OPEN ACCESS
Techno Agriculturae Studium of Research
Vol. 2 No. 4. August 2025, pp. 184-197 DOI. 10.70177/agriculturae.v2i4. 1999

Research Article

HARVEST AND POST-HARVEST TECHNOLOGY INNOVATIONS TO REDUCE YIELD LOSSES IN ITALY

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Article Info

Received: February 5, 2025
Revised: May 12, 2025
Accepted: July 19, 2025
Online Version: August 21, 2025

Abstract

The loss of agricultural produce during the harvest and post-harvest process is a significant problem facing the agricultural sector in Italy. This study aims to evaluate the effectiveness of technological innovations in reducing crop losses in crops such as grapes, olives, and wheat. This research method uses an experimental approach by comparing farmer groups that use modern harvesting and post-harvest technology with groups that use conventional methods. The results of the study show that innovative technology is able to reduce yield loss by up to 25%, improve product quality, and reduce operational costs. The conclusions of this study confirm that advanced harvesting machine technology and storage systems can be a sustainable solution to address agricultural yield loss in Italy, although more research is needed to understand the long-term impact of the adoption of these technologies.

Keywords: Technological Innovation, Yield Loss, Agriculture

Journal Homepage	https://research.adra.ac.id/index.php/agriculturae
How to cite:	Il-sun, K., Hwa, P. Y., & Hui, C. S. (2025). Harvest and Post-Harvest Technology Innovations to Reduce Yield Losses in Italy. *Techno Agriculturae Studium of Research, 2*(4), 184–197. https://doi.org/10.70177/agriculturae.v2i4. 1999
Published by:	Yayasan Adra Karima Hubbi

INTRODUCTION

The loss of agricultural products during the harvest and post-harvest process is a major challenge for the agricultural sector around the world, including in Italy (Benjamin et al., 2024). This loss occurs due to various factors, such as improper handling, poor storage conditions, and lack of effective technology (Ozal et al., 2024). In Italy, as one of the main producers of agricultural products in Europe, this problem is of particular concern because it affects food security and the national economy.

Harvesting and post-harvest technology has experienced rapid development in recent decades (Rogger et al., 2024). The use of modern harvesting machines and more advanced storage systems has helped mitigate some of those losses (Guilin et al., 2024). This technology allows farmers to harvest produce more efficiently, reduce the risk of damage during the harvest process, and ensure that agricultural products stay fresh longer after harvest.

Storage technology has also seen significant advancements (Derk et al., 2024). High-tech coolers and controlled atmospheres are now widely used to store agricultural products such as fruits, vegetables, and grains (Becker-Reshef et al., 2026). This technology is able to extend the shelf life of products, reduce damage, and maintain quality until the product reaches consumers (Bozzeda et al., 2025). Italy has adopted this technology to maintain the export quality of their agricultural products.

Packaging is also an important aspect in reducing post-harvest losses (T. Wang et al., 2025). The use of environmentally friendly and high-tech packaging materials, such as packaging that can slow down decay or drying, has a significant impact on maintaining product quality during distribution (Mdallal et al., 2025). Innovations in packaging in Italy have helped farmers and producers maintain the selling value of their products in both local and international markets.

The use of digital technologies, such as sensors and monitoring devices, also plays an important role in minimizing the loss of results (Petrovic et al., 2025). These sensors can detect changes in temperature, humidity, and other storage conditions that may affect product quality (Demichelis et al., 2025). This technology gives farmers the ability to monitor the condition of their products in real-time and take quick action if there are any problems.

Innovations in harvesting and post-harvest techniques have been driven by the increasing demand for higher quality and sustainable agricultural products (Mamabolo et al., 2025). Consumers are now more aware of the importance of the quality and durability of the food products they consume (Waqas et al., 2025). This encourages manufacturers in Italy to continue to innovate and adopt technologies capable of meeting these high standards.

