VII. MODULE

Practical dealing with climate effects

Module 7. Local agricultural practices in conditions of climate change

Measures of mitigation and adaptation to climate change in the agricultural sector

Agriculture is particularly vulnerable to climate change, considering that this production is a "factory under the sky". In agriculture, plant production (agriculture, horticulture, fruit growing, viticulture), as well as animal husbandry and fishing, and through them also food production, is particularly threatened. Irregularity in the supply chain of raw materials for the food industry causes economic and social insecurity.

Concrete measures of adaptation and offered practical solutions for some of them.

Flood adaptation measures	Construction of drainage systems Construction of reservoir lakes and pools Embankment raising Restoration of wetlands Restoration of wetlands Afforestation Agricultural damage insurance
Adaptation measures in fruit growing and viticulture	Use of anti-hail nets Increased intake of manure and other organic fertilizers in the soil for fertility and better water retention Use of irrigation systems Cultivation of the inter-row space in order to reduce water consumption on flat land Introduction of alternative early varieties and table variety Increased monitoring of the occurrence of weeds and diseases
Adaptation measures for extreme weather events	Construction of anti-hail nets/shading nets Cultivation of early varieties Introduction of new varieties/cultures tolerant to high temperatures Introduction of multiple crops in crop rotation Application of high yielding varieties and hybrids Increase in the areas under winter crops Shifting the time of sowing Reducing tillage Introducing a system of wind protection belts, against snow drifts, wind blows and to preserve moisture in the soil
Measures of crop adaptation during drought	Cultivation of crops under irrigation system Increasing water capacities by using water from canals/well/pits reservoirs for water supply Using drainage channels for irrigation introduction of varieties/hybrids resistant to drought and heat Raising nets for shading in order to save water and lower temperatures Elevation of wind protection belts in order to reduce wind erosion, drying lands and ensuring uniformity of irrigation Agricultural insurance against drought damage
Adaptation measures in animal husbandry	Cooling of stables and chicken houses Provision of water for watering the goods Water cooling in fish ponds Provision of alternative food due to reduction of pastures Breeding of aphthochtonous breeds that are easier to adapt Increased veterinary surveillance due to the emergence of new diseases

Agricultural technology

Time and method of tillage

Of all economic branches, agriculture is the most threatened by the negative impact of climate change.

In order to adapt to the new circumstances, FAO experts are particularly committed to the application of conservation agriculture technology.
The basis of this technology is based on the combined application of three principles: **direct sowing** (without classical plowing), **permanent covering of the soil** (with residues from the previous harvest) and **crop rotation**.
Reduced technology is a system of soil cultivation in which 15-30% of plant residues remain on the surface of the land, while in conservation technology (including direct sowing) more than 30% of the soil is covered with plant residues (Nozdrovicki, 2008).
This tillage technology has great potential for farms of all sizes, although its application is of greatest importance to smallholdings and those facing labor shortages.

Table 2. Advantages and disadvantages of conservation systems

Advantages	Disatvantages
Reducing farm costs, saving time, human labor and machinery; Increasing soil fertility by conserving moisture which increases yields, reduces yield variability and enables reliable food production and supply; Soil conservation and erosion protection measures lead to a reduction in soil erosion; Reduction of air pollution resulting from machines used in tillage; Reduction of CO2 emissions in the atmosphere (carbon sequestration) Protection of biodiversity.	Procurement of specialized sowing machines; Short-term problems with pests due to changes in crop cultivation; Acquisition of new management skills; High risk for farmers due to technological uncertainty; Development of adequate technical packages and trainings;

Different forms of conservation or reduced tillage have different effects on soil organic matter accumulation.
In principle, shallower and simpler processing with fewer procedures or when they are completely omitted, contributes to the accumulation of organic matter in the soil, especially in its surface layer.
According to Kovačević (2004), conservation systems of crop production are based on specific changes in cultivation technology, conditioned primarily by the nature of land cultivation.
The essential principle of their functioning is the significant reduction in the number and intensity of processing operations or their complete omission. In doing so, the entire mass of plant remains is retained on the soil surface.

Table 3. Classification of possible soil conservation systems that can be used in organic agriculture (Kovacevic and Oljaca, 2005)

Form of conservation processing	Concept, strategy / tool
Protective processing	machining with a chisel peeling/trimming processing with combined tools - multivator/ultitiler robust dams rotary cultivators
Partial processing	Processing of tapes Processing in the sowing zone Tearing in/between the lines Bank processing
Bank processing	Mound processing Processing of lei
Direct sowing	System of chisel investors A system of knife-edge investors

	A system of rotating investors A system of hoe investors Duck's foot system Inverted T cutting system

RECCOMENDATION:
For soil conservation, the elimination of plowing (no-till) is recommended, which implies leaving the plant residues from the previous year and applying direct sowing on them. In addition to prevention of erosion, the pressure from fast-growing weeds is also reduced in this way.
Application of these techniques reduces production costs (fuel, depreciation) on the one hand, and on the other hand reduces the consequences of drought due to reduction of erosion and ensuring soil moisture conservation. In addition, the biological activity of the soil and its fertility are stimulated.

Time and methods of sowing

By applying a complex of appropriate agrotechnical measures, it is possible to mitigate them, but not to completely exclude the negative effects of drought.
The most important of those ***agrotechnical measures*** are:

- crop rotation,
- processing,
- fertilization,
- mulching,
- variety selection,
- sowing time and planting density,
- weed control and
- construction of agro-protective forest belts.

