TECHNICAL UNIVERSITY OF MOLDOVA

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INCREASING THE ECONOMIC EFFICIENCY OF TABLE GRAPE PRODUCTION THROUGH THE IMPLEMENTATION OF NEW TECHNOLOGIES UNDER THE CONDITIONS OF THE REPUBLIC OF MOLDOVA

SPECIALTY: 521.03– ECONOMICS AND MANAGEMENT IN THE FIELD OF ACTIVITY

Summary of the Doctoral Thesis in Economic Sciences

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CONCEPTUAL FRAMEWORK OF THE RESEARCH

The Relevance and Importance of the Addressed Topic. The Republic of Moldova, known for its long-standing tradition in viticulture, has significant potential in table grape production, which constitutes an important branch of national agriculture and a valuable segment for export. This is supported by favorable natural conditions, such as a temperate climate and fertile soils, which are ideal factors for vine cultivation. However, achieving efficient production of grapes intended for fresh consumption involves multiple challenges, determined both by environmental conditions (drought, extreme temperatures, diseases) and by the strict requirements of the external market regarding product quality. These aspects necessitate the modernization of production processes through the integration of new table grape cultivation technologies to support the sustainable development of the local viticulture sector. In this context, analyzing the economic performance of table grape production in relation to the use of modern technologies represents a timely and strategically important topic for the Republic of Moldova, a country known for its long-standing viticultural tradition.

The table grape sector is particularly important in Moldovan agriculture, being a significant source of export. Moldova also stands out internationally due to its well-developed viticulture, supported by favorable natural conditions such as a temperate climate and fertile soils, perfect for vine growth. Achieving efficient production of grapes intended for fresh consumption involves various difficulties related both to environmental conditions and market demands. Effective activity in this sector requires adapting the planted material to local specifics and applying modern technological solutions throughout the entire production chain, from planting to distribution.

Presentation of the Context of the Studied Field and Highlighting the Main Research Challenges. In recent years, the area of table grape plantations in the Republic of Moldova has gradually decreased from 19.9 thousand hectares in 2016 to 17.2 thousand hectares in 2023, representing a reduction of 2.7 thousand hectares. However, the yield per hectare has increased, and the quality and variety of grape cultivars have visibly improved. This progress has been supported in part by institutional measures. Since 2009, the Government of the Republic of Moldova has adopted a regulatory framework concerning quality and marketing requirements for fresh fruits and vegetables, including table grapes, thereby contributing to maintaining high standards.

In this context, improving quality and increasing the economic efficiency of table grape production are current strategic objectives focused on adapting cultivars to local conditions and applying new technologies throughout the entire production chain, from planting to distribution. A relevant example in this regard is the intensive Pergola system, widely used in European countries, especially Italy, since the 19th century.

In this thesis, the author demonstrates the importance of implementing new technologies to enhance the economic efficiency of table grape production. As a case study, the intensive Pergola system is presented, whose efficiency is supported by numerous studies, particularly by Italian researchers. This system allows better aeration and sun exposure, thereby improving grape quality and reducing the risk of diseases, which leads to increased economic efficiency.

The Purpose of the Thesis Consists of evaluating the impact of implementing new technologies on increasing the economic efficiency of table grape production in the Republic of Moldova and substantiating the need for their adoption.

Research Objectives. To achieve the stated goal, the following objectives were established:

1. Analysis of the development conditions of the table grape sector in the Republic of Moldova and highlighting its importance for national agriculture.
2. Theoretical and methodological foundation of the concept of economic efficiency specific to table grape production.

3. Analysis of the evolution of table grape production and marketing activities.
4. Comparative assessment of the economic efficiency of table grape production in Pergola and Vertical Trellis systems, in order to justify the need for implementing the Pergola system.
5. Identification and analysis of strategic measures to increase the economic efficiency of table grape production, taking into account current challenges and market trends.

The research hypothesis is expressed by the statement that the implementation of new table grape production technologies significantly contributes to increasing economic efficiency. This hypothesis was validated through a comparative analysis of the economic results obtained in the Pergola system compared to the traditional Vertical Trellis system.

Degree of Study of the Problem. The implementation of new technologies in the viticulture sector, and particularly in the table grape branch, is a highly studied field, recognized as a key factor in increasing economic efficiency. Among these technologies, the Pergola system stands out as an innovative cultivation method in the Republic of Moldova, attracting researchers' interest due to its potential. However, selecting bibliographic sources related to the Pergola system remains a challenge, as it is addressed in comprehensive studies that include agronomic, landscape, and socio-economic aspects. At the same time, most research focuses on specific regions and grape varieties, which limits a complete perspective on the applicability and efficiency of the Pergola system.

Italian researchers such as Gily Maurizio, Colapietra Mario, and Renzo Angelini have made significant contributions to the evaluation of the Pergola system's application, while complementary studies by Boškov K., Cavuto P., Tomasi D., and Battista F. have highlighted its positive effects on the quality and productivity of table grapes, emphasizing the need to adapt new technologies to local conditions.

In the Republic of Moldova, the topic is supported by valuable contributions from researchers Babii L., Cuharschi M., Savin G., Bratco D., Tudor C., Timofti E., Zbancă A., etc., who have provided innovative perspectives and relevant results in the field. However, domestic research predominantly focuses on the wine sector, with the table grape branch being relatively under-studied. Furthermore, the practice of applying the Pergola system in the country has not yet been investigated, which makes the thesis topic particularly relevant and useful.

Research Methodology. To achieve the established objectives, a diverse set of methods specific to economic research was used, including the analytical method, descriptive method, synthesis method, econometric-mathematical method, graphic and tabular methods, supplemented by quantitative and qualitative analysis, induction and deduction, comparison and grouping, systemic approach, and surveying.

The informational support for the thesis consists of legislative acts, reports, and specialized articles, which provide a comprehensive overview of the table grape sector in the Republic of Moldova. Data were sourced from the database of the National Bureau of Statistics, reports from the Ministry of Agriculture and Food Industry of the Republic of Moldova, as well as information obtained directly from table grape producers.

The object of the research is the process of implementing new table grape cultivation technologies in the Republic of Moldova, with a focus on the Pergola system.

The theoretical significance of the thesis lies in the development of the conceptual and methodological framework regarding the implementation of new technologies in table grape production, highlighting the mechanisms through which these technologies influence the economic efficiency of the sector in the Republic of Moldova.

The practical relevance of the thesis is demonstrated through the obtained results and formulated recommendations, which aim to increase the economic efficiency of table grape production by implementing new cultivation technologies. The research results provide practical support to table grape producers for optimizing production processes and enhancing economic efficiency. At the same time, they will be useful to authorities and regulatory bodies in

developing and adjusting agricultural policies aimed at supporting technological innovation. Moreover, the results can be integrated into the activities of professional associations, contributing to strengthening collaboration and the exchange of experience among specialists in the field. The application of these results within the enterprise AMV Grape SRL has confirmed the benefits of implementing new cultivation technologies, particularly the Pergola system, under real production conditions.

The scientific novelty of the obtained results lies in:

- The development of the concept of economic efficiency in table grape production by integrating the time factor, financing conditions, risks, and the dimension of sustainability;
- The elaboration of a differentiated investment model for establishing table grape plantations, structured into four technological variants (Vertical Trellis, Basic Pergola, Pergola with hail net, and Pergola with rainproof film), which supports investment decisions in table grape cultivation;
- The development of an integrated clustering model in the table grape sector involving key relevant participants: producers, local and central public authorities, universities, research institutions, and professional associations;
- The identification of priority development directions for the table grape sector, focused on implementing modern technologies, product certification, adapting grape varieties to local climatic conditions, diversifying the assortment range, and the professional training of viticulturists;
- The formulation of a set of strategic recommendations to increase the economic efficiency of the table grape sector in the Republic of Moldova.

It is noteworthy that, for the first time in the Republic of Moldova, research has been conducted on the efficiency of table grape production cultivated in the Pergola system, as well as on the impact of this technology on the development of the respective sector.

Approval of Scientific Results. The theoretical-methodological and practical aspects of the research have been synthesized and presented in 9 scientific papers, including one article published in journals indexed in other databases accepted by ANACEC (Romania, 2024), 3 articles in national journals of category B, and 5 articles presented at various national (Chișinău, 2022; Comrat, 2024) and international (Ukraine, 2024) conferences.

Implementation of Scientific Results. The research results have been utilized within the Ministry of Agriculture and Food Industry of the Republic of Moldova, the entity AMV Grape SRL, and the Cahul District Council. The conducted study provides a well-founded argument for the implementation of the intensive Pergola system in table grape cultivation. Some aspects of the thesis have been integrated into the research carried out under the USAID project "Rural Competitiveness and Resilience Activity," no. AID-72011722C00002.

Volume and Structure of the Thesis. The thesis includes the following sections: abstract, list of abbreviations, list of tables, list of figures, introduction, three chapters, conclusions, and recommendations. It also presents 170 titles in the bibliography, 55 figures, 21 tables, and 33 appendices, totaling 150 pages of main text.

Keywords: agriculture, certification, cluster, competitiveness, economic efficiency, value chain, intensive production, viticulture sector, table grapes, subsidization, advanced technologies, Pergola system.

CONTENTS OF THE THESIS

Chapter 1: Theoretical and Methodological Approaches to Economic Efficiency and the Use of New Technologies in Table Grape Production develops the theoretical and methodological framework of economic efficiency, highlighting the necessity of rational resource use, productivity improvement, and production cost reduction; it emphasizes the contribution of new technologies to the more efficient management of vineyards, with a focus on sustainability.

The table grape sector is characterized by a series of specific features that influence how the economic efficiency of production is evaluated. These features relate to factors such as the particularities of the cultivation process, technological requirements, climatic conditions, as well as the structure of costs and revenues. Unlike other agricultural sectors, the table grape sector involves significant investments in plantation infrastructure, such as the installation of irrigation systems, support structures, and the acquisition of high-quality planting material. Moreover, the production cycle of table grapes is long-term, and profitability cannot be realized in the short term, which makes the evaluation of economic efficiency more complex. The table grape sector cannot quickly respond to market fluctuations because the selection of varieties is made at the time of planting. Additionally, it largely depends on external conditions, such as regulations on subsidies and crediting, which influence access to financing and the economic sustainability of plantations. These variables must be integrated into the analysis of economic efficiency to provide a complete and realistic picture of the economic viability of table grape production.

Considering the complexity of the production process, the significant investments required, and the dependence on external factors, it is important that decisions regarding the development of plantations are based on a detailed analysis of economic efficiency. Evaluating economic efficiency allows the identification of strengths and vulnerabilities and provides the necessary foundation for optimizing resource allocation, reducing risks, and increasing market competitiveness. Without such an evaluation, there is a risk that the investments made will not yield the expected results. Therefore, the analysis of economic efficiency becomes an indispensable tool for underpinning strategic decisions in table grape production.

The table grape sector is characterized by a series of specific features that influence how economic efficiency is assessed. These relate to the technological specifics of the cultivation process, climatic conditions, the structure of costs and revenues, etc. This requires significant investments in plantation infrastructure, such as irrigation systems, support systems, planting material, and so forth. Additionally, the long production cycle and the extended period until investment recovery make the evaluation of economic efficiency in this sector more complex. The table grape sector cannot quickly respond to market fluctuations because the selection of varieties is made at the time of planting. All these variables must be integrated into the analysis of economic efficiency to provide a complete and realistic picture of the economic viability of table grape production [1].

To determine the economic efficiency of table grape production, it is necessary to analyze the expenses for establishing and maintaining the plantations, taking into account the time factor. In this regard, the value of the expenses for planting and maintaining the plantations is determined over the vegetation period (4 years), that is, updated according to time. At the same time, the direct costs for each type of operation are taken into account.

The results obtained by table grape producers are influenced by the sources of financing used. Many of them resort to bank loans or benefit from subsidies to cover the expenses related to establishing the plantations. These forms of support help reduce the initial financial pressure on producers but involve long-term financial obligations. Therefore, the evaluation of economic efficiency also requires analysing the impact of financing sources.

In order to maintain and increase economic efficiency, special importance is given to identifying and managing the risks associated with production. In the context of climate variability and market fluctuations, which can affect both the quantity and quality of table grape production, it is necessary to evaluate the associated risks. This analysis should include possible extreme weather conditions, the occurrence of pests and diseases specific to the vine, changes in market demand, price fluctuations, quality standards requirements, and the targeted level of productivity. At the same time, it is important to consider technological innovations that could be implemented to optimize production. Based on these factors, the potential economic efficiency of production can be estimated [2].

Given the complexity of the factors influencing the economic efficiency of table grape production, a comprehensive and integrative approach to this concept is necessary. In this regard, the author proposes the following definition: *Economic efficiency of table grape production represents the optimal and dynamic ratio between the economic results obtained and the resources used throughout the entire investment cycle, through the coherent integration of the time factor, financing conditions, anticipated risks, as well as sustainability imperatives*.

Based on this definition, the main directions for evaluating economic efficiency in table grape production are outlined, focusing on the analysis of investment costs, the assessment of productivity and product quality, the examination of revenues and profitability, risk analysis, as well as the integration of sustainability principles (see Figure 1).

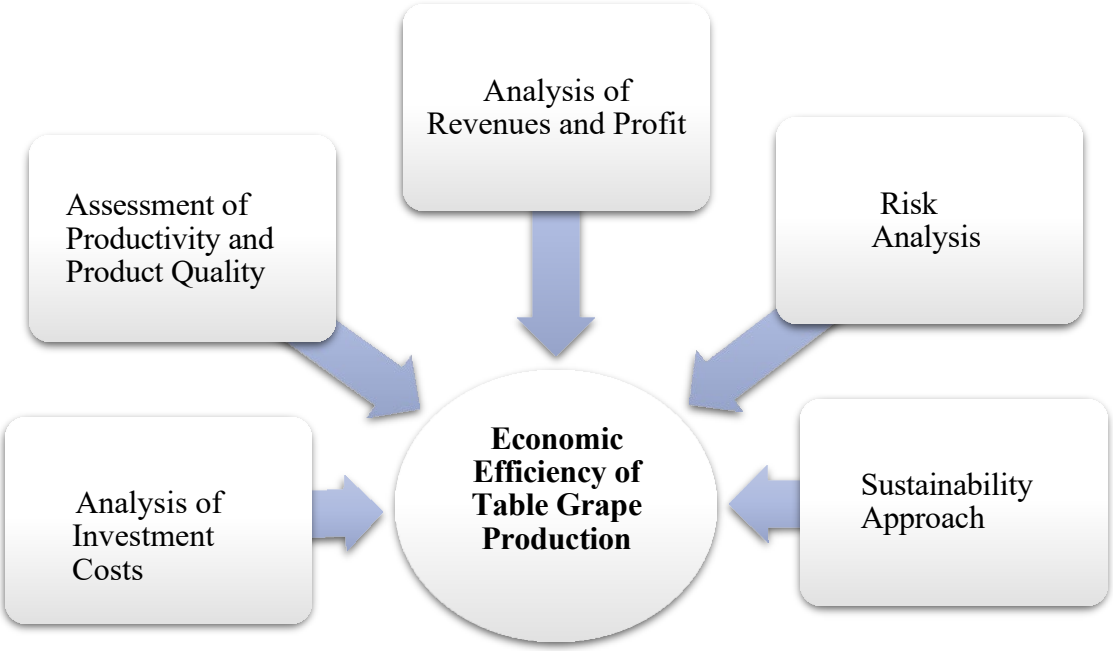

Figure 1. Directions for Evaluating Economic Efficiency in Table Grape Production

Source: prepared by the author

The economic efficiency of table grape production is not limited to the proper management of financial, material, and human resources, but also requires increased attention to environmental protection and the rational use of natural resources. In this context, the introduction of technological innovations, such as modern cultivation systems and the automation of production processes, represents a necessary step to enhance efficiency and maintain the competitiveness of the table grape sector.