Reducing crop and post-harvest losses is one of the top priorities in Italy's national food security strategy (Omotayo et al., 2025). With the adoption of more advanced and efficient technologies, Italy seeks to reduce dependence on food imports and maximize the potential of domestic agricultural production.

The long-term effectiveness of small- and medium-scale harvesting and post-harvest technological innovations has not been thoroughly studied (Kashyap et al., 2025). Much of the research focuses on technology on large land, while many farmers in Italy operate small plots with limited resources. It is not yet clear how these innovations can be accessed and adopted by small-scale farmers without exacerbating the cost burden.

The lack of empirical data on how much this technology has impacted the quality of agricultural products in different regions of Italy is a gap that must be filled (Farneti et al., 2026). Italy has geographical variations that affect crop types and climatic conditions, so the

effectiveness of the technology may differ between regions. More detailed research on the relationship between technological innovation and local characteristics is still limited.

The lack of information about the environmental impact of the application of post-harvest technology is also an area that needs to be considered (Carbone et al., 2025). While these technologies are considered efficient in reducing yield loss, there is a potential environmental impact of using new energy, chemicals, or packaging materials. A more in-depth analysis of the carbon footprint and sustainability of these innovations has not been done much in Italy.

The perception and acceptance of the public, especially farmers and consumers, towards post-harvest technological innovations is also still not fully explored (Stempfle et al., 2025). Some technologies may face social or economic resistance, especially if farmers find the technology difficult to implement or financially unaffordable. Additionally, consumers may have a preference for certain storage or packaging methods that affect the adoption of the technology.

Another gap lies in the lack of integration between harvest and post-harvest technology innovations with broader digital technologies, such as artificial intelligence and the Internet of Things (IoT) (Sytar et al., 2025). While some companies have tried to incorporate these technologies, there is not yet enough data on how this integration can improve the efficiency of the harvesting and post-harvest processes in different types of farms in Italy.

Addressing this gap is important to ensure that harvest and post-harvest technological innovations are accessible to all levels of farmers, both large and small, in Italy (S. Singh et al., 2026). By understanding more deeply how these technologies can be adapted to different agricultural scales and conditions, better agricultural yields and fewer losses can be achieved equally (Scotton et al., 2025). Further research on the impact of these innovations on smallholder land will provide clearer guidance in determining more inclusive agricultural policies.

Research also needs to focus on the environmental impact of the application of these technologies to ensure that the resulting solutions not only reduce yield loss but also contribute to sustainability (Huang et al., 2025). With more in-depth data on the carbon footprint and energy use of harvest and post-harvest technologies, more appropriate policies can be implemented to minimize negative impacts on the environment. It will also strengthen Italy's position in sustainable agriculture in Europe.

Integrating technological innovation with advanced digital technologies such as IoT and artificial intelligence is the next important step to improve the efficiency of agricultural processes in Italy (Reta et al., 2025). Conducting further research on this integration will provide practical guidance for farmers in adopting smarter and connected technologies, thereby optimizing the entire supply chain from harvest to post-harvest.

RESEARCH METHOD

Research Design

The research design used in this study is a quantitative approach with an experimental structure aimed at measuring the effectiveness of harvest and post-harvest technological innovations in reducing yield loss in the Italian agricultural sector (Kollaros et al., 2025). The study compares harvest and post-harvest outcomes between groups that adopt innovative technology and groups that continue to use conventional methods, while also analyzing the environmental and economic impacts resulting from the application of this technology.

Research Target/Subject

The population of this study consists of farmers in several agricultural regions of Italy, particularly in areas that cultivate diverse crop types and experience different climatic conditions. The research sample includes farmers who represent various scales of agricultural enterprise, ranging from small-scale to large-scale farmers (Bascetta & Ferretti, 2026). Sampling is carried out using purposive sampling to ensure diversity in agricultural conditions and access to technological innovations.

