V. MODULE

Mitigation and adaptation measures

Module 5. Mitigation and adaptation measures

Mitigation measures

Mitigation or activities to mitigate climate change in the agricultural sector mean the measures that will contribute to the reduction of greenhouse gas emissions from agricultural production.
Mitigation measures in agricultural production include the application of sustainable examples that will enable:

- increase in vegetative cover,
- improving the ability of the soil to bind carbon in organic form,
- application of moderate amounts of organic fertilizers,
- reducing the use of mineral fertilizers,
- proper waste management,
- use of biogas and others.

More important mitigation measures in agriculture that contribute to the reduction of greenhouse gas emissions are the following:
Weeding of perennial plantations. The purpose of this measure is to prevent or reduce the erosion of soils on sloping terrain, to improve the structure and ability of the soil for infiltration of water from precipitation and irrigation, to increase the content of organic matter in the soil and others.
Replacement of classic tillage with reduced soil tillage. This measure aims to avoid the overturning of the soil, which leads to the destruction of its structure, to reduce the intensity of decomposition.

Picture 16: Reduced tillage
Source: Own photo

Correct management of domestic animal excrement (storage, transport and field application). The aim of this measure is to directly reduce the emission of greenhouse gases.
Adding organic waste to the soil or applying green manure (sideration). The goal is to increase the content of organic matter in the soil and to improve the water-physical properties of the soil.
Application of the cultivation system known as agroforestry. The purpose of this measure is to stop the intensive processes of erosion and soil destruction, but also to bind large amounts of CO2 from the atmosphere in the above-ground and underground vegetative mass of plants on abandoned lands where the vegetation cover has been degraded.

Measures for adaptation of agriculture to climate change

They mean initiatives and activities for the reduction of natural systems and humans towards the real or expected consequences of climate change. For the correct selection and effective implementation of measures for adaptation to climate change, it is important to know their effect and the conditions in

which they will be applied. There are numerous activities that individual farmers can apply in different segments of production (autonomous adaptation).

Measures that contribute to the adaptation of agriculture to climate change include:

- water management measures,
- soil management measures,
- waste management measures,
- selection of varieties,
- installation of safety nets,
- organic farming and others.

Water management measures

Water management measures should ensure water conservation and its efficient use.
The projected shortage of water as a resource is one of the biggest problems expected to arise as a result of climate change, so it is necessary to make adjustments to the ways in which water is used in agriculture.
It is very important in the coming period to examine the possibilities of recycling waste water, collecting rain water and other methods of saving water.
Water-saving measures include the selection of drought-resistant crops, application of irrigation during critical stages of plant growth and development. With these measures, it is necessary to replace old and unsustainable irrigation techniques with new, efficient and economically viable systems.
The use of the "drop by drop" system for irrigation of agricultural crops represents an excellent opportunity to save water (Fig. 2). The use of this irrigation system to cope with climate change compared to other systems has a number of advantages:

- uses very little water,
- eliminates surface evaporation,
- can be used for simultaneous automatic watering, fertilizing and plant protection,
- reduces the possibility of diseases and pests,
- reduces the need for labor and more.

It is necessary to investigate the possibilities of wastewater recycling, rainwater harvesting and other water saving methods. Conservation measures include the selection of crops that are resistant to drought, as well as the application of irrigation at critical stages of plant growth and development. It is necessary to replace the old, unsustainable irrigation techniques (in furrows) with new, efficient and economically viable systems.
Compared to furrow irrigation which has 60% effective utilization of the water used, and the application of artificial rain 75%. The main reasons why the drip system is the most suitable for dealing with climate change is that it uses the least amount of water while eliminating surface evaporation.
Through the drip system, fertilization can be done, as well as some forms of plant protection. This technology is recommended for regions with seasonal droughts.
With overall water savings and labor savings, the costs of agricultural production are reduced. Also, this technology reduces the spread of diseases and pests and thus has an integrated effect on reducing the consequences, as well as easier handling of other aspects of climate change.

