the soil has low biological activity, 2-4 kg/m^2 of stable manure should be employed.

The presence of sufficient nitrogen in the soil, that will be available to plants at the correct time and in sufficient quantities, is certainly the most difficult task for fruit growers. Nitrogen is easily "mobile" and it is often enough to rain or cultivate the soil to find it in the root zone and be made accessible to plants. In general, nitrogen can be obtained from stable manure, compost, legumes, green manure (white clover, ryegrass, fodder peas), as well as organic nitrogen fertilizers. If necessary, during vegetation, nitrogen can be added in smaller amounts (about 5-10 kg/ha) and through the leaf by using compost extract or some plant extracts, for example nettle extracts. This solution is prepared with 10 kg of nettle which is immersed in 10 l of water and left to ferment for 7-10 days. Then strain and dilute with 90 l of water. Foliar nutrition also contributes to better reception of the means for protection of the leaf area.

In the control of diseases, pests and, weeds that occur in apple orchards, the application of preventive measures is of great importance (selection of indigenous varieties, raising an eco-corridor or barriers with plants that are home to beneficial predatory insects, as well as the cultivation of intercrops, mulching, etc.).

Major diseases in apples are: powdery mildew of apple (Podosphaera leucotricha), scab of apple (Venturia inaequalis), collar and fruit rot of apple (Phytophthora cactorum, P. syringae) fire blight (Erwinia amylovora), and the most common pests are: apple sawfly (Hoplocampa testudinea), apple woolly aphid (Eriosoma lanigerum), apple weevil (Anthonomus pomorum) and codling moth (Cydia pomonella).

In case of emergence of any of these diseases or pests, all applicable physical-mechanical, biochemical and biological protection measures are taken (mechanical removal of diseased parts, use of beneficial predatory insects, use of natural protection products, etc.). Removing and burning the diseased parts of the plants, during the dormant period when the temperature is below 0°C, is a safe way to eliminate the source of infection for the next vegetation.

According to the individual protective needs, various treatments are carried out with copper fungicides, sulphur, products based on Bacillus thuringiensis, etc. Potassium soap, pyrethrin and rothenone (plant extract Derris sp.) can be used to control the aphids. Treatments should be performed more often, especially in periods when the risk of disease is higher (April 20 to May 20). Some fungi, such as Athelia bombacina, are hyper parasitic and feed on the fungus that causes scabbing of apples. The extract of the plant Quassia amara can be used continuously before flowering and helps in the control of the apple wasp. On the larvae of the apple sawfly parasitize two wasps Lathrolestes ensator and Aptesis negrocincta that are used in the control of this pest.

In order to achieve the best possible quality of the fruits, it is recommended to harvest several times. During the harvest, the handling of the fruits should be as careful as possible, so as not to damage the outer layer of the fruits or their compaction. Harvesting starts from the lower branches. The harvested fruit should also contain the stalk. The transfer of fruits from one collection container to another should be done extremely carefully. The harvested fruits, until the moment of their transfer to the main warehouse, should be stored in the shade for as short a period of time as possible.

Manner of establishing an organic plantation

Fire blight (Erwinia amylovora)

8.3. Stone fruit

The most important stone fruit grown in our region are: peach (Prunus persica), apricot (Prunus armeniaca), plum (Prunus domestica), cherry (Prunus avium), amarello cherry (Prunus cerasus), etc.

Plum (Prunus domestica) is also one of the crops that have great economic importance for our region. It blooms in April, and the fruit ripens from August to October, depending on the variety. Plum fruit has a low caloric and high nutritional value because it contains carbohydrates, organic acids, tannins, minerals, vitamins and more. Depending on the variety and the phase of maturity, the fruit changes color from green to yellow, red or purple. It is used fresh and in various types of processed foods.

Growing conditions:

The plum grows best on neutral, deep, light and humus soils with good water-air regime. It can be grown on heavier soils, but in that case, it is necessary to improve the soil by using agromeliorative measures and adding manure. During the winter period the plum tolerates absolutely minimal temperatures even down to -30°C, while during the growth, especially in the blooming phase it is very sensitive to low temperatures. When the flower buds open, the flowers die at a temperature of 1°C to -5°C, and at the phase of full bloom at -0,5°C to -2,2°C.

The quality of the fruit depends on the average temperature during June, July and August. The best results are obtained if the average temperature in these months is 18-20°C.

Production techniques:

Before establishment of plantation the surface should be prepared with deep plowing, which is usually done in July or the first half of August. Based on agrochemical analysis, appropriate manures are added for fertilization.

Planting is performed on well-prepared, loose and levelled soil, in spring or autumn, but autumn planting is primarily recommended. It is best that the distance between the rows is 5 m, and the distance in the row is 4 m. The distance in the row can be shorter (2-3 m), but in that case it will be necessary to perform pruning and agrotechnical measures more often.

The fertilization is performed with stale manure, compost, green manure, etc. and it is done with shallow plowing. Compost is an ideal source of humus, rich in nutrients and soil microorganisms, it slowly releases nutrients and prevents nitrogen loss into the soil. If the soil has a low level of biological activity, an intervention should be made with 2-4 kg/m² of stable manure. Overgrowth or cultivation of a crop in the intermediate space, in addition to keeping the soil in good condition by mowing and introducing green mass into the soil, can provide up to 2 t of dry organic matter, about 50 kg/ha nitrogen and 60 kg/ha potassium.

In the control of diseases, pests, and weeds, the use of preventive protection measures is mandatory (selection of indigenous varieties, use of eco-corridors or barriers with plants that are home to beneficial predatory insects, as well as intercropping, mulching, etc.). The first and main physical measure in the control of diseases and pests is the removal of places where pests spend the winter and the removal and destruction of diseased plant parts. The most common diseases that occur in plums are: leaf blotch of plum (Polystigma rubrum), red rust (Puccinia pruni-spinosae), blossom blight (Monilinia laxa), etc., and the most common pests are: European fruit scale (Lecanium corni), plum fruit moth (Laspeyresia funebrana), red plum maggot (Grapholitha funebrana). In more serious cases of a disease or pest attack, and if the biological protection measures are insufficient, treatments with bio fungicides and bioinsecticides are applied which are performed every 10-12 days in colder weather, i.e. 7 days in warmer weather.

Depending on the variety and the purpose, the fruits are harvested in either botanical maturity, if the fruits are intended for fresh consumption or for the production of compote and jam, or in technological maturity, if the purpose is for other processing (marmalade, jam, juice, brandy, drying) i.e. when on the canopy there are 5 to 10% softened fruits. The harvest is performed manually or possibly by shaking (fruits for processing and drying).

Different varieties of plums (Prunus sp.)

8.4. Berries

The most important berry fruit crops grown in our region are: raspberry (Rubus idaeus), blackberry (Rubus fruticosus), blueberry (Vaccinium myrtillus), red currant (Ribes rubrum), strawberry (Fragaria), etc.

Growing strawberries (Fragaria) has several advantages over other fruit species. In addition to providing regular and high yields, the fruit has a high nutritional value. The fruits ripen in early spring when there is not enough fresh fruit on the market and thus achieve a high price.