For each crop grown in a particular habitat, there is an optimal sowing period that is adjusted according to regional and local conditions. The time of sowing changes the rhythm of development, and especially the length of the vegetative phase and the period of formation and filling of the grain, which significantly affects the yield of cultural crops.
In any habitat, the rule applies that crops should be sown as early as possible within the limits of their optimum dates.
Sowing should start with late and end with early genotypes. Sowing at the optimal time is especially important in drought conditions because it ensures better growth and development of the crop and makes better use of the pre-vegetation moisture reserves of the soil.
Intensive cultivars and hybrids should be grown more densely than extensive genotypes under drought conditions.
Growing corn in a denser assembly leads to a reduction in yield by 30-50%, and on sandy soils with poor water retention, it can suffer completely. The same is the case with other trench crops, while sunflower suffers less from the effects of drought in dry years.
Rainfall amounts during the growing season can meet the water needs of plants with a frequency of 10-30%.
That is why it is necessary to know the pre-vegetation moisture reserves in the soil up to two meters deep when planning the assembly of cultivated plants. That water can be used by deep-rooted crops during the growing season.

Based on that, it is possible to plan the optimal density of the assembly for certain varieties and hybrids. But in extremely dry years there is a drastic decrease in yield.
Since the frequency of dry years in our country is higher than average and wet years, the number of plants for small grains and fodder crops should be 10-20% less than recommended. (Molnar, 2001).

In dry conditions, the depth at which certain crops are planted is of particular importance because they dry the soil to a moisture level of permanent wilting.

Crops with a shorter growing season such as winter fodder mixtures, peas, stubble grains can dry the soil up to 100-120 cm; corn up to 180 cm, and sugar beet and alfalfa above 200 cm.
The difference in water content available to plants can exceed 130 mm, which corresponds to the amount of irrigation water in moderately dry years. These differences in the content of pre-vegetation water reserves occur only on soils with a favorable water regime.
On light sandy soils with low water-holding capacity, the influence of pre-crops on spring water content is negligible because water quickly sinks into the deeper layers.

In dry years, crops with a higher proportion of short grain and other early crops are more favorable. This also confirms a more favorable pre-harvest value of crops that leave the field earlier.

RECCOMENDATION :

- ***To change the usual practice of crop rotation in order to make the best use of the available amounts of moisture in the soil;***
- ***To match sowing days with temperature patterns and rainfall patterns;***
- ***To use crop varieties that are more adapted to the new weather conditions;***
- ***To plant hedges or smaller agroforestry belts that reduce the loss of moisture from the soil, contribute to increasing the relative humidity of the air, and at the same time can serve as protection from the wind, which significantly accelerates the drying of the soil.***
- ***Application of accurate and up-to-date data on climate risks for agricultural producers, at the sector level and the support that farmers would receive through advisory services and training, as key adaptation measures.***
- ***Some changes in phenology as a result of mid-year weather changes can already be observed in Europe. For example. in southern France apricots and peaches bloom one to three weeks earlier. In Germany, the sowing of corn and sugar beet is already ten days earlier than usual, and in the south of France 20 days earlier.***

Such changes in the agricultural calendar indicate the fact that farmers will have to independently adapt to new changed weather conditions.
As weather changes intensify, farmers will have to introduce completely new varieties of crops, with new specific cultivation methods.

Drought resistant crops and varieties

The effects of climate change can be mitigated by selecting drought-resistant crops and varieties. However, the question arises as to which crops and varieties are drought resistant. There are several groups and types of such crops and varieties.
Plant species originating from the southern region usually have a higher tolerance to higher temperatures. For example, plants from warmer climates that can be grown here are: sweet potato, soybean, sesame, sorghum, tobacco, cassava and others.
Maize varieties with strong rooting, upright leaf, large panicle and deep seeded kernel are known to have greater tolerance to stress and drought.
Recommendations for new varieties possessing genes for drought resistance are made by scientific institutes dealing with plant breeding and providing agricultural advisory services.
Some domestic (indigenous) or old varieties and populations of plants have special forms of adaptation to local production conditions, including pathogens and climate variability, i.e. the occurrence of high temperatures and drought.
These varieties are often not for sale, but are maintained "od farm" through seed exchanges between farmers.
For example, there are old and domestic varieties of onions, legumes (green beans, beans, broad beans), cabbage, pumpkins, melons and watermelons, and vegetables (peppers, tomatoes). Most of these varieties can be found in the plant gene bank today.
In general, growing drought-resistant varieties does not mean that a high yield will be obtained as when growing non-resistant crops under conditions of intensive agricultural production (with irrigation).
However, drought-resistant varieties do better when there is no irrigation and give a stable yield when the external conditions vary, especially when the air and soil are dry.

RECCOMENDATION:

