Climate-smart and climate-resilient agricultural and agri-processing technologies in Armenia

PROGRESS - Promoting Green Deal Readiness in the Eastern Partnership Countries - Armenia

2025

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IKI INTERNATIONAL CLIMATE INITIATIVE

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Climate-smart and climate-resilient agricultural and agri-processing technologies

Background

The Republic of Armenia has favourable soil and climatic conditions for agricultural production, especially for the production of fruits and berries. They are cultivated in almost all regions of the country, both in small plots adjacent to houses, as well as in bigger plantations. In smaller areas, mixed cultivation of different types and varieties is mainly carried out, which is not of industrial scale and importance.

In Armenia within recent years the plantations of fruits and berries (including apricot and raspberry) began to increase, occupying larger areas. These crops are considered as high-value crops, generating around EUR 10,000 net income per hectare. Though targeted Government support and tremendous increase of production volumes, there are still problems during cultivation and low yields are observed. All this is a result of the numerous challenges in Armenia that are hampering the development of fruits and berries production sector in the country.

Out of which could be mentioned:

- Low level of application of climate-smart, resource-efficient and sustainable management practices and technologies during cultivation.
- Lack of or ineffective application of relevant experience, knowledge and advice.
- Increase in the frequency of hazardous climatic phenomena (e.g., hail, high temperatures, heat waves, drought, strong winds, frost, etc.).
- Lack of mechanisms for uninterrupted financial investments necessary for the implementation of technical solutions and technological improvements.
- Limited opportunities for the local market to consume additional quantities of produced fruits and berries as well as problems related to the sale/export of processed products (in particular, limited export markets, logistics costs, competitive situation, etc.).
- Continuous increase in production costs (for primary production and processing), which leads to low competitiveness of the final product in the market.
- Underdeveloped post-harvest infrastructures, etc.

The climate-smart, resource-efficient and sustainable management practices and technologies

Presentation of good practices

Climate-smart, resource-efficient, and sustainable management practices are widely used in agriculture, which are important for facing the complex challenges of today, as well as help farmers to manage various production risks and better response to the consequences of climate change. They are aimed at ensuring food security and supporting increased adaptation in the face of climate change and growing demand for food. The introduction of more efficient and effective production systems and practices is a serious prerequisite for overcoming environmental, social

and economic challenges. Their importance and necessity for implementation are justified by the following aspects:

1. **Ensuring Food Security**: The implementation of these practices ensures sustainable agricultural productivity to meet the growing demand for food, while minimizing the negative impact on the environment.
2. **Sustainable Resource Management**: Agriculture relies heavily on natural resources such as water, soil, and biodiversity, the overexploitation of which can lead to degradation, reduced yields, and environmental pollution. The implementation of these practices ensures conservation and sustainable use of all resources, maintains soil fertility, reduces water waste and prevents biodiversity loss.
3. **Improved Soil Health and Resilience**: Soil is the foundation of agriculture. Sustainable soil management practices, such as crop rotation, cover cropping, and reduced tillage, help maintain soil fertility and structure, preventing erosion and soil degradation. By implementing these practices, soil health and productivity are ensured.
4. **Increased Productivity:** The implementation of sustainable agricultural practices improves soil health, optimizes water use, and reduces the impact of pests and diseases on crops, ultimately contributing to increased yield. In addition, it becomes possible to reduce the amounts of fertilizer and pesticide applications.
5. **Climate Change Adaptation**: Climate-related weather hazards (such as droughts, floods, temperature fluctuations, pest outbreaks, etc.) have a significant impact on agriculture. Implementing these practices helps farmers cope with the effects of unpredictable weather events and reduces the risks associated with climate change.
6. **Economic Viability and Poverty Reduction:** Implementing climate-smart practices can lead to cost savings, improved crop quality, and higher incomes. By implementing sustainable and resource-efficient practices, farmers can spend less on agricultural inputs (e.g., pesticides, fertilizers), generate more income, and improve the long-term profitability of their farms, helping to reduce poverty and improve economic sustainability.

A number of climate-smart and sustainable practices are applied in fruit and berry production in Armenia, which aim to mitigate climate risks, adapt to climate change, improve production and productivity, conserve resources, and reduce emissions.

1. ***Selection of the most suitable species and varieties for cultivation***
2. ***Production of planting materials/saplings of locally resistant varieties***
   2.1 Production of virus-free planting material via the "in-vitro" method
3. ***Use of hail protection nets***
4. ***Introduction of modern irrigation systems and water-saving technologies***
   4.1 Community small water reservoirs
   4.2 Drip irrigation systems
5. ***Mulching - to prevent soil erosion and moisture loss***
6. ***Application of Integrated Pest Management***
7. ***Organic Agriculture***

8. ***Use of agro-drones (unmanned aerial vehicles-UAV) in agricultural production***
9. ***Processing of organic residues and development of organic fertilizers***
10. ***Application of the principle of resource efficiency and cleaner production in agriculture and agro-processing***
11. ***Modern solutions for reducing post-harvest losses.***

Below are examples of climate-smart, sustainable, agroecological practices used in agriculture and agro-processing in the Republic of Armenia. They can be introduced and successfully applied in farms and agro-processing enterprises to reduce costs, as well as negative environmental impact, increase savings, and obtain high-quality products. As a result, ensuring stable income and contributing to the formation of a healthy society.

This information material could be of use to farmers, agribusinesses, and agri-input suppliers. A brief description of good practices implemented in Armenia is provided, along with links to relevant government support programs and supporting structures. It provides an opportunity for individuals and businesses involved in agriculture to be informed and apply already tested practices.

1. Selection of the most suitable species and varieties for cultivation

The introduction of new crops, as well as endemic and introduced varieties can enhance biodiversity and ecosystem services, while increasing productivity, achieving production sustainability, resilience and promoting the genetic diversity of species. This reduces the impact of adverse weather and climatic phenomena (e.g., frost, drought, etc.) on the agricultural production process. There is a large variety of apricot and raspberry varieties, which differ in their characteristics. For example, raspberry varieties differ in:

- sizes - small, medium and large
- colour - red, yellow, black, purple
- maturing period - early, mid and late season bearing varieties
- purpose of use - fresh, processed jam, juice production, freezing, etc.
- resistance - to diseases, different climatic phenomena
- as well as fruit shape, aroma, taste, potential yield, growth vigour, etc.