Growing conditions:

The most suitable for growing strawberries are well-permeable soils with light mechanical composition belonging to the group of sandy loam, and with a clay content of less than 30% (20% is most suitable). If planted on heavier and less permeable soils, in addition to the lack of various microelements, the possibility of root diseases is increased. This can be alleviated to some extent by choosing resistant varieties of strawberries and growing them in raised rows. Strawberry is tolerant of mild soil acidity (lowest acceptable pH value of 5,5), but the best results are obtained when growing soils with neutral pH value.

The optimal daily temperature for the growth and development of strawberries is 18-22°C. The biological temperature minimum is around 6°C, and at a temperature of -2°C serious damage occurs in production.

Production techniques:

The most common strawberry growing systems are simple or double rows, while in domestic gardens they are usually grown in beds. Simple rows are made at a distance that depends on the method of tillage. In mechanized tillage, the distance is 90 cm between rows and 20 to 30 cm in a row. If the tillage is performing manually the distance should be 60-70 cm and 20-30 cm in a row. For successful production it is necessary to provide irrigation through the drip system, and by placing biodegradable foils or some organic matter (straw, hay, wood shavings, etc.) between the rows the development of weeds is prevented.

Double rows cultivation system with folia

Strawberry has relatively modest fertilizing requirements. Regarding minerals, it has the greatest need for potassium. In soils that are well supplied with minerals and with favorable crop rotation, the addition of fertilizers is almost unnecessary. If fertilized, the minimum amounts of nitrogen of 60 kg/ha in the soil layer of 0-30 cm must not be exceeded. Excessive amounts of nitrogen cause the fruits to soften, the plants become more fragile and susceptible to diseases and pests. For production of strawberry stable manure can be used in the amount of 20-40 t/ha. To meet the need for potassium and organic matters, it is recommended to grow a mixture of grasses and clover 1-2 years before the establishment of the strawberry plantation. You can also use compost in quantities up to 25 t/ha per year that is prepared on your own farm or other organic farms.

As for other crops in organic production, preventive measures are considered priority. Weeds cause more damage to strawberries than diseases and pests combined. Due to the greater viability, the weeds quickly overgrow the strawberry plants, thus impeding its normal growth and development and causing delayed fruit formation. Their mechanical destruction is difficult and causes increased production costs. That is why it is most often used to cover the soil with straw and plant debris, sawdust from deciduous trees, even covering the soil with cardboard which proves to be an extremely suitable material that does not allow the development of weeds. Another way to deal with weeds is the use of superheated water vapor that is directed at the weeds after which it dies, as well as the use of vinegar treatment in a concentration of about 15%.

The most common diseases and pests of strawberry are: powdery mildew of hop (Botrytis cinerea), powdery mildew of hop (Sphaerotheca macularis), rhizome rot of strawberry (Phytophthora cactorum), black spot (Colletotrichum acutatum), strawberry blossom weevil (Anthonomus rubi), strawberry tarsonemid mite (Phytonemus pallidus spp. fragariae), common red spider mite (Tetranychus urticae), strawberry aphids (Chaetosiphon fragaefolii, Aphis forbesii), nematodes, snails, etc. In the attempt to control them all physical-mechanical, biochemical and biological measures for protection are applicable (preparations based on ferroortophosphate, biopesticides, use of predators, parasitic nematodes - Phasmarhabditis hermaphrodita, parasitic mites - Phytoseiulus persimilus, Amblyseus cucumeris, etc.).

To maintain the freshness of the fruits, the harvesting of the fruits should start in the early morning hours. The fruits should be placed immediately in a cool and shaded place. Strawberries are harvested by hand. Harvested strawberries intended for fresh use are packed directly in the containers in which they will be sold. It is imperative to bring them to market as soon as possible.

Soil maintenance in strawberries (mulch)

8.5. Grapevines

Although the grapevine (Vitis vinifera) is a very old crop that has been grown for centuries in the world and in our region, the organic production of this crop is still expanding. Organic grape and wine production are present mainly in small areas, mostly in warmer southern regions where the conditions are more favorable for growing this crop. Organic viticulture technologies are still being developed, and there is a need for new and effective biological products to control diseases and pests, especially in humid areas.

Growing conditions:

For the establishment of a vineyard in organic production, it is desirable that the preparatory activities be carried out in a planned and timely manner. It is best to establish the plantation on a location where previously for at least 3 years cereals and legumes were grown which can be used as green manure. If there are conventional vineyards near the plantation, their distance should be at least 10 m or 5 m, in case there is a protective green barrier or other physical barrier between the plots with a height of at least 1,5 m. Due to the specific needs, the organic production of the vineyard is most successfully organized and controlled on smaller plots.

When selecting varieties, local varieties with known biological and production characteristics are recommended for organic production.

Production techniques:

When preparing the surfaces for establishing a vineyard in autumn, it is recommended to dig the soil with a special plow - digger to a depth of 70-80 cm and make an additional tillage at a depth of 60 cm for plowing organic fertilizer. In the spring, before planting, another surface treatment of the soil is performed, which should be performed in dry weather and with lighter mechanization so as not to disturb the soil structure. In the following years, only surface treatment of the soil with the use of as little mechanization as possible is needed.

Quality vine grafts in our climate are planted in spring, in rows that should not exceed 100 m. After planting, the soil should be cultivated and the row spacing should be covered by sowing some legumes or other varieties. In the following years the inter-row space can be mulched with some organic cover.

In addition to stable manure, compost, peat and green manure, dehydrated poultry manure, some by-products of animal origin (meat and fish flour), seaweed and algae products, natural and mineral fertilizers (aluminium-calcium phosphate, magnesium sulphate, soft ground rock phosphate, etc.) can be used to fertilize the grapes.

The most effective and simplest measure for control of diseases, pests and weeds in vineyards is the cultivation of highly tolerant and resistant varieties. In this control, the application of preventive protection measures is also of great importance. The most common diseases that occur on the vineyards are: powdery mildew of grapevine (Uncinula necator), downy mildew of grapevine (Plasmopara viticola), powdery mildew of hop (Botrytis cinerea), black knot of grapevine (Phomopsis viticola), and the most common pests in the vineyards are: yellow and gray grape moth (Eupecillia ambiguella; Lobesia botrana), red spider (Panonychus ulmi), mites, nematodes, etc. In biological protection, good results are seen in: a solution of baking soda with the addition of oil for better stickiness of the leaves, various stews and fermented products of garlic, mint, nettle, etc. To be effective, herbal products should be applied every 7 days, during the whole vegetation. Among the biological products for protection the following products can be used: “fungastop” which is based on lemon acid and mint, potassium permanganate, and organic fungicides based on gluten, etc. Biochemicals based on Bacillus chitinosporus, Paecilomyces lilacinus or some plant extracts can be used to control nematodes.

The grapes are harvested in the organic viticulture only manually and very carefully. It is best to pick early in the morning. The harvested bunches are carefully placed in baskets or crates, and if transported to the processing site, the transportation should be as short as possible.

