

Some Factors influencing implementation of Apples farmers on post-harvest techniques in Duhok governorate, Kurdistan region of Iraq

Abid Ali Hasan Al-Doski ,Sanya Hishyar Khalid

^{1,2}Extension and Rural Development Department, College of Agricultural Engineering sciences,
University of Duhok, Duhok, Iraq.

¹Corresponding author e-mail: abid.ali@uod.ac

Abstract:

The application of post-harvest practices by apple growers is essential for improving the production chain, increasing apple quality, accessing premium markets, and boosting farmers' income by reducing losses. This research primarily aims to identify the factors influencing the application of post-harvest techniques by apple growers in Duhok Governorate. A random sample of 365 apple growers, representing 10% of the research population (3,650 growers), was selected. Data were collected using a questionnaire specifically designed to measure the level of implementation among the targeted growers. The results revealed that a high percentage of participants (90.685%) used post-harvest techniques at a medium to low level. A statistically significant relationship was found between the level of application by apple growers in the target area and (educational level, land tenure, access to agricultural information sources, and degree of urban openness). The five most important factors affecting the ability of apple farmers to market their produce are: poor harvesting affecting the quality of crop marketing, abundance of damaged and diseased fruits, lack of suitable packing and packaging space, weak links between central and local markets in the governorate, and high storage costs.

Keywords. Attitudes, Agricultural extension centers, coefficient contingency (rc)

1. Introduction

Human beings are the cornerstone of development, both its goal and its means. Therefore, developing their knowledge and skills is an indispensable necessity. Rapid and successive changes in agricultural technology and the continuous influx of diverse agricultural knowledge produced by scientific research centers can lead to a significant qualitative leap in all areas of agricultural production. This necessitates keeping pace with this development and benefiting from it through the continuous improvement of the knowledge and skills of agricultural extension workers and farmers in general [9].

Therefore, it is necessary for the agricultural extension organization to develop itself and the quality of services it provides to farmers and rural residents, and not to limit its role to agricultural crop production operations, but to expand to include new areas, encouraging farmers to cultivate crops and projects that meet market needs, managing the farm to reduce expenses along the value chain, monitoring farm operations, enhancing productivity, adding value to the product that generates greater income, preserving the agricultural environment from pollution, rationalizing water use, encouraging cooperation between the public and private sectors, in addition to developing the human element that drives these operations[14] . Food security is one of the major challenges facing Iraq, and the Kurdistan Region in particular, amidst economic, political, and climatic changes. Iraq suffers from problems in providing sufficient food for its people due to agricultural challenges and low productivity, making food security a pressing issue that requires practical and effective programs, strategies, and solutions. Many development

experts have indicated that the optimal way to narrow the food gap is through scientific solutions that improve and increase production on the one hand, expand cultivated land on the other, and reduce losses in the overall output on the other. [5].

Despite the increase in agricultural production of horticultural crops in general and fruits in particular and the achievement of high production rates of these crops, this productivity is exposed to a large loss. This loss may be due to the fact that the Extension efforts made to improve the productivity of these crops focus primarily on guiding farmers regarding production processes without covering the marketing aspects of these crops, which led to an increase in the percentage of loss of fruit crops due to the special nature of their fruits, or it may be due to the prevalence of many incorrect trading methods among fruit farmers [7].Apple is one of the fruit trees that receives a lot of attention in the world of agriculture. It is one of the most important fruit trees in the world because of the economic importance of its fruits and their high nutritional value. It is an important source of national income and its fruits are important food sources because of the sugars, acids, vitamins, minerals and others they contain. In addition, 5% of its production goes to the manufacture of jams, juices, yeast and vinegar. The economic importance of apples also stems from the fact that its fruits are characterized by their multiple sizes, shapes and colors, and their ripening at successive periods in addition to the possibility of preserving them for a long time.[12]

Apple (*Malus domestica* L.) is a popular fruit in Iraq. Commercial and native variety are widely and successfully grown in Iraq's Kurdistan region. It has a lengthy storage

and shelf life, but its quality deteriorates when harvest is delayed. Though postharvest quality of produce can be preserved, it is possible to limit the rate of quality loss [2]. The use of post-harvest technologies such as drying, sorting, grading, and storage can address the common issue of post-harvest losses in agricultural produce caused by poor infrastructure and handling practices.