Diversification of raspberry varieties includes cultivation of varieties that are better adapted to local climatic conditions, more resilient, have different ripening periods and meet market requirements. These are the key elements to higher income stability for farmers and better-quality produce. The raspberry varieties that are widely recognized, well-adopted and grown by producers in Armenia are: "Polka", "Juan J", "Zyugana", etc. Depending on weather conditions, as well as outbreaks of diseases or pests, their yield can vary within 10-12 t/ha.

Presentation of good practice, case of “Armberry” CJSC

The Armberry CJSC was established in 2017 and operates in the Nairi community of Kotayk region (Yeghvard town area). The organization specializes in raspberry production. The plantations were established with imported high-quality planting material, mainly the "Polka" and "Mapema" raspberry varieties are cultivated. A number of climate-smart practices and technologies that ensure high efficiency and yield have been introduced and successfully applied during production.

Among them are:

- Trellised production system - for more effective crop management (e.g., pruning, spraying, harvesting).
- Tunnel greenhouses - to extend production season (e.g., to start production in early spring and continue until late autumn).
- Hail protection nets - to mitigate hail issue, protect plants from sunburn, as well as to ensure a mild climate under the net.
- A geomembrane-covered reservoir - for water storage and use on demand. Ducks live in the reservoir, which provide natural water purification.
- Drip irrigation system equipped with an injector and water meter - for even and precise distribution and supply of water and fertilizers.
- Cooling area - for temporary storage of the harvested yield at low temperatures (+3^{0}C).
- The electric vehicle - for delivering berries to the local market.

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Joan J Raspberry orchard

Raspberry saplings of the "Polka" variety

Useful information / additional information

The Government of the Republic of Armenia implements several state-support programs in the agricultural sector that enable farmers to implement climate-smart practices. One such example is The state support program on development of intensive fruit orchards, the introduction of modern technologies and promotion of production of non-traditional high-value crops in the Republic of Armenia (https://mineconomy.am/page/1948)

2. Production of saplings of locally resistant varieties

The cultivation of locally resistant varieties has a number of advantages: the ability to adapt to climate change, as well as the high value of local varieties from the point of view of agrobiodiversity.

Apricot has its own place in the agriculture of the Republic of Armenia. Taking into account the varietal characteristics and ripening dates, it is possible to cultivate it in different agricultural zones of the country. This makes it possible to ensure the availability of fresh fruit for a long period (from June to mid-September), to reduce seasonal stress among exporters and processors.

As an early-flowering crop, apricot often suffers from early spring frosts, and in some cases, hail. Armenian apricot is mainly cross-pollinated, and if the flowering period is rainy, then pollination does not occur and the yield is not formed.

The traditional apricot orchards in Armenia are established with saplings grafted onto seed rootstocks, which have strong growth, are late in reaching full fruiting, and form dense foliage. As a result:

- it becomes difficult to carry out quality cultivation (pruning, spraying, harvesting),
- the penetration of light into the foliage is hindered (it effects on the qualitative characteristics of the fruits),
- the movement of air in the foliage is limited (moisture is retained in the foliage, disease outbreaks become more frequent).

The establishment of intensive apricot orchards is imperative for the sustainable development of the sector. This will also allow the introduction of innovative, advanced and efficient cultivation technologies, and the production of high-quality yields in a short time, bringing apricot cultivation to a qualitatively new level. The dwarf saplings are used for intensive orchards, and as a result:

- more plants are planted per unit area (800-3000 trees/ha),
- plant care activities become easier and of higher quality,
- orchards yield earlier and faster pay off the financial investments made in the orchard,
- it becomes possible to manage the harvest and obtain higher quality fruits,
- a high yield is obtained at a lower production cost,
- it becomes possible to introduce climate-resistant technological solutions in orchards (for example, hail protection nets, drip irrigation systems, etc.) to reduce/eliminate the negative impact of climatic phenomena.

2.1 Production of virus-free planting material via the *"in-vitro"* method

The use of high-quality (pest and virus-free) and pure-variety planting material is of primary importance for the establishment of orchards. In intensive gardening, clonal rootstocks are widely used, which differ in growth, soil requirements, resistance to diseases and pests, ensuring graft adhesion, compatibility with varieties, and other indicators. Biotechnological methods, in particular, the production of rootstocks by the "in-vitro" method, are widely used in modern fruit growing. The advantages of this method are:

- development of healthy planting material (free from viral, fungal and bacterial diseases and pests),
- the possibility to produce genetically uniform planting material,
- ensuring a high level of reproduction, rapid multiplication of a valuable plant clones,
- the possibility to work throughout the year and obtain planting material at any time,
- the possibility for long-term storage of saplings without contact with the external environment.

The micropropagation of rootstocks is carried out in a tissue laboratory with appropriate equipment and technology, under artificial lighting and controlled temperature conditions. Until the roots form, the rootstocks are grown in laboratory conditions. To gradually adapt to external conditions, they are first transferred to an area designated for climate training - a fog chamber, then growth continues in greenhouse conditions. After full formation, the rootstocks are transferred to the open field, where grafting activities and sapling production are carried out.

Presentation of good practice on sapling production, case of “Noratunk” CJSC

"Noratunk" CJSC was founded in Arinj settlement of Kotayk region and has been operating in Armenia for more than 30 years. It consists of four nurseries located in different climatic zones. The company specializes in the production of fruit tree saplings, in particular, stone trees (e.g., apricot, peaches, nectarine), as well as limited quantities of pome fruit (e.g., apple) and walnut, almond saplings. The average annual production volume of the nursery is 100,000-130,000 saplings. The nursery has state registration and, in addition to planting material, also provides buyers with all the necessary documents in accordance with the legislation of the Republic of Armenia (including phytosanitary certificate and certificate of origin).

During the production of planting material, complex cultivation measures are applied, such as crop rotation (cereals, fallow, legumes, and vegetable crops follow each other), the use of organic fertilizers, complex protection of crops from harmful organisms, a drip irrigation system, etc. The nursery employs 40-50 employees (the majority are women).

"Noratunk" CJSC is the only one in Armenia that produces semi-dwarf clonal rootstocks of apricot trees, onto which local apricot varieties are subsequently grafted. Semi-dwarf planting material ensures relatively dense, intensive plantings and continuous supply of Armenian apricots to the market. Over the years, clonal rootstocks have been imported to Armenia, tested and evaluated. As a result, the most suitable varieties for use have been selected and recommended. These virus-free, pure-variety rootstocks well adapted to local conditions and ensure the production of uniform and high-quality saplings for fruit growers. Currently, the owner of the nursery has initiated the construction of a laboratory to stimulate the local production of high-quality planting material.