The impact of introducing new technologies is reflected in increased productivity, improved product quality, rational use of resources, environmental protection, access to international markets, logistics optimization, and more. Additionally, automation and the use of agricultural robots help reduce dependence on manual labour and ensure consistent production. Food safety is enhanced through the monitoring and management of risks related to crop health, while advanced technologies such as artificial intelligence and biotechnology enable more efficient plant management and rapid adaptation to climate change [3, 4, 5]. These technologies assist in preventing and combating diseases by using precise crop protection solutions that reduce the need for pesticides and minimize environmental impact. Moreover, soil and weather monitoring technologies allow decisions based on real data, thereby optimizing the use of water, fertilizers, and other resources, leading to more sustainable production.

At the same time, the introduction of new cultivation technologies enables diversification and orientation of production towards more competitive grape varieties. This transformation opens favorable prospects for access to external markets, where quality and sustainability standards are increasingly stringent [6].

It is evident that the efficiency of the table grape sector largely depends on cultivation technologies. Table grape production involves several stages, each based on specific technologies. Some of these technologies aim to increase profitability, while others focus on improving grape quality. Therefore, adopting modern cultivation technologies at all stages of table grape production—from planting and harvesting to packaging and marketing—is important. The effects of introducing new cultivation technologies can be observed in various aspects of production (Figure 2).

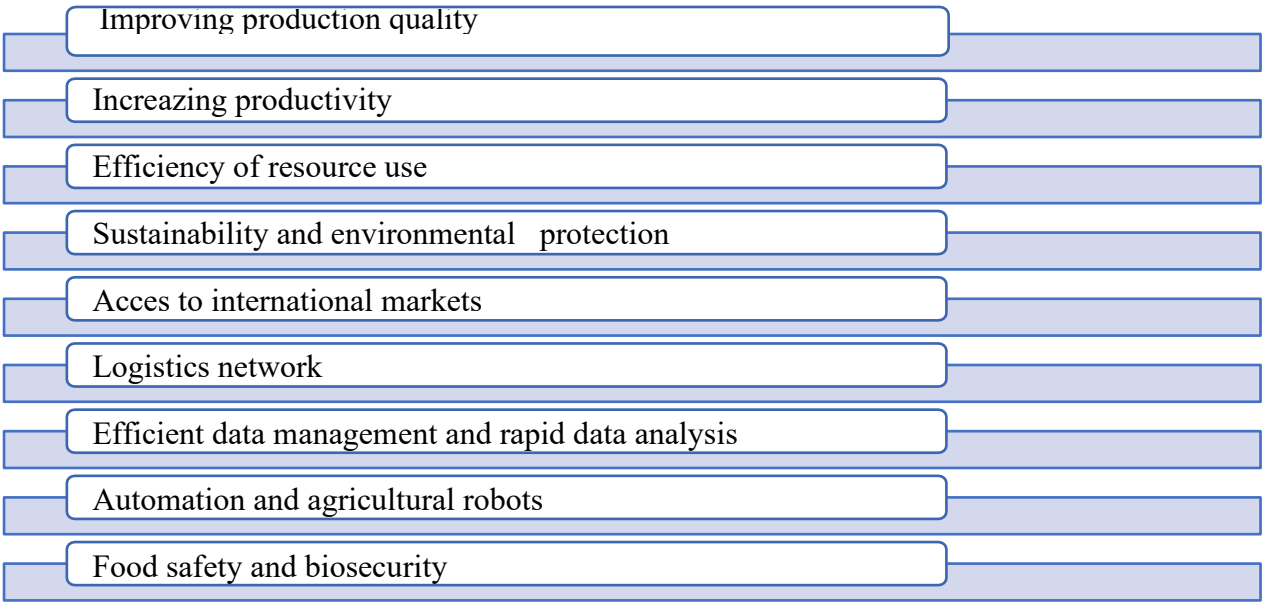

Figure 2. Consequences of Introducing New Technologies on the Efficiency of Table Grape Production

Source: developed by the author

In table grape cultivation, there are various support systems divided into two main categories: unsupported and supported. The unsupported method is less common nowadays and is used in regions where grapes are grown on low-growing vines, such as in some areas of Azerbaijan or Armenia. Most table grape producers prefer supported systems, which allow for better plant management and more efficient production.

Currently, in the Republic of Moldova, most grape producers use the vertical Spalier system. This system works well for wine production but has several drawbacks that affect the yield and quality of table grapes. These include a small leaf surface area that reduces photosynthesis, excessive shoot growth in spring and summer that blocks air circulation and promotes diseases, and fruit orientation toward the inside of the vine, leading to damaged grapes at harvest.

In this context, the adoption of new technologies, such as the Pergola system, is recommended, which allows for the production of large and uniform grapes. This system is much more productive than the traditional one, enabling yields up to four times higher. The system is based on vertical posts that support a horizontal framework on which the branches are tied, providing better sun exposure and favorable conditions for grape growth. Widely used in Italy, Spain, Chile, and Egypt, the Pergola system enhances the efficiency of table grape production [7].

Compared to the vertical Spalier system, Pergola allows for a greater distance between vines, which promotes better aeration and optimal light exposure. As a result, the grapes obtained are of superior quality, and the risks of sunburn are reduced. This system also offers advantages in easier maintenance and the possibility to harvest a larger quantity of grapes (figure 3).

a) Vertical Spalier System

b) Pergola System

Figure 3. Vertical Spalier and Pergola Vine Growing Systems

Source: prepared by the author

The Pergola system includes various types of structures, ranging from slanted pergolas to horizontal pergolas. These options allow the system to be adapted to the requirements of different grape varieties, maximizing sun exposure and efficient use of space. A key element of this system is drip irrigation, used almost exclusively in Pergola plantations, compared to only 5–7% in traditional plantations. This leads to higher productivity, reaching up to 40–50 tons per hectare, and improves grape quality [8].

In recent years, product quality has become an important factor in price determination, and the Pergola system, adapted to regional conditions and equipped with irrigation technologies, helps increase the sustainability and competitiveness of the sector. The adoption of the Pergola system in the Republic of Moldova brings significant benefits by protecting grapes from the sun and maintaining optimal moisture levels. The Pergola system adapts well to Moldova's climate, characterized by hot summers and cold winters, and helps reduce the risks of fungal diseases. It also allows for maximizing grape production, saving time and resources during harvest, and enhances the aesthetic appearance of the plantations. By reducing planting density, less investment is needed in planting material and costs are lowered, which improves profitability. Thus, the Pergola system optimizes production and supports the economic sustainability of Moldovan agriculture, making it an efficient choice adapted to local conditions.

Chapter 2, titled "Diagnosis of the Economic Efficiency of the Intensive Pergola-Type Table Grape Production System," focuses on analysing the technical and economic aspects of the intensive Pergola grape cultivation system. It examines trends in the cultivation and marketing of table grapes on both domestic and international markets. The chapter evaluates the economic efficiency of the Pergola system by comparing maintenance costs and revenues generated with those of the traditional Vertical Spalier system. Additionally, it analyses the results of a questionnaire highlighting producers' perceptions and expectations regarding the implementation of new technologies in the sector.

The analysed data indicate that the European Union is the leader in table grape production, producing an average of 1.7 million tons of table grapes annually (see Figure 4).

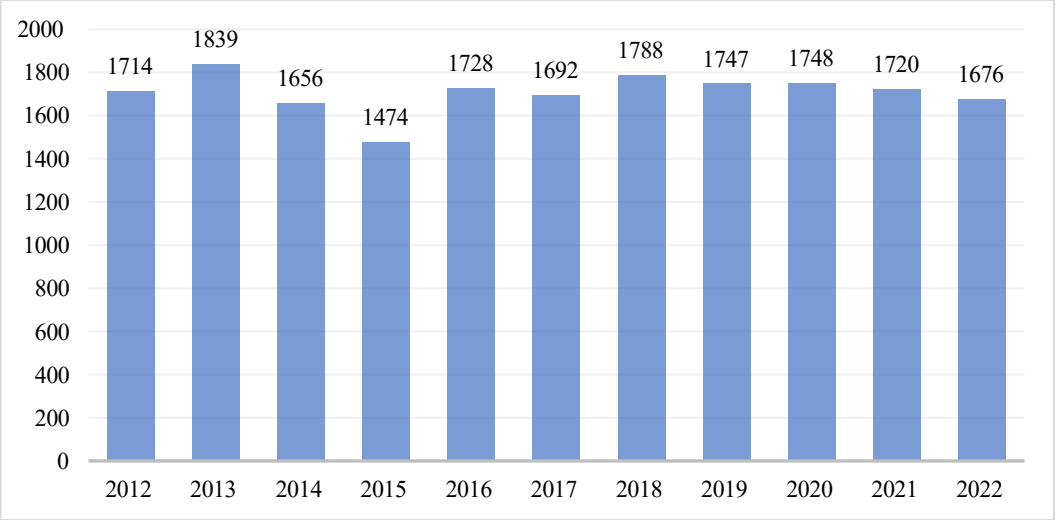

Figure 4. Annual Table Grape Production in the European Union, Thousand Tons

Source: elaborated by the author based on [9; 10]

The annual volume of table grape production in the European Union experienced significant fluctuations between 2012 and 2022. After a sharp decline in 2015, when production dropped to 1,474 thousand tons, it gradually recovered to higher values, stabilizing between 1,600 and 1,800 thousand tons starting from 2016. However, from 2018—when it peaked at 1,788 thousand tons—a gradual decrease in annual production volume has been observed, reaching 1,676 thousand tons in 2022.

Within the European Union, the largest quantities of table grapes are produced by Italy, Greece, and Spain. Among these, Italy holds the largest share of total table grape production, producing 1,042 thousand tons in 2012, although this figure decreased by 3.2 percentage points by 2022, reaching 966 thousand tons. Greece's production remained relatively stable, varying slightly from 293 thousand tons in 2012 to 290 thousand tons in 2022. Spain's production showed an increase from 240 thousand tons in 2012 to 292 thousand tons in 2022. Romania and France produce smaller volumes of table grapes, and both countries have seen a declining trend in recent years. Romania's production decreased from 49 thousand tons in 2012 to 42 thousand tons in 2022, while France's production declined from 48 thousand tons in 2012 to 46 thousand tons in 2022

In the Republic of Moldova, the annual table grape production volume reached 99.3 thousand tons in 2022, positioning our country relatively high compared to EU member states — practically in 4th place, after Spain. This highlights Moldova's potential to become a significant player on the European market for table grape trade.

Over time, table grape production increased from 86.7 thousand tons in 2016 to a peak of 125.9 thousand tons in 2018, and in 2023 it reached 107.7 thousand tons, indicating an overall upward trend, albeit with fluctuations. These developments have been largely influenced by changes in consumer preferences and environmental conditions. Although grape production was

severely affected in 2020, the general trend shows a recovery in the following years (Table 1).

Table 1. Grape Production in the Republic of Moldova, thousand tons

Grape varieties	2016	2017	2018	2019	2020	2021	2022	2023
technical	529,0	566,4	604,3	546,8	377,6	400,5	431,9	463,4
table grapes	**86,7**	**108,7**	**125,9**	**111,9**	**84,4**	**90,2**	**99,3**	**107,7**
Total	615,7	675,1	730,2	658,7	462,0	490,7	531,2	571,1

Source: elaborated by the author [11].

Although the production of technical grape varieties remains dominant compared to that of table grapes, there is a gradual increase in the share of the latter, reflecting the adaptation of the domestic market to consumer preferences and the growing demand for fresh-consumption grapes. Recent trends in viticulture show an increase in the competitiveness of table grape varieties, which are increasingly sought after in European markets due to their favorable quality-to-price ratio.

The competitiveness of these varieties is linked to market demand, adaptability to climatic conditions, and their ability to meet export needs. Internationally, the Republic of Moldova has strengthened its position, recording a significant increase in table grape exports in recent years (Figure 5).

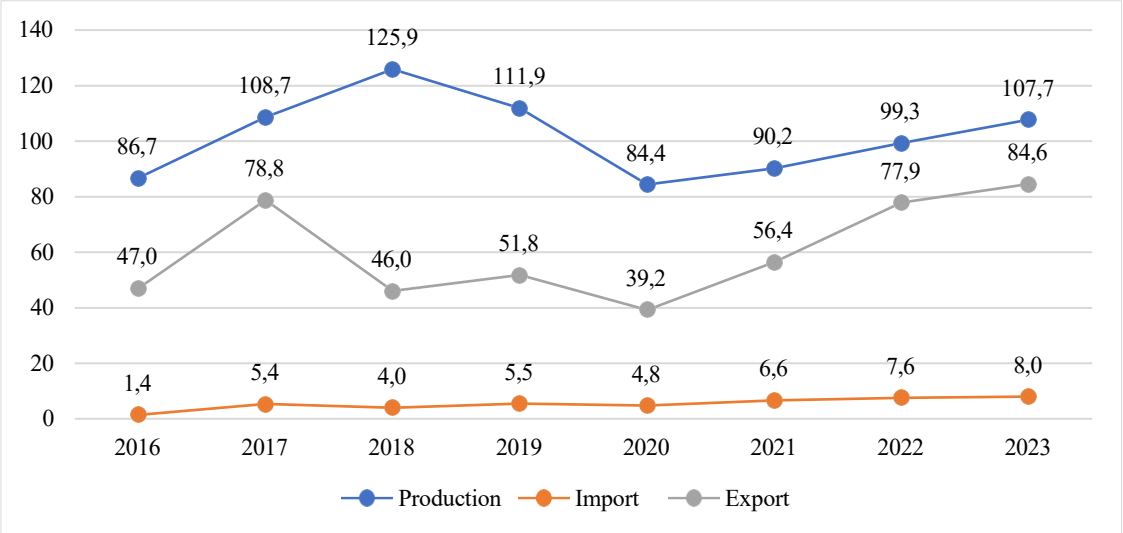

Figure 5. Evolution of table grape import and export flows in relation to production volume in the Republic of Moldova, thousand tons

Source: elaborated by the author based on [11]

During the period 2016–2023, statistics on the production, imports, and exports of table grapes in the Republic of Moldova indicate a fluctuating trend. In 2018, production reached 125.9 thousand tons, compared to 86.7 thousand tons in 2016, marking an increase of 45.2%. However, in 2020, a significant decrease was recorded, down to 84.4 thousand tons, equivalent to a 32.9% reduction. After a period of fluctuations, production gradually stabilized, reaching 107.7 thousand tons in 2023.

Meanwhile, table grape imports steadily increased, from 1.4 thousand tons in 2016 to nearly 8.0 thousand tons in 2023—more than five times higher—reflecting a growing reliance on external products. As for exports, the peak level was recorded in 2017, at 78.8 thousand tons, followed by a sharp decline of 41.6% in 2018. In the following years, exports fluctuated, returning to a high level in 2023, when they reached 84.6 thousand tons.