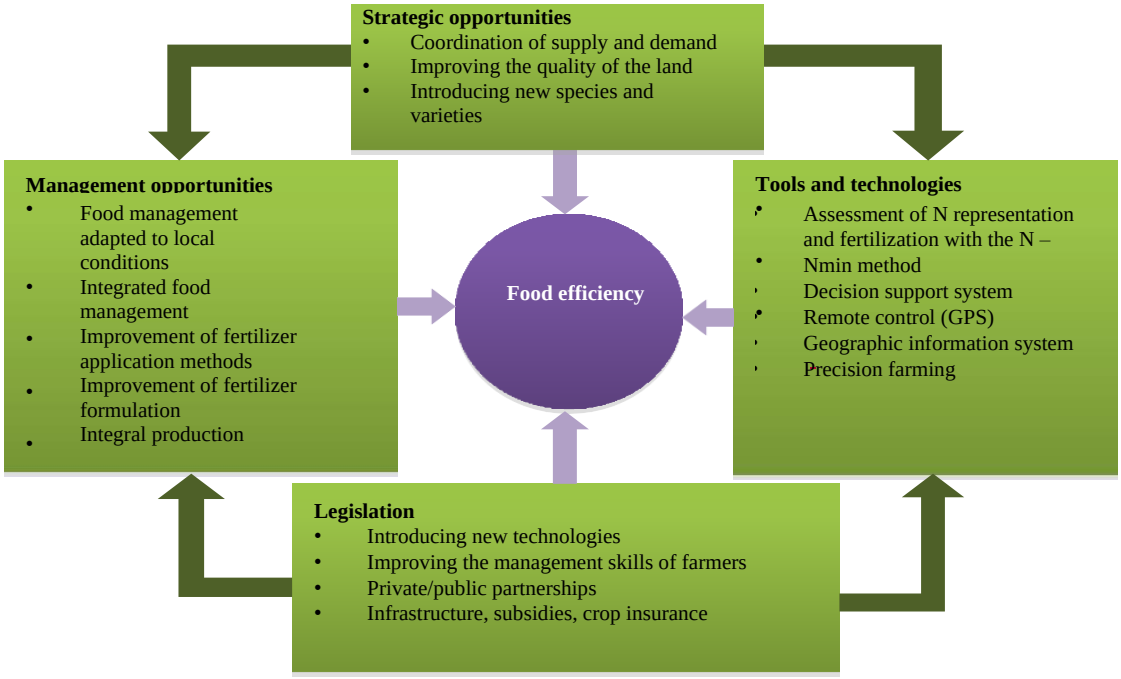
- ***To make a selection of suitable varieties that will be resistant to drought or to replace the species with others that have lower requirements in terms of irrigation.***
- ***In fruit growing and viticulture, grafting is standard practice.***
- ***When planting, it is necessary to introduce materials, such as hydrogel and zeolite.***
- ***In horticultural production, numerous advantages of seedling grafting have been determined, especially for the production of fruit crops (tomato, pepper, eggplant) due to the introduction of resistance to abiotic and biotic stress.***
- ***It is necessary to choose substrates that will be suitable for the existing environmental conditions and will enable stable growth, development and quality yield of the nursery stock.***

Fertilizers and fertilization

Fertilizers (mineral and organic) have a great influence on the yield of cultural plants and the quality of soil, water and air. In the wake of climate change, the importance of timely and appropriate application of fertilizers is even greater. On the one hand, fertilizers (nitrogen, mineral and stable manure) are responsible for the emission of nitrogen oxides from the soil and methane from the stables.

On the other hand, plants will better adapt to the changed distribution of precipitation, changed humidity and temperature conditions, if the correct selection of fertilizer, its form, the amount of nutrients, as well as the time and method of application, is carried out.

The application of the fertilizer should be in accordance with the local conditions, adapted to the production system, the type and quality of the land, available content of nutrients, plant species, varieties and varieties. Since nitrogen (N) has the greatest impact on plant yield, but also negative impacts on greenhouse gas emissions, N use efficiency is a significant aspect of fertilizer application in order to mitigate climate change and adapt production to the resulting changes.



Graphics. Approaches to improve the efficiency and use of nitrogen (N)

RECCOMENDATION:

- ***Application of organic fertilizers (stable, green manure) and plowing of the harvest residues will make it possible to increase/maintain the content of organic soil substances; to maintain/increase soil water capacity and reduce the risk of soil erosion and compaction, and thus denitrification and emission of nitrogen oxides.***
- ***Fertilizing with stable manure should be adapted to local conditions - different properties of the soil, climatic and weather conditions. The collection, preservation and care of stable litter is key to its quality. Better control of the waste management system in order to reduce the release of methane into the atmosphere.***
- ***Recycling of organic waste and application of compost and mulch will allow return/accumulation of organic substances in the soil and reduction of evapotranspiration.***
- ***Including leguminous crops in the crop rotation will reduce the need for N - mineral fertilizers, the production of which consumes natural gas and emits CO2 and nitrogen oxides.***
- ***Perennial legumes should not be fertilized with N-fertilizers. Crops coming into the plot where there was a perennial leguminous crop should not be fertilized with N-fertilizers in the first year. After annual leguminous crops can be fertilized with N-fertilizers based on the Nmin method.***
- ***Fertilizing with N fertilizers based on the Nmin method, it is necessary to adapt to weather conditions.***

- ***Fertilization recommendations based on crop needs, soil fertility control and plant material analysis should be adjusted according to weather conditions.***

Picture 29: Composting
Source: Own photo

Mulching

Mulching is covering the surface with various organic substances. Mulch has multiple effects:

- prevents erosion;
- conserves moisture;
- reduces the appearance of weeds;
- during hot days it reduces the soil temperature;
- increases the activity of soil flora and fauna;
- increases the content of humus and nutrients;
- improves the absorption of nutrients;
- helps in the distribution of the root system in the shallower soil layers, etc.