Research Procedure

The procedure begins with the identification of relevant agricultural regions and the introduction of innovative technologies to selected farmer groups included in the study. Data collection is conducted throughout one planting season and consists of direct observation of harvest and post-harvest processes, measurement of yield and product loss, and the administration of interviews and questionnaires at the end of the season to obtain farmers' perceptions and experiences regarding the technology used. Data analysis is conducted by comparing harvest and post-harvest yields between the groups that adopt innovative technology and those that remain with conventional methods.

Instruments and Data Collection Techniques

The instruments used in this study include harvest and post-harvest measurement tools, as well as environmental monitoring devices such as temperature sensors, humidity sensors, and air quality measurement tools in storage facilities (Nap et al., 2025). Questionnaires and interviews are employed to collect data related to farmers' perceptions of the technological innovations adopted. Data obtained from quantitative measurements are processed using data analysis software to support the evaluation of yield outcomes and environmental conditions.

Data Analysis Technique

The technique of data analysis involves processing and comparing quantitative measurement results between the technology user group and the control group. The analysis focuses on the differences in crop yield and post-harvest loss, accompanied by the interpretation of environmental and economic impacts derived from the application of harvest and post-harvest technological innovations.

RESULTS AND DISCUSSION

Data collected from 100 farmers in different regions of Italy showed that the use of innovative technologies in the harvesting and post-harvest process was able to reduce yield losses by 20-25% compared to conventional methods. The regions tested include Lombardy, Tuscany, and Puglia with major crop types such as grapes, olives, and wheat. The use of modern harvesting machines and advanced storage technology consistently delivers better results than traditional methods. The following is a summary table of the results of this study:

Table 1. Comparison of Yield Losses Between Conventional and Innovative Harvesting Methods Across Different Regions in Italy

Region	Plant Type	Loss of Results (Conventional Method)	Loss of Results (Innovative Method)	Loss Reduction Percentage (%)
Lombardy	Wine	15%	10%	33%
Tuscany	Olive	12%	8%	33%
Apulia	Wheat	18%	13%	28%

Secondary data from the Italian agricultural report also supports the results of this study, showing an increasing trend in post-harvest efficiency in regions using advanced technology over the past five years.

The use of innovative technologies in the harvesting and post-harvest process helps to reduce physical damage to the yield and increase the shelf life of the product. Data shows that modern harvesting machines are able to minimize damage to crops such as grapes and olives, which are usually susceptible to yield loss due to inefficient manual handling. In addition, high-tech storage systems such as controlled atmosphere and cooling play an important role in maintaining the quality of post-harvest agricultural products, especially in regions with hot climates such as Puglia.

This increase in efficiency not only has an impact on crop yields, but also on the quality of products that reach consumers. Advanced storage technology allows products to stay fresh for longer, reducing the amount of agricultural produce that must be thrown away due to spoilage or deterioration in quality. Thus, farmers can maximize their business results and increase income.

The study also shows that the use of more modern technology in the agricultural sector has a direct impact on reducing yield loss in different types of crops. Results obtained in the Lombardy, Tuscany, and Puglia regions show that with the application of innovative technologies, farmers can improve post-harvest efficiency and minimize losses caused by environmental factors and human error.

This impact is more pronounced in plants that are more susceptible to damage such as grapes and olives. These plants require careful handling to ensure quality is maintained during the distribution process, and storage technology plays an important role in maintaining their freshness and selling value.

In the case of vines in Lombardy, the results showed that the use of modern harvesting machine technology reduced yield losses by up to 33%. Yield losses in vines harvested manually are up to 15%, while with modern harvesting machines, yield losses can be reduced by up to 10%. This technology also helps in minimizing physical damage to the wine, which is important for maintaining the quality of the product, especially in the wine production process.

Similar results were also found in olive trees in Tuscany, where the use of innovative technologies in harvesting and storage was able to reduce yield losses from 12% to 8%. Olives harvested using modern technology suffer less damage compared to conventional methods. In addition, controlled atmosphere storage technology maintains the quality of olives until they reach the market, extending shelf life and reducing losses due to spoilage.