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General view of the nursery

Local apricot semi-dwarf orchard – produced from saplings

Saplings grafted on dwarf rootstocks

Useful information / additional information

In the list of main directions ensuring the economic development of the agricultural sector in the Republic of Armenia, the importance of increasing the competitiveness and efficiency of the agricultural sector is emphasized. To this end, the Ministry of Economy of the Republic of Armenia supports the promotion of the production of certified seeds, seedlings and planting material through scientific centres, registered seed producers and nurseries.

3. Use of hail protection nets

Hail is the most frequently recorded weather phenomenon that causes significant damage to agriculture. All crops suffer from hail, the quantity and quality of the yield decreases, the harvest period is delayed, and a longer period and intensive care are required for plant recovery. Hail protection nets are specially designed and used to protect crops from hail damage. They are made of durable materials and are successfully used in agricultural fields, orchards and vineyards to protect crops from the negative effects of natural phenomena. This measure is a way to protect and resist the negative effects of climate change.

About hail protecting net system:

- **Materials**: The hail nets are made of strong, UV-resistant nylon or polyethylene that can withstand adverse weather conditions. The nets are attached to wire and poles that hold the net above the crops.
- **Mesh Size**: The size of the net can vary depending on the crop. Finer meshes are used for small fruits, such as berries. While larger meshes are suitable for use in large-fruited orchards.
- **Colour**: The choice of colour can affect the amount of sunlight that passes through the net. Black nets provide more shade, while white nets allow more light to penetrate.
- **Use and Maintenance**: Nets are mainly used during periods when there is a risk of hail. They can be removed or retracted after harvest (when they are no longer needed). For the effective operation of the hail protection system, it is necessary to carry out regular inspections and do repairs in case of damage.

The installation of hail protection nets is becoming more widespread in the fruit-growing areas of the Republic, where hail is more frequently recorded. Although the installation of a hail protection system is costly and labour-intensive, at the same time it:

- Helps to protect crops from hail damage,
- Improves crop quality,
- Reduces losses, due to other weather-related factors, such as wind or heavy rain.
- Regulates microclimate. It provides some shading, reducing the temperature during hot weather and decreasing the risk of sunburn on crops.
- The hail nets can also serve as a barrier to birds and certain pests.

Only the crops with limited growth can be grown under hail protection nets. For example, various types of berries, vegetables and fruit trees grafted onto dwarf or semi-dwarf rootstocks. Although the installation of a hail protection system requires significant initial investments (about 10.0 million AMD/ha), it is fully justified, since the negative impact of hail is successfully mitigated and the annual harvest is guaranteed.

In the framework of state support programs of the Government of the Republic of Armenia 3,270 hectares of intensive orchards have been established, some of which have hail protection nets installed.

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Hail protection nets in the fruit orchards and berry plantations

Useful information / additional information

The Government of the Republic of Armenia is implementing an affordable mechanism for the installation of hail protection nets for businesses operating in 270 settlements located in the most active hail zones through state support. The support is aimed at compensating 50-75% of the actual costs incurred for the installation of hail protection nets in 0.5-3 ha of perennial plantations.

In particular, those wishing to install hail protection nets can apply to the state support program on the "Development of Intensive Horticulture, Introduction of Modern Technologies and Stimulation of the Production of Non-Traditional High-Quality crops in the Republic of Armenia" (https://mineconomy.am/en/page/1948), as well as the "Agricultural Machinery Leasing Support Project in the Republic of Armenia" program (https://mineconomy.am/en/page/2069%20).

In addition, there is an agricultural insurance system in place for 13 crops and 4 risks (including hail), and the government provides subsidies of up to 80 percent (inclusive) of the insurance premium.

4. Introduction of modern irrigation systems and water-saving technologies

The agricultural production is continuously developing, aiming to use water resources economically and efficiently. In general, water loss in irrigated agriculture reaches up to 60%. Agricultural producers and scientific potential are aimed at improving water use efficiency and minimizing water losses. Limited access to water, scarcity, as well as improper management are among the main factors limiting the establishment of new fruit and berry plantations and their cultivation. This is especially evident during the production season, when insufficient access to irrigation water has a significant impact on the quantity and quality of the crop and yield. Thus, the establishment of a water collection, storage and efficient distribution system will help manage water availability issues during the production season.

The system includes:

- surface runoff collection,
- construction of a small reservoir or water storage pond.
- establishment of an efficient water supply and distribution system.
- to avoid water leakage, the bottom and walls of the reservoir can be covered with a geomembrane layer.
- in addition, to manage water quality, fish farming and duck farming can be carried out in the reservoir. The cost of constructing a geomembrane reservoir is approximately 6,000-8,000 AMD/m^3.
- when planning the volume of the reservoir, in addition to the crop and water requirements, it is necessary to take into account other factors, such as the geographical location of the plantation, climatic conditions, mechanical composition of the soil, etc.

4.1 Community small water reservoirs

As a successful example of establishment “smart” irrigation system, can be mentioned the system built in Shoghakat community of Gegharkunik region, financed by UNDP. It includes a deep well, a water pumping station, a geomembrane reservoir, a solar station and a complex of other infrastructures. It was built as a result of joint investments of various stakeholders and serves to irrigate an area of about 300 hectares.

With the support of UNDP, smart land and water management practices have been introduced in Lori region, applying innovative and cost-effective solutions and management approaches. In particular, in the settlements of Lernavan and Shenavan, the following were built:

- 13,000m^3 geomembrane reservoirs,
- an irrigation system with a length of about 17,000 meters, equipped with an energy-efficient pumping station,
- about 400 households in settlements and 120 hectares of previously unirrigated, degraded land areas have received access to water.

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Geomembrane water reservoir

Source: https://www.sgp.am/en/pages/projects/159

Geomembrane water reservoir for irrigation of orchards

Useful information / additional information

The "Irrigated agriculture development in Ararat and Armavir marzes" (IADAAM) grant program, financed through the European Union (EU) with implementation by the French Development Agency (AFD) is an integrated initiative aimed at transforming irrigated agriculture in Armenia. It aims to modernize at least 2,000 hectares of irrigated areas. The main goal of the program is to support the Government of Armenia in implementing of ongoing reforms in the irrigation sector, as well as in introducing innovative sustainable mechanisms aimed at the development of irrigated agriculture.