The use of post-harvest technologies such as drying, sorting, grading, and storage can address the common issue of post-harvest losses in agricultural produce caused by poor infrastructure and handling practices. By incorporating modern technologies to improve traditional postharvest handling methods, farmers can reduce losses, improve food security, and increase economic opportunities. This gap raises concerns regarding the effectiveness of present agricultural extension initiatives and the availability of post-harvest technologies. Understanding how these factors affect farmers' income and the sustainability of their farm operations is critical for devising focused remedies. Agriculture extension can effectively educate farmers on marketing issues and minimize losses by implementing modern agricultural and post-harvest techniques that match farmers' abilities and local conditions. [13].

[8] noted that one of the most important requirements for implementing new agricultural practices, especially for small farmers, is raising awareness of the importance of applying these practices at the farmer, consumer, and environmental levels; addressing the weaknesses of extension organizations in communicating and explaining the concept of good agricultural practices and their importance to both farmers and end consumers; helping to reduce the costs of implementing these

practices, especially for small farmers; clarifying the returns on implementing good practices; and providing government support to farmers.

[2] in their study, assessing the marketing problems faced by apple farmers and evaluating their marketing education needs, indicated that extreme price fluctuations and high agricultural production costs are among the most significant problems for apple producers. The farmers' most pressing educational needs regarding marketing were: first, increasing their negotiating power with consumers, traders, and exporters; second, determining the optimal time for harvesting, market delivery, sorting, grading, and packaging; and third, choosing effective marketing channels and reaching consumers. The results show that visits by agricultural extension agents, the use of audiovisual materials, and participation in field schools increase farmers' marketing awareness by 50%.

There is a shortage of study on post-harvest techniques in Kurdistan and Iraq. Therefore, this study was conducted to answer the following questions: What is the level of implementation of post-harvest techniques among apple farmers in Duhok governorate? What variables influence the apple farmer's implementation level? What are the problems and challenges of employing post-harvest techniques? The study will assist policymakers, administrators, and industrialists, as well as researchers, enhance apple crop production and post-harvest techniques with the goal of reducing post-harvest losses.

Objectives of the Study

The study aims to assess the level of implementation of post-harvest techniques among apple farmers in Duhok governorate.

Specific objectives include:

1. To determine the level of post-harvest technique implementation among apple farmers in the Duhok governorate.
2. To determine the relationship between the implementation level of apple farmers on post-harvest techniques in Duhok governorate and the independent variables: age, educational level, Land Tenure, farm size, number of years working in agriculture, years of apple cultivation, attitudes toward modernization, agriculture information sources, and degree of urban openness
3. To determine the importance of the problems and challenges associated with post-harvest techniques implementation and apple marketing in Duhok governorate.

Hypotheses of the Study

The following hypothesis will be conducted:

1. There is no significant relationship between Apple farmer's implementation level of post-harvest techniques as a dependent variable and the following independent variables: (Age, Educational level, Land Tenure, Farm size, Number of years working in Agriculture, Years of apple cultivation, Attitudes towards Modernization, Agricultural information Source, Degree of urban openness).

Research Methodology

The study methodology was based on a descriptive approach using a sample of apple farmers in Duhok Governorate. A special questionnaire consisting of three sections was prepared to measure the level of application of post-harvest techniques by the surveyed farmers. The reliability of the study instrument was verified using Kuder Richardson 21, and the results were analyzed using SPSS software.

Population and Sample:

The study employed a geographical area sampling method. The First, two Districts (Zakho and Amedi) were randomly selected from the seven districts of Duhok Governorate. Second, two sub-districts from each District were chosen. The sub-districts chosen were Kani Mase (129 farmers), Sersing (86), Batifa (100), and Darkar (50). Then, samples were selected using a simple process known as proportionate sample allocation. The sample size in each sub-district is proportional to its size. Then a sample of (365) apple farmers were selected representing approximately 10% of the research population, excluding 60 respondents covered by the questionnaire reliability measure and disregarding some incomplete forms. The stratified random sample is used. This method depends on the stratified divisions of the research population from which the sample is chosen. In this method, the research population is divided into categories or basic strata depending on a given feature. [3].

