

# Methodology for assessing the loss of agricultural products in conditions of ensuring food security

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**Abstract.** Ensuring food security in many countries of the world is considered a pressing problem of today. The post-Covid period throughout the world is characterized by a decrease in population incomes, rising prices for food products, means of production and energy resources, accompanied by worsening hunger. A mitigating circumstance of the current situation and in solving the problem of the population's lack of the most basic microelements and vitamins, the inclusion of melon products in the diet is an important means of ensuring food security. In the context of global climate change, environmental and political crises, increasing the volume of cultivation of melon products will make a sufficient contribution to providing the population with safe food. Therefore, in prestigious scientific institutions and centers around the world, the scope of research has been expanded in such areas as the development of the industry on an innovative basis, the organization of non-traditional production, and the cultivation of organic melons. Special attention is paid to scientific research aimed at solving problems of developing melon growing on protected lands, creating competitive varieties and hybrids in melon growing, reducing quality losses during storage and transportation of products, organizing waste-free production of cultivated products.

## 1 Introduction

Billions of people around the world do not have access to nutritious and wholesome food. The UN Food and Agriculture Organization estimates that between 691 million and 783 million people will suffer from hunger in 2022. If we consider the average figure (about 735 million people), then in 2022 the number of hungry people was 122 million higher than in 2019 [1].

The Republic of Uzbekistan is a country that has potential natural factors that have a positive impact on ensuring its own food security. The country has implemented a number of structural reforms aimed at developing the food supply. In particular, specialization in melon growing based on natural climatic conditions, water supply in the regions, to diversify the agricultural industry, due to the reduction of cotton growing fields, land is allocated for

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food products, including fruits and melons. However, a number of problems are observed in reducing losses in production and processing of products based on cooperative and cluster farm management systems, in creating competitive varieties and hybrids for sale on foreign and domestic markets, in increasing the seed production system, and also productivity. In this regard, "...improving scientific research on the creation of potatoes and potato crops adapted to local soil and climatic conditions, varieties and hybrids with high yields, resistance to diseases, pests and high-quality indicators, as well as on the organization of primary seed production" identified as an industry priority. From this point of view, in the context of climate change, the development of scientific proposals and practical recommendations aimed at radically improving the country's food supply problems is considered relevant.

The influence of production, economic, social and cultural factors on the efficiency of the melon growing industry, at the micro and macro levels, has been widely studied by foreign scientists such as N. A. Antsyfrov, L. Ayodeji, Beate Richter, J. Parfitt, J. Gustavsson, W. O. Oyediran [1,2].

In the scientific research of Uzbek scientists such as A. Kadirov, D. Chuyanova, F. Fayzibaeva, V. Zuev, Kh. Buriev, A. Karimova, R. Khakimov, V. Ermokhin, special attention was paid to such aspects as morphology, biology and agricultural technology of melons. Problems associated with diseases and the cultivation of melons were analyzed.

It is also worth noting the results of the work of I. Rudenko, B. Dzshuraev, Sh. Murodov, S. Eshmatov, Kh. Khushvaktova and other scientists on fruit and vegetable integration and cooperation, marketing system, value chain and increasing the income of producers in agriculture.

However, in the above-mentioned research works, insufficient attention is paid to such aspects as the peculiarities of melon growing, the methodology for determining losses in the quantity and quality of products and assessing influencing factors. This requires research, improvement of the natural and climatic conditions of our republic, development of the melon growing industry, considering the unmet need of the population for melon products and ways to increase efficiency. This statement became the basis for choosing the topic of the research work.

## 2 Materials and methods

The purpose of this study is to develop scientifically based proposals and recommendations for increasing the efficiency of melon and melon production. Economic entities operating in the republic that grow melons and melons were selected as the object of the study.

The subject of the study is the system of organizational and economic relations associated with the cultivation of melons and melons in agriculture.