4.2 Drip irrigation systems

Drip irrigation is one of the most efficient irrigation methods, helping farmers to optimize the use of water and fertilizers. Unlike traditional irrigation methods, such as furrow irrigation and sprinkler irrigation, drip irrigation allows water to be delivered directly to the plant roots, minimizing evaporation and runoff. This irrigation technology is especially important in areas characterized by drought and water scarcity, as it conserves water resources while providing plants with sufficient moisture during critical growth stages.

The advantages of drip irrigation system are:

- Significant savings in irrigation water.
- Improved water use efficiency.
- Increased crop yields.
- Applicability in complex relief conditions, as well as in land areas with high water permeability.
- Reduced risk of soil salinization and erosion.
- Possibility of full automation of the irrigation process.
- Improved irrigation regime.
- Combined implementation of irrigation and fertilization.
- Higher absorption of applied fertilizers by plants.
- Less labour intensity (reduction of labour, increased work efficiency).

The disadvantages of drip irrigation systems include:

- The need for capital investments.
- Additional costs for maintenance and operation of the system.
- Requirements for water quality.
- Energy consumption.

Installation of drip irrigation system costs around 2,5 million AMD/ha, however, transitioning to drip irrigation can cut down irrigation costs for the season to AMD 35,000 per ha.

Digitalization of irrigation process and organization of "smart" irrigation are a qualitatively new solution in modern agriculture. Among the many companies involved in this field, the Armenian startup "Revalcon" stands out. The technology developed by this startup makes it possible to simplify the entire irrigation process by controlling the work with a smartphone (via mobile and web applications).

The system is fully remotely controlled, ensuring high efficiency. Based on the analysis of information continuously collected from the field, irrigation schedules are coordinated, water and electricity saved, human resources are efficiently allocated, and the operation of pumps and valves is controlled. With limited human resources, it becomes possible to manage large areas, while saving both water and electricity and all other resources.

The introduction of water-saving practices, such as rainwater harvesting, water reuse, and the use of efficient irrigation methods help reduce water withdrawal. They can stimulate carbon accumulation in the soil, contributing to increased yields, while improving water quality, soil ecosystems, and biodiversity.

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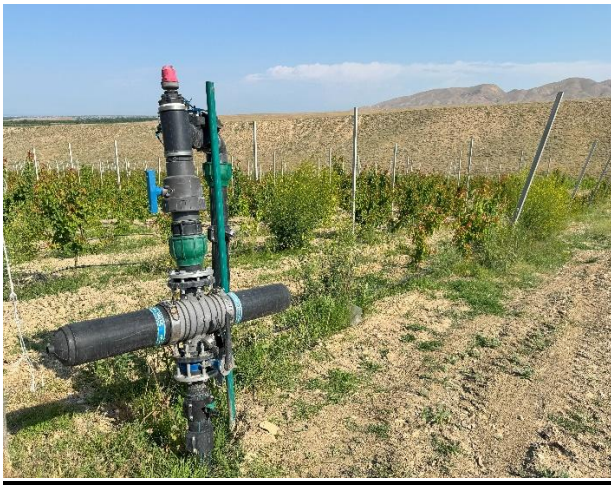
Drip irrigation



The head unit of drip irrigation system

Useful information / additional information

In the framework of "Development of Intensive Horticulture, Introduction of Modern Technologies and Stimulation of the Production of Non-Traditional High-Quality crops in the Republic of Armenia" (https://mineconomy.am/en/page/1948) program in 2024, in the Republic of Armenia, applications for the establishment of orchards on about 1350 hectares were approved. From the start of the program to 31.12.2024, about 3270 hectares of orchards were actually established, where water-saving technologies are used.

Within the framework of "Introduction and Promotion of Advanced Irrigation Technologies" activity, the RA Ministry of Economy signed contracts for the introduction of modern irrigation systems in an area of about 310 hectares with a loan and compensation component in 2024 and provided compensation for 326 hectares.

5. Mulching

Mulching is the process of covering the soil around plants with various materials. As mulch, you can use both organic materials (for example, straw, wood chips, leaves, grass, compost, etc.), and non-organic materials (for example, polyethylene film, landscape fabric, gravel, etc.). It is successfully used in homesteads and agricultural areas, around trees, shrubs.

Mulch has a number of advantages for both plants and soil. For example,

- **Retains moisture**. Mulch helps reduce evaporation, so the soil stays moist longer. This is especially important in hot, dry climates.
- **Reduces weed growth.** Covering the soil surface blocks sunlight from reaching the soil, making it harder for weeds to grow. This reduces the need for chemical weed control.
- **Regulates soil temperature.** Mulch insulates the soil, keeps it warmer in the winter and cooler in the summer, which promotes healthy root growth.
- **Controls erosion**. It helps prevent soil erosion during heavy rain or wind.
- **Improves soil quality (in case of organic mulch usage)**. Over time, organic mulch breaks down, improvs soil structure and fertility.
- **Reduces the spread of diseases.** The “contact” between the soil and the crop is reduced.
- **Gives an aesthetic appearance to the area.** A layer of clean mulch makes the agricultural landscape look more well-groomed and neater.

Climate-smart practices: example of “Green Training Centre”

The Green Training Centre was established in 2015 in the Dzoraghbyur settlement of Kotayk region, the founder is Green Lane NGO. Almost all the up-to-date agricultural technologies are demonstrated here, such as new methods of plant cultivation, sustainable land management, effective irrigation systems, pest control, etc. In particular, on an area of 1.4 hectares, extensive experience has already been gained in the areas of growing more than a hundred high-value crops, rainwater harvesting, solar energy use, organic plant cultivation methods, as well as application of improved disease, pest and weed control methods.

The centre exists the long-term experience in the use of mulching (with straw, sawdust, weeds, etc.) as an effective measure of nourishing and protecting the soil, preventing evaporation and weed growth. In addition, agricultural waste (including leaves, manure, crop residues, household waste, etc.) is composted and successfully used to improve soil condition.