Organic vineyards

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9.1. Introduction and concepts

Animal husbandry

Animal husbandry is a branch of agriculture that deals with the breeding and exploitation of domestic animals for economic purposes. Animals are mainly used for food, but also for the production of secondary raw materials such as wool, for work, etc. In total, about thirty species of animals have been domesticated around the world.

The following are the most important categories of animal husbandry:

Cattle breeding

Cattle breeding is divided into three types according to production abilities

- milk
- meat
- combined

There are two basic ways to keep cattle

- tie-stall housing

The characteristic of this way of keeping is that the feeding, milking and care of the cows take place at one place. The advantage of this system is good control of all parts of the breeding cycle, while the disadvantage is poor hygiene and welfare of cows.- free-stall housing

Free keeping is considered to be one of the best cow keeping systems that enables maximum mechanization, milking automation and achieves high productivity in milk production. In free holding, the space is divided into a space for lying and resting, draining, feeding and milking space. Apart from the listed advantages, the system also brings some disadvantage as the control is more difficult and the system is not effective if there are less than 10 cows.

Horse breeding

- independent keeping

Self-keeping of horses takes place indoors to allow easier access and supervision. Breeding takes place in stand-alone boxes or on a leash.

- group keeping

- closed facilities,
- semi-open facilities
- open facilities with or without drain

Although control is difficult with this method, it has its advantage because the mental and physical condition of the animals is much better.

Calves in organic dairy farm Global Seed company, Curug, Serbia (Photo: S. Oljaca)

Pig farming

There are three types of accommodation in pig breeding:

- open

It is characteristic of primitive breeds and in extensive production. The new trend is to keep breeding heads in an open form of accommodation.

- semi

In addition to the covered part, the pigs have freedom of movement on the outside.

- closed type

Characteristic of intensive production and is the most represented in the world.

Poultry

- raising chickens

Production of chickens is divided into:

- ornamental and dwarf breeds,
- combatants,
- light breeds,
- heavy breeds
- combined.

Combined breeds are especially important for meat production, while light breeds are important in egg production.

- Ducks and turkeys and geese

Production of turkeys, geese and ducks is divided into:

- light breeds,
- medium heavy breeds
- heavy breeds

Sheep breeding

- extensive

The feature of an extensive sheep breeding system is a small number of heads per unit area, usually 1 sheep to 1 ha of pasture area.

This form of cultivation is found in areas where it is difficult to practice other types of agriculture. This system is characterized by low investment, but also low production results. Sheep in this system spend the whole year grazing, with hay supplementation mainly in winter.

Indigenous breeds are most often adapted to this method of breeding.

- semi-intensive

In the semi-intensive system, sheep graze during the growing season, while in the period without vegetation they feed on hay and quality fodder. 5 to 8 sheep per 1 ha of surface.

- Intensive

Intensive system is a system that requires the most stakes, but also the highest productivity. Highly productive breeds are used in breeding, which must ensure high-quality nutrition in order for this method of production to have economic viability.

Goat breeding

- intensive

Intensive cultivation usually takes place in closed or semi-closed accommodation. Accommodation must be equipped with feeding, milking and watering equipment.

- extensive

Extensive production is mainly indigenous breeds of low productivity that require low investment.

Bee keeping

Bee products:

- honey
- wax
- propolis
- Royal Jelly
- pollen
- bee venom

Animal husbandry in the world has different forms:

Nomadic animal husbandry

Nomadic animal husbandry is a form of animal husbandry in which, for better grazing, breeding takes place in constant motion.

Transhuman livestock

A form of mobile animal husbandry in which better grazing is provided by moving with the livestock outside the permanent place of residence for longer periods of time and in more remote areas. It was mostly used in sheep breeding and included two seasonal directions of movement: climbing up with the herd to the mountain pastures in summer and descending (to a lesser extent) from the hilly areas to warmer lowland or coastal areas in winter.

Commercial extensive husbandry

Commercial extensive livestock farming is a farming method characterized by large farms with a small number of head per unit area.

Indoor breeding system

Indoor breeding system is characterized by constant monitoring of animals, highly concentrated diet and use of drugs aiming at maximizing productivity.

Alpine livestock

It is commercial cattle breeding in the Alpine area with seasonal livestock migration.

9.2. Role of animal husbandry in farm ecosystems

Animals play a significant role in the agro-ecological system. Despite being without the ability to convert solar energy into organic matter which is proper to plants, animals, and especially ruminants, they represent an extremely important link between man and plant since they are able to eat inedible plant products (grass, straw, bran, corn, etc.) and on the other hand produce products very important to man (milk, eggs, meat, wool, etc.)

In addition, animals regulate the circulation and dynamics of mineral and organic matter within the agro-ecological system. By consuming organic matter of plant origin, they incorporate it into their own body (meat), or other products (milk, wool, etc.). But to build these products, relatively little organic matter and nutrients are consumed. However, most of the organic matter animals do not use for themselves, but excrete them in the form of urine and feces, which are a concentrated form of mineral and organic matter, enriched with animal hormones and other substances that have a beneficial effect on plant development and soil life and its structure.

For most of the depleted soil, nutrient and organic matter in the form of animal excrement is an irreplaceable and valuable manure, without which a stable and long-term productive agro-ecological system is unthinkable and unsustainable. Because of this, it is logical that animals, as a rule, are almost always an integral part of the ecological economy (most eco-farms are of a mixed type). Of course, in order for a farm to be harmonious, and able to produce sufficient quantities of quality animal feed, and to harmonize it with other requirements (e.g. economic efficiency), it is important to achieve the right ratio between the size of the farm, the plants produced on it, and the species and number of animals.

There are many advantages for farms that have livestock, compared to those that are oriented exclusively to crop production.

Livestock farms can:

- make more efficient use of inedible plant products and waste from the farm
- use fertile and less fertile soils (pastures) more efficiently
- have a faster "turnover" of nutrients and therefore higher production (organic matter is in principle transformed much faster in the digestive tract of animals than in the soil)
- have wider and more efficient crop rotation (many plants inedible by humans which either fix nitrogen, or serve as cover, for pre-sowing, subsequent pre-sowing, under-sowing or as a crop for green manure, are mostly at the same time fodder plants) which will improve soil fertility, reduce weeds and attack diseases and pests
- close the cycle regarding the circulation of nutrients, organic matter and energy. With the production of manure of animal origin, which is also one of the most important factors in the long-term fertility of the soil, such farms are in principle independent of the purchase of mineral and organic fertilizers;

- have effective protection against erosion (manure improves soil structure, so such soils are less erosive)
- have higher productivity per unit area and more stable economic result;
- use animals for towing and processing;
- produce outside the vegetation period, and the best possible distribution of labor, and a more uniform supply and offer of agricultural products.

However, livestock and mixed farms also have several negative aspects, which are reflected in:

- greater possibility of loss of nutrients, especially nitrogen, which can occur due to inadequate handling, storage, maturation, and application of fertilizers of animal origin.
- danger of soil compaction and destruction of its structure due to the action of animal hooves, etc.
- demands regarding the knowledge and experience of the producer, his/her ability to understand the complexity of the agro-ecosystem, the need for more diverse mechanization, etc.