To achieve the study's objectives, a three-part questionnaire was created: the first part involves a number of questions designed to identify personal and functional characteristics of Apple farmers in Duhok Governorate. The second part includes a 33-item scale used to assess Apple farmer's level of implementation of post-harvest technologies. The final part is a number of questions designed to identify the key problem and challenges for implementing post-harvest techniques in Duhok governorate. To ensure the reliability and validity of the tests, the pretest results reveal a Kuder Richardson 21 value of (0.87). The data were evaluated statistically using percentages, mean scores, Chi square, and the coefficient of contingency (rc).The Research

Data collection was conducted between 21 April and 15 July 2025.

Results and Discussion

4.2. To determine the implementation level of Apple farmers on post-harvest techniques.

Table (1) shows the distribution of apple farmers in Duhok Governorate according to their level of implementation of post-harvest technologies, into three categories (low, medium, high). The majority of farmers (253 farmers) belonged to the category of medium application of post-harvest

technologies, with a percentage of (69.315%). In the low application category, the number of farmers reached (78 farmers) with a percentage of (21.370%). As for the high application category, the number of farmers reached (34 farmers) with a percentage of (9.315%). The results of the table (1) show that the vast majority of the respondents (90.685%) implement post-harvest techniques to a medium or low degree. This may be due to the fact that the vast majority of the respondents have a medium or low level of knowledge, as the more knowledge the farmer has of post-harvest techniques, the greater his ability to apply the appropriate method in separating, sorting, storing and packaging the fruits.

Table (1) Distribution of apple farmers according to their implementation level of post-harvest techniques in Duhok governorate

Implementation	Frequency	Percentage
Low 4-15	78	21.370%
Medium 16-26	253	69.315%
High 27 more	34	9.315%
Total	365	100

Table (2) shows the ranking of implementation level of apple farmers on post-harvest techniques the result showed that out of (33) items , the most five significant items were; (Collect apples in large boxes placed in the shade near the main road.) with mean (0.847), (Use ladder when picking apples.) with the mean(0.84) (Collect apples in large boxes designated for harvesting.) with mean (0.833), Grade apples and place each grade in a separate container) with mean (0.803) and (Dry apples by exposing them to air or spreading them out.) with mean (0.800).

Picking apples in the right way and at the right time is very important to ensure their quality and storability and helps them retain their moisture and properties. In addition, packing them in suitable containers and boxes protects them from friction and damage during storage and transportation. Therefore, it is considered an important

indicator that farmers who have been studying in recent years have implemented these techniques.

In the same time the results reveals that the five last items were, (Use refrigerated trucks to transport the product to markets.), (Store apples in refrigerated warehouse.), (If apples are not sold, store them in refrigerated storage to preserve their quality.), Store apples in cold storage to obtain the best conditions, Use clean cloths when cleaning apples to ensure effective cleaning. With mean (0.228), (0.279), (0.329) (0.329) (0.332) respectively. The last five phrases are a clear indication that the research area suffers from a lack of storage and refrigeration facilities, which requires the relevant authorities in the region to help farmers provide these facilities. It also requires the agricultural extension organization in the region to advocate for solving this problem.

Table (2) Rank Order of items of the implementation level of Apple farmers on post-harvest techniques in Duhok governorate

No	Items	Mean	Ranking
1	Collect apples in large boxes placed in the shade near the main road.	0.847	1
2	Use ladder when picking apples.	0.841	2
3	Collect apples in large boxes designated for harvesting.	0.833	3
4	Grade apples and place each grade in a separate container.	0.803	4
5	Dry apples by exposing them to air or spreading them out.	0.800	5.5
6	Sort apples to ensure uniform sales batches.	0.800	5.5
7	Sorting apples make them more attractive and acceptable to consumer.	0.797	7
8	Discard damaged apples or those infested with insects and containing pesticide residues.	0.778	8
9	Pack apples manually when necessary.	0.759	9
10	Store apples at a temperature between 0 and 4 C.	0.745	10

