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Research Article

Estimation of Post-Harvest Losses of Grape Fruit: Evidence from Recent Study in Balochistan

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Abstract

The main objective of this study was to estimate post-harvest losses of grapes and identify their determinants. Cross-sectional data were collected from two main grape-growing districts (Killa Abdullah and Pishin) of Balochistan province, Pakistan. A sample of 180 farmers was drawn from selected areas using multistage sampling techniques and Cochran's proportional allocation techniques. The data were analyzed using the linear multiple regression analysis technique. The study findings showed that post-harvest losses in selected areas ranged from 19% to 29%, and the Killa Abdullah district was found to face relatively more losses. The results of regression analysis showed that socioeconomic factors such as age, education, and experience had a significant negative impact on post-harvest losses, implying that increases in these factors may reduce post-harvest losses. The results further suggest that distance from farm to market increases losses. The average post-harvest losses in the district of Pishin were 227 kg/Ton or 22.72%. Within the respective district, losses ranged from 19% to 27%. The minimum losses were suffered by grapes growers in UC Sheikhalzai whereas the maximum losses occurred in UC Huramzai. In addition, growers who harvest in the morning, use shears/scissors as picking tools, color as maturity indicator, and refrigerated trucks as transport have fewer losses than other growers. However, the losses in the entire surveyed area range from 18% to 28.54%. The least losses suffering UC among all UCs was Sheikhalzai (18.84%) while the most affected UC was Pir Alizai (28.54%) based on the data analysis. It was concluded that the demographics of the operations involved in postharvest management had a large impact on postharvest damage. Based on the results suggested by the study, growers should harvest grapes in the morning using modern picking tools.

Keywords: Fruits and vegetables; Grapes losses; Post-Harvest losses; Pakistan.

Introduction

Grapes (*Vitis vinifera*) come from the family *Vitaceae* and remain a significant horticultural crop. Grapes among other deciduous fruits have a historical link with the development

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of humankind and are most widely grown across the world. It is said, grapes are the only specie of the *Vitaceae* family which has emerged about 65 million years ago (De Saporta, 1879). In earlier times, wine was considered a major product of grapes (McGovern, 2015). European states such as Italy, Spain and France, Middle-East North America, and East Asia are the major producing hubs of grapes. Grapes have tremendous nutritional value as it contains Vitamins, minerals sugar, and several other valuable ingredients (Kumar *et al.*, 2017; Ammar *et al.*, 2004).

Literature unveils that grape cultivars existing currently are numbered in thousands while the global market is subjugated by a few of them. Conferring Food and Agriculture organization, 76,720 KM2 area is dedicated to grapes and the production remains at 91.50 Million Tonnes. Area wise Spain has allocated the largest area to grapes 0.93 million hectares, followed by France (0.75 million hectares), China (0.74 million hectares), Italy (0.69 million hectares) turkey (0.4 million hectares). However, in the production, China is the top producer with (14.3 million Tonnes) followed by Italy (7.9 million Tonnes), Unites States (6.2 million Tonnes) Spain (5.8 million Tonnes), and France (5.4 million Tonnes). Similarly, yield wise china remains first with (32.65 Tonnes/hectare), followed by Egypt (22.65 Tonnes/ hectare) Saudi Arabia (21.87 Tonnes/hectare) India (21.72 Tonnes/hectare). Considering the facts Pakistan's position in global grapes production is devastating for instance in production Pakistan ranks 43rd and yield-wise at 80th position (FAO, 2020).

Pakistan’s economy is reliant on the agriculture sector to a very large extent. This sector contributed 19.2% to the Gross Domestic Product (GDP) of the country. This sector has engrossed about 38.5% of the total labor force and about 70% of the country's population is directly or indirectly associated with it Government of Pakistan (GOP, 2021). Over the last decade, the agriculture sector experienced several challenges such as climate change, pest attacks, water crisis, and many others. Due to these issues, the performance of this sector is declining year to year. However, during the year 2020-21 agriculture sector observed growth of 2.77% greater than the last year which was 2.67% Government of Pakistan (GOP, 2020, 2021). The substantial growth of 4.65% was witnessed by the crop sector last year. After food crops, fruit crops also play a vital role in the enhancement of this sector. Pakistan allocated 0.746 million hectares to 30 different fruits which produced 6.96 million Tonnes. The major fruits are Mango, Guava, Melons, Apple, Dates, Banana, Apricot, Peach, and Grapes. All provinces have a noteworthy share in fruit production however Balochistan particularly contributes the major share in apple, grape, dates, apricot, and melons. This sector retains the potential to produce surplus rather than fulfilling the country's domestic demand. This sector is responsible for the provision of raw materials to the industrial sector. Its advancement has a gigantic impact on Pakistan’s social and economic development and also poverty alleviation and uplifting living standard of the farming community Government of Pakistan (GOP, 2021).