To achieve our goal, the following tasks were completed:

- determination of the objective need, features of increasing the efficiency of growing melons in agriculture;
- - systematization of efficiency indicators for growing melon products, as well as analysis of existing methods for assessing the level of losses of melon products;
- development of proposals for studying significant experience in the development of melon growing and its implementation in our country;
- assessment of the current state of efficiency of growing melons and identifying existing problems;
- development of proposals to improve the mechanisms of state support for the development of the melon growing network (industry);
- development of proposals for organizing a seed cluster in order to stimulate seed storage and the creation of new seeds, also on sources of their financing;

- determination of forecast indicators for the volume of cultivation of melon products, with the identified relationship of factors influencing the cultivation of melon products.

The research process used monographic research methods, statistical and econometric modeling, economic analysis and synthesis, the ARIMA (ARMA) model, the Trend model, the Triple Helix Model, etc. [3].

Increasing the efficiency of the melon growing network, considered the most important task in ensuring the country's food security, in this process requires considering its inherent features. Because melon growing, along with its inherent features, differs in relation to other branches of agriculture in the limitations of long-distance transportation, long-term storage, the predominance of manual labor in growing products, and at the same time, the availability of opportunities for growing products in two ways (in open and protected land areas). Also, the development of melon growing is considered directly related to the influence of existing economic, socio-demographic, organizational and legal factors. Of course, all factors are interpreted based on the level of influence. In our opinion, the factors influencing the sustainable development of the melon growing network can be divided into the following groups:

- socio-economic factors that determine the quality of the integration of all aspects of the production process;
- institutional factors containing the legal, economic and political foundations of the activities of entities growing agricultural products;
- technological factors aimed at intensifying the cultivation of agricultural products based on modern technologies and machines, high-yielding varieties and hybrids;
- market mechanisms ensuring continuity and compatibility of melon production processes.

The main problem today is the level of loss of agricultural products. While studying the problem of quantitative losses of agricultural products, we made sure that the main attention was paid to losses associated with their seasonality and market sensitivity. Our research is aimed at systematizing the assessment of loss criteria, in the value chain separately or at all its stages, considering its inherent quality.

As a result of the study, the feasibility of grouping melon products into sickly, rotten, overripe, tanned, and damaged was determined. The goal of agricultural producers is to sell their products without losses and generate high income. At the same time, a high factor in reducing losses is maintaining the quality of the product after harvesting. However, failure to meet infrastructure requirements, insufficient competencies and practical skills of manufacturers, and failure to use modern technologies in the field can cause product losses. Therefore, in our opinion, it is necessary to pay attention to the analysis of all stages of technology from production of products to delivery to the consumer (Table 1).

**Table 1.** Methodology for assessing the loss of melon products (author's development).

Loss of melon products on farms during production	Production process	Quantitative loss: products left in the fields during production
		Quality loss: deterioration in the quality of manufactured products
	After harvesting at the farm	Quantitative loss: total loss of production on farms after harvest
		Quality loss: deterioration in quality during post-harvest operations
Mediation loss		Quantitative loss: loss of off-farm production after harvest

	After off-farm harvesting	Quality loss: deterioration of product quality in subsequent post-harvest operations
Loss during processing	Processing	Quantitative loss: total loss of product during processing
		Quality loss: deterioration in product quality during processing

To calculate product losses at different stages of the value chain, we used the “Category Method” (C-method). This method was first developed in 1999 by scientists Camton and Sherington to calculate quantitative and qualitative grain loss. They adopted the product category property as the basis for the natural loss coefficient. It is also advisable for us to consider the natural and climatic conditions of the region as a basis. Based on this, we determined the quantitative and qualitative losses of products at the manufacturer level using the following equations [4]:

$$OY_p = \sum_{i=1}^I C_i * QC_{Iph} + (Q_{Prod} - Q_{PH}) \tag{1}$$

$$SY_p = \sum_{i=1}^I (P_{ideal} - P_{Ci}) * QC_{Iph} + (V_{prod} - V_{PH}) \tag{2}$$

where:  $C_i$  – natural loss coefficient (recommendation);  $P_{ideal}$  – average selling price for ideal products c.u.;  $P_{ci}$  – average selling price of products for  $i$  category c.u.;  $QC_{iPH}$  – quantity in each category after harvest, ton;  $Q_{PH}$  and  $V_{PH}$  – quantity and cost of post-harvest crop, respectively, ton and c.u.;  $Q_{prod}$  and  $V_{prod}$  – quantity and cost of all products after production, ton and c.u.