11	Harvest apples when they are fully ripe.	0.734	11
12	Sort the apples.	0.732	12
13	Store apples at a humidity level of 90-95%.	0.721	13
14	Handle apples carefully to avoid bruising and spoilage.	0.707	14
15	Pack apples carefully to avoid bruising or rotting.	0.688	15
16	Packaging helps protect apples from diseases to damage.	0.674	16
17	Prefer manual harvesting, as it helps preserve apple quality.	0.658	17
18	Do not overfill containers beyond their capacity.	0.630	18
19	Avoid water inside containers to prevent spoilage.	0.625	19
20	Store apples in refrigerated warehouses for a period ranging from 2 to 3 months.	0.605	20
21	Use apple packaging only necessary.	0.592	21
22	Pick apple fruits from the farm early in the morning.	0.584	22
23	Store apples in warehouses designed for short-term display (up to 15 days).	0.501	23
24	Apply wax to the apples to delay wilting and improve appearance.	0.477	24
25	Seal apples only when storage is necessary to preserve their quality.	0.458	25
26	Dry the apples after cleaning them by exposing them to a stream of fast air.	0.381	26
27	Use refrigerated containers for shipping apples to markets.	0.353	27
28	Wash apples thoroughly with clean water.	0.342	28
29	Use clean cloths when cleaning apples to ensure effective cleaning.	0.332	29
30	Store apples in cold storage to obtain the best conditions.	0.329	30.5
31	If apples are not sold, store them in refrigerated storage to preserve their quality.	0.329	30.5
32	Store apples in refrigerated warehouse.	0.279	32
33	Use refrigerated trucks to transport the product to markets.	0.228	33

4.5. To determine the relationship between implementation level of Apple farmers of post-harvest techniques and each of the following the independent variables. (Age ,Educational level , Land Tenure , Farm size , Number of years working in Agriculture ,Years of apple cultivation , Attitudes towards Modernization, Agricultural Information Sources , Degree of urban openness).

4.5.1. Age

To assess the relationship between apple farmers implementation level of post-harvest techniques and the Age , the correlation

contingency was used with the result($rc=0.1581$).The table (3) indicate that the research hypothesis (that there is no significant relationship between respondents implementation level of post-harvest techniques and the age variable) is accepted. This implies that there is no relationship between the apple farmer's implementation level of post-harvest techniques and age. There may not be a direct relationship between farmer age and implementation of post-harvest technologies, but age may indirectly influence the level of implementation. Older farmers may have more experience and

deeper knowledge of traditional practices, while younger farmers may be more open to post-harvest techniques implementation. This can be match with [10], *and can't be match with* [11].

4.5.2. Level of education

To find the relationship between apple farmers implementation level of post-harvest techniques and their Education level, the coefficient contingency was used with value($rc = 0.2408$). The table (3) indicate that at 5% level of significance, the research hypothesis (that there is no significant relationship between respondents implementation level of post-harvest techniques and the level of education variable) is reject. This mean that there is a significant relationship between the apple farmer's implementation level of post-harvest techniques and Education level. Perhaps because more educated apple growers are better able to understand and apply technical recommendations aimed at reducing waste and improving quality, they are also more able to apply post-harvest techniques more effectively and efficiently. This can be match with [1], *and can't be match with* [15].

4.5.3. Land tenure

To find the relationship between the respondents implementation level of post-harvest techniques and Land tenure, the correlation contingency was used with value ($rc=0.2209$). The findings shows that there is a significant relation between the two variables at the significance level (5%), this mean that the research hypothesis (there is no significant relationship between implementation level of post-harvest techniques of respondent and land tenure) is rejected. Perhaps this is because land ownership has a special economic power

and status that gives farmers the ability to invest in post-harvest technologies. This can't be match with [4].

4.5.4. Farm size

The findings of Table (3) indicate the relationship between respondents implementation level of post-harvest techniques and farm size, the research hypothesis (that there is no significant relationship between implementation level of respondent and Farm size) is accepted (correlation coefficient was used with value ($r=0.1174$)). This suggests that there is no significant relationship between the implementation level of the apple farmers in the targeted area and their farm size. This may be due to the fact that the majority of apple farmers in the target area lack knowledge about post-harvest techniques, regardless of the size of their farms. This is in addition to the unavailability or sometimes high cost of post-harvest facilities, which results in their low level of implementation of post-harvest practices. This can be match with [15], *and can't be match with* [1].

4.5.5. Number of years working in Agriculture

To find the relationship between respondents implementation level of post-harvest techniques and years working in agriculture coefficient of contingency was used with the result($rc=0.105$) as showed in the table(3). The research hypothesis (that there is no significant relationship between the implementation level of the respondent and Years of working in agriculture) is accepted. This implies that there is no significant relationship between apple farmer's implementation level of post-harvest techniques and Years of working in

agriculture. Perhaps the reason is that the vast majority of apple farmers in the target area belong to the category of long years in agricultural work, and therefore there is no difference in the degree of their implementation of post-harvest techniques.