This dynamic suggests an overall upward trend in both production and exports, reflecting

the positive development of the table grape sector.

The geographical distribution of table grape exports varies depending on the producing country and the preferred target markets. Countries such as Italy, Spain, Chile, and the United States primarily direct their exports toward Europe, North America, and Asia, while the Republic of Moldova focuses mainly on neighboring countries and Eastern Europe. Export market diversification reduces the risk associated with dependency on a single market, protecting producers against price fluctuations or sudden changes in international demand. Therefore, it becomes necessary to analyze the geographical distribution of table grape exports (Figure 6).

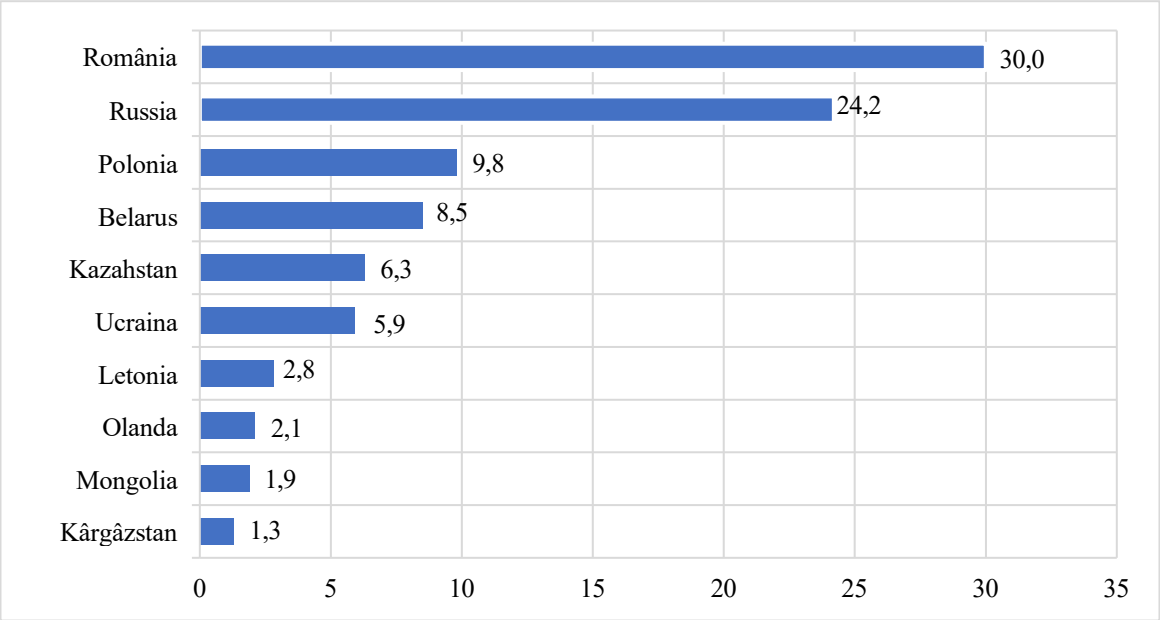

Figure 6. Geographical distribution of table grape exports from the Republic of Moldova in 2023, %

Source: elaborated by the author based on [11]

The geographical distribution of table grape exports from the Republic of Moldova in 2023 highlights a predominant orientation towards Central and Eastern European markets, with a clear trend of regional diversification. Romania remained the main trading partner, absorbing 30% of the total exported volume. The Russian Federation holds the second position, with 24.2%, indicating a still significant dependence on Eastern markets. Poland (9.8%) and Belarus (8.5%) consolidate the role of the Eastern European region in the export structure. At the same time, Kazakhstan (6.3%) and Ukraine (5.9%) reflect a broader penetration of markets in Central Asia and the eastern neighborhood. Export volumes to markets such as Latvia (2.8%), the Netherlands (2.1%), Mongolia (1.9%), and Kyrgyzstan (1.3%) are more modest but reveal efforts to expand into new destinations, which can contribute to reducing commercial risks and strengthening Moldova's position in the international table grape market.

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Exports to countries such as Latvia (2.8%), the Netherlands (2.1%), Mongolia (1.9%), and Kyrgyzstan (1.3%) remain modest but indicate efforts to expand into new destinations. These

efforts may help reduce commercial risks and strengthen Moldova's position in the international table grape market.

Moldova's table grape exports are directed toward diverse markets, with significant variation in both the degree of export concentration and export prices. In 2023, the average export price of table grapes across destination countries was USD 1.04/kg. The highest export prices were observed in the Netherlands (USD 1.47/kg) and Germany (USD 1.46/kg), suggesting a higher demand for premium-quality grapes or generally elevated price levels in those countries.

In contrast, markets such as Russia and Ukraine recorded the lowest export prices—USD 0.90/kg and USD 0.48/kg respectively—being more oriented toward high volumes and competitive pricing. Romania, which accounts for 30% of Moldova's table grape exports, is a key trade partner despite its export price being slightly below the average, at USD 1.03/kg.

Thus, Moldova benefits from the opportunity to sell table grapes on more profitable Western markets, yet remains dependent on Eastern markets where export volumes are higher but prices are lower. Export diversification and improving grape quality represent effective strategies for capitalizing on more profitable markets [12].

On the domestic market, table grape selling prices have shown significant fluctuations. Between 2016 and 2018, a sharp decline was observed, followed by an upward trend starting in 2019. In 2021, the selling price decreased to 6.69 MDL/kg from 7.87 MDL/kg in 2020, marking a 15% drop. However, it remained relatively high compared to the values recorded in 2018 and 2019. In 2022, the average selling price decreased again, reaching 5.83 MDL/kg. In 2023, however, it reached the highest level of the analyzed period—8.22 MDL/kg. This significant increase in 2023 was influenced by factors such as rising production costs and inflation.

The annual level of table grape consumption on the domestic market in the Republic of Moldova increased significantly between 2016 and 2023, growing from 7.9 kg per capita in 2016 to 13.2 kg per capita in 2023. Between 2016 and 2019, consumption rose steadily, followed by stagnation in 2020 and 2022, and a drop to 10 kg in 2021. The year 2023 marked a record level of table grape consumption, reaching 13.2 kg per capita, indicating a steady increase in demand for this product [11].

The development of table grape production and marketing activity shows accelerated growth due to integration into international markets and diversification of distribution channels. To support the growth of both production and sales on domestic and international markets, it is essential to identify grape varieties suitable for local conditions, apply modern technologies in the production process, and properly plan and manage vineyard plantations.

Additionally, establishing strong partnerships with distributors and retailers, as well as promoting products to attract consumers, are important strategies for maximizing market impact. In recent years, the Republic of Moldova has become increasingly competitive, strengthening its position on foreign markets through exports, including to countries with strict quality requirements.

For a deeper understanding of the mechanisms behind the development dynamics of the table grape sector, it is necessary to examine the table grape value chain, which highlights the processes and relationships between the key actors involved in ensuring the availability and quality of grapes on the market. Value chain analysis is a fundamental tool for understanding how added value is generated throughout the stages of raw material and resource supply, production, packaging, and marketing [13].

The most vulnerable point within the domestic value chain is the table grape production stage, where the lowest prices are recorded, especially during the mass harvesting period. This situation generates negative effects on production volume and leads to deterioration in fruit quality. To address this problem, it is necessary to create cold storage facilities that ensure optimal conditions for preserving table grapes.

Currently, in the Republic of Moldova, production volume is increasing at a much faster pace compared to investments made in post-harvest operations, especially in sorting and packaging infrastructure. This dynamic is unsustainable and represents a strategic obstacle for the development of the domestic viticulture sector [14].

In the case of the Republic of Moldova, the value chain of the table grape sector has a relatively simplified structure, with potential that is not fully exploited (Figure 7).

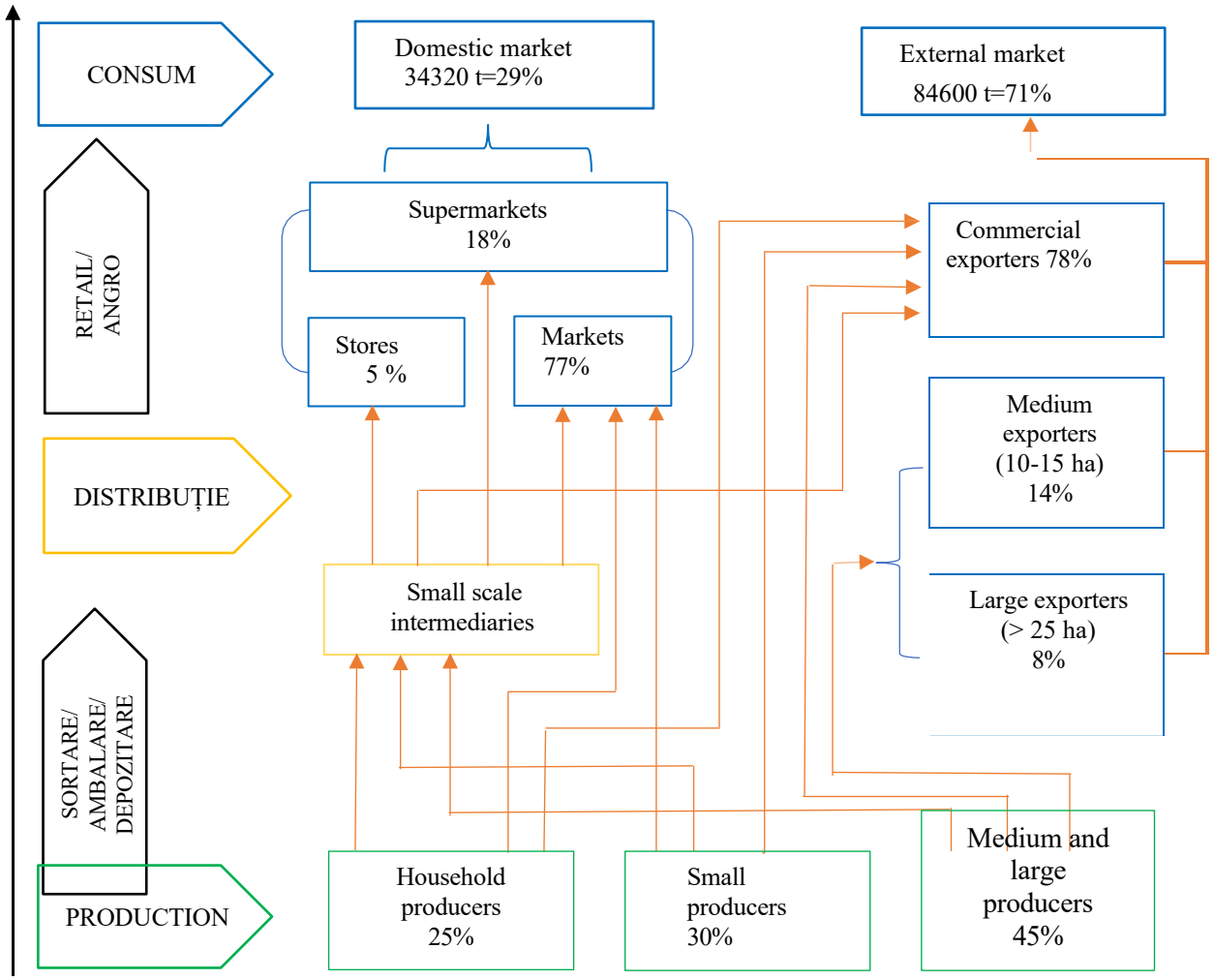

Figure 7. Analysis of the value chain segments of fresh table grapes in the Republic of Moldova, year 2023

Source: elaborated by the author

The existence of cold storage facilities for grape preservation in the Republic of Moldova is not accompanied by appropriate infrastructure for sorting and packaging, which negatively affects the quality and competitiveness of table grape production. This situation particularly hinders access to foreign markets, where quality standards are more stringent. The post-harvest stage, which includes storage and sorting-packaging, plays a significant role in the table grape value chain, directly influencing quality preservation and distribution optimization. Storage under controlled conditions prevents early deterioration and maintains freshness, ensuring the availability of grapes over extended periods. In parallel, sorting and packaging allow for the selection of grapes in accordance with quality standards and their preparation for transport and commercialization. Modern infrastructure at this stage contributes to reducing losses, increasing efficiency, and enhancing market competitiveness. Without a well-organized post-harvest process, the entire value chain can be affected, negatively impacting both producers and consumers. In our opinion, the table grape value chain requires continuous modernization in order to ensure sustainable development and increase its competitiveness on the international market. A central role in the development of the value chain is played by industry-specific associations, which contribute to the consolidation of small producers' output and facilitate connections with buyers. The main indicator reflecting economic efficiency in the table grape sector is the productivity of vineyardplantations(Figure8).

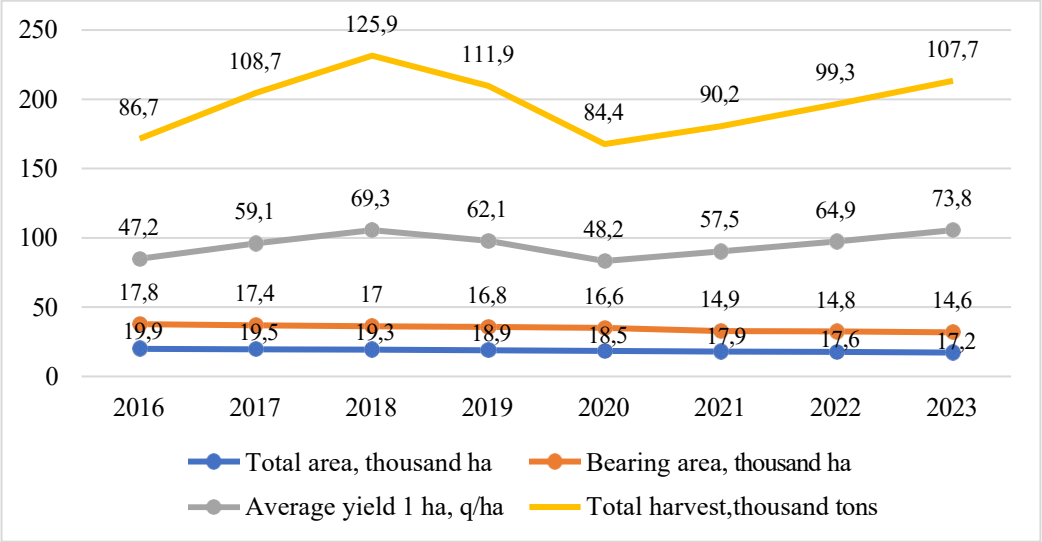

Figure 8. Analysis of productivity indicators in the table grape sector in the Republic of Moldova

Source: elaborated by the author [11]

Examination of productivity indicators in the table grape sector in the Republic of Moldova shows a continuous decrease in the cultivated area with this type of grape during the period 2016 – 2023, from 19.9 thousand ha to 17.2 thousand ha, while the bearing area decreased from 17.8 thousand ha to 14.6 thousand ha. However, the average yield per hectare increased significantly, from 47.2 q/ha in 2016 to 73.8 q/ha in 2023, indicating improvements in agricultural technologies and variety selection. As a result, the total grape harvest fluctuated but reached 107.7 thousand tons in 2023, compared to 86.7 thousand tons in 2016.