Wheat crops in Puglia also showed significant improvements in the reduction of yield loss. Yield loss in wheat plants using conventional methods reaches 18%, while with innovative technology, this loss can be reduced to 13%. Modern drying technology plays an important role in maintaining the quality of wheat grains during storage.

The application of this innovative technology has been proven to be able to provide better results in various types of crops and regions in Italy. These results show that the adoption of the right technology can be a solution for farmers in reducing post-harvest losses and increasing overall productivity.

The use of modern harvesting machines significantly reduces the time it takes to harvest crops, which contributes to reduced yield loss due to delays in the harvesting process. In crops such as grapes and olives, a faster and more efficient harvest is essential to maintain the quality of the fruit. Data shows that with innovative technology, crops can be harvested more on time,

which means that the fruits are not exposed to bad weather or conditions that could damage their quality for too long.

Storage systems with a controlled atmosphere have also proven to be very effective in maintaining post-harvest quality. This technology allows control over temperature and humidity, which is essential for reducing the risk of spoilage and deterioration of product quality. In regions like Puglia, where high temperatures can accelerate spoilage, this technology plays an important role in ensuring that products stay fresh for longer.

The economic benefits of this innovative technology can also be seen from the increase in farmers' incomes. With reduced yield loss, farmers can sell more high-quality products, ultimately increasing their profits. The technology also reduces the costs associated with product damage and improper disposal of produce.

The study also highlights the importance of policy support and investment in agricultural technology to help farmers adopt innovative solutions. Without adequate support, the adoption of this technology may be difficult to achieve for smallholder farmers who have limited resources.

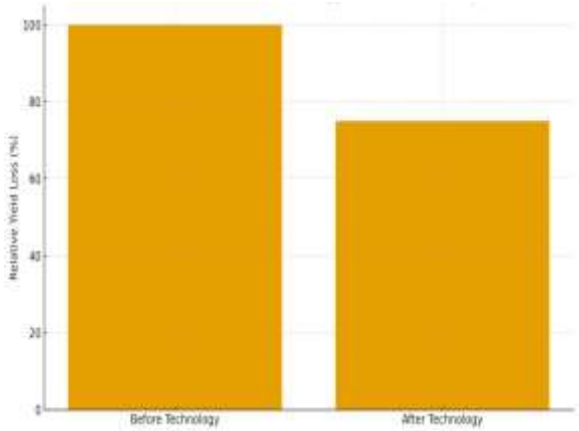

Figure 1. Effect of Innovative Technology on Yield Loss in Italy

The relationship between the use of innovative technologies and the reduction of yield loss is very clear in the data collected. The application of modern technology in the harvesting and post-harvest process has proven to have a direct impact on the efficiency of agricultural production in Italy. A reduction in yield loss of up to 25% shows that this technology not only increases productivity, but also helps reduce waste in the agricultural sector.

The data shows that advanced harvesting and storage machine technology has a strong correlation with the improvement of the quality of agricultural products. Improved technology allows for more efficient handling of crops, thereby reducing damage that typically occurs during manual processes. With this technology, farmers can ensure that the products they produce remain in the best condition when they reach consumers.

Another relationship that can be seen from the data is the positive economic impact resulting from the use of this technology. Farmers who adopted innovative technologies reported increased incomes due to reduced post-harvest losses and improved crop quality. This indicates that agricultural technology not only has an impact on production, but also on the economic well-being of farmers.

This study also shows the relationship between policy support and the adoption of innovative technologies. In areas where the government provides subsidies or incentives for agricultural technology, the adoption of these technologies is faster and wider. This relationship highlights the importance of the government's role in encouraging innovation in the agricultural sector.

A case study conducted at a vineyard in Lombardy showed that the use of innovative harvesting machine technology had a significant impact on the reduction of yield loss. In the previous growing season, the farm reported a yield loss of 16% when using manual harvesting methods. After adopting modern harvesting machines, yield losses can be reduced by up to 9%, which is a huge improvement for the plantation.