4.5.6. Years of apple cultivation

To Assess the relationship between apple farmers implementation level of post-harvest techniques and the years of apple cultivation , the correlation contingency was used with value($r=0.1407$) showed in the table(3). Research hypothesis (that there is no significant implementation level of post-harvest techniques and the years of apple cultivation variable) is accepted. This mean that there is no relationship between the apple farmer's implementation level of post-harvest techniques and the years of apple cultivation. Perhaps the reason is that the vast majority of apple growers in the target area belong to the category of long years in apple cultivation and therefore there is no difference in the degree of their implementation of post-harvest techniques. This cannot be match with [10].

4.5.7. Attitudes towards Modernization

To assess the relationship between apple farmer's implementation level of post-harvest techniques and their attitude towards modernization, the correlation contingency was used. The table (3) results indicate the research hypothesis (that there is no significant relationship between respondents implementation level of post-harvest techniques and Farmers attitude towards modernization variable) is accepted ($r = 0.0959$). This mean that there is no significant relationship between the apple farmers implementation level of post-harvest techniques and their attitude towards

modernization, may be the reason is that high majority of the targeted apple farmers in the targeted area possess neutral or positive attitudes toward Agriculture extension. This means that there are other factors that affect the level of application of post-harvest services by the respondent's apple farmers. This can be match with [4].

4.5.8. Agriculture Information sources

The Table (3) results reveal that there is a Significant relationship between respondents implementation level of post-harvest techniques and their degree of using agricultural information sources at 5% level that coefficient contingency was used with value ($r= 0.205$), this mean that the research hypothesis (that there is no significant relationship between respondents implementation level of post-harvest techniques and agriculture information source) is rejected . This implies that there is a significant relationship between apple farmer's implementation level of post-harvest techniques and degree of using agricultural information sources. May be because increased use of agricultural information sources by respondents leads to increased awareness of the importance of post-harvest technologies and leads to effective implementation of these technologies. This can be match with [4].

4.5.9. Urban openness

The table (3) results reveal that there is Significant relationship between respondents implementation level of post-harvest techniques and their urban contact with level 5% that coefficient contingency was used ($r= 0.2238$), this mean that the research hypothesis (that there is no significant relationship between respondents

implementation level of post-harvest techniques and urban openness) is rejected . This implies that there is a significant relationship between apple farmer's implementation level of post-harvest techniques and Urban Openness. May be the reason is Farmers who are culturally open

tend to constantly evaluate their practices and look for ways to improve them, which positively impacts their application of post-harvest techniques to reduce spoilage and increase the shelf life of apples. This can be match with [4].

Table (3) shows determine the relationship between the implementation level of the Apple farmers about post-harvest techniques and some social and personal characteristics:

No.	Personal variables	Relation between Personal variables*implementation level
1	Age	0.1581 N.S
2	Educational Level	0.2408*
3	Land Tenure	0.2209*
4	Farm Size	0.1111 N.S
5	Years of working in agriculture	0.105 N.S
6	Years of cultivation of apple	0.1407 N.S
7	Attitude towards agricultural extension	0.0959 N.S
8	Information Source	0.2004*
9	Degree of Urban openness	0.2238*

4.6. To determine the importance of the problems of applying post-harvest techniques and Apples marketing in in Duhok governorate.

This objective is related to the problems facing apple farmers in Duhok Governorate in implementing post-harvest technologies and marketing their product. The problems

have been classified into five sections (problems at Collecting and cleaning stage, problems at the sorting or grading stage, problems at the packaging stage, problems at the transportation stage, and problems at the storage stage).

Of the problems facing apple farmers in Duhok Governorate during the apple harvest and cleaning stage from the perspective of the research sample. The table shows that the most important problem facing the respondents at this stage is (Many damaged and infected fruits) with the mean(2.633).May be the reason is that Harvesting, cleaning, and removing damaged and diseased fruit are vital to improving product quality and safety, ensuring the removal of spoilage agents and the spread of diseases and insects. This process is essential to preserving the crop from the moment it is separated from the plant until it reaches the consumer.