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Using wood chips as mulch


Mulching in the fruit orchard

Useful information / additional information

Fruit trees should be mulched in the spring. However, when mulch is applied close to the trunk of trees and in large quantities (in a heap), moisture accumulates around the trunk and in the area of root system spread, which can have undesirable consequences. In particular, rotting processes may be observed, root development is impaired. Moreover, too much mulch placed around the trunk of trees prevents moisture from penetrating to the roots. To avoid the described undesirable phenomena, it is necessary to pour mulch around the trees in a 5-10 cm thick layer, in the form of a pancake, at a distance of several centimetres from the trunk. It is preferable to use mulch of organic origin (for example, wood chips, straw, etc.). The mulch should cover an area of 70-80 cm in all directions around the trunk of the tree.

Trees with mulched root zones grow larger, faster, and have better root growth. Gardens with mulched areas have lower weed infestations. The soil under mulch stays warmer in winter and warms up faster in spring.

6. Integrated Pest Management (IPM)

It is an environmentally friendly crop production and protection approach. IPM emphasizes the use of integrated and alternative control methods, taking into account the development stages of crops and harmful organisms. It includes various cultivation practices aimed at obtaining a healthy crop and reducing the use of pesticides. Such as crop rotation, mechanical cultivation, the use of biological preparations, etc. The IPM approach not only helps to improve crop yields but also it manages pest damage by the most economical means, and with the least possible hazard to people, property and the environment.

The integrated approach of pest management encourages:

- application of preventive, mechanical, biological, physical methods of control,
- developing habitats for beneficial insects,
- use of different traps (e.g. colour traps, pheromone traps, sticky belts, etc.) to detect precise time of spraying,
- use of organic fertilizers,
- implementation of sustainable management practices, such as crop rotation, intercropping, etc.,
- implementation of mechanical weed control measures,
- destruction of plant residues,
- decreasing/adjusting number of sprayings and application rates based on the monitoring data,
- cultivating pest resistant varieties,
- use of higher quality agricultural equipment and inputs.

Implementation of Integrated Pest Management approach: Case of “ArLeAm” LLC

Within recent years in Armenia rapidly increased areas of industrial fruit and berry plantations where various climate smart, green and sustainable practices are implemented. “ArLeAm” LLC is one of the leading companies specialized on fruit growing in intensive orchard system. The cultivated fruit types include apple, pear, sweet cherry, apricot and peaches. Advanced and up to date fruit management technologies and practices are implemented in the orchards to develop higher-quantity and better-quality yields of fruits. Innovative solutions include the use of the following practices:

- intensively grown fruit-tree saplings,
- early warning system,
- inter-row cultivation and use of branch shredding machines and equipment,
- use of bumblebees for pollination,
- use of hail-protection nets,
- use of drip irrigation system,
- application of organic fertilization system.

In close cooperation with Duch company “Rimpro” **an early warning system** is being implemented in the orchards. For this purpose, the real-time monitoring tools and equipment are installed and operated in the orchards to apply timely, comprehensive and more effective crop

management measures. For instance, the meteorological station equipped with sensors is installed to collect on-going data on climate. It includes data on air temperature, humidity in the soil, air, and on the leaf surface, wind speed, etc. Besides, the pheromone traps are used to monitor the lifecycle of the most harmful insects. After processing data outbreaks of diseases or development stage of insects are forecasted to detect the most sensitive stages and implement pest control measures on proper and exact periods to avoid additional, non-effective sprayings.

The application of monitoring and knowledge-based systems enables the company to be more economical in their use of pest control agents: applying them only when and where necessary.

During the production season special attention is being paid to the improvement and strengthening of crop immune system, application of biological pest control methods, developing the habitat for the natural enemies and pollinator insects and mulching the inter-raw areas with grinded branches. Overall, the crop management system is based on the application of green, sustainable and preventive measures.

The components of early warning system: pheromone trap and weather station

Useful information / additional information

Additional information can be obtained by visiting the websites: https://www.arleam.love/about and https://rimpro.cloud/.

7. Organic agriculture

Organic agriculture aims to produce food using natural resources and practices. Organic agriculture is a climate-smart practice, it has a limited impact on the environment and promotes:

- responsible use of energy and natural resources,
- conservation of biodiversity,
- maintenance of regional ecological balance,
- improvement of soil fertility,
- preservation of water quality.

Development and promotion of organic agriculture in Armenia was started in late 1990s within the frames of international development programs. Quite many local organizations started their operations in the market of organic production in Armenia, among others “Shen” NGO, “Green Lane” NGO, “Organic Armenia” Association, “Green Day” LLC, etc. However, one organization played a key role in the formation of the organic production sector of Armenia, and that was the certification body - “EcoGlobe” LLC. The company was founded in 2002 as an organic certification entity. Organizations operating in the field of organic agriculture aim to promote organic production in the local market, as well as open up opportunities for presence in international markets.

In recent years, Armenia has seen a growing interest in organic agriculture as more farmers, businesses, and consumers are recognizing its potential benefits. The country's diverse climate, rich biodiversity, and fertile soil offer a suitable environment for organic farming. The sector is primarily driven by small-scale farmers, focusing on high-value crops such as fruits, berries, vegetables, herbs, and nuts. The Armenian government has recognized the importance of organic agriculture and has prioritized the sector in the country’s agriculture development strategies.

While shifting to organic production the farmer applies measures and technologies that are beneficial for the environment and the ecosystem, targeting protection and enhancement of natural resources as well as biodiversity. For instance, use of organic fertilizers promotes organic carbon storage in soils. Organic farming practices generate high levels of soil organic matter. This improves water storage capacity and strengthens resilience to both droughts and floods. Management of natural resources and consideration of proper waste management is an integral part to make agricultural production sustainable.

Organic agriculture provides opportunities for the introduction of quality assurance systems (certification) for smallholders, enabling them to benefit from access to premium niche markets. Developing local and regional markets for organic products will be vital for the sector's growth. This could include promotion of organic products through marketing campaigns, establishment of organic distribution centres, and supporting the development of organic retail chains.

Armenia's organic agriculture sector has promising growth potential, both domestically and in export markets, which will contribute to the country's overall economic development and environmental sustainability.

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Good practice of Organic raspberry production

Mr. Tigran Ghazaryan is one of the pioneers who established a raspberry plantation in the early 2000s and is still engaged in organic raspberry production. The production area is located in the Alapars settlement of Kotayk region. Already in 2001, he received an organic certificate.