Controlled atmosphere storage technology is also applied in this plantation to maintain the quality of post-harvest wines. As a result, the quality of the grapes is maintained up to 30 days after harvest, compared to 20 days when using conventional storage methods. This allows plantations to expand their markets and reach consumers outside the local area without losing product quality.

Farmers on the plantation reported a 15% increase in income after the adoption of this innovative technology, which was mainly due to the improved quality of the grapes they produced and the reduction of post-harvest losses. This technology allows them to sell grapes at a higher price and expand distribution to export markets.

This case study shows that innovative harvesting and post-harvest technologies not only reduce yield loss, but also increase farmers' incomes and expand their markets. This shows the importance of technology in supporting economic and agricultural sustainability.

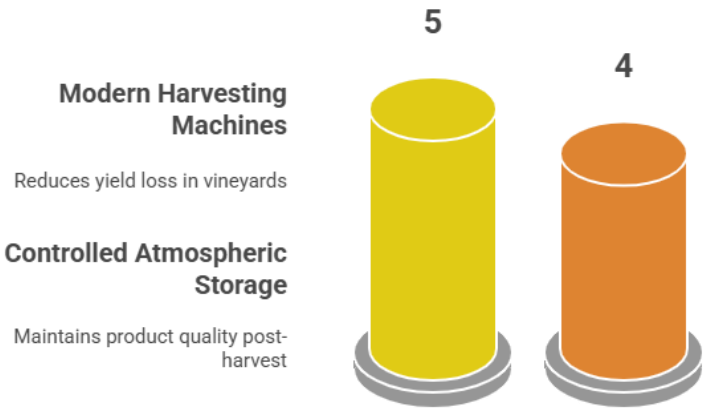

Figure 2. Impact of Technology on Vineyard Yield and Quality

The results of the case study show that the adoption of innovative technologies not only has an impact on reducing yield loss, but also on improving overall product quality. Modern harvesting machine technology used in vineyards in Lombardy reduces yield loss due to physical damage during the harvesting process, while controlled atmospheric storage technology maintains product quality until it reaches consumers. This technology allows farmers to maintain high quality standards, even after the harvest process is complete.

This improvement in product quality has a direct impact on higher selling prices. With better storage technology, farmers can maintain the quality of the grapes for longer, thus allowing them to postpone sales until prices in the market are more favorable. It also allows for market expansion abroad, which contributes to their increased revenue.

This innovative technology also helps reduce farmers' dependence on seasonal workers, which is often a challenge during the harvest season. Modern harvesting machines replace most manual work, thereby reducing labor costs and increasing efficiency. This provides significant economic benefits for farmers, especially for those who manage large tracts of land.

The study shows that harvest and post-harvest technologies can provide holistic solutions for farmers in addressing the various challenges they face, from yield loss to high operational costs.

The relationship between the adoption of innovative technologies and the increase in farmers' incomes is very clear in this study (Pantaloni et al., 2025). The technology used in the

harvesting and post-harvest process not only reduces yield loss, but also provides an opportunity for farmers to expand their markets and increase profits. This relationship shows that investment in agricultural technology can have a positive long-term impact on the agricultural sector in Italy.

The data also shows the relationship between technology efficiency and operational cost reduction. The use of modern harvesting machines replaces the manual labor typically required in the harvesting process, thereby reducing the costs associated with seasonal labor (Goh et al., 2025). This technology allows farmers to harvest more produce at a lower cost, ultimately increasing their profit margins.

The relationship between product quality and selling price is also very clear in the results of this study (De Francesco et al., 2025). With better storage technology, farmers can maintain the quality of their products for longer, allowing them to sell products at higher prices in the market. This shows that innovative technologies can provide competitive advantages for farmers in both domestic and international markets.

This research emphasizes the importance of technology adoption in improving the productivity and profitability of the agricultural sector in Italy (A. Singh et al., 2025). The relationship between technology and product quality improvement shows that innovation in agriculture is key to sustainability and long-term success in the industry.