4.6.1: Problems of Collecting and Cleaning

The table (4) shows the relative importance

Table (4) shows ranking of the problems of Collecting and cleaning stage

production in this is (Abundance of

Items	Mean	Ranking
Many damaged and infected fruits.	2.633	1
Bad harvest affects the marketing quality of the crop.	2.592	2
Harvesting at the wrong time.	1.929	3
Lack of training labor.	1.912	4
Unripe or poorly ripened apples.	1.91	5
Failure to carry out pre-cooling.	1.882	6
High costs.	1.762	7

4.6.2: problems of Sorting and grading

The table (5) shows the relative importance of the problems facing apple farmers in Duhok Governorate during the Sorting and grading stage from the perspective of the respondents Apple farmers. The results shows that the greatest factor that affects apple farmer's abilities in marketing their

damaged and infected fruits.) with the mean (2.386). Perhaps the reason is that the large number of damaged and infected fruits has serious damages represented by the spread of diseases and pests and huge economic losses due to the decrease in the quality and quantity of the crop. Therefore, removing and destroying these fruits in a safe manner

is necessary to ensure the continued crop.
production of a healthy and high-quality

Table (5) shows ranking of the problems of Sorting and grading Stage

Items	Mean	Ranking
Abundance of damaged and infected fruits.	2.386	1
Lack of clear grading standards.	2.348	2
Farmers lack of understanding of the grading process and its benefits.	2.088	3
Lack of trained workers.	1.882	4
Absence of a suitable place for that.	1.797	5
High labor costs.	1.616	6

4.6.3: Problems of Packaging

The table (6) shows the relative importance of the problems facing apple farmers in Duhok Governorate during the packaging stage from the perspective of the respondents Apple farmers. The data reveals that the greatest factor that affects apple

farmer's abilities in this stage is (Lack of suitable space for packaging.) with the mean (2.274). Lack of suitable packaging space leads to increased transportation costs and inefficient use of space, and unsuitable packaging causes product losses and additional costs to protect it.

Table (6) shows ranking of Packaging Stage problems

Items	Mean	Ranking
Lack of suitable space for packaging.	2.274	1
High packaging costs.	2.233	2
Inappropriate packaging shapes and sizes.	2.126	3
Lack of expertise in packaging operations.	1.088	4
Lack of packaging.	1.989	5
Insufficient packaging.	1.986	6

4.6.4: Problems of transporting stage

The table (7) shows the relative importance of the problems facing apple farmers in Duhok Governorate during the

transportation stage from the perspective of the respondents Apple farmers. The data indicate that the greatest factor that affects apple farmer's abilities in this stage is (Weak links between central markets and local markets in the province.) with the mean (2.4). May be because weak connection between local and central

markets weakens the competitiveness of local products. The distance of markets from agricultural fields also increases transportation costs and reduces the competitiveness of agricultural products, which harms farmers and raises prices for consumers.

Table (7) shows ranking of Transporting Stage problems

of (2.4). High apple storage costs negatively

Items	Mean	Ranking
Weak links between central markets and local markets in the province.	2.4	1
Limited availability of good means transportation at the right time.	2.285	2
Lack of marketing information in magazines and advisory bulletins.	2.112	3
Difficulty in obtaining information at the right time.	2.022	4
Remoteness of marketing-related equipment.	1.984	5
Lack of means transportation.	1.934	6
Difficulty in communicating with some agricultural areas.	1.921	7

4.6.5: Problems of Storing Stage

Table (8) shows that one of the most significant factors affecting apple growers' ability to implement post-harvest techniques and market their produce in the target region is (high storage costs ,) with a mean score

impact growers by increasing their expenses, reducing their profits, diminishing their competitiveness, and causing crop losses due to storage damage. Therefore, understanding these costs is essential for developing cost-reduction strategies and providing support to farmers.

Table (8) shows ranking of storing Stage problems

Items	Mean	Ranking
High storage costs.	2.751	1
Lack of knowledge and skills in correct storage procedures.	2.436	2
Lack of cold storage facilities near apple fields.	2.312	3
Scarcity of refrigerators.	2.173	4
Lack of equipment in the available refrigerators.	2.17	5

Conclusions

The results revealed that the vast majority of respondents (90.685%) have a medium to low level of application of post-harvest techniques. This indicates that the targeted farmers lack basic knowledge regarding post-harvest handling methods. So effective training courses are required to improve their knowledge and skills in post-harvest technology, with an emphasis on those mentioned disciplines. The study indicated that the variables (education level, land tenure, agricultural information sources, and degree of urban openness) were substantially associated with the level of post-harvest implementation of technology among apple farmers in Duhok Governorate. According to the results of this study, policymakers are advised to take the following strategies to reduce post-harvest losses: Provision of adequate storage facilities for collected produce before it is sent to market. This will help to reduce farm-level losses, and agricultural extension staff in the targeted area must be trained and updated to effectively communicate with farmers and aid them in making decisions about post-harvest handling processes. Farmers markets and cooperative marketing should be encouraged to reduce marketing-related losses. To reduce losses, research on apple storage is required, and farmers must be informed of the results.