Currently, on an area of 4 hectares, he cultivates 2 raspberry varieties imported from the USA ("Nova" and "Carolina"). "Nova" is a summer variety, bears fruit twice during the season, and "Carolina" is an everbearing variety, it is fruiting regularly during the season.

The presence of varieties with different ripening periods allows the producer to properly manage the workforce, having an almost even distribution throughout the production season. The yield of these varieties is almost equal and varies within 10-15 t/ha. Up to 15 seasonal workers are involved in raspberry production activities (which includes pruning, fertilizing, weeding, harvesting), most of them are women. The yield is successfully consumed both in processing plants and at retail outlets.

A drip irrigation system has been installed in the production area, which significantly simplifies the irrigation process. A significant water saving has been registered and the irrigation fee was reduced 4-5 times (the cost of irrigation water per hectare decreased from 120,000 drams to 25,000-30,000 drams).

Useful information / additional information

Organic certification procedures in Armenia and a list of certified organizations and farms can be found on the websites of the certification bodies: https://www.ecoglobe.com/hy; https://www.ecocert.com/en-US/certification

8. Drones in Agriculture (unmanned aerial vehicles-UAV)

Within recent years steps were undertaken to use drones in agricultural production, which is related to the introduction of new technologies to agriculture, including the Internet of Things (IoT), Big Data and Artificial Intelligence. This requires investments in new machinery and the knowledge to use the new technologies. It is worth emphasizing that among the new technologies, drones are an important tool for use in precision agriculture. Compared to traditional methods and practices, the use of unmanned aerial vehicles (UAV) provides faster and more accurate results and labor savings. In addition, drones also provide significant cost reductions.

Agricultural drones could be equipped with sensors and/or imaging devices to provide real-time data on crop health, moisture levels, pest infection, nutrient deficiency levels, etc. After analyses the collected information serves to implement targeted and precise intervention on the exact areas that need treatment, thus reducing the overall use of chemical preparations and decreasing chemical pressure on agricultural landscapes.

The drones could be used in different stages of agricultural production to improve effectiveness and efficiency of agricultural processes including:

- **Soil and field analysis**. With the drones the 3D maps of the fields could be developed to use for the design of seed-planting patterns and the generation of different data for further use in many applications. Simultaneously soil health parameters could be monitored (such as nutrient and pH levels, compaction, etc.) to improve soil and nutrient management practices.
- **Crop monitoring**. Drones can monitor crops quite accurately and frequently, delivering regularly updated data to provide insight into crop development and highlight inefficient or ineffective practices.
- **Health assessment**. Drones can be used to generate multispectral images of crops, which are analysed to monitor changes in their health and growth. For example, if an infection is detected, early identification enables prompt and targeted intervention to address the problem and potentially reduce the need for extensive chemical treatments later in the growing season.
- **Irrigation**. With the sensor drones it is possible to identify parts of a field that are dry or need improvement. Equipped with infrared and thermal sensors, drones capture comprehensive images of entire fields, enabling precise diagnosis of areas with excessive or insufficient water to adjust irrigation process. This helps conserve water and reduce water waste.
- **Crop spraying**. Drones' ability to easily modify their altitude and flight paths based on the surrounding topography makes them highly effective for crop spraying. They can swiftly scan the ground and apply liquids with exceptional precision. Crop spraying by drones is:
  - more accurate than traditional sprayings,
  - up to five times faster than with regular spraying machinery,
  - allows to spray at the stage of crop development when access by regular sprayers is impossible,
  - Implement spot treatment of hotbeds of diseases.

  Besides, by applying agricultural drones for spraying purposes, farmers can minimize their environmental footprint by:

- reducing chemical usage,
- optimizing resource efficiency, and
- promoting sustainable crop management practices.

➢ **Aerial planting**. Drone-planting systems are being developed to reduce labor costs by 85% and use compressed air to shoot seed pods with seeds and nutrients directly into the soil.

Challenges. *While the potential for drone-use in agriculture is significant, there are still several obstacles to overcome, such as:*

- *Lack of finances.* Drones require substantial capital investment and technical expertise to be acquired and properly utilized, which is scarcely assessable to many small and medium sized farmers.
- *Quality of data.* The effectiveness of drone technology largely depends on its ability to provide precise and accurate data. As a result, ensuring high data quality should be a central consideration in drone usage decisions.
- *The ability of farmers to modernize.* Widespread uptake of new technology requires farmers to adapt and modernize production practices.

However, it's only a matter of time before drone technology will replace traditional methods. The industry is swiftly adopting new sensors, cameras, and processing technologies, continuously enhancing the quality of the data collected.

Use of agri-drones to provide agricultural services, case of "SkyAgro" LLC

Agricultural drones and drone-spraying service became available in Armenia starting from 2021, when "SkyAgro" LLC was established. It uses agri-drones to provide pest control services (e.g. spraying) to farmers in Armenia. The operating team of the company, as well as clients and served areas are steadily growing. Currently 3 teams operate and serve up to 280 clients (in 2024 the total sprayed area comprised 1,700 ha). The service price varies depending on crop type, landscape, used water quantity, etc. For example, for cereal crops one spraying costs on average 11,000-15,000 AMD/ha, in case of orchards and vineyards this number could reach 15,000-19,000 AMD/ha.

Spraying agricultural areas with drones

Useful information / additional information

You can learn more about digital agriculture and especially the use of agro-drones at the following link https://skyagro.am/hy/.

The agro-drones for spraying are possible to purchase through application and receiving assistance from the "Agricultural Machinery Leasing Support Project in the Republic of Armenia" program (https://mineconomy.am/en/page/2069%20).

9. Processing of organic residues and production of organic fertilizers

In the context of the continuous development of agriculture, organic fertilizers are gaining more and more importance and significance. They are natural substances of plant, animal or mineral origin, which play an important role in improving soil fertility and health, as well as stimulating plant growth. Unlike mineral fertilizers, organic ones do not have a negative impact on the environment and contribute to the organization of sustainable agricultural production. The use of organic fertilizers not only improves soil structure, but also improves its capacity for retention of water and nutrients, making the soil more resistant to drought and other environmental stresses.

As a result of the activity of beneficial microorganisms (such as bacteria and fungi) in the soil, organic fertilizers decompose, and nutrients become available to plants. Soils rich in organic matter are light, do not compact, retain moisture and nutrients well, and promote the rapid development of soil microorganisms and the root system. Agricultural products grown with organic fertilizers are tasty, have a long shelf life, a characteristic aroma and high nutritional value. The use of organic fertilizers results in healthier plants with high resistance to diseases and pests, ensuring sustainable agricultural production in the long term.