Grazing systems cover over 2.2 million km2 worldwide. Livestock is spread all over the world in all regions producing a whole range of meat products, dairy products, wool, leather, natural fertilizers. More than half of the world's farms are engaged in some form of livestock that is very important as a source of food and income. Grazing reduces the biomass, which reduces the possibility of fires. Livestock on outdoor pastures spread plant seeds, break the hard earth's crust, etc.

If livestock is properly managed, it can make a significant contribution to the functioning of the ecosystem, especially in nutrient cycling, carbon sequestration and the preservation of agricultural landscapes. Accelerated development of livestock, especially intensive livestock, poses significant risks. The risks relate to the impact of climate change, the role of livestock in the world diet, the spread of zoonoses in and the impact on animal welfare and human health. Prolonged grazing contributes to the extinction of palatable species and the dominance of other less palatable species. The extinction of certain plant species also has a negative impact on animal biodiversity. Extensive livestock farming affects soil erosion and reduced soil fertility as well as the soil's ability to store water and the proportion of organic matter.

The challenge is to find the right policies, institutional measures and technologies to reap the benefits while minimizing the disadvantages of livestock farming. Measures to be taken depend on the geographical, climatic and other conditions on the farm. Optimizing the relationship between humans, animals and the environment is a key to developing a quality approach that will apply environmental concepts and principles. When developing a quality approach, all aspects of the society in which it takes place should be taken into account.

Farmers who produce on mixed farms produce half of the world's food in different production systems. The diversity of species and breeds allows people to produce food in all environmental conditions in the world. In all ecosystems local breeds have characteristics that help them cope with climate, parasites, resources and so on.

Livestock that have grazing habits that are complementary to the organic production can contribute to increasing biomass productivity and reducing health risks. Efforts should be focused on farmers and researchers working together to select the best breeds for certain circumstances. Community-based breed development can help develop locally adapted genetics. Biodiversity usually decreases as production intensity increases. Biodiversity of the semi-natural pastures is comparable to the forests' biodiversity regarding the number of habitats for insects, birds and mammals.

Busha breed, organic farm in Stara planina, Serbia (Photo: S. Oljaca)

Monoculture production reduces the diversity of species. However, production systems such as crop-livestock systems can create a landscape that supports many ecosystems. Preserving production diversity is key to increasing food production safety and also to increasing resilience. Farmers who have diversified production are more resilient to droughts, floods and market changes. They most often produce a whole range of products that are highly valued by customers.

Livestock production is responsible for 14.5% of global anthropogenic greenhouse gas emissions of which 2/3 comes from milk and meat production. But that doesn't have to be the case.

FAO proposes the following three ways to substantially reduce emissions from livestock production:

„Productivity improvements that reduce emission intensities";

- Feed and Nutrition;
- Animal Health and Husbandry;
- Animal Genetic Resources and Breeding;

„Carbon sequestration through improved pasture management"

Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change

„Better livestock integration in the circular bioeconomy.

9.3.Pasture management

Natural pastures are the most important source of green fodder for livestock. Compared to the feeding of cattle in the barn (in the manger), the advantage of grazing on pastures is that the animals are in the sun and fresh air and it favorably affects their health, vitality and productive abilities.

Pasture gazing on Durmitor mauntain in organic farm HM "Durmitor" (Photo: S. Oljaca)

Control of the number of animals per unit of pasture area is the basic and most important principle in the management of natural pasture resources, both from the point of view of vegetation protection and animal production, i.e. the economic effects of that production. Grazing time and the level of forage utilization on pasture is the basic mechanism that controls the botanical composition (quality) and productivity of forage on pasture. With an appropriate number of animals per unit of pasture area, it is important to furtherly monitor the type of livestock grazing, and the distribution of livestock on pasture and grazing season. There are several basic aspects in natural pasture management that are achieved by grazing:

- by regenerating desirable pasture species, the pasture is maintained in good condition,
- overburdening of pastures leads to over-utilization of pastures, which reduces plant vigor, i.e. pushes desirable pasture species from pastures,
- pasture degradation begins when higher quality pasture species give way to lower quality (desirable) pasture species and eventually there is instability and soil erosion,
- replacing damaged vegetation with oversowing is expensive, and in addition the number of livestock on young sown pastures must be strictly controlled.

Pasture turf contains on average 70 - 80% water, 1.5 - 3% crude protein, 0.7 - 1% crude fat, about 3.5 - 8% crude fiber, 2 - 4% minerals and 9 - 10% soulless extractives (NET). However, regardless of the average nutrient content in the pasture, the quality of green pasture can vary greatly, depending on various factors, such as floral composition of pastures, phenological stage of main pasture species, soil properties, climate, fertilization, etc.

If there is too much unevenness on the pasture, then the cattle are usually collected on more suitable flat terrains, such as smaller bays and plateaus. In such places, damage to pasture vegetation is more pronounced. Pasture terrains with a slope exceeding 60% are not acceptable for grazing cattle.

Autochthonous Karakachanska sheep, Sergej Ivanov organic farm in Stara planina, Serbia (Photo: S. Oljaca)

Sheep and goats are much better adapted to uneven terrain than cattle primarily due to their smaller body size. In addition, goats have a very developed natural climbing instinct so they can be used to feed on very inaccessible terrains. McDaniel and Tiedeman (1981) found that sheep, if the slope of the terrain is less than 45%, uniformly use pasture vegetation.

However, if the slope of the terrain exceeds 45%, the uniformity of pasture use is significantly reduced. Therefore, pastures with a slope exceeding 45% should not be considered suitable areas for sheep and grazing capacity should be corrected in such areas.

Grazing organized on the basis of grazing systems is only one segment in the overall management of natural pasture resources. In general, grazing systems include determining the beginning and time of grazing, the period of non-use of pastures, density and number of livestock during the grazing period, and then grazing time during vegetative years, as the intensity and frequency of defoliation of pasture species to achieve greater (optimal) plant and animal production.

The most commonly used grazing systems are:

- uncontrolled grazing,
- continuous grazing
- rotary or alternating grazing,
- delayed-rotational grazing,
- restitution - rotational grazing,
- grazing of high intensity and low frequency as well
- short-term grazing

However, the real problem with continuous grazing is that it does not restrict grazing throughout the grazing season, which means that the grazing season and the grazing period coincide in time. In warmer climates, continuous grazing takes place throughout the year. In conditions of continuous grazing, cattle prefer certain areas on pasture more than others. These are generally the most productive places on pasture, and they are overexploited even under moderate pasture use. The disadvantage of a continuous grazing system is that cattle graze on the entire pasture and in this way (especially if the grazing pressure is high) from year to year affects the reduction of productivity and feed quality because cattle choose better quality species, so they are depleted faster and so pushed out of the pasture. This causes a change in the floral composition, and a deterioration in the forage value of pastures.

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10.1. Control and certification procedures

Organic production is a comprehensive management system for farms and food production that combines best practices in terms of environment and climate, high levels of biodiversity, conservation of natural resources and the application of high standards for animal welfare and high production standards that are in line with the growing demand of consumers for products produced using natural substances and processes.