References

1. Abdel Salam, M. F. S., & Hassan, A. A. (2019). Farmers' knowledge and implementation level of marketing practices for tomato crop in Luxor Governorate. *Journal of the Scientific Society for Agricultural Extension*, 23(3).page 96–117.
2. Ahmadi, S., Saadi, H., Irfan, M., & Movahedi, R. (2022). The Role of Agricultural Extension in Apple crop Marketing in Paktia Province-Afghanistan. *Academic Journal of Research and Scientific Publishing*| Vol, 3(34).
3. Alabbassi, A. F. K. (2018). *Methods of scientific research and statistical analysis in behavioral sciences*. College of Agriculture and Forestry, University of Mosul, Iraq: Dar-Non.
4. Al-Doski, A. A. H., & Hasan, K. J. (2017). Level of implementation of tomato farmers on postharvest techniques in Halabja governorate, Kurdistan region of Iraq. *Thi Qar University Journal of Agricultural Research*, 6(2).
5. Al-Doski, A.A.H. (2007) .The Current Situation of the Agricultural Extension Centers Activities in Duhok, Erbil and Sulaimania Governorates. (PHD. Thesis).
6. Audish.N. S., & Ali.S. F. (2016). Effect of Calcuimcarbonate, Calcium Chloride and Storage Period on Some Fruit Chemical Characteristics of Two Apple Cultivars. In *The 2nd Scientific Agricultural Conference*.19 (1). Page394.
7. El-Sharbatly, S. I., Saker, K. S. I., El-Khalifa, Z. S., & Mahmoud, A. H. (2024). The Role of Agricultural Extension in Improving Marketing Services for Artichoke Farmers in one of the Villages of the Ayser Banjar Area in Mattoon Governorate .*Journal of the Advances in Agricultural Researches*, 29(1). Page 85-106.
8. ESCWA (2020) *Guide to Good Practices in Agriculture and Post-Harvest Handling, Processing and Packaging within the Framework of Training on Sustainable Energy Use*,

- United Nations
9. Hagra, H.A. ; M. E. N. El-Sharqawy and H. A. El-Deeb (2022)The farmers' visions in using websites to provide agricultural extension service In Kafr El-Sheikh and Dakahlia governorates J. Agric. & Env. Sci. (Damanhour University) 21(3).
 10. Ismail. (2020).Farmers’ knowledge and implementation of irrigation extension recommendations for tomato cultivation in Village 27, Sugar Beet Area. Al-Azhar Journal of Agricultural Research, 45(2), page 126–135.
 11. Sabri, M. S. (2024). Knowledge, implementation, and attitudes of cotton farmers in Italy El-Baroud District, Beheira Governorate. Alexandria Journal for Scientific Exchange, 45(4), page1317–1338.
 12. Shah. I. A. (2020). An Analysis on Marketing Problems of Apple Fruit Growers in Jammu and Kashmir. Journal of Postharvest Technology, 8(2), 43-53.
 13. Silamat, E., Ginting, A. P., & Sutrisno, E. (2024). The Effect of Agricultural Extension and Post-Harvest Processing Technology in Increasing Farmers' Income and Farm Business Sustainability in Rural Bandung Regency. West Science Interdisciplinary Studies, 2(07).page 1490-1499.
 14. Singh, Jogender and Ayush Mishr, (2024) Challenges and Future Prospects of Agricultural Extension, Haryana, Futuristic Trends in Social Sciences Edition: Volume 3, Book 26.
 15. Youssef, K., Shabara, M., El-Ruwaini, & Mahmoud, A. M. (2024). Farmers’ knowledge and implementation of extension recommendations related to controlling Cercospora leaf spot disease on sugar beet crop in Sidi Salem District, Kafr El-Sheikh Governorate. Journal of Agricultural Economics and Social Sciences, 15(4). Page 83–91