The benefits of organic fertilizers include:

- **Improved soil quality**: They improve soil structure, enhancing its ability to retain water and nutrients.
- **Long-Term Soil Fertility**: They promote soil microbial activity, soil drainage and aeration. The nutrients are becoming available for crops more gradually over time. The risk related to overfertilizing, leaching and burning of the roots is minimized.
- **Healthy soil ecosystem:** Organic fertilizers contain soil organic carbon, which supports beneficial bacteria responsible for nutrient breakdown and cycling.
- **Environmentally friendly:** Do not contain the harmful chemicals that contribute to the pollution and contamination of water and land.

The cons of organic fertilizers stem from their nature and include:

- **Varying nutrient content and lower nutrient concentration:** The amount of nutrients is not fixed, and generally larger quantities are required.
- **Slower release of nutrients and effect on plants:** The decomposition of organic matter occurs with the participation of soil microbes. The soil microbial population requires suitable temperature and sufficient moisture to break down the organic components, so it may take longer for bacteria to reproduce and decompose organic substances, and it may not provide immediate results.
- **Labor-Intensive**: Some forms, like compost, require more preparation and application effort.

Many farmers prefer using organic fertilizers for cultivation of fruits, vegetables and berries. For this purpose, they mainly apply manure, which remains more affordable, especially for those farmers who engage in animal husbandry. However, the use of manure is not widespread related to some objective reasons; it is unpleasant, smells badly, there is no machinery for application (manpower used which is expensive), etc. In addition, weed seeds and harmful organisms do not lose their viability in immature and fresh manure. When such manure is used, pathogenic

organisms are easily transported and a significant increase in the number of weeds and pests is observed in the fields.

Processing organic waste (including food scraps, manure and plant matter) and developing better quality organic fertilizers are one of the main priorities in agriculture and environmental protection. Different types of earthworms or bacteria were breaded and cultivated to break down the organic matter into nutrient-rich organic fertilizers.

There are many companies in Armenia that specialize in production of solid (such as bio humus or vermicompost) and liquid organic fertilizers with earthworms, bacteria, biotechnological interventions. Among those companies could be mentioned “ORWACO” CJSC, “Zulal Agro” LLC, “Green Farm” LLC, “Eco Plant” LLC, “Fulken” etc.

Case of Manure processing using bacteria

"Ecoplant" LLC processes manure using bacteria to produce nutrient-rich organic fertilizers. The bacteria are produced in Armenia by "VIPECO AM" LLC https://www.vipeco.am/hy and are available to all farmers. In addition to organic matter, the fertilizer also contains humic and fulvic acids, biologically active compounds. It has a positive effect on crop yields (a 15-20% increase in yield is recorded), while improving soil structure, biological activity and health. The company produces both liquid and dry organic fertilizers.

The nutrient content of liquid biomass is 7-10%, it also contains humic and fulvic acids 5%, nitrogen 3%, phosphorus 5%, potassium 3%, as well as some microelements: Fe, Mn, Zn, Cu, B, Mo, etc. This is a water-soluble fertilizer which could be applied during whole production season through all known types of irrigation, including drip irrigation systems and sprinklers, as well as through traditional furrows.

Liquid biomass: Mass of nutrients (active substance) comprises 7-10% of the volume of biomass. The liquid fertilizer contains humic and fulvic acids – 5%, Nitrogen – 3%, Phosphorus – 5%, Potassium – 3%, as well as several microelements – Fe, Mn, Zn, Cu, B, Mo, etc. It is water soluble fertilizer which could be applied during whole production season through all known types of irrigation, including drip irrigation systems and sprinklers, as well as through traditional furrows.

As a result of drying the biomass, the company obtains dry fertilizer (biohumus), which is then granulated and packaged. Although dry fertilizer is considered as a by-product, it contains the same nutrients and exhibits high efficiency as liquid biomass.

Useful information / additional information

The Armenian government considers the promotion of local production of organic fertilizers a priority. In this regard, a program has been developed that compensates 40% of capital investments to businesses that invest in the production of organic fertilizers. Those who are interested in purchasing the necessary equipment for processing organic residues can apply and benefit from the Productivity Promotion Target Program approved by the RA Government's Resolution No. 355-L in 2020, https://www.arlis.am/hy/acts/204471.

10. Resource Efficiency and Cleaner Production (RECP) in Agribusiness

Resource Efficiency and Cleaner Production (RECP) is a methodology that combines environmental sustainability with economic efficiency and reduces risks to people and the environment. It refers to optimizing the use of natural resources while minimizing waste, emissions and pollution. This approach is applied in manufacturing with the aim of improving productivity while reducing environmental impact. The food processing industry has a huge potential for implementing RECP practices, as it typically uses large amounts of water, energy and raw materials, and generates significant amounts of organic waste and wastewater. RECP can effectively reduce production costs, while improving companies' competitive advantages and implementing environmentally sound practices in the production unit.

The introduction of resource efficiency and cleaner production principles in agribusiness is an important complement to climate-smart practices. RECP aims to achieve maximum results with minimal input of raw materials, water, energy and other resources, while reducing emissions and waste. RECP measures in the post-harvest phase of fruits and berries can reduce losses by up to 30%, as well as improve product quality and shelf life. RECP audits conducted in Armenia under the EU4Environment project (UNIDO and REC Caucasus) funded by the EU have shown that water use in agro-SMEs and processing enterprises can be reduced by 20-35% and energy costs by up to 30%, while introducing new solutions for waste analysis and utilization.

The main principles of RECP include:

- **Material efficiency**: Reducing the use of raw materials, optimizing the use of materials in processes, promoting reuse and recycling.
- **Energy efficiency**: Efficient use of energy in production processes, application of energy-saving technologies, transition to renewable energy sources where possible.
- **Water efficiency**: Reducing water use, as well as wastewater volumes, reusing treated water in production processes, preventing water pollution.
- **Pollution prevention**: Minimizing waste generation, replacing hazardous substances with safer alternatives, improving waste management and recycling

In each production unit, a detailed assessment and analysis of all products and production processes is carried out, "hot spots" are identified and recommendations are made for their improvement. The application of the RECP methodology in the food processing industry helps to reduce costs, improve productivity, comply with environmental regulations, and enhance brand reputation.