Therefore, organic production has a dual role in the society; supplying a specific market in response to consumer demand for organic products and providing publicly available goods that contribute to environmental protection and animal welfare, as well as rural development. Adherence to high standards in the field of animal health, environment and welfare in the production of organic products is inherent to the high quality of these products.

All operators who manufacture, prepare, store or distribute organic or transitional products, who import such products or place them on the market in any way must report their activities to the competent authority of the country in which the activity takes place and in which their company is subject to a control system.

The competent authorities shall, in accordance with their authority, issue certificates to certain entities.

Steps to certification:

1. Establishment of an agricultural subject

In order to start the certification of production at all, it is necessary to have a certain entity that will be the holder of certification, depending on the applicable legal system.

The specified entity then must be registered with the register of agricultural entities.

2. Introduction to regulations

In order for an entity to engage in organic production, it is necessary to get acquainted with the regulations of its own country, EU regulations if it is in an EU member state or if EU is it's aimed market.

3. Addressing the certification body

The entity should contact a private or public certification company depending on the rules of the country in which the activity takes place.

4. First professional supervision

The contract with the certification body is followed by the first professional supervision.

5. Register of organic products

After the first professional supervision, the subject acquires the right to with the register with the Register of organic producers.

6. Acquisition of the eco-label

At the end of the transitional period, the entity acquires the right to use the organic production label pursuant to the competent law of the home country.

Organic production is under constant supervision by the institutions authorized by the public bodies, most often by the ministry in charge of agricultural affairs. The competent authority gives authorization to control bodies to carry out professional supervision, control and certification in the field of organic agriculture. All certification bodies have their own registration number. The task of the control bodies is to ensure that all entities under their supervision adhere to all production standards that they accepted when they entered the organic production system. If the subjects comply with all the rules, the competent authorities issue them a certificate.

The certificate contains basic information such as the identity of the subject, type or range of products, as well as the expiration date. Control bodies are obliged to keep records of all entities under their supervision. Records of supervised entities are submitted to the competent authority. Control bodies also perform field control depending on the risk assessment, field situation, etc., but usually at least once a year.

When an entity decides to move on to organic production, it must select a body to carry out surveillance or certification. After the selection, the entity will request the first supervision in accordance with the prescribed documentation. Certification requests are most often available at the websites of certification bodies. In addition to the data provided by the entity, it is necessary to submit additional documentation depending on the certification body.

Example documentation:

- certificate of ownership or lease contact for agricultural land - for all plots and for registered processing and storage facilities that are to be subject to professional control
- plan for the transition to organic farming
- soil analysis results
- photographic documentation

After the cooperation agreement is reached, the control body performs the first supervision. The entity is obliged to provide the control body with access to the entire property and insight into all necessary documentation. After the completion of the first inspection, the entity enters the register of organic producers. Each country prescribes data to be collected within the register.

Transitional period

All producers who want to engage in organic production must go through a transitional period, whether they are new producers or had changed their production processes. The transitional period is the time that passess from the moment the production in accordance with ecological standards is introduced until the certificate of organic production is obtained. The moment of the first inspection is considered as the beginning of the transitional period and from that moment, the producer is obliged to adhere to the standards of organic production. The transitional period is the most difficult period for the manufacturer because they cannot yet label the products with the eco-label but must comply with all the production rules. During the transitional period, the producer should master all the laws of organic production.

Under special conditions, the transitional period may also be shortened.

ECO-label

At the end of the transitional period, the producer acquires the right to use the eco-label. The eco-label is recognizable among customers and its purpose is to communicate confidence and security to the customer.

Types of certification

Certification can be done in two ways:
Individual manufacturers
Group certification

Group certification is advantageous for small producers who have similar or the same production in the same area. Group certification can reduce the cost of certification. Such group can also jointly enter the market or organize a cooperative.

Prohibition of the use of GMOs

GMOs, products produced from GMOs and products produced by GMOs must not be used in food or feed or as food, feed, processing aids, plant protection products, fertilizers, soil conditioners, plant reproductive material, microorganisms or animals in organic production.

Precautions to avoid the presence of unauthorized products and substances

In order to prevent contamination by products or substances not authorized in accordance with the rules on organic production, operators shall take the following precautions at each stage of production, preparation and distribution:

(a) introduce and maintain proportionate and appropriate measures to identify risks of contamination of organic production and products by unauthorized products or substances, including the systematic identification of critical procedural steps;

(b) introduce and maintain proportionate and appropriate measures to avoid risks of contamination of organic production and products by unauthorized products or substances;

(c) regularly review and adjust such measures;

(d) meet other relevant requirements to ensure the separation of organic, transitional and non-organic products.

If the operator suspects the presence of products or substances that are not approved in organic production the procedure is the following:

(a) identify and separate the product concerned;

(b) verify that the suspicion can be substantiated;

(c) does not place the product concerned on the market as an organic product or a product of a transitional period and does not use it in organic production unless the suspicion can be removed;

(d) if the suspicion is substantiated or cannot be remedied, it shall immediately inform the relevant competent authority or, where appropriate, the relevant control authority or control body and, where appropriate, provide them with the available elements;

(e) cooperate fully with the relevant competent authority or, where appropriate, the relevant control authority or control body in identifying and verifying the reasons for the presence of unauthorized products or substances.

Trade with third countries

When trading organic products from non-EU countries with EU countries, the following provisions of REGULATION (EU) 2018/848 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on organic production and labeling of organic products and repealing Council Regulation (EC) No . 834/2007) are applied:

Export of ecological products

1. A product may be exported from the Union as an organic product and bear the European Union logo for organic production if it complies with the rules for organic production.

Imports of organic and transitional products

1. A product may be imported from a third country to be placed on the market within the Union as an organic product or a product in a transitional period provided that the following three conditions are met:

(a) product is a product as referred to in Article 2 (1); Regulation

- applies to the following products of agricultural origin, including aquaculture and beekeeping products, as listed in Annex I TFEU, and to products derived from such products, when such products are produced, prepared, labeled, distributed, placed on the market, imported into or exported from the Union or intended to be produced, prepared, labeled, distributed, placed on the market, imported into the Union or exported from the Union:

(b) one of the following applies:

i. the product complies with Chapters II, III. and IV. Regulation, and all entities and groups of entities referred to in Article 36, including exporters in the third country concerned, have been subject to controls by control bodies or control bodies recognized in accordance with Article 46.

Recognition of control authorities and control bodies

European Commission may adopt implementing acts to recognize control authorities and control bodies that are competent to carry out controls and to issue organic certificates in third countries or to withdraw the recognition of such control authorities and control bodies, and to establish a list of recognized control authorities and control bodies which are authorized to issue certificates to all such entities, groups of entities and exporters in compliance with this Regulation;

ii. in cases where the product comes from a third country recognized in accordance with Article 47, that product fulfills the conditions laid down in the relevant trade agreement;

iii. in cases where the product comes from a third country recognized in accordance with Article 48, that product complies with the equivalent production and control rules of that third country and is imported with an inspection certificate attesting that conformity and issued by the competent authorities, control bodies or control authorities of that third country;

(c) operators in third countries may at any time provide information to importers and national authorities in the Union and in those third countries to enable them to identify their suppliers and the control bodies or control bodies of those suppliers, in order to ensure the traceability of the organic product concerned; products from the transition period. This information shall also be made available to the control authorities or control bodies of the importers.