The area occupied by Pergola-type plantations amounted to 850 ha in 2023, which is 21.3 times more compared to the 4 ha in the first planting year – 2016. Thus, while in 2016 they represented only 0.02% of the total, by 2023 they occupied about 5%. This fact indicates a growing trend of adopting this system due to its advantages, such as increased productivity and resource use efficiency (Figure 9).

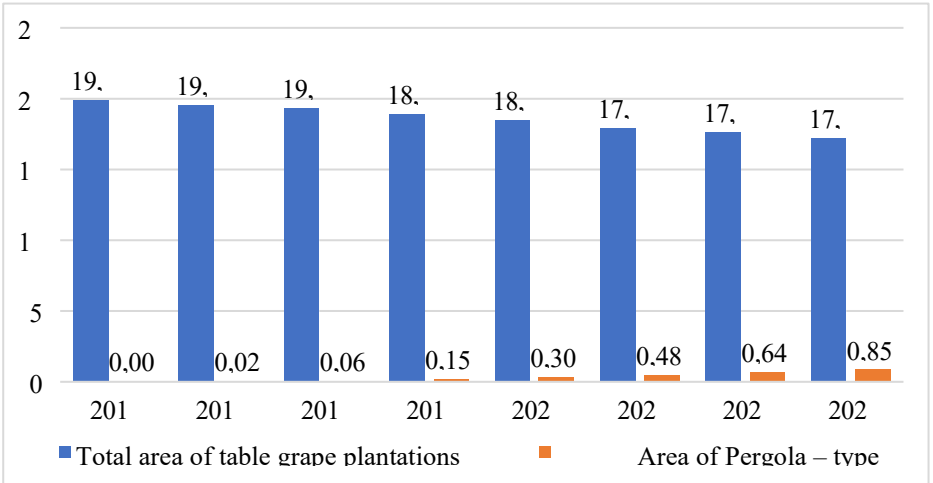

Figure 9. Area of Pergola-type table grape plantations in the Republic of Moldova, thousand ha

Source: elaborated by the author [8; 11]

An important aspect of vineyards is represented by establishment costs, which are influenced by the planting scheme. In the Pergola system, various planting schemes can be applied, such as 2.5×2.5 or 3×2. Although the 3×2 scheme involves higher establishment costs, it proves to be more efficient, contributing to increased productivity and obtaining a higher quality harvest (table 2).

Table 2. Investments required for establishing support and protection infrastructure for table grape plantations using the Pergola system with a 3×2 m scheme, year 2023

Nr. d/o	Investment items	Unit of measurement	Quantity	Amount, MDL/ha
1	**Irrigation system**			**55 000**
2	**Support system**			**472 867**
2.1	anchors and stakes			189 797
	anchors	buc.	120	30 000
	Concrete stakes 7x8 / h3.80	buc.	833	130 781
	Concrete stakes 9x9.5 / h3.80	buc.	124	29 016
2.2	Connecting elements			130 230
	Steel rope d5	m	6 800	55 080
	Steel rope d7	m	1 425	19 950
	Galvanized wire Al d2.4	kg	1 500	55 200
2.3	Support elements			37 212
	Intermediate arm 50x70/4 holes	buc.	820	23 616
	Front arm 40m	buc.	66	6 468
	Front arm 60m	buc.	66	7 128
2.4	Connectors			30 128
	Flanges 9x9.5	buc.	120	3 600
	Gripple locks d3.2	buc.	520	8 528
	M8 clamps	buc.	2 100	12 600
	Wire fastening hook	buc.	6 000	5 400
2.5	Acesorii			15 500
2.6	Support system installation works			70 000
	Total base pergola system			**527 867**
3	**Option: Anti-hail net**			**326 813**
	Galvanized wire 18 gauge (Ø4.0 mm)	kg	800	27 200
	Anti-hail net	m^2	12 300	152 520
	Flanges 7x8	buc.	833	21 658
	Caps	buc.	899	58 435
	Other accessories	buc.		45 000
	Hail protection system installation works			22 000
	Total base pergola system with hail protection			**854 680**
4	**Rain protection film**			**453 668**
	Galvanized wire 18 gauge (Ø4.0 mm)	kg	800	27 200
	Rain protection film	m^2	12 300	261 375
	Flanges 7x8	buc.	833	21 658
	Caps	buc.	899	58 435
	Other accessories	buc.		45 000
	Hail protection system installation works			40 000
	Total base pergola system with rain protection			**981 535**

Source: Created by the author.

A detailed analysis of the cost structure for establishing and maintaining table grape plantations allows the identification of essential elements influencing production profitability,

such as equipment depreciation, labor expenses, and necessary materials. Evaluating these costs is necessary to make informed decisions regarding resource planning and cost optimization.

In the case of table grape cultivation using the Pergola system (planting scheme 3x2 m), the cost structure varies depending on the protection system components (hail protection and rain protection), as well as by period: (1) costs until bearing age, which include initial investments and plantation care expenses up to the point when the vine starts producing fruit; (2) bearing costs, referring to maintenance, harvesting, and marketing expenses.

According to our estimates, the investments required for establishing and maintaining one hectare of table grapes in the Pergola system (3x2 m) until bearing age amount to 768,638 lei, with 75.9% of the costs allocated to production means. In the case of the Pergola system equipped with hail protection net (3x2 m), the investment sum is 1,120,592 lei, and the production means costs represent 79.7% of the total investment value. For the Pergola system with rain protection film (3x2 m), total investments reach 1,264,135 lei, with production means costs accounting for 80.2%. Table grape production in the Pergola system (3x2 m) is profitable, enabling an annual gross profit of 108,171 lei per hectare, with sales revenues of 279,600 lei and cost of sales amounting to 171,429 lei. The Pergola system (3x2 m) equipped with hail protection net shows medium profitability, generating an annual gross profit of 230,002 lei per hectare, with sales revenues of 454,187 lei and cost of sales of 224,185 lei. The Pergola system (3x2 m) equipped with rain protection film is the most profitable, allowing an annual gross profit of 363,915 lei per hectare, with sales revenues of 666,810 lei and cost of sales of 302,894 lei.

The total investment budget for planting one hectare of table grapes in the Pergola system (3x2 m) is 776,138 lei. This estimate is indicative, as actual expenses may vary depending on the specific characteristics and requirements of each table grape producer.

Total investments per hectare are significantly higher when additional protection systems are added (see Table 3).

Table 3. Investment structure required for establishing table grape plantations using the Pergola system (3×2 m), year 2023

Indicators	Measurement unit	Total investments at 1 hectar, lei/ha		
		base system	Protective system with:	
			Anti-hail net	Rainproof film
Vineyard planting project preparation costs	lei	7 500	7 500	7 500
Planting and maintenance costs until bearing age	lei	768 638	1 120 592	1 264 135
including:				
- Drip irrigation system	lei	55 000	55 000	55 000
- Pergola support system + accessories	lei	402 867	402 867	402 867
- Protection system	lei	x	304 813	413 668
- Other expenses		310 771	357 912	392 600
Total investments summ	**lei**	**776 138**	**1 128 092**	**1 271 635**

Source: Created by the author.

Comparatively, the analysis of the three variants highlights that the use of hail nets and rainproof films leads to significant increases in cumulative profit. This is due to the additional protection provided, which favors the enhancement of productivity and production quality. Covering systems bring multiple advantages, such as reducing the risk of berry cracking during rainy periods; limiting the occurrence of fungal diseases; and decreasing the need for phytosanitary treatments. Additionally, they protect the commercial appearance of the grapes, maintain taste quality, and allow harvesting at the optimal time, which positively influences the market value and profitability of table grape production [15].
The cultivation and maintenance of table grape plantations using the Pergola system (3x2 m) enable producers to achieve remarkable results in terms of economic efficiency (Table 4).

Table 4. Economic efficiency analysis of table grape production using the Pergola system (Moldova variety), year 2023

Nr. d/o	Indicators	Sistem Pergola (3x2 m)		
		basic	with hail protection net	with rainproof film
1	Investment costs for establishing the plantation, lei/ha	776 138	1 128 092	1 271 635
2	Available subsidies (all measures), lei/ha	272 500	422 500	472 500
3	Sales revenue, lei/ha	279 600	454 188	666 810
4	Operational costs,lei/ha	171 429	224 185	302 894
5	Gross profit, lei/ha	108 171	230 002	363 916
6	Economic profitability,%	63,1	102,6	120,1
7	Unit cost, lei/kg	7,14	6,90	7,60
8	Average selling price, lei/kg	11,65	13,98	16,74
9	Commercial markup, lei/kg	4,51	7,08	9,14
10	Investment payback period, productive years	4,7	3,1	2,2
11	Investment payback period from planting, years from planting	7,0	6,0	5,0

Source: prepared by the author.

The economic profitability of production in the basic system is 63.1%, while the average commercial markup on grapes is 4.51 lei/kg. In the case of equipment with hail nets and rainproof film, these indicators increase significantly: economic profitability rises to 102.6% and respectively to 120.1%, while the commercial markup reaches 7.08 lei/kg and 9.14 lei/kg. The Pergola system (3x2 m) with rainproof film proves to be the most advantageous in terms of economics and competitiveness. Although it requires the highest investment costs (1,271,635 lei/ha), it ensures the highest gross profit (363,916 lei/ha), the highest economic profitability (120.1%), and the greatest sales revenue (666,810 lei/ha). At the same time, it has the shortest investment payback period (2.2 productive years), supported by higher subsidies (472,500 lei/ha) and a superior average selling price (16.74 lei/kg). Although operational costs are higher (302,894 lei/ha), they are fully compensated by the revenues obtained and the commercial markup (9.14 lei/kg), reflecting superior product quality and increased market competitiveness. Therefore, additional investments in this protection system are justified due to long-term economic and commercial benefits.
The decision regarding the optimal investment option for establishing table grape plantations can be made based on the comparative evaluation of technological parameters (Table 5).

Table 5. Comparative analysis of technological indicators in table grape cultivation, year 2023

Cultivation technology	Operating period, years			Exploitation period, years	Number of plants per hectare, vines	Yield per hectare, t/ha	Investment payback period, years
	Total, years	including					
		Growing season	Production period				
Vertical trellis system plantation	30	5	25	3x1,75	1 905	17,52	7,00
Basic Pergola system plantation	30	4	26	3x2	1 667	24,00	7,00
Pergola system plantation with hail net	30	4	26	3x2	1 667	32,50	6,00
Pergola system plantation with rainproof film	30	4	26	3x2	1 667	39,83	5,00

Source: prepared by the author

The analyzed data show that all presented systems have similar durability, with a total operational period of 30 years and a productive period of 25-26 years. Regarding plant density, the Vertical Trellis system allows planting a higher number of plants per hectare (1,905 vines) compared to the Pergola systems (1,667 vines/ha). However, the Pergola systems prove to be more productive, with much higher yields: 24.00 t/ha for the basic Pergola, 32.50 t/ha for the Pergola with hail net, and 39.83 t/ha for the Pergola with rainproof film. In terms of investment payback, the Pergola systems with hail net and rainproof film have a shorter payback period (5-6 years) compared to other systems, which require 7 years. Thus, the Pergola systems, especially those with additional protection (hail net and rainproof film), are the most efficient in terms of productivity and profitability, recommended for maximizing economic efficiency in table grape cultivation.

For an accurate estimation of the investments required for implementing the Pergola system, it is necessary to develop and analyze not only the investments needed for planting and maintaining productive table grapes but also those until the vineyard reaches production, because, even if no harvest is obtained during this period, the expenses incurred directly influence the economic efficiency of table grape production [16].

This analysis allows the evaluation of costs involved in implementing different cultivation technologies, such as the Vertical Trellis and Pergola systems, to determine which offers the best long-term profitability. Although cultivation technologies in the Pergola system involve significantly higher investment costs than the Vertical Trellis system, they benefit from higher subsidies and consequently achieve a higher percentage of investment recovery from subsidies. Thus, Pergola systems, especially those with hail nets and rainproof films, offer a recovery percentage between 35.1% and 37.5%, compared to only 25.1% in the case of the Vertical Trellis system. This suggests that although initial investments are higher, Pergola technologies allow faster cost recovery through available subsidies and can contribute to obtaining more stable and profitable yields (Table 6).

Table 6. Comparative analysis of investments for planting table grapes, year 2023

Cultivation technology	Investment costslei/ha	Investment costs by items from planting until bearing (growing period), lei/ha						Available subsidieslei/h	Recovery of investments
		total, lei/ha	including						
			Means of production	Hail net, film	Mechanized services	Manual operations	Unexpected costs		
Vertical trellis system plantation	278 748	271 248	170 095	x	30 163	58 073	12 917	70 000	25,1
Basic Pergola system plantation	776 138	768 638	583 517	x	26 881	121 638	36 602	272 500	35,1
Pergola system plantation with hail net	1 128 092	1 120 592	588 631	304 813	30 149	143 638	53 362	422 500	37,5
Pergola system plantation with rainproof film	1 271 635	1 264 135	600 421	413 668	30 149	159 700	60 197	472 500	37,2

Source: prepared by the author.

By comparing investment costs and anticipated returns, table grape producers can identify the optimal solution that meets both market demands and their financial capacity. Thus, comparative budget analysis is an indispensable tool for making correct decisions regarding the planting system, contributing to maximizing economic efficiency and minimizing risks associated with investments in this field (Table 7).

Table 7. Comparative analysis of revenues and expenses in table grape cultivation, year 2023

Cultivation technology	Sales revenue, lei/ha	Cost of sales, lei/ha						Profit brut, lei/ha	Economic profitability (of the productive vineyard), %
		total, lei/ha	including						
			Means of production	Mechanized services	Manual operations	Other costs and taxes, including depreciation	Unforeseen expenses		
Vertical trellis system plantation	144 571	97 471	30 689	5 552	46 145	10 960	4 125	47 101	48,3
Basic Pergola system plantation	279 600	171 429	53 909	9 111	68 757	33 058	6 594	108 171	63,1
Pergola system plantation with hail net	454 188	224 185	65 580	9 391	81 133	60 272	7 811	230 002	102,6
Pergola system plantation with rainproof film	666 810	302 894	75 048	9 587	90 556	118 938	8 765	363 916	120,1

Source: prepared by the author.

The calculations carried out demonstrate that, although cultivation technologies using the pergola system involve higher initial costs, they generate significantly higher revenues and greater economic profitability compared to the Vertical Spalier system. Thus, the Pergola systems, especially the one with rainproof film, achieve a profitability of 120.1%, compared to only 48.3% for the Vertical Spalier system. This suggests that, in the long term, investments in cultivation technologies based on the Pergola system are more profitable, considering the higher revenues and gross profit, even though they involve additional expenses for implementation and maintenance.

To make the final decision regarding the establishment of table grape plantations, viticulturists must analyze the added value and gross profit that can be obtained throughout the entire useful exploitation period of the plantation. This evaluation helps estimate the long-term profitability of investments, providing a clear overview of the business viability (Table 8).