All these positive aspects of mulching the row surface in fruit orchards allow better growth and yield of fruit plants.
As a mulch material it can be used, e.g. sawdust, especially from coniferous plants, in a layer of 8-10 cm.
Mulch material should be replenished every year but with smaller amounts. The simplest and cheapest way of mulching the surface of the row is by placing straw in a layer of 15 cm. Over time, thatch rots and needs to be replaced every year. In this way, the soil is constantly enriched with organic matter. The disadvantage of straw as a mulch material is that it is light and can be blown by the wind, leaving the soil bare and weeds growing on it.
Peat is quite effective as a mulch material, but it is quite expensive and requires the allocation of a large amount of financial resources for its application. Different synthetic mulch materials can be used to cover the surface in the row, which can be used to successfully control weeds in the plantations. For this purpose, polyethylene film, polypropylene fabric, polyacrylic fabric, jute, wool or linen textiles, etc. can be used.
Geotextile is very effective in mulching the surface. It lasts a long time, if care is taken not to damage it, it can last for ten years, it has a good permeability of water from precipitation, it does not allow the growth of weeds at all, it has a good conservation of moisture, the fallen fruits remain clean. The only drawback is its high price.
Black film can be used to cover the surface in the row, but it is very difficult to place between the stems of the fruit trees, it does not let the water from the precipitation into the zone of the root

system around the stem, it is easily lifted by the wind, it is easily damaged. Due to these shortcomings, it cannot be recommended for mass application in orchards. The negative sides of mulching are: the possibility of rodents inhabiting the bark of the ground part of the trunk and roots, which is why the mulch around the trunk should be removed in the fall, and a large number of insects overwinter under and in the mulch material.

Cover crops

These are plant species that are sown between the rows in the plantation. Their purpose is to reduce erosion problems; fertility and soil quality; to reduce the occurrence of weeds, pests and diseases; to maintain biodiversity in agroecosystems (Lu et al. 2000).

Cover crops can also be sown on empty areas, due to the effect of green manure and enrichment of the soil with organic matter. The selection of plants should be done carefully. First of all, they should develop well in the climatic conditions suitable for the region, and the plants should not demand too much from the soil and accumulate more biomass in a short time. It should be emphasized that cover crops use a large amount of moisture and therefore should be applied in wetter areas or under irrigation conditions. The method of application is determined depending on their place in the crop rotation and the way of using the resulting green mass. Therefore, cover crops can be applied throughout the year, as a subsequent main crop of the crop, as a previous crop or by sowing as an annual or biennial, together with the main crop.

Although this measure initially increases irrigation costs, the positive effects are felt over many years.

Safety nets

Fruit production is closely related to numerous climatic conditions that operate in a certain space and time. Life functions of plants take place correctly only in certain amplitudes of each climatic factor.

Deviation from the optimal limits of each factor causes certain disturbances in the processes of fruit trees, which negatively affects the vegetative growth, fertility, quality of the fruits, and finally, the profitability of their cultivation. Often the occurrence of a single hailstorm, heat wave or strong wind can be enough to compromise or destroy the entire crop in plantations of any agricultural crop. Due to the specificities of long-term plantations, the action of these natural elements

Picture 30: Fruits damaged by hail and high insolation

Source: Own photo

Raising intensive plantations is an expensive investment, and during further cultivation all risks that may compromise production should be eliminated or minimized. Therefore, the need to introduce new alternative technologies and methods in the cultivation of plantations is imposed. One of those methods is the installation of safety nets.

Hail protective and UV protective nets and how to install them

Safety nets are a novelty for our producers, while in developed countries, especially for high income crops, it has long been a common practice. The main reason for installing protective nets is to combat hail. A secondary objective is the shading of the plants, which reduces the sunburn of the fruits and leaf mass, due to which the producers suffer huge financial losses. Protective nets also play a role in changing the microclimate in the plantations. In plantations covered with a net, the relative humidity of the air increases, the light and temperature in the plantation are reduced, thus reducing the conditions

for moisture loss through transpiration and evaporation. The network also plays a role in reducing heat radiation from the soil, as a result of which damage from late spring frosts is reduced.
With the installation of the protective nets, the wind speed is reduced by up to 50%, which enables a more efficient application of protective agents in the plantations. It follows from this that in plantations that are not covered with a protective net, the overall environment for the normal development of all processes in the plants is improved.
By placing the nets in the plantations, the illumination of the leaf surface is reduced. Light is one of the basic factors necessary for plant life. That's why any unprofessional installation of protective nets can cause negative effects from excessive shading. Vegetative growth will reduce the quality of the fruits (decrease in size, weaker color and lower content of dry matter).
Current knowledge shows that the color and density of the net have an impact on the vegetative growth of the plants, the yield and the quality of the fruits, which is why the selection of an appropriate net is of particular importance. A wide range of safety nets is available on the market, both in terms of the dimensions of the openings and the color of the net itself. The openings of the nets should be adjusted according to the size of the grains of the city. The choice of mesh density depends on the crop as well as the insolation conditions in the respective region. In our production regions, nets that transmit light of 80-85 % are suitable. The color of the net has significance in the shading of the plantations. Therefore, depending on the intensity of the light, the appropriate color of the nets is chosen. At the same time, in brighter conditions, networks with a darker color are placed, which provides greater shading, and vice versa, in regions with less light, networks with a lighter color are better, which has a greater reflection of light.
For the proper functioning of protective nets, the support structure to which the net is attached is of particular importance. Pillars of different materials (metal, concrete or wood) are used for construction, which are usually placed at a height of 3.8 m for fruit plantations. The supporting structure should be 4.5 m long and 8x8 cm or 7x8 cm thick. The posts are driven into the soil at a depth of 70 cm, and they will be 3.8 m high above the ground. Anchor posts measuring 10x12 cm are placed at the ends of the row.
The support structure, i.e. the poles, are usually placed at a distance of 10 m and wires will be placed on them to which the seedlings will be tied. For better attachment of the net, metal ropes, wires and other elements are used, with which a good connection of the net is ensured by the wind.
The net must be placed obliquely towards the interrow so that the grains of the city can fall into the space where there are no plants. If the network is not well stretched and slanted, the city stays on it and the weight can tear it. The posts for the net serve simultaneously as a trellis support structure. The best and easiest way to set up the construction for the net is before raising the plantation. The overall installation of the system is quite complex and it is best to hire professionals who have experience and equipment to easily, quickly and simply perform all operations for setting up the network. In our conditions, the protective nets should be installed at the beginning of April to enable protection from late spring frosts. The nets are collected and attached to the metal ropes in the autumn period when the risk of hail has passed, but before snow falls that can damage them. Taking into account the high investments in raising intensive plantations, the expected results of their cultivation and the risks arising from climate change
During dry and sunny periods, the net becomes electrostatically charged and attracts dust particles. This dust that remains on the grid reduces the excessive light intensity during the summer period. With the first autumn rains, the dust falls from the nets, which thus return to their original state.
The correct balance between shade and light intensity promotes a balanced photosynthesis process that allows plants to absorb nutrients and develop plant tissues.