Picture 17: Drip system
Source: Own photo

Soil management measures

Soil adaptation measures should be aimed at solving the basic problems caused by climate change such as erosion and reduction of organic matter. Fertile soil is necessary for productive agriculture, so the sustainable management of this natural resource is of particular importance. Producers have numerous opportunities available to them to apply sustainable soil resource management practices.

Soil management measures should address the fundamental problems caused by climate change: soil degradation and increased soil erosion. These measures should enable the creation and retention of soil fertility. Measures for sustainable soil management include:

- **Reduced tillage**. The intensive processing and utilization of the soil, which is used in modern horticultural production, contributes to changing its natural structure, increased erosion, reduction of organic matter and microbiological activity and fertility of the soil. Reduced cultivated soil (protective plowing) as a measure to deal with climate change, should prevent or reduce these harmful impacts and preserve soil fertility. With the reduced processing, one third of the plant residues remain on the field, which enables the reduction of erosive processes and the conservation of moisture in the soil. Reduced processing can also be performed without plowing, whereby plant residues from the previous year are completely left and direct seeding is applied to them. Research shows that this method of processing is appropriate and successful in the production of grain, garden, fruit and grape crops.

Picture 18: Conservation plowing
Source: Own photo

For soil conservation, it is also recommended to eliminate plowing, 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.

- **Mulching** is also another soil management measure, a widely known practice of artificially covering the soil surface. The materials used for mulching can be of organic or inorganic origin. If organic matter is used, it should be applied in thinner layers, otherwise anaerobic processes are created, which release poisons for plants and soil microorganisms.

Of the inorganic materials, the most widespread is the plastic film, which is offered in different thicknesses and different colors. The advantages of applying mulching are multiple:

- the emergence of weeds is prevented
- the soil is protected from drying and hardening, and the capacity for preserving humidity increases
- the biological activity of soil microorganisms is retained and increased
- temperature oscillations are mitigated
- the soil structure is maintained and erosion is prevented, thereby preventing the leaching of nutrients
- saving of irrigation water is ensured

Picture 19: Mulching
Source: Own photos

Cover crops are plant species that are sown between the rows in the plantation in order to reduce problems with erosion, fertility and soil quality, to reduce the pressure from the appearance of weeds, pests, diseases, as well as to maintain biodiversity in agroecosystems. 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.

Picture 20: Cover crops
Source: Own photo

Manure management measures

Improper use of mineral fertilizers, and especially nitrogen fertilizers, has a significant negative impact on increasing climate change. Fertilization should correspond to the nutrient needs of vegetable crops and maintain optimal soil fertility with minimal environmental pollution.

When fertilizing, preference should be given to nitrogen fertilizers that are in the form of ammonium ions, which will contribute to the reduction of greenhouse gas emissions. The use of organic waste is particularly noteworthy, which enriches the soil with organic matter and improves its biological activity and fertility.

The use of organic and mineral fertilizers is an effective way to manage soil fertility and crop production. Fertilization should match the nutrient needs of crops and maintain optimal soil fertility with minimal environmental pollution. Under conditions of climate change, there is a high risk to the availability and utilization of nutrients by plants. Research shows that the use of nitrogen fertilizers in the form of ammonium ions, instead of the often used nitrate forms, has numerous advantages in the development of plants, but also in the reduction of greenhouse gas emissions from agriculture. The application of organic manure is strongly recommended because it enriches the soil with organic matter and, in combination with other techniques, can give strong positive effects in improving its biological activity and quality.

Picture 21: Organic fertilizer
Source: Own photo

Selection of varieties

One of the basic conditions for successful crop production is the correct choice of variety. Apart from the productive and quality properties of the variety, farmers should take into account the biological requirements of the variety and the environmental conditions prevailing in the production region, in order to make a correct assessment of the possibilities for successful production. According to the

predicted climate scenarios for our country, it is recommended to choose appropriate 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. However, numerous advantages of seedling grafting have been established in horticultural production, especially for the production of fruit crops (tomato, pepper, eggplant) due to the introduction of resistance to abiotic and biotic stress. And in this case, 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.