The next stage, quantitative and qualitative losses at the intermediary level are calculated using the following equation:

$$OY_p = \sum_{i=1}^I C_i * (QC_{iSale} - QC_{iPurchase}) + WTL \tag{3}$$

$$SY_p = \sum_{i=1}^I (P_{ideal} - P_{Ci}) * (QC_{iSale} - QC_{iPurchase}) + WTL \tag{4}$$

where:  $QC_{iSale}$  – quantity in each category during sales, ton;  $QC_{iPurchase}$  – quantity in each category when purchasing, WTL – amount of total loss of production, ton [5].

In our opinion, based on this methodology, it is advisable to sort the natural loss coefficient in the context of the central, southern and northern regions of Uzbekistan (Table 2).

**Table 2.** Natural loss rate of melon products by region.

No	Region	Small zones	District	C coefficient	C Regional coefficient
1	Central region	First small zone	Fergana Valley, Tashkent, Sirdarya and Samarkand regions	1.007	1.008
		Second small zone	Sirdarya, Jizzakh and Samarkand regions	1.008	
		Third small zone	Jizzakh, Samarkand regions and new irrigated territories of Kashkadarya	1.009	
Fergana Valley, 2	Southern region	First small zone	Kashkadarya region and southern regions of Bukhara	1.009	1.01
		Second small zone	Surkhandarya region	1.01	
3	Nothern region	First small zone	Republics of Karakalpakstan and	1.008	1.007

			northern regions of Khorezm region		
		Second small zone	Foothill areas of Tashkent and Samarakand regions	1.006	

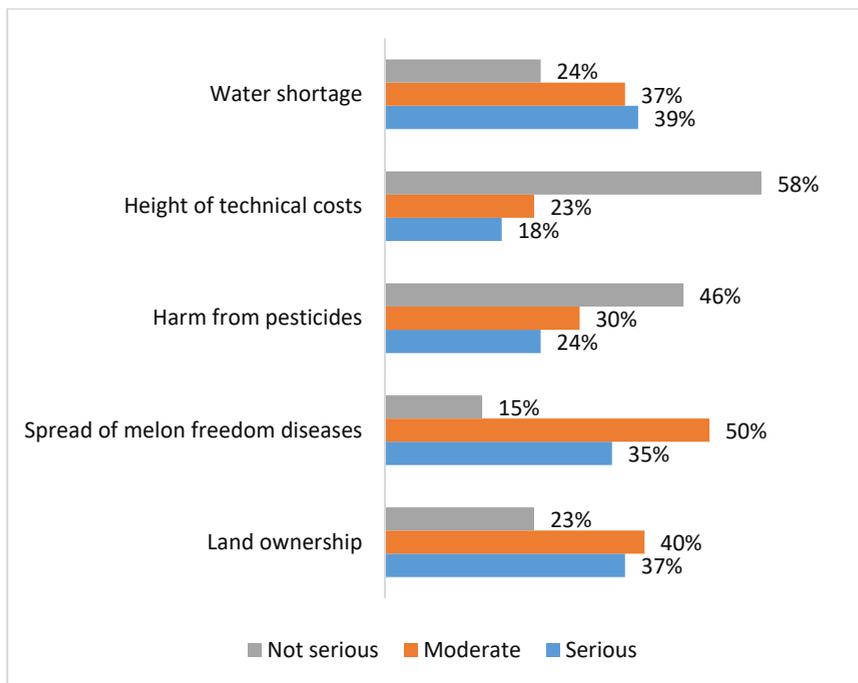
### 3 Results

Based on the results of monographic studies in the farms “Toshmurod Tupi” in Jizzakh region and “Mirzachul bedapoyasi” in Sirdarya region, an increase in the cost of production was determined due to their cultivation in protected fields. Since the product was grown in conditions where market demand exceeded supply, this allowed it to be sold at a higher price and achieve a higher level of profitability (Table 3).