Picture 31: A diagonally placed and well-tensioned net
Source: Own photo

Water resources and irrigation

On Earth, 97% is salt water and only 3% is fresh water. Just over two-thirds of that water is frozen in glaciers and polar ice caps. The remaining, thawed portion of fresh water is found mainly as groundwater, and only a small portion is present above ground or in the air. Water supply is mainly based on the use of underground water and springs (80-90%), a smaller percentage is from rivers (10-20%) and only about 1% from natural lakes and artificial reservoirs.

Watering. Irrigation is the controlled application of water, artificially, for agricultural purposes. It is a measure in plant production by which, through special man-made systems, water is added to the soil to meet the plants' water needs when they do not have enough water from rainfall. When irrigating, water should always be used efficiently, applying only the required amount for the crop plants and in a dose that a certain soil can infiltrate to a certain depth.

Infiltration of water into the root zone of plants should be without runoff. How much water will be added to one irrigation and how often it will be watered depends on: soil type, mechanical (textured) composition of the soil and its structure, density of the crop and the need of plants for water.

Sandy soils and sandy loams absorb water quickly, so they need to be irrigated more often with smaller amounts of water to prevent water losses outside the plant roots. On the other hand, clay soils absorb water slowly, so water runs off if it is added too quickly during irrigation. In them, water must be added alternately, giving time to the land to absorb the previously added water, before adding next amount which is known as "cyclic" / "pulse" irrigation.

There are several divisions of land irrigation methods. They are usually divided into:

a) surface, with which the water is brought to its surface and

b) subsurface, with which water is brought to the root zone of plants below the surface of the soil by capillary means.

In surface irrigation, water can be brought to the surface of the soil by gravity or under pressure. Surface irrigation, which brings water by gravity, is carried out by the following methods: furrows (infiltration into furrows), overflow and immersion. If the water during surface irrigation is brought under pressure, then it is by sprinkling; "drop by drop" or with micro-sprayers.

If the water is brought under the surface of the earth, then it is called subsurface irrigation and it can be done with open channels and under pressure.

Each of the above irrigation methods and methods has certain advantages and disadvantages, and the choice of the appropriate method depends on:

- Size, shape and slope of the plot
- The type and mechanical-physical properties of the soil,
- The nature, quality and availability of water to supply the irrigation system,
- The type of plants grown
- Initial costs and availability of funds, and
- Priorities and previous experience of farmers with irrigation

In the context of climate change, drought adaptation is one of the most important tasks.

Therefore, the management of water resources is of particular importance. In arid areas, but not only, there is a great need to collect water through micro and macro reservoirs, supply canals or waterways, water supply networks, and through wells, dams, cisterns, etc.

Reservoirs (artificial lakes) are formed by dividing river flows in valleys. Reservoirs are used to store water in times of abundance and which can be used in times of water scarcity (as a source of water for irrigation when there is a dry period and when there is not enough water for the needs of cultivated plants), but and for other needs. When building reservoirs, it is important to take care of the design of dams and foundations, with appropriate buildings and equipment (overflows, outfalls, hydromechanical equipment) that allow: realization of the accumulation and retention (retention) of water, capture of water for irrigation and others different purposes, diversion of water flow (if necessary), and division and management of water.

Artificially dug canals for providing irrigation water (waterways) are the most well-known way of using water in small and water-poor agricultural areas. In this way, farmers are given access to irrigation water, which creates better conditions for agricultural production. There are several names for channels: groove, gutter, gap. Such canals are a social rural good. Through canals or waterways, water can be brought from one area to another and in this way ensure the distribution of water in different ways.

A pit or cistern is a water reservoir in arid regions. The former construction technology was complex. First, a hole was dug in the ground. The wall had to be made of hard stone. The plaster was made from red earth. It was built with it, and later smoothed from the inside. The pits were closed from the top, and an opening called a shaft (shaft) was left in the middle. Rainwater is collected from the surrounding, landscaped area called. The water is reached with a bucket tied to a rope. Today, with the discovery of new construction materials, the construction of the pit has become faster and easier.