Table 8. Comparative analysis of economic efficiency in table grape cultivation for the useful exploitation period of the plantation, year 2023

Cultivation technology	Unit cost, lei/kg	Average selling price, lei/kg	Commercial markup (gross margin), lei/kg	Available cash flow for the fruit-bearing year, lei/ha	Key indicators for the vine's fruit-bearing period, thousand lei			Cumulative gross profit over the useful xploitation period, lei/ha	Average profitability over the useful exploitation period, %
					Cumulative sales revenue	Cumulative cost of sales	Cumulative gross profit		
Vertical trellis system plantation	5,56	8,25	2,69	57 951	3 865	2 419	1 446	48 198	59,8
Basic Pergola system plantation	7,14	11,65	4,51	141 119	7 836	4 351	3 485	116 142	80,1
Pergola system plantation with hail net	6,90	13,98	7,08	290 164	12 858	5 687	7 171	239 031	126,1
Pergola system plantation with rainproof film	7,60	16,74	9,14	482 744	19 310	7 954	11 356	378 541	142,8

Source: prepared by the author.

Based on the presented data, it can be concluded that cultivation technologies using the Pergola system (especially those with hail net and rainproof film) offer a significantly higher commercial markup and a much higher available cash flow compared to the Vertical Spalier system. These technologies allow for a considerably greater cumulative gross profit over the entire fruit-bearing period, with an average profitability over the useful exploitation period ranging from 59.8% for the Vertical Spalier to 142.8% for the Pergola system with rainproof film.

Thus, despite the higher unit costs of the Pergola technologies, they prove to be more economically efficient in the long term, generating higher revenues and profits, making them a viable choice for viticulturists aiming to maximize the return on their investments. At the same time, the cultivation technology with rainproof film offers greater economic benefits compared to the other analyzed technologies. Therefore, it can be stated with certainty that adopting the Pergola system increases the efficiency of table grape production.

It is important to note that a considerable portion of the maintenance costs of vineyards is allocated to fertilization, an essential component for maintaining vine health and obtaining quality yields. The efficiency of fertilizer application or fertilization technologies...

influențează în mod semnificativ rezultatele producției de struguri.

These practices directly influence the number of grape clusters per plant, their commercial appearance, and the total mass obtained. Besides quantity, it is important to emphasize the quality of the grapes, which can be significantly improved through the correct application of fertilization and fertigation during the growing season. In this regard, careful monitoring of parameters such as sugar content, acidity, and other quality indicators is necessary [17].

A significant impact on the efficiency of table grape production is attributed to labor costs, which in recent years have become a challenge for growers due to workforce shortages. Labor in viticulture plays a crucial role in ensuring both the quality and quantity of grape production. Skilled workers are needed for manual harvesting, which is often preferred to preserve the integrity of the grapes. This importance is also reflected in vine care processes, such as pruning, which requires specific knowledge to stimulate a good harvest.

The costs associated with mechanized services for maintaining table grape plantations cultivated under the Pergola system vary significantly compared to manual labor, depending on the nature and specifics of the tasks performed. These tasks include operations such as soil preparation and maintenance, fertilizer application, branch shredding, inter-row cultivation, etc., each requiring specific equipment and resources. The structure of mechanized service expenses varies according to vineyard characteristics (location, size, etc.). Large plantations require greater investments in mechanized equipment, while smaller areas use simpler and cheaper machinery. Additionally, table grape varieties, compared to technical ones, require a larger volume of manual labor, which influences the cost structure [18].

An advantage of the Pergola system is that mechanized services ease the work in the plantations. The use of agricultural machinery for various maintenance operations allows these activities to be completed in a much shorter time compared to manual labor.

In light of the above, we emphasize that the developed investment model constitutes a practical and comprehensive tool designed to serve as a guide for table grape producers in the investment decision-making process. It can be successfully applied under real sector conditions, having been validated and already implemented within AMV Grape SRL, which attests to its feasibility and relevance in optimizing the investment process and enhancing economic efficiency.

Chapter 3: Directions for Increasing the Economic Efficiency of Table Grape Production through the Implementation of New Technologies

This chapter highlights the role of subsidies in enhancing the economic efficiency of the table grape sector. It presents a model for clustering producers to increase economic efficiency within the sector. The importance of aligning product quality with European market requirements is demonstrated through product certification, implementation of new cultivation technologies, selection of grape varieties adapted to local climatic conditions, and diversification of the table grape assortment.

Subsidies have a significant impact on table grape production by contributing to the modernization of agricultural infrastructure and improving product quality and competitiveness on both domestic and international markets. By supporting the table grape sector, subsidies stimulate rural economic growth, create jobs, and help reduce poverty [19]. Moreover, they serve as an important tool for promoting sustainable agricultural practices and environmental protection, ensuring the achievement of sustainable production [20].

An analysis of subsidy distribution directions shows that funds are concentrated on supporting agricultural activities through a set of measures, including "Encouraging investments for the establishment, modernization, and clearing of perennial plantations, viticulture, and fruit-growing." The National Fund for Agricultural and Rural Development provides financial support for the establishment of vineyards; installation of modern support systems in vineyards; installation of anti-hail or anti-rain equipment; implementation of irrigation and fertigation techniques; purchase of agricultural machinery and equipment; and production certification.

For the establishment of table grape plantations, the state grants financial support of 45,000 lei per hectare. If the producer uses biologically certified planting material sourced from local nurseries, an additional 10,000 lei per hectare is provided. The Pergola support system benefits from a subsidy of up to 200,000 lei/ha. Costs related to irrigation systems, agricultural machinery necessary for vineyard maintenance, and plantation protection systems are also subsidized (Table 9).

Table 9. Subsidized activities for the establishment and maintenance of vineyards using the Pergola system, year 2023

Nr. d/o	Activities	Amount, lei/ha
1	Plantation establishment	45 000
	• including planting material of biological category "Certified," sourced from local nurseries	10 000
2	Pergola support system	200 000
3	Irrigation system	50% of the eligible amount (excluding VAT)
4	Agricultural machinery	25% of the eligible amount
5	Protection systems	
	• hail protection	50% of the eligible amount, but no more than 150,000 lei/ha
	• rain protection	50% of the eligible amount, but no more than 200,000 lei/ha
	• combined (hail protection + rain protection)	50% of the eligible amount, but no more than 350,000 lei/ha

Source: prepared by the author.

The agricultural machinery required for the establishment and maintenance of vineyards benefits from subsidies that cover part of the investments. Total investments in machinery used for the Pergola system amount to approximately 65,000 euros (around 1,260,000 lei), of which 25% are covered through subsidies (Table 10).

Table 10. Estimated Budget for the Purchase of Agricultural Machinery Required for Table Grape Cultivation in the Pergola System, Year 2023

Types of Investments	Estimated total investments, Euro	Sources of financing, Euro	
		Own funds	Subsidies
Specialized tractor (60-80 HP)	42 000	31 500	10 500
Sprayer (2 tons)	14 000	10 500	3 500
Cultivator with sensor (or probe)	15 000	11 250	3 750
Herbicide sprayer	2 500	1 875	625
Shredder for plant residues	8 000	6 000	2 000
Trolleys (4 units for transporting the harvest)	4 200	3 150	1 050
Total investments	**85 700**	**64 275**	**21 425**
Investment structure,%	**100.0%**	**75.0%**	**25.0%**

Source: elaborated by the author.

The total estimated investments for the equipment necessary for cultivating table grapes using the Pergola system amount to 85,700 Euros. A significant portion of this total is attributed to the specialized tractor (60-80 HP), which accounts for 49% of the total value. Following are investments in the cultivator with palpator, representing 17.5%, and in the sprayer with 16.3%. The shredder for vegetative residues holds 9.3% of the investments, followed by the carts for harvesting transport at 4.9%, and the herbicide sprayer at 2.9%. The total estimated value of investments in agricultural machinery and equipment is quite substantial (approximately 85,700 Euros). In this context, cooperation among several producers is necessary, which will facilitate investment realization and contribute to increasing economic efficiency.

For the establishment of vineyards in 2023, subsidies amounting to 15.1 million lei were allocated, covering an area of 305 hectares of vineyards. Of the total area, 89.31 hectares are allocated to plantations with table grape varieties, representing 29.3% of the entire area. Analysis of the evolution shows a decrease in vineyard areas established through subsidies, including those with table grape varieties, from 294 hectares in 2016 to 89.31 hectares in 2023, which represents a 69.6% decline. At the same time, the area of cleared table grape plantations was reduced to 314.72 hectares [21].

In addition to the support provided by FNDAMR, various initiatives stimulate investments in modern technologies and partially compensate for deficiencies in the agricultural financing system. Among these are the "One Country One Priority Product" initiative (FAO), the IFAD Project (International Fund for Agricultural Development), the Regional Support Project for Small and Medium Enterprises (RISP) funded by the World Bank, EBRD projects, etc.

Consequently, we emphasize that subsidizing table grape production as well as access to external financing are key determinants for the efficient development of the table grape sector, including production obtained through the Pergola system. Although subsidies may not have an immediate significant impact, they create long-term incentives. To maximize the effects of subsidy policies, it is important that subsidies be directed toward strategic investment projects that aim not only at expanding cultivated areas but also at improving infrastructure and implementing new technologies, which guarantee higher quality throughout the entire value chain of table grapes.

One of the main obstacles in the table grape value chain is the insufficient collaboration among small local producers. To increase their competitiveness in external markets, they need to focus on producing high-quality grapes with appropriate packaging and consistent deliveries in significant quantities. These objectives can be achieved through cooperation, which allows for better utilization of adjacent lands, the exchange of advanced agricultural techniques, and joint purchases of fertilizers at advantageous prices.

Agricultural cooperatives, producer organizations, and other collective action forms play an important role in the development of the value chain. They can aggregate products from small producers, facilitate coordination with buyers, process raw materials to add value, and keep this added value within the community. However, the number of viticulturists who associate remains low compared to other countries. Generally, agricultural producers are reluctant to cooperate due to a lack of interpersonal trust that all members will fulfill their obligations. Another factor inhibiting cooperation may be that small farmers do not join associations or cooperatives because the membership costs (both monetary and time investment) outweigh potential benefits. Since large-scale farmers can achieve economies of scale without collaborative actions, cooperation is more attractive to small and medium-sized producers [22].

In our opinion, the best way to increase the competitiveness of table grape producers is through the formation of clusters. Creating an integrative structure for the table grape sector in the Republic of Moldova would ensure economic advantages. Unlike other forms of association, a cluster allows the unification of the separate efforts of key actors to jointly solve a problem recognized by all segments of the value chain. By its nature, a cluster integrates a wide range of actors within the value chain, starting from nursery material producers and resource suppliers,

continuing with table grape growers, cold storage facilities equipped with sorting and packaging lines, and up to specialized transport operators.

Given that clustering in the table grape sector in the Republic of Moldova is underdeveloped, we recommend the creation of a "Four Clover" type cluster association focused on the table grape producer (Figure 10).

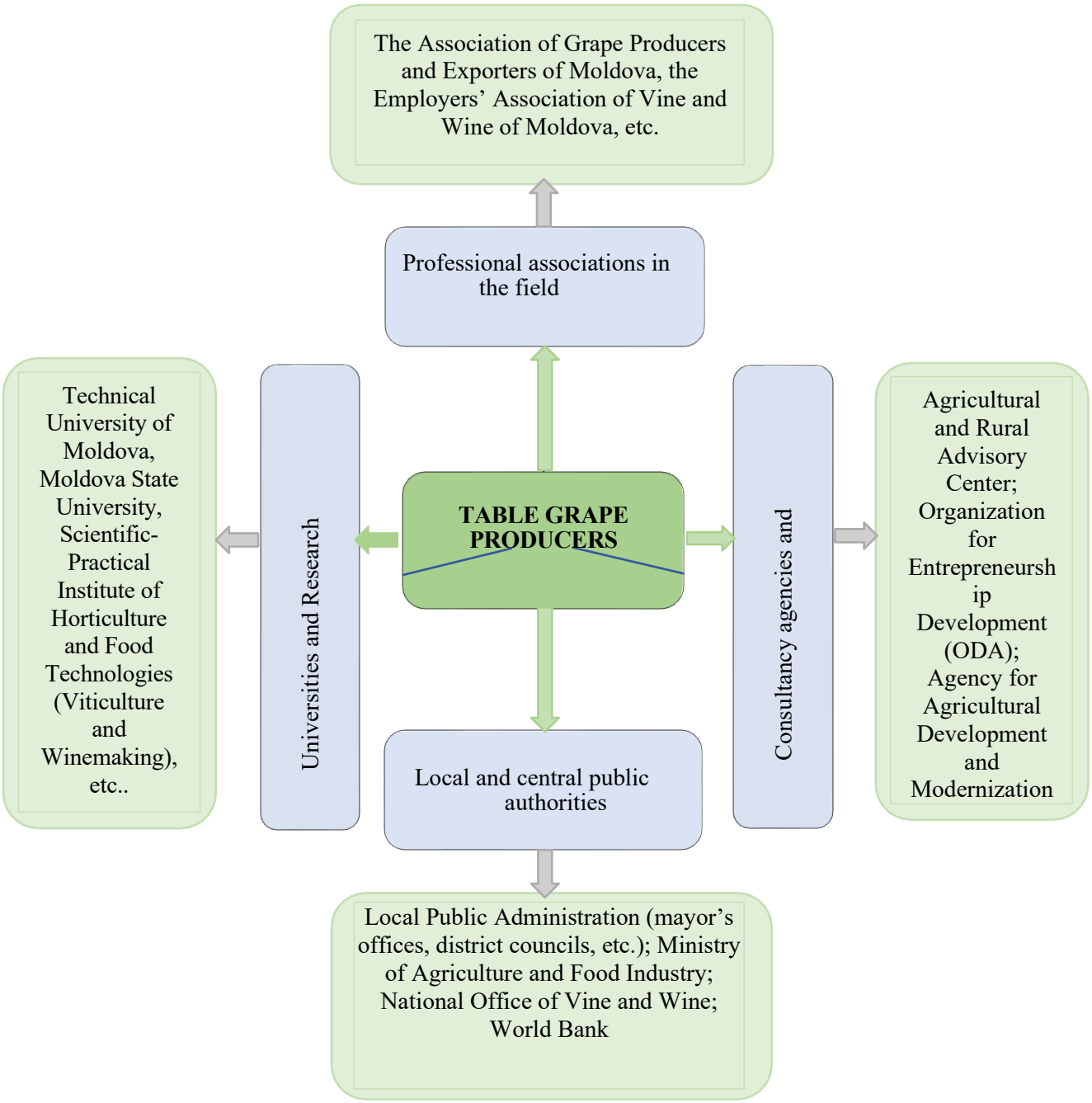

Figure 10. The "Four Clover" Cluster Model for the Table Grape Sector in the Republic of Moldova

Source: prepared by the author

The formation of clusters has an economic and social impact on the entire community, ensuring the exchange of knowledge and experience, the creation of local jobs, and the negotiation of advantageous prices for cultivated agricultural products. These benefits can be highlighted through the evaluation of cluster performance in the table grape sector. Thus, viticulturists can identify the most effective practices for obtaining superior quality grapes. Moreover, the evaluation helps discover synergies among cluster members. Performance measurement also highlights sustainability practices, such as the implementation of innovative irrigation technologies and the use of organic fertilizers, which contribute to improving grape quality. Therefore, cluster evaluation not only optimizes production but also supports sustainable development, increasing market competitiveness.

In 2022, in the Cahul district of the Republic of Moldova, the first cluster specialized in the table grape sector was established under the name "Table Grapes." It was created with the support of the "EU4Moldova: Focal Regions" program, funded by the European Union and implemented in partnership with UNDP and UNICEF. The cluster is coordinated by the Association of Table Grape Producers from Cahul municipality and brings together 11 business members, 5 representatives from local public administration, and 2 from the research–innovation–education sector.