The advantages of the RECP methodology are:

- **Economic**: Reduced operating costs through resource use and waste reduction. It contributes to increased savings.
- **Environmental**: Fewer emissions, reduced pollution, resource conservation.
- **Social**: Safer working environment and better relations.
- **Compliance**: Helps to comply with environmental regulations and standards.

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A case of application of the RECP methodology in the "Lukashin Agricultural Association" consumer cooperative

The consumer cooperative "Lukashin Agricultural Association" consists of 42 members and operates in the Lukashin settlement of Armavir region. They are engaged in the production of dried fruits (dried apricots, peaches, apples, pears, figs and grapes). The raw materials are produced by farmers from the Lukashin settlement. The average annual production capacity of the cooperative is about 14,000 kg of dried fruits, which are mainly consumed in the local market, as well as exported to the Russian Federation and the countries of the European Union.

As a result of the RECP study and assessment conducted at the cooperative, 14 recommendations were identified and proposed for implementation, which were aimed at the proper management of farms, the elimination of chemicals and harmful waste, the reduction of energy consumption, production waste and emissions, as well as improving product marketing and increasing the overall reputation of the company.

- Thus, halving the length of the ventilation pipeline allowed to speed up the drying process, as a result the energy consumption (electricity, gas) was reduced by 20%.
- Installation of a two-stage electric meter and better control of the use of dual tariffs made it possible to ensure an annual saving of 8% in electricity consumption.
- Installation of convective solar dryers and a solar water heater made it possible to avoid the use of non-renewable energy.
- The use of nitrogen instead of sulphur for product packaging is not only an innovative technological solution, but also made it possible to reduce sulphur oxide emissions and production costs. The elimination of caustic soda used for the pre-treatment of some fruit varieties also provided a similar result.
- Reuse of water reduced water consumption by about 30%.
- In the framework of EU for Environment Programme, Armenia team supported the company to install a solar heating system. It was a precedent for “green” production among dried fruit producers.

As a result of the implementation of the proposed measures in the cooperative:

- The consumption of electricity reduced by about 21% (34,500 kWh per year), and natural gas consumption by about 12%,
- The annual water savings amounted to 1,500 m^3,
- The annual carbon dioxide emissions reduction amounted to 0.3 tons,
- Production costs within one production season decreased by about 13%,
- The annual savings amounted to 1,470 euros.

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Food drying/processing

Ready packaged products

Ready packaged products

Useful information / additional information

You can learn more about the RECP methodology at https://recp.am/hy/news/recp-materials or contact the Armenian branch of the Caucasus Regional Environmental Center (RECC) https://rec-caucasus.am/?lang=hy

11. Introduction of improved post-harvest practices in the fruit and berry value chains

Raspberry easily adapts and is successfully cultivated in different climatic zones of the Republic of Armenia. The diversity of varietal and cultivation conditions ensures a relatively long raspberry fruiting period, covering the period from mid-summer to the first frosts of autumn. If previously wild raspberry harvesting and limited production in homesteads prevailed, now raspberry production plantations occupy significant areas. There is also a certain growing demand for raspberries in the market.

Considering the limited storage capacity of the crop and low transportability, diversification of post-harvest/processing opportunities and the introduction of innovative approaches are of particular importance for the development of the raspberry value chain. Among them could be stated, for example, drying and freezing of raspberries, obtaining juice, jam, as well as wine, liqueur or vodka. Relatively large producers enter the market with branded products, often establishing their own processing plants in order to minimize the risks associated with sales.

Presentation of good practice: Case of “Yans” CJSC

The company operates in Aqori settlement of Lori province and specializes in primary production and processing of raspberries and Marketed under the brand name "Freezy Breezy". The raspberry production initiated in 2011, starting from 4 hectares, gradually the cultivated areas increased and reached 7 hectares. The annual raspberry production volume comprises 80 tons. Considering remoteness of production area and distance of market, as well as shorter shelf-life of raspberries and underdeveloped relationship with processing enterprises the company owner established shock freezing and cold storing unit. Post-harvest processing of the yield makes it possible to mitigate risks related to market access, as well as reduce post-harvest losses. While implementing shock freezing the raspberries are rapidly frozen at extremely low temperatures, typically between -30°C to -50°C, using specialized equipment. The freezing process is almost instantaneous, often taking only a few minutes. As an advantage of shock freezing could be stated:

- The rapid freezing process results in the formation of small ice crystals, which do not damage the cell structure of the raspberries. This preserves the texture, flavor, and nutritional content.
- Raspberries retain their bright color, fresh taste, and firm texture when thawed.
- There is minimal loss of juice upon thawing.

From the economic perspective if the wholesale price of fresh raspberries varies from 500 to 550 AMD/kg, the sale price of shock frozen raspberries varies from 2,000 to 2,600 AMD/kg.

Although the shock freezing and cold-storing chain consumes huge amounts of electricity, but established solar photovoltaic system fully covers the amount of electricity required for the processing of raspberries, so the climate neutral post-harvest handling implemented.

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Pre-processing of raw material

Shock-freezed raspberry

Ready product

Stored product

It is also worth mentioning the activities of the “Anahit Harutyunyan” private enterprise, founded in 2001 in the Gharibjanyan settlement of the Shirak region of the Republic of Armenia. The enterprise is a family business specializing in the processing of fruits, berries and vegetables and is represented in the local market under the “Sunny food” trademark. Within the framework of the EU “Green Agriculture Initiative in Armenia” program, in addition to the support provided for the automation of production, a 25 kW solar photovoltaic station and a cold storage for the initial storage of raw materials for processing were also established. As a result, it became possible to reduce production costs by about 20%, reduce logistics costs and raw material losses, increase the productivity of the enterprise, and reduce the cost of production.

Solar photovoltaic station

Cold Storage

Useful information / additional information

The Government of the Republic of Armenia is implementing "Agricultural Machinery Leasing Support Project in the Republic of Armenia" (https://mineconomy.am/en/page/2069%20), as well as "Programs for subsidizing interest rates on loans provided to the sector for the purpose of procurement (purchase) of agricultural raw materials" (https://mineconomy.am/page/2083) programs, within the framework of which there is an opportunity to purchase raw material, equipment and devices intended for the processing of raw materials, which will reduce post-harvest losses, increase the productivity of enterprises, as well as competitiveness in the market.