In order to achieve high and quality yields, the selection of the substrate in fruit production is essential. The basic requirements in fruit production when choosing the substrate are:

- Resistance to diseases and pests;
- Adaptability to soil and climate conditions;
- Good rooting;
- Longevity;
- Suitability for intensive cultivation systems;
- Ensuring constant and quality fertility.

The agroecological conditions in Macedonia impose the need to use fruit rootstocks that have a high tolerance to soil moisture deficit, that is, they must be resistant to drought.

Installation of safety nets

The application of protective nets in agricultural production, as a relatively new technology, has spread globally in a short time. And in our conditions, their application is more common due to the numerous benefits in plant production. Depending on the needs, nets with different densities are available on the market, which can provide up to 90% shading. Apart from light regulation as a factor, they also provide crop protection from other external influences such as hail, strong winds, strong solar radiation, etc.

Research shows that the use of nets affects the microclimate in the plantations, reducing air temperature and reducing moisture loss. In addition, the nets can provide protection from insects and birds. They are suitable for use in gardening, fruit growing, viticulture, as well as production of flower and spice species.

Research confirms that color also has an impact on the quality of crops, their size, durability, as well as the ripening period, through the management of the solar spectrum, the way of distribution and the intensity of light. The introduction of safety nets is a relatively simple and economically viable investment.

The installation of protective nets in the plantations is a promising, new technology that needs special attention in the future.

Protective nets are a novelty for our producers, while in developed countries, especially for high income crops, it has long become a common practice.

The reasons for installing safety nets are numerous. With them, agricultural producers fight against natural elements such as hail, drought, high light intensity and high temperatures.

The main motivating factor for the installation of the protective nets is the fight against hail, and as a secondary goal is the shading of the plants, thus reducing the sun burns of the fruits and leaf mass, which cause huge financial losses for the producers all over the world.

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.

Picture 22: Safety nets in viticulture
Source: Own photo

Covering nets are increasingly used in the protection of vineyards. They have a multipurpose function:

- Protection from hail;
- Protection from direct solar radiation;
- Protection from spring frosts.

Nets of different density and color are in use. White nets reduce harmful ultraviolet radiation by 8 to 12%. The yield and quality of the grapes decrease linearly with the increase of shading intensity. In regions where there is a critical number of sunny hours, the use of white nets is recommended.

Picture 23: Netting in fruit growing
Source: Own photo

The network also plays a role in reducing heat radiation from the soil, as a result of which the damage from late spring frosts is reduced. Other benefits associated with the installation of protective nets are a reduction in wind speed, up to 50%, which allows for a more efficient application of protective agents in plantations. It follows from this that in plantations covered with a protective net, the overall environment for the normal development of all processes in the plants is improved.

Organic production

Organic production represents a significant measure for mitigation and adaptation of agriculture to climate change, as it promotes and practices the combination of sustainable examples from practice that should ensure the rational use of natural resources.

Numerous studies show that the emission of greenhouse gases from organic production is lower compared to conventional production. This is due to the application of combined soil protection measures (organic waste, production of leguminous species, crop rotation, mulching, etc.). The non-use of synthetic fertilizers and protective agents also plays a role in the reduction of emissions, because large amounts of energy are consumed during their production.

Nitrogen oxides, which are a big problem in conventional production, are also reduced in this way due to the non-application of mineral nutrition, at the expense of the use of organic fertilizers and additional measures to improve and maintain the fertility of the soil, while achieving large yields. And organic animal production has low greenhouse gas emissions due to the fact that the standards require an adequate number of animals per unit area, and consequently excessive amounts of agricultural waste are not produced.

Animal nutrition is based on reduced protein intake and increased vegetable fiber intake, which facilitate the digestive process. The system of organic production promotes the application and combination of sustainable practices that ensure the rational use of natural resources, which is why it is included in the measures for mitigation and adaptation of agriculture to climate change.