**Table 3.** Costs of growing watermelon per 1 hectare of area in melon farms.

Types of costs	“Toshmurod Tupi” Farm		“Mirzachul bedapoyasi” Farm	
	USD	%	USD	%
Manufacturing material costs including:	667	45.3	1.110	50.3
Seed and planting materials	41	2.8	98	4.4
Pest and disease control products	16	1.1	33	1.5
Mineral fertilizers	260	17.7	309	14.0
Organic fertilizers	0	0.0	81	3.7
Electricity costs	244	16.6	163	7.4
Costs of fuels and lubricants	41	2.8	36	1.7
Protective films and metal wires	0	0.0	333	15.1
Agrotechnical measures	65	4.4	57	2.6
Labor costs	569	38.7	773	35.0
Other significant production costs including:	236	16.0	325	14.7
Food expenses	130	8.8	179	8.1
Costs of maintaining fixed production assets in working condition	24	1.7	10	2.9
Expenses of current lease of fixed assets	82	5.5	81	3.7
Total production costs	1472	100	2208	100
Productivity, t/ha	35	–	30	–
Cost of 1 kg of products	46	–	88	–
Price 1 kg of products	65	–	236	–
Net revenue from product sales	2277	–	7075	–
Profitability, %	54.7	–	220.4	–

To identify production problems, a survey was conducted among 108 respondents growing melons and melons in the Sirdarya and Jizzakh regions. According to the results, 69 respondents (63%) indicated that the quality and condition of the seeds used were satisfactory, the remaining 39 (37%) respondents expressed dissatisfaction with the quality of the seeds. Also, respondents noted as the main problems the shortage of water resources, the spread of diseases of melon crops, damage to crop yields from pesticides and high technical costs (Fig. 1).



**Fig. 1.** Problems of growing melons and melons.

The opinions of the respondents also differed on the significance of the existing problems in the cultivation of melons; if 37% of respondents argued that land ownership rights were a significant problem, then 40% were of the opinion of moderate importance. In addition, 35% of respondents noted the presence of the spread of diseases in melon crops, 18% high technical costs and 24% the harmfulness of pesticides.

Our study of the structure of production costs showed a significant impact on their level by the costs of fuels and lubricants, due to the irrational distribution of equipment across the territory.

The survey showed that the majority of respondents use their own savings in economic activities, only 17% use bank loans. Local authorities do not provide subsidies to support producers, and there are bureaucratic problems that prevent the full use of economic levers.

Using the above methods, an analysis of the quantitative and qualitative losses of melon products in the farms “Toshmurod Tupi” and “Mirzachul Bedapoyasi” was carried out. Based on the category of losses, we divided the products produced on farms into three groups.

In the Toshmurod Tupi farm, the loss of produce before its sale to the intermediary amounted to 7.33 tons, which was 15% of the gross output.

In the Mirzachul Bedapoyasi farm, when growing products in protected fields, the quantitative loss amounted to 2.55 tons, i.e. 7.3% of gross output (Table 4).

**Table 4.** Indicators of quantitative and qualitative loss of products in farms “Toshmurot Tupi” va Mirzachul Bedapoyasi”.