RECCOMENDATION:

- ***Economical use of water in periods when plants need it most***
- ***Using drip irrigation techniques***
- ***Application of the concept of accumulating water through micro and macro reservoirs, and through wells, pits or cisterns, (should be more and more popular and introduced in the context of the development of the rural area and its sustainability).***
- ***Maintenance of existing and construction of new reservoirs***
- ***Regular maintenance and cleaning of the drainage channel network***
- ***Maintenance of drainage systems***
- ***Reuse of treated wastewater***
- ***Prevention of backfilling of drainage channels due to the formation of artificial passages more accessible to the plots.***

Picture 32: Water reservoir in arid regions
Source: Own photo

Picture 33: Rainwater harvesting in a modern way
Source: Own photo

Practical management of climate effects in agriculture

Practical handling of climate effects in fruit and viticulture production

The changed climatic effects in viticulture and fruit production affect in different ways. We will single out the most important ones:

- Change in the proper acclimatization of the varieties (irregular flowering and dissatisfaction with the required amount of low temperatures);
- Earlier flowering of fruit plants and increased risk of late spring frosts;
- Extremely high temperatures cause problems in differentiating flower buds (double flowers), pollination and fertilization of flowers;
- High temperatures and lack of moisture cause disturbances in physiological processes;
- High insolation and temperature cause scorching of the leaves and damage to the fruits;
- Changes in the distribution of existing diseases and pests and the emergence of new crop hazards;
- They reduce the quality of the fruits;
- Occurrence of soil diseases and pests as a result of heavy rainfall and higher temperatures;
- Increased risk of erosion;
- Strong winds and storms cause uprooting of fruit trees, breaking of branches and pushing of fruits;
- The seeds of the city make wounds in the organs of the plants, for the healing of which the plants consume huge amounts of nutrients. In addition, these wounds often represent openings for infection by various diseases and pests.

Picture 34: Fruit damage caused by high temperatures
Source: Own photo

Adaptive measures should be designed for easy and simple application and preferably not require large financial investments.

There are a number of adaptation measures, but we will cover the most important ones:

- Selection of substrates, varieties and fruit species, resistant to climate changes
- Adequate preparation of the surface before raising plantations
- New planting technology, in which the planting depth and use of water-retaining substances will be adapted;
- Adequate maintenance of the surface in the plantations
- Application of appropriate ways of pruning the fruit trees and formation of appropriate types of crowns
- Application of mulching in the rows
- Installation of protective UV and anti-chest nets
- Application of appropriate ways of pruning the fruit trees and formation of appropriate types of crowns
- Selection of substrates, varieties and fruit species, resistant to climate changes
- Adequate preparation of the surface before raising plantations

Selection of suitable fruit species, varieties and rootstocks

1. **Selection of fruit species** - The selection of fruit species, when planting fruit plantations, should be based on the natural conditions in the given region, while the new climate changes and the need to adapt the fruit plants to them must not be neglected.

RECCOMENDATION:

In the western region of our country, apple, autumn and winter varieties of pear, sour cherry, cherry, and in certain micro-regions hazelnut, walnut and strawberry fruit species are recommended for planting.

In the central region, warm-loving fruit species such as peach, apricot, almond, summer and autumn varieties of pear, early varieties of cherries and strawberries, sour cherries are recommended.

In the Gevgelija-Valandovo area, subtropical fruit species are recommended - fig, pomegranate, Japanese apple, actinidia, etc. In some micro-regions, apples can also be grown with success, but only early summer or early autumn varieties or varieties with long vegetation.

In the eastern region, apples, plums, cherries, aronia, raspberries are recommended, and in certain micro-regions, hazelnuts and walnuts. In arid regions, it is necessary to give preference to crops that ripen early before the beginning of summer, and to avoid late-ripening crops.

2. Selection of varieties when raising fruit plantations -. The variety is a very important and often a key factor in creating more profit from plantation cultivation. Seen from the perspective of climate changes (in addition to biological, production and quality traits), when choosing varieties, their requirements for specific environmental conditions should also be taken into account. Some fruit varieties give excellent results in some environmental conditions, but completely different yields in regions with other conditions.

RECCOMENDATION:

In arid regions where there is a shortage of irrigation water, it is recommended to plant early fruit varieties that are harvested before the summer drought occurs.

Unlike fruit-bearing fruit trees, fruitless fruit trees tolerate drought more easily. In more southern regions, early maturing varieties should also be planted. This is important because early ripening

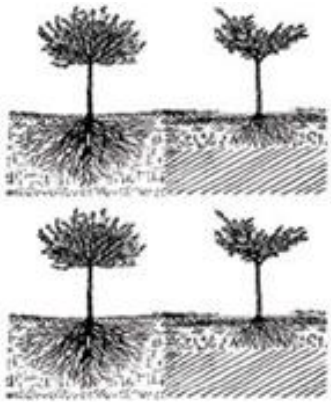
in these warmer conditions ensures fruits that reach the market at a time when there is no competition from other regions.
In areas exposed to the wind, it is recommended to grow varieties with stronger stems that hold the fruits firmly to the branches.
In regions where late spring frosts occur more often, it is necessary to avoid varieties with early flowering because they are more sensitive to low temperatures. But it is not a rule, because varietal characteristics for resistance to low temperatures should also be taken into account.
In rainy regions, it is recommended to grow cherry varieties that are resistant to skin cracking.

3. Choice of substrates when raising fruit plantations - Choosing a suitable substrate is a difficult and critical decision when raising fruit plantations. Biological properties of the substrate should interact with the specific pedoclimatic conditions in the given region as well as with the planned cultivation technology. The biological characteristics of the variety will come to full expression with the correct selection of the substrate in the specific pedoclimatic conditions and the application of appropriate cultivation technology. Each substrate in given situations has its own advantages and disadvantages and there is no ideal one. That is why it is important to choose a substrate that, under suitable climatic conditions, will show the least negativity. Each substrate has its own specific characteristics related to various aspects such as: lushness, rooting, adaptability to climatic and soil conditions, tolerance to low temperatures, resistance to diseases and pests and others. In modern fruit growing, preference is given to lushness.
Lushness - although in modern fruit growing, when raising fruit plantations, low-growing substrates are used because they have many advantages (they enable the raising of dense plantations, the fruit trees are lower and easy to manage, they have regular and high yields per unit area, they give quality fruits from more lush substrates and more economical and profitable production), however, they also have disadvantages (poorly developed and shallowly placed root system). Because of this, poorly lush substrates are in principle much more sensitive to a lack of moisture in the surface layers of the soil. Thus, the dilemma arises as to whether to always and in all conditions apply weakly lush substrates or to choose more lush substrates with a more developed root system, and to control the lushness and fertility of the fruit trees by applying other measures.
In addition to lushness, the following characteristics are taken into account:

- adaptability to environmental conditions, especially pH,
- tolerance of drought or excess moisture in the soil,
- high temperature resistance, disease and pest resistance etc.