The analysis of this cluster, which is currently unique in the table grape sector of the Republic of Moldova, highlights its benefits for business representatives, including table grape producers. This analysis, covering the period 2020–2023, includes both the time before the cluster was established in 2022 and the subsequent developments. Thus, we can observe the development trends of its members both before and after the creation of the cluster. (figure 11).

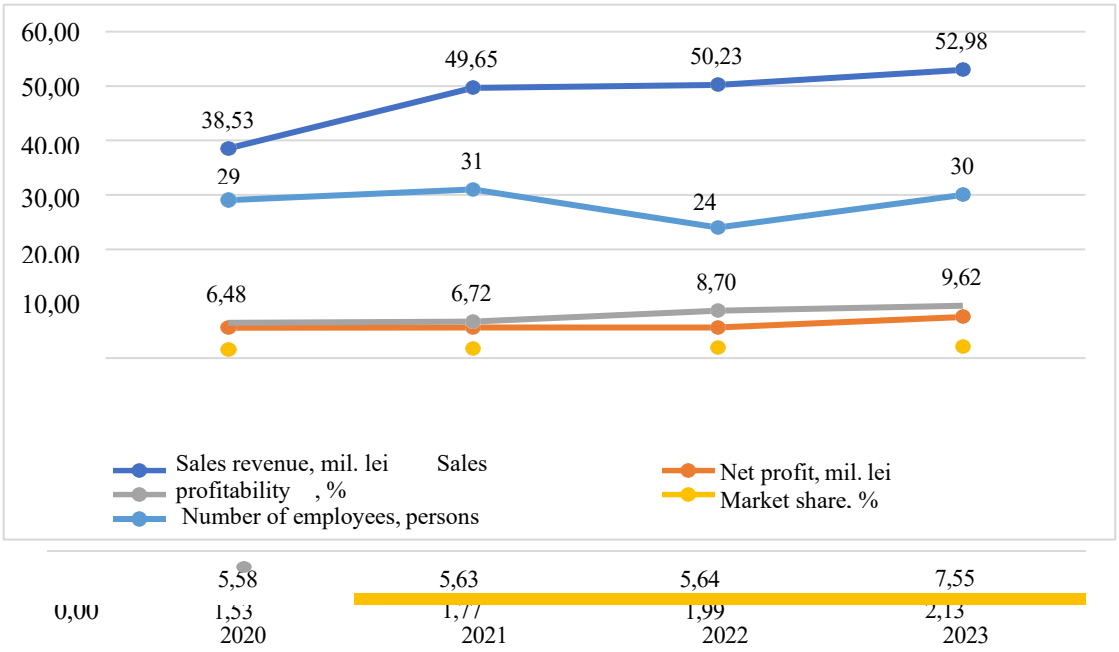

Figure 11. Evaluation of the economic results of the "Table Grapes" cluster in Cahul, Republic of Moldova, during the period 2020–2023

Source: elaborated by the author

The "Table Grapes" cluster in the Cahul region recorded a steady increase in sales revenue, from 38.53 million MDL in 2020 to 52.98 million MDL in 2023, along with a rise in net profit from 6.48 million MDL to 9.62 million MDL over the same period. Sales profitability

increased from 5.58% to 7.55%, indicating solid economic efficiency, while market share rose slightly from 1.53% in 2020 to 2.13% in 2023. As for the number of employees, it fluctuated—rising to 31 in 2021, dropping to 24 in 2022, and returning to 30 in 2023. Overall, the economic results of the "Table Grapes" cluster reflect a positive trend, with continuous growth in sales revenue and profit, alongside a gradual strengthening of its market position.

Consequently, we can conclude that clusters are effective tools for entrepreneurial and regional development policies. However, the mere geographical concentration of enterprises does not automatically guarantee cluster performance. The advantages associated with clustering do not manifest effortlessly, especially in countries with weak institutions and developing market mechanisms. The Republic of Moldova, which aims to integrate this tool into its economic development strategies, must develop effective support and assistance policies to facilitate the creation and growth of clusters. Although a Concept for the Cluster Development of the Industrial Sector [23] has been adopted and the notion of clusters has been introduced into national legislation [24; 25], there are still no specific policies and mechanisms to effectively support the creation and development of clusters.

Enhancing the competitiveness of table grapes is a key factor for the integration of the Republic of Moldova into the European market. This is mainly determined by two fundamental factors – quality and price. In addition, product promotion conditions, sales strategies and after-sales services, advertising campaigns, the perceived image of the product, and the dynamics of the target market [26] also play important roles.

To analyze ways to improve the quality of table grapes, we focused on aligning production with competitiveness management strategies, based on the following key aspects: the implementation of modern cultivation technologies (including the Pergola system); adoption of quality and safety management systems for table grapes by certifying production according to the GLOBALG.A.P. standard, including organic production; adaptation of table grape varieties to local climatic conditions; analysis of the existing varietal range; as well as professional training of farmers.

The use of modern cultivation methods allows table grape producers to optimize their activities by reducing manual labor, lowering costs, and increasing yields. The Pergola system is a modern and innovative technology for the Republic of Moldova, designed to optimize table grape production through the intensive use of advanced solutions. A key element of this system is drip irrigation. This technology ensures a uniform and consistent distribution of water and fertilizers directly to the root zone [27].

In vineyards, both surface and subsurface irrigation systems can be used. For the Pergola system, subsurface irrigation is recommended in order to prevent damage to the irrigation system, considering that agricultural machinery accesses these plantations from multiple directions (see Figure 12).

Figure 12. Drip irrigation system in Pergola plantations in the Republic of Moldova

Another innovative aspect of the Pergola system is the plant protection system, which helps reduce crop losses and ensures a uniform, high-quality harvest. This includes hail nets and rainproof films, which decrease the risk of grape damage and extend their shelf life. The use of hail nets reduces losses caused by hail by up to 70-80%, and the shelf life of grapes can be extended by 15-20%, thus providing an advantage on the sales market. These technologies help create a stable microclimate for the vineyard, leading to a uniform harvest without major fluctuations in quality or quantity. The impact on uniformity results in an approximate 10-15% increase in product quality compared to traditional methods.

The following images illustrate how the protection system is implemented in Pergola-type plantations (Figure 13).

Figure 13. Pergola system plantation equipped with hail net in the Republic of Moldova

Source: elaborated by the author

To remain competitive and gain an advantage in the market, table grape producers must implement effective strategies for planning, control, and improvement of product quality and safety by adopting quality and safety management systems that comply with international standards. Agricultural standards focus on the application of good agricultural practices and food safety, being integrated throughout the entire process—from planning and harvesting to packaging and transportation—thus ensuring food safety and product traceability.

The GLOBALG.A.P. standards [28] are the most widely used worldwide, and their implementation enables producers to comply with the food safety legislation of the Republic of Moldova and the European Union, as well as requirements related to worker health and welfare, environmental protection, and other target markets. In the Republic of Moldova, GLOBALG.A.P. standards have been introduced since 2006. By 2020, the number of certifications awarded to agricultural producers showed an upward trend, reaching up to 26 certifications annually. Subsequently, a steady decline is observed, decreasing to 12 certifications in 2023. The decrease in GLOBALG.A.P. certifications after 2020 can be attributed to factors such as the COVID-19 pandemic, changes in market requirements, internal economic difficulties, and lack of support for implementing international standards. These elements reduced accessibility and interest in obtaining certifications, thus impacting their evolution. However, in recent years, table grape producers have shown increasing interest in obtaining GLOBALG.A.P. certificates, as the requirements imposed by European Union importers for confirming the implementation of these standards have grown significantly, becoming essential for those wishing to export grapes.

We consider that the adoption of GLOBALG.A.P. standards by local table grape producers offers numerous advantages. These standards facilitate access to demanding markets regarding product quality and safety, contribute to increased competitiveness through transparency and traceability, optimize production processes, and reduce environmental impact. In this way, GLOBALG.A.P. supports building trust among customers by meeting their demands for safe, high-quality, and sustainable products. At the same time, producers demonstrate their commitment to sustainability and safe working conditions for employees.

An important factor for increasing the competitiveness of table grapes is practicing organic farming, which brings multiple environmental benefits and helps prevent climate change. Since 2019, the Republic of Moldova has initiated the alignment of its legislation with European standards by implementing the provisions of EU Regulation 2018/848 [29], which targets organic production and labeling of organic products. From 2022, this regulation introduced stricter rules for inspecting organic products, requiring producers from third countries to comply with these standards just like those from the European Union.

Organic certification is an effective tool for ensuring the quality of table grapes. To obtain this certification, specific cultivation standards must be met and sustainable production methods adopted, subject to regular inspections by accredited certification bodies. According to data from MAIA, in 2023, 10 grape growers were registered, of whom 3 obtained organic farming certification, while the other 7 are in the conversion period to reach the same standards [30].

However, although essential for supporting sustainable agriculture, organic certification presents some economic challenges. Investments in alternative protection measures, such as natural insecticides or pest control methods, cost up to 50% more compared to chemical products used in conventional agriculture. On the other hand, the selling price of organic grapes is about 20% higher than that of conventional grapes, but the yield is 40% lower. Thus, although the revenue is higher, the high production costs make net profit lower, which discourages table grape producers.

These discrepancies lead to a perception of inefficiency of organic certification, especially among small farmers who face financial difficulties. Therefore, it is necessary to develop policies to support farmers, through subsidies or tax incentives, to encourage sustainable practices and reduce economic pressure.

The steady increase in average annual temperature in recent decades affects grape production and quality. To respond to the new climatic conditions and market demands, it is necessary to diversify the grape assortment by developing new varieties, including seedless (apirenic) types, with increased resistance to unfavorable environmental factors. Grapevine breeding thus becomes a necessary solution for competitive and sustainable viticulture in Moldova, adapted to new economic and climatic challenges [31].

The breeding objectives are focused on the following main directions: increasing productivity; optimizing the ripening period; enhancing resistance to diseases and pests; improving frost resistance; increasing drought tolerance; improving quality; and obtaining seedless varieties [32]. To achieve these objectives, various breeding methods are applied, each playing a specific role in obtaining grape varieties adapted to market requirements and the specific climatic conditions of the region.

Table grape producers in the Republic of Moldova largely opt for the “in vitro culture” breeding method. This technique allows obtaining plants with specific traits, such as disease resistance, adaptability to different climatic conditions, and improvement of organoleptic characteristics, such as taste, appearance, and texture [33]. In vitro breeding is carried out in a shorter time compared to traditional selection methods and can take place throughout the year, ensuring a constant source of planting material [34].

Improved table grape varieties are more productive and competitive on the market due to their superior characteristics. They ensure higher yields per hectare thanks to enhanced genetic potential and are more resistant to various climatic conditions, diseases, and pests, which guarantees stable production. Grapes from these varieties have larger berries, more attractive color, better texture, and superior taste, making them highly appreciated by consumers. Additionally, improved varieties have better storage and transport resistance, reducing post-harvest losses. Production costs are lower due to increased resistance to diseases and pests, which decreases the need for chemical treatments. By aligning with strict quality standards, these varieties facilitate access to premium markets. Investments in such varieties often benefit from subsidies, supporting competitiveness growth. Furthermore, by reducing the use of chemicals and promoting sustainable agricultural practices, they help diminish environmental impact.

Consumer preferences are influenced by factors such as taste, aroma, texture, and appearance of grapes. Traditional table grape varieties remain commercially attractive mainly because of their extended shelf life. However, there is a clear trend towards seedless varieties, valued for their sweetness. The color of grapes also influences preferences, with higher demand for white and pink varieties, perceived as sweeter and more visually appealing. Economically, the market price for white/pink seedless grapes is higher compared to black grapes (such as the Moldova variety). This reflects a greater appreciation for these varieties in European markets. Thus, although their price is higher than other varieties, consumers are willing to pay more for their qualities, demonstrating a clear preference for these types of grapes.

Consumer choices regarding table grape color are influenced by seasonal demands. During summer, white or pink varieties are preferred due to their light and refreshing taste, suitable for high temperatures. Conversely, in the cold season, preferences shift towards black varieties, which are sweeter and contain more biologically active substances. This approach allows table grape producers to adapt to market demands and satisfy year-round consumer needs.

In the Republic of Moldova, the table grape assortment is diversified, but white varieties predominate (Figure 14).

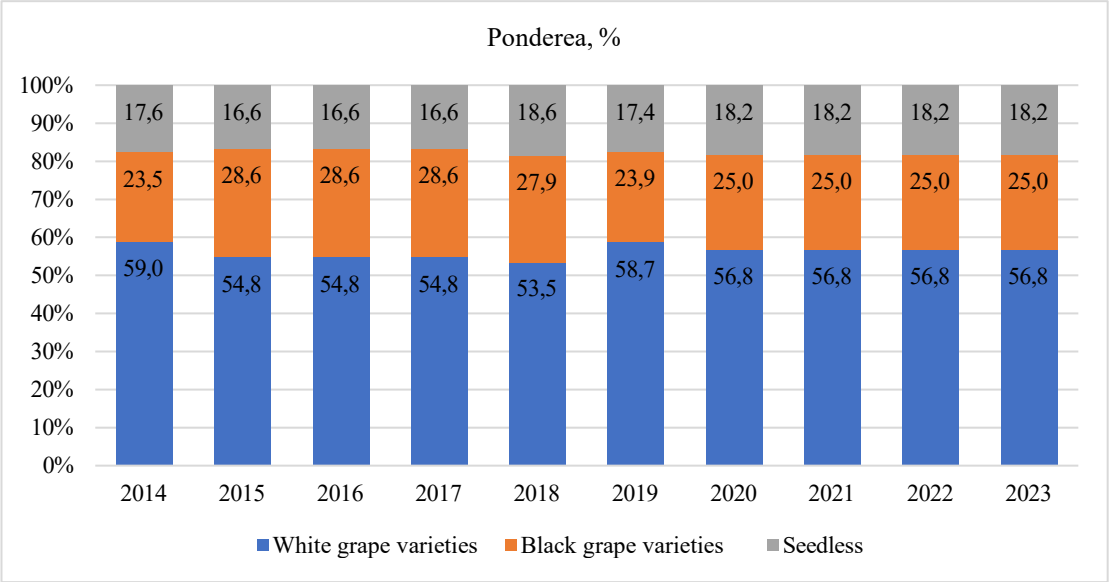

Figure 14. Distribution of table grape varieties in the Republic of Moldova by color and seed presence, %

Source: prepared by the author [35]

Examining the evolution of the distribution of table grape varieties cultivated in the Republic of Moldova between 2014 and 2023, there is a consistent predominance of white-berried varieties, accounting for approximately 56-59%. Black-berried varieties represent a smaller share, between 23-29%, without significant fluctuations, while seedless (apirenic) varieties remain stable around 17-18%.

Considering the demands of international markets, white and seedless varieties are more sought after than black varieties, making it necessary to diversify the assortment of table grape varieties for export from the Republic of Moldova. Varieties such as Roshfor, Kishmish Lucistii, and Pink Apiren, which are among the best-selling domestically, can significantly enhance the competitiveness of local producers in European markets, enabling access to better prices and a broader product range.