Loss period	Category	“Toshmurod Tupi” Farm		“Mirzachul bedapoyasi” Farm	
		Quantative loss	Qualitative loss	Quantative loss	Qualitative loss
		ton/%	Mln sum/%	ton/%	Mln sum/%
Manufacturer	1	2.5/5.0	2.03/2.1	1.25/3.7	4.15/1,5
	2	2.3/4.7	2.04/2.1	0.7/1.9	4.08/1,6

	3	2.53/5.3	2.04/2.1	0.6/1.7	4.01/1,5
Total losses at manufacturer level		7.33/15.0	6.11/6.3	2.55/7.3	2.55/7.3
Mediator	1	1.3/2.7	0.26/0.2	1.2/3.7	1.6/0.4
	2	1.7/3.1	0.425/0.3	0.9/2.8	1.4/0,3
Total losses at the entrepreneur level		3.1/6.3	0.685/0.5	2.1/6.4	3.0/0.7
Total loss of production		10.43/21.3	6.79/6.8	4.65/13.7	15.24/5.3

The table shows that the quantitative and qualitative losses of the products of the Toshmurod Tupi farm at the level of delivery to consumers amounted to 3.1 tons, respectively (6.3% of gross output). Similarly, for farming they are equal to 2.1 tons, respectively.

Analysis of product loss indicators at different stages (production, transportation, storage, sorting and sales) helps to identify reserves for increasing the efficiency of economic activity.

### 4 Discussion

Our research has shown the effectiveness of growing melons and melons on protected lands that require government support, the levers of which are organizational, economic, social and environmental incentives. For the field of melon growing, their sensitivity is very high.

Conducted studies show that the costs associated with organizing the cultivation of melons per hectare of protected land can be recouped within five years; if it is aimed at effective export, only from the fifth year the farm begins to make a profit. In this regard, we have developed proposals for issuing tax holidays from the state to farms producing melons and melons in the winter and spring periods, for a period of five months in each five-year initial year of export (Table 5).

**Table 5.** Mechanisms of state incentives for producers of melons and melons in protected fields.

	Direct stimulation	Indirect stimulation
Melon farming providing simple reproduction	Providing 5 months of annual tax holidays during the first 5 years for farms growing crops in the winter and spring seasons.	Subsidies in the amount of 30 percent of the positive difference between the import price and the selling price of local products for each kg of seeds grown by farms reproducing seeds of melon varieties in protected fields
	Creation of a system for guaranteed supply of protected fields with constant energy at a market price and compensation for damage caused by power outages.	Improvement of melon seedlings, construction of “In vitro” laboratories, allocation of grants for scientific research.
Extended reproduction farm	Exemption from property tax for 3 years if 50% of annual energy consumption is provided by alternative energy for farms using it for protected fields, and for 5 years with 100% provision of alternative energy.	Introduction of leasing services for digital technologies, facilities and construction of greenhouses. At the same time, private leasing companies will be exempt from property and income taxes.
	Linking the compensated part of export costs to foreign currency when exporting melon products	Reimbursement of 40% of costs to private marketing enterprises when providing services such as melon export, marketing research in foreign markets in the autumn-winter season.

World experience in clustering shows the effectiveness of organizing clusters with the participation of the state and research institutions based on the “Triple Helix Model” [6]. The application of this experience in the field of melon growing in the conditions of Uzbekistan, in our opinion, is effective. It is proposed to create seed production clusters within the Ministries of Agriculture of Uzbekistan, Higher Education, Science and Innovation, the Center for the Development of Seed Production and the Inspectorate for Control of the Agro-Industrial Complex.

It seems appropriate to us to implement the following measures for organizational support by the state for seed production clusters:

- allocation of land plots for the creation of experimental farms and seed plantations of a seed cluster in areas specializing in fruit and vegetable growing and the predominant areas of melon growing
- granting the right to free use of the material and technical base of research institutions under mutual cooperation agreements;
- increasing the cultivation of melons and melons on newly developed lands and dry areas, giving priority to clusters when placing export and high-yielding varieties, taking into account the soil and climatic conditions of the regions;
- construction of laboratories, providing them with qualified specialists, creating new jobs for scientifically qualified personnel, leasing unused buildings and structures on the state balance at a zero rate in accordance with the rent for the land plot allocated for the experimental site;
- giving priority to registration, patenting, legal registration of newly created, improved seed varieties;
- widespread development of the regional form and network forms of the cluster, the formation of an equal agribusiness environment to create healthy mutual competition;
- provision of benefits for customs clearance of export of melon seeds based on the national brand “Uzbek seeds”;
- ensuring the allocation of non-residential space when establishing seed trading stores in areas where agricultural yields have increased by 30 percent, by planting new seeds, etc.