10.2. Traceability in organic farming

In the food market today, accurate and timely traceability has become a very important factor. The modern consumer is increasingly looking for proof of traceability. Traceability is the capability to trace a particular product through all its stages, from production and processing to distribution. Traceability plays an essential role in product competitiveness. Product traceability through all phases from field to the table is becoming the standard of today's market. Traceability is especially important for products that carry a particular brand or certificate such as organic farming. The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) defined, in Codex Alimentarius, organic agriculture as "a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, cultural, biological and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system "(Joint FAO / WHO Codex Alimentarius Commission, Food and Agriculture Organization of the United Nations, et World Health Organization 2007).

The consumer is ready to set aside a certain amount of money for a certain product if it is organic, but that's exactly why they have to make sure they get what pay for. Since the organic products market is constantly growing, the fear of fraud and the market size itself make a real challenge in tracking products. Globalization and industrialization made traceability controls even more difficult. With the growth of the market, the ways and number of frauds are constantly increasing which negatively affects customer's perception and trust in a particular certificate or brand. It represents a challenge for manufacturers, distributors and public authorities.

Organic agriculture is a certain way of sustainable production in accordance with agricultural practices that vary from country to country. What they have in common is that organic agriculture represents product quality per se. Organic agriculture is controlled by bodies authorized by the public authority. Farmers who opt for organic farming must adapt to particular specifications and standards depending on the country they come from. The risks of fraud in organic farming vary from country to country and are mostly price motivated.

The regulation of organic agriculture is very complex because it varies from country to country. Legislation governing organic agriculture is focused mainly on the mode of production and not on product quality. For this reason, it is difficult to determine what exactly distinguishes organic product from a conventional one. It is expected that organic plant products contain less pesticides and that those of animal origin contain fewer antibiotics, but due to the absence of world standard that is not necessarily the case. The assumption is that different methods of production will give products of different chemical composition. However, this does not have to be the case because the chemical composition is also affected by many other things like climate, soil composition etc. Because of all above mentioned, there is a great need for analytical methods which would result in universally applicable discriminatory markers for distinguishing organic from conventional agriculture.

Pesticides/antibiotics residues

The most expected difference between organic and conventional products regards the amount of pesticides and antibiotics in the products. However, practice has shown that there are no significant differences in products of plant origin and that they are very difficult to notice and difficult to set as discriminatory markers. The reason for this is inconsistent practice and use of pesticides in certain conditions and for certain crops. Treating animals with antibiotics is generally banned in organic farming in all countries and all animals that have received an antibiotic must be strictly separated and sold on the non-organic market.

Stable isotope analysis

This method is based on the detection and measurement of stable isotopes of main elements (C, N, O and S) in food products. Stable isotopes ratios (SIR) are determined by isotope ratio mass spectrometry (IRMS) and have proved to be very useful and reliable method to detect adulteration and certify the geographical origin of various added value products, especially wine. This approach provides insight into the fertilization history of the plant. Products grown in the conventional way with synthetic fertilizers have a lower δ15N[1] than those grown organically. The main disadvantage of this method is that in order for it to work, it is necessary to have a huge database that would serve as a reference.

Directed analysis of chemical compounds

Certain groups of chemical compounds can show a distinction between food produced conventionally and organically because the method of production can be determined by discriminatory markers. Profiling of yolk carotenoids (by HPLC) can help authenticate organic

1 δ15N is a measure of the ratio of the two stable isotopes of nitrogen.

eggs. The total composition of carotenoids in organic and conventional eggs differs depending on the additives used in chicken feed. The combined analysis of two carotenoids (carotenes and xanthophylls) provides a set of markers that allows the multivariate authentication of organic eggs.

Spectral signatures (NIR - MIR - NMR - spectroscopy) - hyperspectral imaging

Spectroscopic methods have been greatly utilized for assessing food quality. These methods are very convenient for food analysis as they usually require minimal sample preparation, provide rapid and on-line analysis, and have the potential to be applied to virtually any type of food samples.

Foodomics / big data

The term "foodomics" was first employed in 2009 by Aljandro Cifuentes. Foodomics is a discipline that integrates untargeted "OMICS" analyses in a holistic approach to food and nutrition. This includes metabolomics, proteomics, ionomics and any other type of high-throughput approaches.

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Organic agriculture seeks to apply the concept of multifunctionality in practice in specific work and living spaces, including biodiversity, indigenous species and breeds, animal care, but also repopulation of rural areas, and increasing social and economic standards of living. This way of food production is important for the sustainable development of rural areas.

Therefore, especially in transition countries facing a number of economic problems (disintegration of large agricultural and industrial complexes, layoffs, high unemployment, inflation, imports of foreign substandard food), organic agriculture is important for the state and society, especially rural, for several reasons:

- Establishes a relationship between biodiversity and socio-cultural heritage of rural areas (thus creating a basis for the development of rural tourism)
- Encourages the connection between protected natural areas and agriculture (within national parks and nature parks it is possible to practice only an organic way of agricultural production), which creates a basis for the development of ecotourism.
- Within its own region, it encourages the consumption of organically "healthy" food and thus reduces energy and transport costs.

One of the ways in which farmers strive to enter the market and achieve better product competitiveness and thus income is certainly the shift to organic agriculture.

Apart from food production, agriculture also creates numerous other (non-market) functions that should not be neglected. It is these non-market functions that are the basis for the creation of the agricultural system known as "multifunctional agriculture".

Proponents of such a system believe that it would be fair to reward those farmers who, to a greater or lesser extent, contribute to the development of non-market functions in the form of subsidies. Non-market functions or benefits are reflected through:

- contribution to the vitality of rural communities (through the maintenance of family agriculture, rural employment and cultural heritage);
- biodiversity;
- recreation and tourism;
- health and conservation of soil and water;
- bioenergy;
- landscape;
- quality and safety of food and animal welfare;

The emphasis on 'multifunctionality' is to point out the added value that agriculture can produce, in addition to the food that farmers sell in the market.

Those benefits can be defined quite broadly, but generally include values for the rural community such as a large number of independent family farms, strong local economies that provide agricultural goods and services, rural employment, and the maintenance of rural culture. Environmental benefits that are often mentioned include contributions to biodiversity, clean water and air, bioenergy, improved soil quality. Protecting the soil and the environment is a key task for organic farmers, as fertile soil is a basic resource for successful production of food of high nutritional value. Therefore, organic agriculture is increasingly present as a significant economic activity in protected natural areas and national parks. This, in addition to preserving biodiversity, autochthony of varieties and breeds in such areas, encourages a new economic activity: agri-eco tourism. In addition, such areas are sought to be preserved from rural decay due to depopulation.