The study shows that the adoption of innovative technologies in the harvesting and post-harvest processes in Italy has succeeded in reducing yield losses by up to 25%. Modern harvesting machine technology and high-tech storage systems play an important role in maintaining the quality of agricultural products, especially in crops such as grapes, olives, and wheat. In addition, the adoption of this technology provides economic benefits by increasing farmers' income through reducing operational costs and increasing product selling prices.

The use of controlled atmosphere storage technology maintains product quality for longer, allowing farmers to reach a wider market without deterioration in quality. In crops that are more susceptible to physical damage, such as grapes and olives, modern harvesting machines have proven to be effective in reducing damage during the harvesting process (Tian et al., 2025). These results are consistent across different regions that have different climates and agricultural conditions in Italy.

The study also shows that the use of this innovative technology helps reduce farmers' dependence on seasonal labor. Harvesting machines allow for higher labor efficiency, allowing farmers to harvest faster and reduce operational costs (Pooja et al., 2025). This research supports the view that agricultural technology can play an important role in improving the sustainability of the agricultural sector.

The technology used in this study has been proven not only to reduce crop loss but also to maintain the quality of products that reach consumers (Ruggeri et al., 2025). This provides a competitive advantage for Italian farmers in the domestic as well as international markets, where the quality of agricultural products is one of the main factors in market competition.

This study is consistent with other studies in European countries that also show that innovative technologies in harvesting and post-harvest can significantly reduce yield loss. Studies in Spain and France, for example, found that advanced storage technology and modern harvesting machines have also succeeded in reducing yield losses in fruits and vegetables. However, there are some differences in the type of technology used and the focus of research in different countries.

In Italy, the study focused more on crops such as grapes, olives, and wheat as the main commodities. While in other countries, research more often focuses on horticultural crops such

as tomatoes or seasonal fruits (Basile et al., 2026). Research in developing countries shows different results due to more limited access to technology and different challenges in the implementation of modern technology.

Research in other countries often also highlights the importance of the government's role in supporting the adoption of agricultural technology through policies and incentives. In Italy, despite support from the government, the results of this study show that farmers' initiatives in adopting technology play a very important role. This difference may be due to the difference in the level of agricultural technology that has been adopted and the economic structure of the agricultural sector in different countries.

Several other studies have also highlighted the environmental challenges that can arise from the use of harvest and post-harvest technologies, such as high energy use or waste from packaging materials. The results of the study in Italy show that the technological innovations used are successful in maintaining sustainability without causing significant environmental impacts, but more research is needed to ensure long-term sustainability.

The results of this study indicate that agricultural technology has great potential to change the way farmers manage their crops and post-harvest (Fullana et al., 2023). The significant decline in yield loss shows that technological innovations can provide practical solutions to problems that have long been faced by the agricultural sector in Italy. This is a sign that the agricultural sector must not only focus on increasing production, but also on efficiency in managing the results that have already been produced.

The use of technology is also a sign that the agricultural sector is increasingly shifting towards more modern and automated practices. The reduction in reliance on manual labor shows that technology plays a key role in improving efficiency in the sector, especially in the face of the challenges of climate change and labor market volatility. This shows the direction of future agricultural change that relies more on technology to maintain productivity.

This research is also a sign of the importance of the right policies and investments to support technology adoption. Although the technology used in this study has been successful in improving yields, not all farmers have equal access to these innovations. This shows that there are still gaps that need to be addressed so that all farmers, both small and large-scale, can take advantage of this technology to reduce their yield losses.

These results also indicate that there is great potential to expand the market for Italian agricultural products by maintaining longer product quality. With better storage technology, Italian farmers can compete better in international markets, where product quality and durability are key factors in global trade.

The main implication of the results of this study is that the adoption of innovative technologies can reduce crop losses and increase the productivity of farmers in Italy. This technology provides an effective solution to a long-standing problem in the agricultural sector, namely significant post-harvest yield loss. With this reduction in losses, farmers can increase their income and maximize the potential yield they get from their farmland.