To attract consumers, we recommend implementing a packaging strategy that combines white, pink, and black varieties in clamshell containers, offering diversity and originality. This mix aligns with market trends where consumers are increasingly drawn to innovative and visually appealing products, thereby strengthening the image of domestic grapes as diverse and attractive.

Most white and pink varieties are early or very early ripening, providing a significant economic advantage by reaching the market before other varieties, at a time when supply is limited and prices are higher. Early harvesting also reduces plantation maintenance costs. In contrast, black varieties are generally late ripening and marketed later, when competition is higher and prices are lower.

The domestic production is dominated by the Moldova variety, which, although highly appreciated for its organoleptic qualities (9.5 out of 10 points according to a survey [36]), is a late-ripening variety. Late harvest limits market opportunities and competitiveness compared to earlier varieties. To ensure a continuous supply of fresh grapes, diversification with varieties having different ripening periods is necessary.

Since early and very early varieties generate higher revenues due to premium prices, we recommend promoting early maturation through the use of anti-rain film covers. This technique can advance harvest by 15-20 days, facilitating market entry at the beginning of the season when prices are more favorable.

For late varieties, it is beneficial to extend the ripening period by leaving grapes on the vine for 15 to 30 additional days, resulting in superior quality and increased demand. This strategy allows off-season marketing at better prices (up to 28-30 MDL/kg). For example, the Moldova variety, typically harvested between September 15 and 30, can be harvested until November using anti-rain film covers.

Direct marketing from the vineyard, avoiding storage that affects quality, reduces transportation and storage costs, thus improving the economic efficiency of production.

We consider that utilizing very early varieties combined with innovative techniques such as anti-rain films that delay the ripening period is an effective method to maximize the added value of grape production. These practices enable obtaining higher quality harvests earlier in the season, enhancing market competitiveness by meeting external market demands and accessing higher prices due to product quality and rarity.

Training individuals involved in agriculture is one of the primary objectives for the development of the agrarian sector in the Republic of Moldova, having a direct impact on increasing competitiveness and ensuring its sustainability [37; 38]. Trained farmers are able to adopt innovative methods, optimize production processes, and meet the demands of both domestic and international markets, thereby enhancing competitiveness. It is important to note that not all individuals practicing agriculture, including viticulture, have formal education in the field.

In the author's opinion, professional training for farmers—especially for table grape producers—should cover modern cultivation techniques; fertilization strategies adapted to soil type and climatic conditions; resource management; certification and quality standards (e.g., ISO, Global G.A.P., etc.) and certification processes; market trends and marketing strategies; and organic farming practices.

Concluding the analysis carried out in this research, we emphasize that establishing priority development directions for the table grape sector represents a strategic step towards increasing its efficiency and competitiveness. A concrete outcome of this process is the formation of a regional viticulture cluster, in which the author actively participated. This initiative demonstrates the practical applicability of the identified directions and their relevance for regional development. Therefore, the directions outlined in this research constitute a useful and practice-validated reference, contributing to the consolidation and modernization of the table grape sector.

General Conclusions and Recommendations

The investigations carried out within this thesis aimed to scientifically and practically substantiate the application of the Pergola system in table grape cultivation, with the objective of demonstrating that the integration of modern technologies significantly contributes to increasing the economic efficiency of table grape production in the Republic of Moldova. The results obtained led to the formulation of the following conclusions:

1. To achieve the objective of analyzing the development conditions of the table grape sector in the Republic of Moldova and highlighting its importance for national agriculture, an extensive review of specialized literature and relevant documents was conducted, leading to the following conclusions:

   1.1. Table grape cultivation in the Republic of Moldova represents a long-standing tradition, being an agricultural activity with deep roots in the country's history and culture. This tradition is reflected both in agricultural practices passed down through generations and in the important role viticulture plays in rural life and the local economy (Chapter I, paragraph 1.1).

   1.2. The region's specific pedoclimatic conditions, characterized by warm summers, moderate winters, and fertile soils, are favorable for table grape cultivation. This natural environment allows for consistent and high-quality harvests, giving the table grape sector a significant competitive advantage in the market (Chapter I, paragraph 1.1).

   Thus, the combination of a long tradition with favorable natural conditions constitutes a solid premise for strengthening the table grape sector, emphasizing its important role in the agricultural development of the Republic of Moldova.

2. Efforts made to theoretically and methodologically substantiate the concept of economic efficiency specific to table grape production led to the following conclusions:

   2.1. The concept of economic efficiency is complex and multidimensional, defined as the optimal ratio between resources used and results obtained, with an emphasis on maximizing production and minimizing costs. The author supports this definition especially in the context of the table grape sector, where costs (effort) are significant, and production and, consequently, profit (effect) are realized only about 4 years after planting (Chapter I, paragraph 1.2).

   2.2. The evaluation of economic efficiency is based on a set of essential indicators such as productivity, profitability, unit costs, and resource utilization level. In table grape cultivation, the author highlights that the calculation of economic efficiency must consider not only initial investments and plantation maintenance costs but also sector-specific risks such as diseases, pests, hail, or drought, which can significantly influence economic outcomes (Chapter I, paragraph 1.2).

   2.3. The introduction and application of new technologies in table grape cultivation have a significant impact on increasing economic efficiency. These technologies help optimize production costs, improve product quality, and reduce risks associated with climatic and biological factors. In this context, the Pergola system plays an important role by offering

multiple advantages, including optimal sun exposure of grape clusters, better fruit maturation, and efficient air circulation, which reduces the risk of fungal diseases (Chapter I, paragraph 1.3).

3. The objective regarding the analysis of the evolution of table grape production and marketing was achieved through the study of statistical data and sector reports, allowing the formulation of the following conclusions:
3.1. Globally, the table grape sector is well developed, representing an important and competitive segment of agriculture. In the Republic of Moldova, this sector is in an expansion phase, with the share of table grape production in total grape production steadily increasing from 14.08% in 2016 to 18.86% in 2023, with an almost 34% increase in volume produced during this period. However, technical grape varieties remain dominant, and competition on the international and European markets is high, necessitating continuous consolidation and modernization of the sector (Chapter II, paragraph 2.2).
3.2. Table grape production in the Republic of Moldova experienced significant fluctuations between 2016 and 2023, rising from 86.7 thousand tons in 2016 to 125.9 thousand tons in 2018, followed by a decline in 2020 and a gradual recovery up to 107.7 thousand tons in 2023. At the same time, imports increased more than fivefold, reflecting growing dependence on the external market. Exports have diversified geographically, with table grapes shipped to 36 countries, Romania and the Russian Federation being the main markets (Chapter II, paragraph 2.2).

4. As a result of research conducted to comparatively evaluate the economic efficiency of table grape production under the Pergola and Vertical Spalier systems, the following conclusions were drawn (Chapter II, paragraph 2.3):
4.1. The Vertical Spalier system allows a higher planting density of 1,905 vines/ha compared to 1,667 vines/ha in the Pergola system. However, yields obtained in the Pergola system are significantly higher, ranging between 24 and nearly 40 t/ha. Also, the investment recovery period in the Pergola system is shorter (5-6 years) compared to 7 years in the Vertical Spalier system. Easier access and maintenance operations in vineyards make the Pergola system more practical and efficient compared to the Vertical Spalier system.
4.2. Initial investments in the Pergola system are higher, but subsidies allow for recovery of over 35% of costs compared to approximately 25% in the Vertical Spalier system. Economic profitability reaches 120.1% in the Pergola system, compared to 48.3% in the Vertical Spalier system. Likewise, gross profit and commercial margin are considerably higher in the Pergola system. These results highlight the economic superiority of the Pergola system, especially when additional protection (hail nets and rain film) is applied, justifying its implementation in table grape cultivation.
4.3. Moldovan table grape producers support the adoption of the Pergola system, emphasizing its advantages regarding more efficient irrigation and fertilization as well as stricter pest control. The technologies applied in the Pergola system, along with the possibility of certifying production according to international standards, contribute to obtaining superior quality grapes, making production more competitive and facilitating access to external markets (Chapter II, paragraph 2.3).

5. Research conducted to identify and analyze strategic measures to increase the economic efficiency of table grape production, considering current challenges and market trends, led to the following conclusions:
5.1. The assessment of specific factors influencing the economic efficiency of the table grape sector highlighted that the implementation of modern cultivation technologies is a primary condition for increasing economic efficiency. These technologies enable increased productivity, improved grape quality, and reduced losses through more efficient resource and climatic risk management. Technological adaptation also contributes to reducing production costs and increasing market competitiveness, being a fundamental factor in ensuring profitability (Chapter III, paragraph 3.1).

5.2. An important factor in increasing economic efficiency is the development of an efficient value chain capable of optimizing product valorization and meeting market demands. In the table grape sector, the most vulnerable segment is production, where prices are lowest, affecting quality and profitability. Analysis shows that the current production growth rate exceeds the capacity of existing post-harvest infrastructure, limiting valorization and access to external markets. This underlines the need for investments in cold storage and especially in sorting and packaging facilities (Chapter III, paragraph 3.1).
5.3. The association of table grape producers through clustering is an effective measure for increasing competitiveness and economic efficiency. Collaboration facilitates access to modern technologies, common markets, and integrated services, optimizing resources and reducing costs. The analysis of the "Table Grapes" cluster in the Cahul region during 2020-2023 shows positive evolution of revenues and profitability, demonstrating that clustering brings real benefits to its members and contributes to efficient sector development (Chapter III, paragraph 3.2).
5.4. Implementation of quality standards such as GLOBALG.A.P. and GRASP increases consumer confidence and facilitates access to international markets, where traceability and compliance requirements are stricter. Certification of table grape production enables product differentiation, increasing their value and supporting more competitive prices. In the Republic of Moldova, GLOBALG.A.P. has been applied since 2006. While the number of certifications initially increased from 8 to 26 per year in 2020, it subsequently dropped to 12 per year in 2023, indicating the need to support the certification process to maintain access to external markets (Chapter III, paragraph 3.3).
5.5. Breeding table grape varieties adapted to local climatic conditions is an important factor for increasing resilience and, consequently, economic efficiency. Although several breeding methods exist, the most used by local producers is in vitro micropropagation due to its efficiency, multiplication speed, and ability to provide healthy and uniform planting material. Breeding allows obtaining productive varieties resistant to diseases, drought, and frost, with superior organoleptic qualities and increased market potential (Chapter III, paragraph 3.3).
5.6. Diversification of table grape varieties significantly contributes to increasing economic efficiency. In the Republic of Moldova, the dominant share is held by the Moldova variety (23-29%), which is late ripening, limiting competitiveness in the early season. By cultivating early and extra-early varieties (which accounted for 56.8% in 2023), producers can access the market earlier and at higher prices. At the same time, the use of rain film allows advancing or delaying harvesting by 15-20 days, thus increasing the added value of table grape production. Therefore, diversification of the assortment, correlated with innovative technologies and adaptation to seasonal demand, contributes to increasing the income of table grape producers and strengthening the competitiveness of Moldovan table grapes on international markets (Chapter III, paragraph 3.3).

As a result of the detailed analysis of the implementation of new technologies in the table grape sector, the following recommendations have been developed, aimed at achieving the established objective:

I. Recommendations for Government Institutions:

1.Ensure adequate funding by directing subsidy funds toward the adoption of modern technologies in the table grape sector. 2. Develop access to foreign markets through export-support policies. It is recommended to create an online platform for domestic table grape producers, allowing them to interact directly with international importers. 3. Promote specialized clusters in table grape production by creating a favorable institutional and economic framework, especially in the early years of operation, as well as by investing in research and development activities; establish a national platform for cluster registration to strengthen collaboration among them. 4. Train

consultants specialized in modern technologies, including the use of the Pergola system, to facilitate knowledge transfer and the adaptation of solutions to the real needs of table grape producers.

II. Recommendations for Producer Associations:

1.Actively represent the interests of table grape producers by collaborating with authorities in the development of public policies. 2.Facilitate the exchange of experience among members through trainings, events, and study visits that promote best practices and the use of innovative technologies. 3.Support table grape producers in the certification and standardization process to facilitate access to international markets by providing consultancy and enabling collaboration with field experts. 4.Create collaboration programs for joint investments, collective purchasing groups, or partnerships among members to enable access to high-performance equipment—which is often expensive—and to ensure fair cost distribution, thereby encouraging the adoption of modern technologies in the table grape sector.

III. Recommendations for Table Grape Producers:

1.Implement modern technologies at all stages of table grape production and marketing (cultivation, harvesting, post-harvest, storage, and commercialization), which will help reduce losses, improve quality, and optimize the value chain, thereby strengthening market position. 2. Cooperate with other producers to jointly implement new technologies, access funding, promote products, and exchange experiences—contributing to resource optimization and increased competitiveness. 3.Implement the Pergola system, which, although it involves higher maintenance costs compared to traditional systems, ensures higher yields and greater profitability. 4.Create added value through product diversification and branding, including innovative packaging, premium-quality varieties, or the development of proprietary brands. 5.Diversify the assortment of table grapes by cultivating varieties in line with market trends, with an emphasis on white, pink, or seedless varieties appreciated for their pleasant flavors—facilitating entry into new market segments. 6.Collaborate with research institutes to improve existing varieties by selecting those that are disease-resistant and adapted to local climatic conditions. 7.Adopt integrated pest management practices (Low IPM) in the cultivation of table grapes, in response to food safety requirements, thereby opening access to premium markets.

The conducted research makes a significant contribution to solving the scientific problem concerning the theoretical and methodological foundation of directions for increasing the economic efficiency of table grape production through the application of new technologies under the conditions of the Republic of Moldova, resulting in improved economic performance both for viticultural entities and for the table grape sector as a whole.

Among the main results of the research, the following can be highlighted:

1) The natural, economic, and technological conditions influencing the development of the table grape sector in the Republic of Moldova have been identified and characterized, highlighting its potential for the development of national agriculture (Chapter I, Section 1.1);

2) The integrated concept of economic efficiency in table grape production has been developed and substantiated by including the time factor, financing conditions, anticipated risks, and the sustainability dimension, adapted to the specific characteristics of the table grape sector (Chapter I, Section 1.2);

3) A retrospective analysis of the evolution of table grape production and marketing in the Republic of Moldova was carried out, highlighting key trends, market constraints, and potential development directions (Chapter II, Section 2.2);

4) A comparative assessment of the economic efficiency of table grape production in the Pergola and Vertical Spalier systems was conducted, demonstrating the superiority of the Pergola system (Chapter II, Section 2.3);

5) A differentiated investment model for establishing table grape plantations was developed, structured around four technological variants (Vertical Spalier, Basic Pergola, Pergola with hail netting, and Pergola with rainproof film), which underpins investment decisions in table grape cultivation (Chapter II, Section 2.3);

6) An integrated clustering model in the table grape sector was developed, which involves synergistic collaboration among producers, public authorities, research institutions, universities, and professional associations, aimed at strengthening the competitiveness of the sector (Chapter III, Section 3.2);

7) Strategic measures to increase the economic efficiency of table grape production have been identified and analyzed, focusing on the implementation of modern technologies, certification of production according to international standards, adaptation of varieties to local climatic conditions, diversification of the assortment range, and professional development of viticulturists (Chapter III, Section 3.3).În cadrul cercetării au fost remarcate câteva limitări importante:

- The available official data are mainly focused on agriculture as a whole, with much less detailed information related to the viticulture sector, and data specific to table grape production are even more limited;
- At the national level, data on table grape cultivation using the Pergola system are not collected. In the absence of official and comprehensive statistics, the national-level analysis was conducted based on partial sources and indirect information. The research at the enterprise level was based on the analysis of data obtained from the company managed by the author, which is the first in the country to implement the Pergola system;
- The diversity and complexity of the numerous factors influencing the cultivation and marketing of table grapes (a wide range of interdependent and complex variables) did not allow for the integration of all of them within the thesis, due to the complexity and the large volume of information required for a comprehensive analysis.