Educating producers and consumers develops attitude towards genetically modified organisms, percieved as a constant threat to biodiversity and human health. However, such concepts are quite abstract to the ordinary inhabitant of rural areas, , so it is necessary to work on raising awareness. The multifunctional role of agriculture, and its connection with the development of agriculture and the economy as a whole should be explained to farmers and also to actors in rural tourism, . For small farmers at the countryside, it is extremely important to understand the connection between agricultural production and the preservation of tradition, cultural heritage, nature protection and multipurpose land use.

Only then do new perspectives open up, when a small agricultural producer becomes a privileged user of the diverse potentials of agriculture that he can offer to interested visitors through rural tourism services.

11.1. Agritourism and rural tourism

The difference between rural tourism and agritourism is in the criterion according to which it is defined, primarily because rural tourism implies tourist activity in rural areas, while agritourism is based on connecting agricultural and tourist activities. Furthermore, in agritourism, members of the local community offer visitors various activities and tours as part of their own agricultural projects, and thus allow visitors to participate in the following activities:

- harvesting,
- food producing of a certain locality,
- farm holidays,
- education

The most important characteristic of agritourism is that the owners own their agricultural land and agricultural production, domestic animals and livestock, as well as a clean and peaceful environment and good communication.

The basic component of agritourism also contains a component of sustainable development, the relationship between dynamic economic systems designed by man and larger dynamic ecological systems that are slowly changing, and must be in ecological balance.

Nowadays, sustainable agritourism is based on agreement with the local community, businesspeople and other factors, while the basic forms of agritourism imply division in terms of services and facilities.

Future and opportunity

Agritourism is a significant factor in the activation and maintenance of rural areas that helps preserve local identity, traditions and customs, protects the environment, strengthens indigenous, traditional and ecological production, and helps rural development based on sustainable development, and rightly can be called the future of world tourism.

The importance of agritourism is reflected in:

- preservation of settlements and buildings from decay,
- connection between agricultural production and tourism,
- cultivation of biological-organic food,
- development of non-agricultural activities,
- production of traditional products,
- revival of old crafts
- hiring new employees,
- keeping young people in the countryside,
- promotion of local customs,
- gastronomy and culture of a certain area,
- economic development,
- preserving local identity

Thanks to the overall development of agritourism, additional employment possibilities are also provided, as well as those of earning additional income. Furthermore, since agritourism offers its own products, it therefore affects the revival of agricultural production, especially healthy food. Ultimately, encouraging agritourism, as well as other family farms, contributes significantly to economic development.

For most tourists who opt for agritourism, the primary motive is not a passive vacation with good food and drink, but the “first hand” experience of rural life.

Additional facilities will certainly raise agritourism to a higher level and improve the interest of guests, because, as already mentioned, it can include:

* participation in agricultural activities such as fruit and vegetable harvesting, crops harvesting, etc.,

* hunting and fishing, carriage driving, boat rowing, cycling, horseback riding, hiking, and similar activities, as well as renting of equipment and accessories for these activities,

* of creative and educational workshops related to agriculture, traditional crafts, etc., presentation of agricultural holdings and natural and cultural values

* visits to registered private ethnic collections, etc., organization of excursions for guests who use accommodation services, including services of using the cable car, ski lifts, funiculars and renting picnic areas.

The greatest benefit from agritourism is gained by the local population, and not by tourist workers or hotels. Often, due to tourism, the nature is destructed to the long-term detriment of earnings. Agritourism and ecotourism are alternative forms of harmful practices such as tree felling, coastal destruction.... Tourists observe or participate in traditional agricultural activities, without negative effects on the ecosystem or on the productivity of the rural household.

11.2. Landscape management, protected areas and native flora

Protected area management refers to the management of human activities taking place in a specific area; some of these are limited or adapted, while others are encouraged. In management, there is a significant emphasis on the protection of natural diversity and cultural heritage, on education and recreation, and on strengthening local communities. Accordingly, the tool for protective planning and management, environmental impact assessment with the aim of protecting naturalness, the human environment and protecting the long-term productivity of resources represents the potential for the development of crucial areas.

The success of management of an individual protected area is primarily reflected in the manner in which it fulfills the tasks for which it was established. These tasks primarily relate to the realization of the basic functions of protected areas, among which the key ones are those of public interest, and these are the following:

- monitoring and protection of flora, fauna and the general environment of the protected area, which is physically carried out through a specially established supervisory service as part of the institution that manages the area;
- continuous evaluation of the area through the professional service activities of the institution on the inventory and monitoring of its natural and other values;
- environmental education by implementing various programs and activities of professional services of the institution aimed at raising environmental awareness of citizens and OF certain special interest groups, e.g. preschool children, etc. This includes developmentof educational trails, organization of environmental workshops, printing brochures, etc.;
- tourism and recreation organized and implemented by the institution in order to meet the needs of visitors for active recreation, e.g. climbing, diving, mountain biking, hiking, etc.;
- organized visiting system, which includes programs developed by the institution to explore the protected area under professional guidance and by using internal transport system.

Certainly, other functions are as important for the management of protected areas - especially those related to technical maintenance of park infrastructure and fire protection, but also to activities organized by the institution in order to earn its own income, such as selling souvenirs, books, postcards, rental of sports equipment, sale of beverages, etc.

All activities in the protected area and natural development should be carefully programmed and systematically monitored in order to determine progress towards the set objectives and to enable identification of changes in the natural and cultural environment.

The monitoring results will provide a basis for plan revision (after 5 years) or for drafting of a new plan (after 10 years). Accordingly, it is extremely important to monitor the effectiveness of the management plan, which serves as an indicator of management success.

Many different techniques and approaches have been developed to overcome the ignorance faced by all participants in planning, development, economic or protection process. It is important to find and establish a unique and comprehensive approach to evaluation, that would not only assess the current state and sustainability of the implemented measures, but would also allow to check the viability of each proposal.

The World Congresses on National Parks and Protected Areas have been a driving force in the development of planning effectiveness assessment. In the 1990s, it became clear that the existing management system needed to be improved.

The environment has different values in relation to a specific project or activity in a certain area, depending on the specifics of each project at a particular location. In general, the space cannot be protectively valued in advance, only simultaneously with the development of goals and specific situations that an area possesses. This significantly emphasizes the need for a comprehensive strategic approach, instead of decision-making through sectoral programs, but also the importance of including management in development strategies, and thus in sectoral strategies for sustainable development.

Sustainable management of a protected area is characterized by the presence of various impacts that are primarily political, economic and environmental in nature.

It is a complex and demanding process which, if carried out thoughtfully and adapted to the conditions in which it takes place, usually makes sense. Simply put, protected area management is a cyclical process in which the implementation of predetermined activities achieves the set goals. This process includes assessing or evaluating the state of the area, defining management objectives and planning the activities that need to be carried out to achieve them, implementing these activities while monitoring their implementation and assessing effectiveness, and adjusting planned activities if necessary, after which the whole process is repeated. The goal of management is a well-defined description of what is to be achieved by management. Management activities are actions that need to be undertaken in order to achieve a given goal, or goals. Implementation of objectives implies the implementation of planned activities. Monitoring, in this context, refers to two different activities: monitoring the implementation of planned activities (what was done, how and when) and monitoring their effectiveness (monitoring changes in the state of what is to be preserved or protected).