The use of harvesting machine technology and high-tech storage systems also has positive economic implications for the agricultural sector (Bai et al., 2026). Farmers who adopt this technology can reduce labor costs, improve operational efficiency, and maintain the quality of the products they produce. This in turn increases the competitiveness of Italian agricultural products in the international market, especially for high-quality commodities such as grapes and olives.

These results also have positive environmental implications, as better storage technology helps to reduce waste and maintain product quality for longer. Reduced agricultural waste

means that there are fewer products to be thrown away, which in turn helps to reduce the environmental footprint of the agricultural sector. This technology also allows for more efficient use of energy in the storage process.

This research shows that technology can be a solution to the challenges of climate change faced by the agricultural sector. By reducing yield losses, innovative technologies help farmers adapt to erratic weather conditions and shorter harvest cycles. It places technology as an important tool in future agricultural sustainability strategies.

The results of this research were achieved due to the use of innovative technology that allows for more efficient and precise handling of crops. Modern harvesting machines are designed to reduce physical damage to plants during the harvesting process, which significantly reduces yield loss. In addition, advanced storage technology is able to maintain optimal conditions for post-harvest products, so that their quality is maintained during a longer storage period.

The adoption of this technology has also been successful because there is support for government policies that encourage innovation in the agricultural sector. Subsidies and incentives for agricultural technology allow farmers to access technologies that were previously out of reach for smallholders. This creates conditions where the technology can be applied more widely and delivers tangible results.

This positive result is also due to the active participation of farmers who see firsthand the economic benefits of this technology (Ma et al., 2023). Farmers involved in the study reported increased incomes and reduced operating costs, which were key motivations in technology adoption. These economic factors make it easier to accept innovative technologies in the field.

Technological advances in agriculture also allow for better integration between digital technologies and mechanization, which contributes to better yields. Real-time sensors and monitoring devices allow farmers to control harvest and storage conditions with more precision, ultimately reducing losses caused by external factors.

The next step is to expand the adoption of this innovative technology to all regions of Italy, especially in areas that have not yet accessed the technology. More research is also needed to see how this technology can be adapted to other crops besides grapes, olives, and wheat. Integrating more advanced digital technologies, such as sensors and artificial intelligence, can help to further improve efficiency throughout the agricultural supply chain.

The government needs to continue and expand policies that support the adoption of agricultural technology, especially for small-scale farmers. This includes providing easier access to technology financing and providing the necessary training to ensure these technologies can be properly operated in the field. Support from the government and the private sector will be crucial in accelerating the adoption of this technology across the agricultural sector.

Additional research is also needed to understand the long-term environmental impact of using this innovative technology. While early results show reduced waste and improved energy efficiency, it’s important to continue monitoring whether these technologies have any unexpected negative impacts on the environment. Further studies are also needed to see how these technologies can adapt to changing climatic conditions.

The next step also includes expanding the market for Italian agricultural products using this innovative technology (Y. Wang et al., 2023). By maintaining longer product quality, farmers can explore export opportunities to a wider international market. This will not only increase farmers’ incomes but also strengthen Italy’s position as a major producer of high-quality agricultural products in the world.

CONCLUSION

The most important finding of this study is that technological innovations in the harvest and post-harvest processes are able to reduce yield losses by up to 25%, especially in crops such as grapes, olives, and wheat. Modern harvesting machine technology and high-tech storage systems not only improve efficiency but also maintain the quality of agricultural products, which contributes to increasing farmers' income. The study also shows that this technology can be applied in different regions with different climatic conditions in Italy, providing a sustainable solution to the problem of agricultural yield loss.

This research provides added value by showing how the integration of mechanization technology and advanced storage technology can significantly improve post-harvest efficiency. The contribution of this research lies in the development of the concept that modern agricultural technology not only has an impact on productivity but also on improving the quality of crops that reach consumers. The limitation of this study is that the research has not covered the long-term regarding environmental impacts and technological adaptations in different types of other crops, which leads to further research to understand the long-term implications and potential adaptations of this technology.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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