<u>RECCOMENDATION:</u>
- ***On carbonate soils with a high pH, peaches should be grafted onto almonds or peach x almond hybrids;***
- ***Pears of wild pear and gorse; cherry trees are grafted on frosts and sour cherries in drier areas should also be grafted on frosts.***

Deep preparation of the surface before raising the plantations
Plants with a better and more deeply developed root system can also draw water and nutrients from the deeper soil layers, where there is usually more moisture in the dry part of the vegetation period.



Picture 35: Schematic representation of the influence of soil loosening on the development of fruit plants
Source: (Stanković 1990)

Depending on the climate and soil conditions, the type of fruit, the substrate, the cultivation system, etc., the preparation of the surface for raising a fruit plantation can be done in several ways, namely: deep plowing, semi-rugging, rutting, undermining, rippering, digging holes etc.

RECCOMENDATION:

- ***Deep plowing at 35 – 45 cm - is performed before raising strawberry fruit plantations, which have a shallow root system and are grown in semi-humid areas or with irrigation;***
- ***Semi-cultivation at a depth of 50-60 cm - applied to plantations under irrigation conditions and intensive plantations on vegetative substrates, for light, permeable, alluvial soils;***
- ***Rigging at a depth of 70-90 cm - recommended for plantations that are not irrigated, in order to enable deep penetration of the root system and the greatest possible accumulation and conservation of natural moisture. Rigging is also recommended in cases where the impervious layer needs to be destroyed, to enable water permeability, aeration, development and functioning of the root system;***
- ***Undermining with blasting machines at a depth of 50-70 cm. The soil is just plowed (no turning). It is recommended for lighter soils, soils with a shallower humus horizon lying on rocks, stones, etc.***
- ***Digging holes is justified when raising rare plants with a planting distance of 8-10 m. The diameter of the hole should be at least 120 cm, and the depth 60-70 cm. On heavier soils, the diameter of the hole should be 150 cm. On light, alluvial, permeable soils, smaller holes can be dug, with a diameter of 80-100 cm and a depth of 60 cm.***

Adaptive planting technology

From a scientific point of view, and also in practice, the opinion is accepted that the seedlings should be planted at a depth up to the root neck, just as they were in the nursery. However, there are cases when it can be planted shallower or deeper than usual. In our arid regions, where there is a lack of moisture in the surface layers of the soil, there is a need for deeper planting of the seedlings. The advantage of this method is that the root, even during planting, is placed at a greater soil depth, where it continues to grow and spread in the deeper layers. A root thus developed and spread has the power to use water and nutrients from a larger volume of soil. For the application of this technique, it is necessary to graft the seedlings in the nursery higher than the standard grafting, ie 30 cm above the soil. When planting, the seedlings are placed at a depth of 50 cm, so that the junction between the substrate and the seedling should be above the ground.

Use of water-retaining substances (hydrogel, zeolite, zeophyte, etc.)

In the fight against drought in agricultural production, materials are often used that have the ability to absorb air moisture and retain water in the zone of the root system of plants and do not allow its loss through evaporation. This moisture further becomes available to the plants during the period when there is not enough water in the soil for the root hairs to absorb. A larger number of this type of materials are available on the market, but hydrogel and zeolite (zeophyte) are more widely used. **Hydrogel** is an organic polymer of starch with different granule sizes. It has a great power of absorbing moisture. In the world, it is mostly used in arid and semi-arid regions. It is introduced into the soil before planting the plants. In fruit growing, it is used before planting the seedlings by applying 15-20 g of the granules in the hole or in the furrow per planting site. The ability to retain moisture preserves it for up to 4 years after application and for that entire period contributes to a better use of moisture from the soil. **Zeophyte** (zeophyte) is a silicate mineral of natural origin that is produced by grinding natural rocks. It is produced in the form of granules or powder with particle sizes of 0-3 mm. It mostly contains silicon dioxide and aluminum dioxide in its composition. A larger percentage also contains iron, calcium, magnesium, sodium and potassium, and to a lesser extent there is manganese, phosphorus, titanium, etc. It has the ability to absorb moisture up to 43%. Added to the soil, along with the moisture, it retains some of the nutrients that the root system can use in the dry period. Zeophyte in fruit growing can be applied during the planting of seedlings, that is, by adding 0.5-1 kg to the hole or furrow per planting site.

Picture 36: Application of hydrogel (left) and zeophyte (right) during planting of seedlings
Source: Own photo

Use of water-retaining measures The area in the plantations can be maintained in different ways, but each of the ways that will be chosen must ensure the growth and fertility of the plants in conditions of economic profitability.

1. Barren black fallow - means occasional tillage and prevention of weeds throughout the year, through deep autumn, shallow summer plowing and several summer cultivations.