To ensure the food market in the context of modern global climate change, sustainable development of agriculture, in particular increasing the production of grain legumes, and substantiating forecast values by systematizing factors influencing the development of the industry, are of urgent importance.

Using multifactor econometric models, it is desirable to assess the levels of interaction of selected factors and draw conclusions.

Factors selected for the model included total cultivated area, rice yield, average annual precipitation, average annual temperature, soil moisture, mineral fertilizers used, fuels and lubricants used, and the volume of seeds used.

Using the ARIMA model in the Stata program, the volume of cultivation of melon products, the total sown area, the yield of polyproducts, the average annual precipitation, the average annual temperature, soil moisture, the total volume of consumed mineral fertilizers, the total volume of consumed fuels and lubricants, the total consumed indicators of the type of seeds were used to determine the forecast indicators of the volume of cultivation of melon and melon products in the Syrdarya region in 2023-2030 (Table 6).

**Table 6.** Volume of melon production in Syrdarya region (forecast indicators for 2023-2030).

Years	Product volume, ton						
1992	137,398	2002	79,745	2012	246,076	2022	268,000
1993	99,992	2003	106,827	2013	265,489	2023*	269,211
1994	54,365	2004	100,075	2014	285,286	2024*	272,320
1995	25,509	2005	107,413	2015	307,414	2025*	275,750
1996	38,829	2006	123,652	2016	342,039	2026*	279,295
1997	38,323	2007	139,397	2017	326,902	2027*	284,850
1998	47,258	2008	164,047	2018	216,256	2028*	289,300
1999	58,440	2009	185,908	2019	237,039	2029*	296,210
2000	67,758	2010	209,348	2020	252,647	2030*	302,567
2001	75,872	2011	224,687	2021	260,799	-	-

\*forecast indicators for growing melons.

In the Syrdarya region, the volume of melon production is expected to increase by 112.3 percent in 2030 compared to 2023. This circumstance can be explained by an increase in the population, a further increase in its demand for food, and widespread measures to further improve the food supply.

## 5 Conclusion

The field of melon growing is a part of agriculture and is considered a branch that studies the mythology, biology of melons, watermelons and pumpkins, which are considered agricultural crops, as well as theoretical and practical methods for obtaining high yields from them.

The importance of developing a melon and melon network is to grow melons between the rows of young orchards, to be a good predecessor of cotton and grain, which are the main crops of national importance as repeat crops, to improve soil fertility, to increase the efficiency of use of natural resources through the efficient use of groundwater and sunny days.

In the process of production, storage and transportation of melon products, along with natural losses, losses occur in qualitative and quantitative form.

Quality and quantity make it possible to determine the size of losses at each stage and the reasons for their occurrence by assessing losses at the level of the manufacturer and intermediary.

Based on the results of the monographic study, special attention is paid to the organizational, economic, environmental, social and technological areas of state support in farms producing melons, and it is noted that the main direction is the provision of tax, insurance and customs benefits, as well as improving the subsidy system to increase productivity in sector.

In the context of improving state policy to ensure food security, the state encourages the cultivation of organic products, monitoring changes in soil composition, pollution levels and groundwater volume, providing support in the environmental direction, for example: it is necessary to optimize the supply of resources (water, fertilizers, seeds) to adapt to changes climate.

One of the main problems in melon growing is the lack of development of the seed production system. Based on world experience, when forming a system of organizational and legal support for the state, it is advisable to organize clusters according to the “Triple Helix” model.

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