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LISTA PUBLICAȚIILOR AUTORULUI LA TEMA TEZEI

1. Articole în reviste științifice

1.1. în reviste din alte baze de date acceptate de către ANACEC

1. MOCANU, Natalia, **BOTEZATU, Andrei**. The intensive production sistem of table grapes on the Pergola sistem vs the traditional trellis sistem. In: *Management agricol: Materialele conferinței științifice internaționale*. Timișoara, Seria I, Vol. XXVI, nr. 2, 2024, pp. 107-111. EBSCO GABI, ISSN 1453-1410, E-ISSN 2069-2307.

1.2. în reviste din Registru National al revistelor de profil, categoria B

2. MOCANU, Natalia, **BOTEZATU, Andrei**. Asociația producătorilor de struguri de masă. In: *Vector European*, 2024, nr. 2, pp. 103-110. ISSN 2345-1106. DOI: https://doi.org/10.52507/2345-1106.2024-2.19.

3. **BOTEZATU, Andrei**. Rain cover for table grapes and its benefits. In: *Vector European*, 2024, nr. 1, pp. 112-116. ISSN 2345-1106. DOI: https://doi.org/10.52507/2345-1106.2024-1.22.

4. **BOTEZATU, Andrei**. Analysis of the establishment and maintenance costs of table grape plantations according to the pergola support system. In: *Journal of Social Sciences*, 2024, vol. 7, nr. 3, pp. 88-98. ISSN 2587-3490. DOI: https://doi.org/10.52326/jss.utm.2024.7(3).05.

2. Articole în lucrările conferințelor și altor manifestări științifice

2.1. *în lucrările conferințelor științifice internaționale (peste hotare)*

5. **BOTEZATU Andrei.** Economic efficiency of fertilization in intensive table grape productions. In: *The VI International scientific-practical conference "Modernization of Economy: Current Realities, Forecast Scenarios and Development Prospects"*. Ucraina, Kherson-Khmelnytskyi, 2024, pp. 11-17. ISBN 978-617-8187-22-4.

6. MOCANU Natalia, **BOTEZATU Andrei.** The role of viticulture in the development of the agricultural sector. In: *The VI International scientific-practical conference "Modernization of Economy: Current Realities, Forecast Scenarios and Development Prospects"*. Ucraina, Kherson-Khmelnitskyi, 2024, pp. 19-22. ISBN 978-617-8187-22-4.

2.2. *în lucrările conferințelor științifice internaționale (în Republica Moldova)*

7. MOCANU, Natalia, **BOTEZATU, Andrei**, DAVYDENKO, Nadiia. The role of the production of table grapes in the development of the economy. In: *International Scientific Conference "Modern Paradigms in the Development of the National and World Economy"*, 17th Edition, October 24-26, Comrat, 2024, pp.111-118.

8. **BOTEZATU, Andrei,** MOCANU, Natalia, MATEOC-SÎRB, Nicoleta. Sistemul Pergola și beneficiile sale în cultivarea strugurilor de masă. In: *The 4th Economic International Conference "Competitiveness and sustainable development"*, UTM, Chișinău, 2022, pp. 197-200. ISBN 978-9975-45-872-6. DOI: https://doi.org/10.52326/csd2022.35.

9. **BOTEZATU, Andrei,** MOCANU, Natalia, MATEOC-SÎRB, Nicoleta. Bugetarea și importanța economică în producerea strugurilor de masă. In: *The 4th Economic International Conference "Competitiveness and sustainable development"*, UTM, Chișinău, 2022, pp. 230-233. ISBN 978-9975-45-872-6. DOI: https://doi.org/10.52326/csd2022.41.

ADNOTARE

Botezatu Andrei „Sporirea eficienței economice a producerii strugurilor de masă prin implementarea noilor tehnologii în condițiile Republicii Moldova”, teză de doctor în științe economice, Chișinău, 2025

Structura tezei: introducere, trei capitole, concluzii generale și recomandări, bibliografie din 170 titluri, 55 figuri, 21 tabele, 150 de pagini de text de bază, 33 anexe. Rezultatele cercetării sunt publicate în 9 lucrări științifice.

Cuvinte cheie: agricultură, certificare, cluster, competitivitate, eficiență economică, lanț valoric, producere intensivă, sector viticol, struguri de masă, subvenționare, tehnologii avansate.

Scopul lucrării: evaluarea impactului implementării noilor tehnologii asupra creșterii eficienței economice a producerii strugurilor de masă în Republica Moldova și argumentarea necesității adoptării acestora.

Obiectivele cercetării: analiza condițiilor de dezvoltare a ramurii strugurilor de masă în Republica Moldova și evidențierea importanței acesteia pentru agricultura națională; fundamentarea teoretică și metodologică a conceptului de eficiență economică specific producerii strugurilor de masă; analiza evoluției activității de producere și comercializare a strugurilor de masă; estimarea comparativă a eficienței economice a producției strugurilor de masă în sistemele Pergola și Spalier vertical, în vederea argumentării necesității implementării sistemului Pergola; identificarea și analiza măsurilor strategice pentru sporirea eficienței economice a producției strugurilor de masă, ținând cont de provocările actuale și tendințele pieței.

Noutatea și originalitatea științifică a lucrării rezidă în dezvoltarea conceptului de eficiență economică a producerii strugurilor de masă, prin integrarea factorului timp, a condițiilor de finanțare, a riscurilor și a dimensiunii sustenabilității; elaborarea unui model investițional diferențiat pentru înființarea plantațiilor de struguri de masă, structurat pe patru variante tehnologice (Spalier vertical, Pergola de bază, Pergola cu plasă antigrindină și Pergola cu peliculă antiploaie), care fundamentează deciziile investiționale în cultivarea strugurilor de masă; elaborarea unui model integrat de clusterizare în ramura strugurilor de masă, care implică principalii participanți relevanți: producători, autoritățile publice locale și centrale, universități, instituții de cercetare și asociații de profil; stabilirea direcțiilor prioritare de dezvoltare a ramurii strugurilor de masă, axate pe implementarea tehnologiilor moderne, certificarea producției, adaptarea soiurilor la condițiile climatice locale, diversificarea gamei sortimentale și pregătirea profesională a viticultorilor; elaborarea unui set de recomandări strategice pentru sporirea eficienței economice a ramurii strugurilor de masă din Republica Moldova.

Problema științifică abordată constă în fundamentarea teoretico-metodologică a direcțiilor de sporire a eficienței economice a producerii strugurilor de masă prin aplicarea noilor tehnologii în condițiile Republicii Moldova, având drept consecință îmbunătățirea performanțelor economice atât a entităților viticole, cât și a ramurii strugurilor de masă în ansamblu.

Importanța teoretică a lucrării: dezvoltarea cadrului conceptual și metodologic referitor la implementarea noilor tehnologii în producția strugurilor de masă, evidențiind mecanismele prin care aceste tehnologii influențează eficiența economică a ramurii în Republica Moldova.

Valoarea aplicativă a lucrării se manifestă prin rezultatele obținute și recomandările formulate, care vizează creșterea eficienței economice a producției strugurilor de masă prin implementarea tehnologiilor noi de cultivare. Rezultatele cercetării oferă un suport practic producătorilor de struguri de masă pentru optimizarea proceselor de producție și sporirea eficienței economice; vor fi utile autorităților și organismelor de reglementare în elaborarea și ajustarea politicilor agricole care vizează susținerea inovării tehnologice; pot fi integrate în activitatea asociațiilor de profil, contribuind la intensificarea colaborării și schimbului de experiență a specialiștilor din domeniu.

Implementarea rezultatelor științifice: rezultatele cercetării au fost valorificate în cadrul Ministerului Agriculturii și Industriei Alimentare a Republicii Moldova, a entității AMV Grape SRL și Consiliului raional Cahul. Unele aspecte ale tezei au fost integrate în cercetările din cadrul proiectului USAID „Competitivitate și Reziliență Rurală (Rural Competitiveness and Resilience Activity)”, nr. AID-72011722C00002.

АННОТАЦИЯ

Ботезату Андрей, «Повышение экономической эффективности производства столового винограда за счет внедрения новых технологий в условиях Республики Молдова», докторская диссертация по экономике, Кишинев, 2025

Структура работы: введение, три главы, общие выводы и рекомендации, библиография из 170 источников, 55 рисунков, 21 таблиц, 150 страниц основного текста, 33 приложений. Результаты исследований опубликованы в 9 научных статьях.

Ключевые слова: сельское хозяйство, сертификация, кластер, конкурентоспособность, экономическая эффективность, цепочка добавленной стоимости, интенсивное производство, винодельческий сектор, столовый виноград, субсидии, передовые технологии, система Пергола.

Цель научной работы: оценка воздействия внедрения новых технологий на повышение экономической эффективности производства столового винограда в Республике Молдова и обоснование необходимости их применения.

Задачи исследования: анализ условий развития столового винограда в Республике Молдова и выявление ее значения для национального сельского хозяйства; теоретическое и методологическое обоснование концепции экономической эффективности, характерной для производства столового винограда; анализ динамики производства и сбыта столового винограда; сравнительная оценка экономической эффективности производства столового винограда в системах Пергола и Вертикальная шпалера, с целью обоснования необходимости внедрения системы Пергола; выявление и анализ стратегических мер по повышению экономической эффективности производства столового винограда с учетом текущих вызовов и рыночных тенденций.

Научная новизна и оригинальность исследования заключается в разработке концепции экономической эффективности производства столового винограда с интеграцией фактора времени, условий финансирования, рисков и аспекта устойчивого развития; разработке дифференцированной инвестиционной модели для создания плантаций столового винограда, структурированной на четыре технологических варианта; разработка интегрированной модели кластеризации в отрасли столового виноградарства; определение приоритетных направлений развития отрасли столового виноградарства, сосредоточенных на внедрении современных технологий, сертификации продукции, адаптации сортов к местным климатическим условиям, диверсификации сортового ассортимента и профессиональной подготовке виноградарей; разработка набора стратегических рекомендаций по повышению экономической эффективности столового виноградарства в Республике Молдова.

Научная проблема, рассматриваемая в работе, заключается в теоретико-методологическом обосновании направлений повышения экономической эффективности производства столового винограда путем внедрения новых технологий в условиях Республики Молдова, что ведет к улучшению экономических показателей как винодельческих предприятий, так и отрасли столового винограда в целом.

Теоретическая значимость работы заключается в разработке концептуальной и методологической базы, касающейся внедрения новых технологий в производство столового винограда, с акцентом на механизмы, посредством которых эти технологии влияют на экономическую эффективность отрасли в Республике Молдова.

Практическая значимость работы заключается в том, что результаты выполненного исследования, направленны на повышение экономической эффективности производства столового винограда за счёт внедрения новых технологий выращивания. Результаты исследования представляют собой практическую поддержку для производителей столового винограда в оптимизации производственных процессов и повышении экономической эффективности; могут быть полезны органам власти и регулирующим структурам при разработке и корректировке аграрной политики, направленной на поддержку технологических инноваций; могут быть интегрированы в деятельность профильных ассоциаций, способствуя усилению сотрудничества и обмену опытом между специалистами отрасли.

Внедрение научных результатов: результаты исследования были внедрены в Министерстве сельского хозяйства и пищевой промышленности Республики Молдова, на предприятии AMV Grape SRL и в Районном совете города Кагул. Отдельные аспекты диссертации были интегрированы в исследования, осуществляемые в рамках проекта USAID «Конкурентоспособность и устойчивость сельских районов», № AID-72011722C00002.

ANNOTATION

Botezatu Andrei "Increasing the economic efficiency of the production of table grapes by implementing new technologies in the conditions of the Republic of Moldova", PhD in Economic Sciences thesis, Chisinau, 2025

Thesis structure: introduction, three chapters, general conclusions and recommendations, bibliography of 170 titles, 55 figures, 21 tables, 150 pages of basic text, 33 annexes. The research results are published in 9 scientific papers.

Key words: agriculture, certification, cluster, competitiveness, economic efficiency, value chain, intensive production, wine sector, table grapes, subsidies, advanced technologies, Pergola system.

Research Aim: assessment of the impact of implementing new technologies on improving the economic efficiency of table grape production in the Republic of Moldova and justification of the need for their adoption.

Research objectives: analysis of the development conditions of the table grape sector in the Republic of Moldova and highlighting its importance for national agriculture; theoretical and methodological substantiation of the concept of economic efficiency specific to table grape production; analysis of the evolution of production and marketing activities related to table grapes; comparative assessment of the economic efficiency of table grape production in Pergola and Vertical Trellis systems, in order to justify the need to implementing the Pergola system; identification and analysis of strategic measures to increase the economic efficiency of table grape production, taking into account current challenges and market trends.

Scientific novelty and originality of the paper resides in the development of the concept of economic efficiency in table grape production by integrating the time factor, financing conditions, risks, and sustainability dimension; the elaboration of a differentiated investment model for establishing table grape plantations, structured into four technological variants (Vertical Trellis, Basic Pergola, Pergola with Anti-Hail Net, and Pergola with Rainproof Film), which support investment decisions in table grape cultivation; development of an integrated clustering model in the table grape sector, involving key relevant stakeholders: producers, local and central public authorities, universities, research institutions, and professional associations; identification of priority development directions for the table grape sector, focused on the implementation of modern technologies, product certification, adaptation of grape varieties to local climatic conditions, diversification of the varietal range, and professional training of viticulturists; development of a set of strategic recommendations to increase the economic efficiency of the table grape sector in the Republic of Moldova.

The fundamental scientific problem consists in the theoretical and methodological substantiation of directions to increase the economic efficiency of table grape production through the implementation of new technologies under the conditions of the Republic of Moldova, resulting in the improvement of economic performance both for viticultural entities and for the table grape sector as a whole.

The theoretical importance of the study lies in the development of the conceptual and methodological framework related to the implementation of new technologies in table grape production, highlighting the mechanisms through which these technologies influence the economic efficiency of the sector in the Republic of Moldova.

The applicative value of the study is manifested by the obtained results and formulated recommendations aimed at increasing the economic efficiency of table grape production through the implementation of new cultivation technologies. The research results provide practical support to table grape producers in optimizing production processes and improving economic performance; they may also be useful to authorities and regulatory bodies in developing and adjusting agricultural policies that support technological innovation; and can be integrated into the activities of professional associations, contributing to enhanced collaboration and experience sharing among specialists in the field. The application of these results at the AMV Grape SRL enterprise confirmed the benefits of implementing new cultivation technologies, particularly the Pergola system, under real production conditions.

Implementation of the scientific results: the research results were implemented within the Ministry of Agriculture and Food Industry of the Republic of Moldova, the AMV Grape SRL enterprise, and the Cahul District Council. Certain aspects of the thesis were also integrated into research activities carried out under the USAID project "Rural Competitiveness and Resilience Activity", no. AID-72011722C00002.