Positive sides:

- Destruction of weeds is carried out
- Nitrates increase (favorable conditions are created for nitrogen fixers)
- There is a greater accumulation of moisture in the soil

Negative sides:

- The humus is lost
- Soil structure deteriorates
- Erosion occurs on sloping terrains

RECCOMENDATION:

- ***this is a unique, effective way of soil maintenance in young plantations, and in arid regions, without enough water for irrigation***

Weeding of the surfaces

The weeding of the surface in the plantations can be done with natural grasses or by sowing seeds of individual types of grasses or grass mixtures. Grasses are used, several species such as: meadowsweet (Poa trivialis), English ryegrass (Lolium perrene), Italian ryegrass (Lolium italicum), fescue (Festuca sp.) and others. Of the legumes, white and red clover, etc. are used.

RECCOMENDATION:

- ***it is recommended in areas with an amount of precipitation over 800 mm per year, properly distributed during the vegetation or in plantations where there is enough water for irrigation.***

Formation of alternative crowns and methods of pruning of plants

Climate change and harmful sun rays cause damage to fruit trees. In the absence of additional protection from strong insolation, there is a need to introduce new, modified principles in the formation and pruning of fruit plants.

Picture 37: Damage to apple from strong insolation

Source: Own photo

RECCOMENDATIONS:

- ***Formation of wider, more closed and more shaded crowns;***
- ***When applying summer pruning, moderate removal of shoots should be practiced;***
- ***during the winter pruning of the plants, it is possible to apply the so-called short and long pruning in apples, pears, peaches, some varieties of plums;***
- ***Application of short pruning in peaches;***
- ***Placing the rows of the fruit plantation in the direction of the blowing wind in order to reduce the negative effect of the wind;***
- ***Installation of protective nets at the beginning of April to enable protection from late spring frosts;***
- ***The protective nets are collected and attached to the metal ropes in the autumn period when the risk of hail has passed, but before snow falls that can damage them.***

Adaptation measures specific to viticulture

RECCOMENDATIONS:

- ***Increasing the number of meteorological stations in these regions.***

- ***Timely notification of vine producers about weather conditions (ice, hail, high temperatures).***
- ***Availability of information of public interest to individual farmers.***
- ***Training of individual farmers on climate change and adaptation measures.***
- ***Recommendations for choosing varieties that are easier to adapt or tolerate climate changes.***
- ***Applied technique, the T-system of pruning (placement of native shoots at an angle of 45o, which allows shading of the bunches)***
- ***Reduction of transpiration in grapevines with new technologies and modernization of production.***
- ***Increased use of nitrogen fertilizers to extend grapevine phenophases and later harvest.***
- ***The dislocation of vines in colder places, at higher altitudes or in coastal areas (lower temperatures, higher rainfall and lower irrigation costs)***

Practical management of climate effects in agriculture and horticulture

The basis for mitigating the consequences of climate change in agriculture and gardening is the application of appropriate agrotechnical measures. These include crop rotation, tillage, tillage, variety (hybrid) selection, seeding, plant nutrition, weed and pest control, irrigation, drainage and harvesting.

Table: Measures of adaptation in agriculture and horticulture

Good horticulture practice	Adaptation measures
Crop rotation	Choosing an adequate starter Avoiding monoculture
Tillage of the soil	Plowing of the harvest residues Timely basic processing Good pre-sowing preparation Inter-row cultivation
Undermining	Undermining
Selection of varieties	Procurement of certified seed material Selection of modern varieties adapted to the climatic conditions Diversified assortment
Sowing	Seed inoculation as needed Timely sowing at an adequate depth Regulation of sowing density according to climate conditions
Nutrition of plants	Soil analysis Optimal basic fertilization Optimum initial fertilization and feeding
Weed and pest control	A combination of agrotechnical, biological and chemical measures to control weeds, bacteria, viruses, insects and other pests
Irrigation and drainage	Irrigation according to the needs of the plants with the required irrigation rate Regular maintenance of channels and drainage systems
Harvest	Timely and correct harvest

Alternative agrotechnical measures - With the development of agriculture, a whole range of alternative agricultural technologies seem to mitigate the consequences of climatic fluctuations in agriculture: soil conservation, mulching, cultivation of cover and joint crops, agroforestry and others. Measures that have proven useful in certain countries of the world are being tested in our conditions, on our countries, cultures and varieties. Numerous alternative adaptation measures are beginning to find their place in horticultural production and are increasingly prevalent on arable land.

Many of these measures have found application in organic agriculture, which in an ecologically sustainable way, using natural processes and substances, contributes to reducing the use of non-renewable energy sources and the emission of harmful gases into the atmosphere and is an effective strategy for mitigating climate change. In recent years, various variants of reduced processing have been applied, which leaves part of the harvest residues on the unprocessed surface layer of the soil, which conserves moisture and increases microbiological processes.

Adaptation measures that are specific to HORTICULTURE

RECCOMENDATIONS:

- ***Elimination of the harmful effect of wind and insolation by growing vegetable crops between plant backgrounds (corn, sorghum, sunflower, winter cereals, tall grass, clover, fodder pea)***
- ***Technique with curtains to be used when growing tomatoes, cucumbers, watermelons, melons, peppers, green beans, eggplants, cauliflower, salads***
- ***Application of biodegradable paper mulch***
- ***Covering the greenhouses with nets - nets***
- ***It is recommended to use less irrigation water than needed to reach the PVK: 100% of the PVK should be irrigated in summer when no rain is expected or for crops under greenhouses, and 80% of the PVK should be irrigated in the months when rainfall is expected. Proper watering only adds to the difference between TM and PVC.Правилното наводнување, само ја надополнува разликата помеѓу ТМ и ПВК.***