Protected area management should be:

- based on a commitment - in accordance with the objectives for which the area is protected;
- appropriately adapted to the specific conditions and needs of the area and based on already established practice and established ways of decision-making;
- adaptable - implies the possibility of adapting the activities to the changed conditions in which the management takes place, without jeopardizing the achievement of the objectives for which the area is protected;
- participatory - stakeholders actively, with their advice, proposals and / or implementation of specific activities, participate in the management of the protected area; not spontaneously
- transparent - open to the public and well-defined.

To increase the potential of protected areas, managers and policy makers require information on the strengths and weaknesses in their management, and on the pressures and threats that protected areas face.

There are many motives for evaluation of management effectiveness. For example, governing bodies want to improve their performance through adaptive management. Local and national governments and funding agencies want to invest wisely in protected areas - to understand the pressures and threats that protected areas face and set priorities. Local communities and non-governmental organizations (NGOs) want to know how their interests have been taken into account when planning the area. Requirements from all stakeholders for appropriate accountability, good business practice, and transparency in reporting are also presented.

Assessment (evaluation) of the condition of an area (or some part of it, or some value that wants to be preserved) is actually an analysis of all relevant collected information to a particular area, which serves as a basis and argumentation for defining management goals and activities.

It is possible to establish a code of conduct for the environment, manage only declared sustainable practices, but also “green” branding based on good certified practices, as well as management based on accreditation schemes and internationally recognized eco-labels.

It is a misconception that ecology as a science (and other natural sciences) has the final word in management and planning. This science does not offer answers about the relationship between man and the environment. The answer is given by the moral factor of space - man as its user. Incorporating different social interests and attitudes into the environment brings to the planner the necessary information and reduces insecurity. Therefore, the main management problem for sustainable development is the relationship between man and nature.

Numerous studies on this topic primarily emphasize the climate factor defined by global climate change, which ultimately brings local consequences. Climate change has been the focus of research and scientific discourse for two decades, and its intensity can have significant negative effects, manifested through a significant reduction or increase in rainfall, which can have direct consequences on hydrological systems of protected areas, but also on habitats whose change leads to a change or landscape.

The second most important element of this factor is the pressure of the population, whose negative effects are manifested in two ways, through the expansion of the population, and through demographic extinction.

The environment, as one of the fundamental factors of tourist activity, is irreversibly changing with the development of tourism, leaving traces on ecological and landscape, as well as sociological and cultural aspects of space. Tourism and the environment are in constant feedback, which is positive in its initial and less intensive phases, but with the increase in tourist activity, negative feedback occurs. By further intensifying development, tourism threatens and affects the environment, and accordingly, the economic benefit may become equal to or greater than the cost of environmental degradation, which is usually not stated or calculated but possibly estimated as an opportunity cost.

Multivariate analysis revealed factors that describe different dimensions of pressures on the ecosystem of protected areas (PAs). The factor point represents the intensity of pressures on the protected area that are characteristic of each factor. The purpose and main objectives of PAs should be defined very clearly. The basic purpose of the PA is the preservation of natural sites of national importance, the preservation of wilderness, the integrity of ecosystems and natural processes, the preservation of landscapes and biological diversity, the protection of animal and plant habitats, the protection of cultural heritage. Sustainable development of local communities is supported to the extent that it does not contradict the main objectives of the PA, and relates primarily to agriculture, forestry and tourism.

The main object of the concept of arranging and using the PA, wherever possible, is to avoid possible conflicts between the management institution and owners and users of the space.

Based on the definition of the protected area, the necessary regime of general and differentiated protection is determined, which is further implemented in practice through spatial plans (zoning!) and other regulations (Management plan, ordinances).

Experience shows that the success of governance largely depends on the goodwill and support of local communities.

Public institutions perform activities of protection, maintenance and promotion of protected areas in order to protect and preserve the originality of nature, ensure the smooth running of natural processes and sustainable use of natural resources, and monitor the implementation of conditions and measures for nature protection in the area they manage.

Precisely in order to take into account the issue of realization of the tourist-recreational function in the PA in the internal organization of the space / territory of the PA, two areas are distinguished: the area with fundamental values, due to which the park was established; and the area of mixed use, for recreation and tourism. In addition to this interesting zoning within the boundaries of the PA, special areas / zones are singled out acording to their natural and other values or special characteristics (e.g. settlements). The purpose of allocating such zones is to assign special management regimes in terms of protection and use.

In the near future, the harmonization of tourism focused on protected areas with the principles of sustainability should be achieved, but other branches of tourism (agritourism, hunting tourism, etc.) should also approach sustainability. It is extremely positive that the responses of mostly nature conservation workers largely reflect the interest of local communities, and thus the presence of aspects of rural development that are focused on sustainability. But this approach should not be present only in tourism in protected areas.

There are no unique and sufficient data on the presence of ecotourism in protected areas, although this should be the goal of nature conservation experts. Tourism can pose a risk

to the environment, so it is crucial that countries have a complete picture of the details of value-oriented tourism. Due to the diversity of regulations, monitoring of protected values takes place and is regulated with different intensity, which is another risk. It would be important that nature conservation bodies or organizations are continuously informed about tourism that affects protected areas or protected species so that they could mitigate risks through appropriate intervention.

Tourism facilities and programs within protected areas should also act as those that set standards in environmentally sensitive planning and business. Good planning and compassionate action can increase local and visitor awareness of the key values of the protected area and show all visitors the commitment of the protected area management to environmental protection.

This can be achieved by minimizing the negative environmental impact of visitor support services by creating an atmosphere in which visitors feel in a special place by setting examples of environmentally sensitive planning and ways of working, to educate and demonstrate the value and practicality of sustainable, innovative and effective solutions.

The balance of the ecological, economic, and socio-cultural components of tourism is therefore increasingly mentioned in tourism development programs and strategies. Ecotourism is a form of sustainable tourism especially applicable in the tourism development of protected natural assets.

Natural areas, such as national parks, nature parks, reserves, etc. are increasingly popular areas for a diverse tourist offer, and most often it is ecotourism in which education, volunteer activities and learning about nature helps to preserve and protect nature.

Tourist activity can have an intensive impact on the environment, starting from increased human activity to infrastructural interventions in the environment, there is a need for additional protection of the space in which it takes place. Sustainable tourism is proving to be the most appropriate type of tourism development in protected areas because it is based on ecological principles, protection of natural resources, training of all participants and the well-being of the local community.

Harmonization of tourism policy and environmental protection, with full respect for the principles of sustainable development, is needed in both global and regional and local contexts. Sustainable use of natural resources should be enabled without damaging parts of nature and with as little disturbance of its balance as possible. However, in order to reduce the number of possibly dangerous effects on nature, which arise from ignorance, it is necessary to comprehensively build a system of education about natural heritage and man in their environment.

By empowering environmental, social and economic stakeholders, tourism meets local development needs, not only in protected areas but also in the entire local community.

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