Post-harvest losses are the top-ranking issue in the production of fruits. The hike in population is concerned the food security and thus its issues remain of great interest to researchers (El-Ramady *et al.*, 2015; Kader, 1992) reported that 5 to 25% of fruits and vegetables leaving the farm gate are being spoiled and not consumable. Post-harvest losses are relatively high than vegetables and other crops. It is not the only issue of

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developing states but also the developed states. Recent studies revealed that 30%-40% of post-harvest losses are experienced in developing nations (Dhatt and Mahajan, 2007). Even some underdeveloped nations lose more than this percentage of their fruits. Maturity is the most significant factor to determine the post-harvest life and final quality such as the color, texture, size, and nutritive value of fruits and vegetables (Kader, 1992). The literature highlighted various factors that are responsible for losses in fruits. Inappropriate handling and transportation involved in destroying the fruits. Respiration of ethylene production, compositional variations, transpiration, physiological breakdown, physical damage pathological breakdown is some biological factors that are responsible for destroying the fruit quality. Some climatic factors like temperature, precipitation, relative humidity, and ethylene also decline the quality of fruits (Negi and Anand, 2015).

Balochistan the largest province of Pakistan is legitimately called the fruit basket of Pakistan. It spreads over vast areas and has significant economic importance in terms of mines, minerals, agriculture, and other natural resources. Broadly speaking, the province produces more than 20 different fruits and vegetables and other important crops still there is lack a of self-sufficiency in food crops. The majority of the population is concerned with agriculture as farming remains a major source of earning for most of the rural communities of Balochistan. In grapes production interestingly, it produces 98% of total grapes in the country and has allocated about 99% of the total area (GOP, 2021). In 2021, Balochistan produced 81268 Tonnes of grapes over an area of 15574 hectares. Five different cultivars; Sunderkhani, Kashmishi, Haita, and Shekhali, are grown mostly whereas Sahibi and Red globe are also found on a partial level (Aujla *et al.*, 2011). The Major grapes producing districts are Pishin, Quetta, Killa Abdullah, and Mustang (GoB, 2020). Grapes in Balochistan remain of vital importance. Different cultivars are being utilized for various purposes for instance Sunderkhani and Kashmishi are mostly consumed as table grapes whereas Haita is mainly processed into raisins. Farmers' up to their knowledge and shelf life of grapes decide whether to sell their produce as table grapes or add value to the process of raisins (Khair and Sattar Shah, 2005).

The production of grapes faces different constraints in Balochistan such as lack of credit facilities, insufficient supply of inputs, chain of middlemen, substandard packaging, worst marketing infrastructure, improper post-harvest handling, etc. (Balaji and Arshinder, 2016). Mainly the post-harvest losses in Balochistan occurred due to improper post-harvest management. A considerable quantity of fresh fruits is lost at various stages of marketing due to the non-availability of suitable post-harvest technologies and infrastructure (Bishnoi *et al.*, 2018; Shah *et al.*, 2002). On the other hand, market intermediaries exploit producer and consumer both by charging a fixed high margin on their investment. Moreover, the low returns and huge monetary loss increase the transportation cost and marketing costs. Ultimately the growers remain poor economically. Decreasing the post-harvest losses could increase returns to producers and can reduce the cost of production and distribution (Subrahmanyam, 1986).

Grapes production is directly associated with the primary income of many farming families. This study not only concentrated on socioeconomic factors i.e. Age, education,

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experience, credit, facilities, etc. but also investigated post-harvest handling factors to reach a meaningful conclusion in southern districts of Balochistan i.e. Pishin and Killa Abdullah of Balochistan. This research work attempted to point out the pivotal socioeconomic and operational determinants of post-harvest losses in grapes production. The findings of this study are anticipated to facilitate farmers in mitigating the grapes' post-harvest losses and increasing their returns. Moreover, this research work has put forward recommendations to policymakers that might assist them in formulating the policies regarding grapes.

Methodology

Study area description and data collection

The study was carried out in the southern districts of Balochistan namely, Pishin and Killa Abdullah. The primary source of income for the majority of the population in both districts is agriculture, with only a few involved in the business sector. Pishin district stands out as a major contributor to fruit production in Balochistan, particularly known for cultivating apples, grapes, palms, peaches, and cherries. Apples, in particular, hold a significant position in the market, commanding higher prices. In the previous year, the combined output of both districts exceeded 50 thousand tonnes of grapes, representing more than half of the country's total grape production. Grapes rank as the second most cultivated fruit, with prevalent varieties in the study areas such as Kashmishi, Sunderkhani, and Haita. Sunderkhani variety is grown the most because of its profitability followed by Kashmishi. The Haita variety is grown mainly processed to make raisins Government of Pakistan (GOP, 2021).

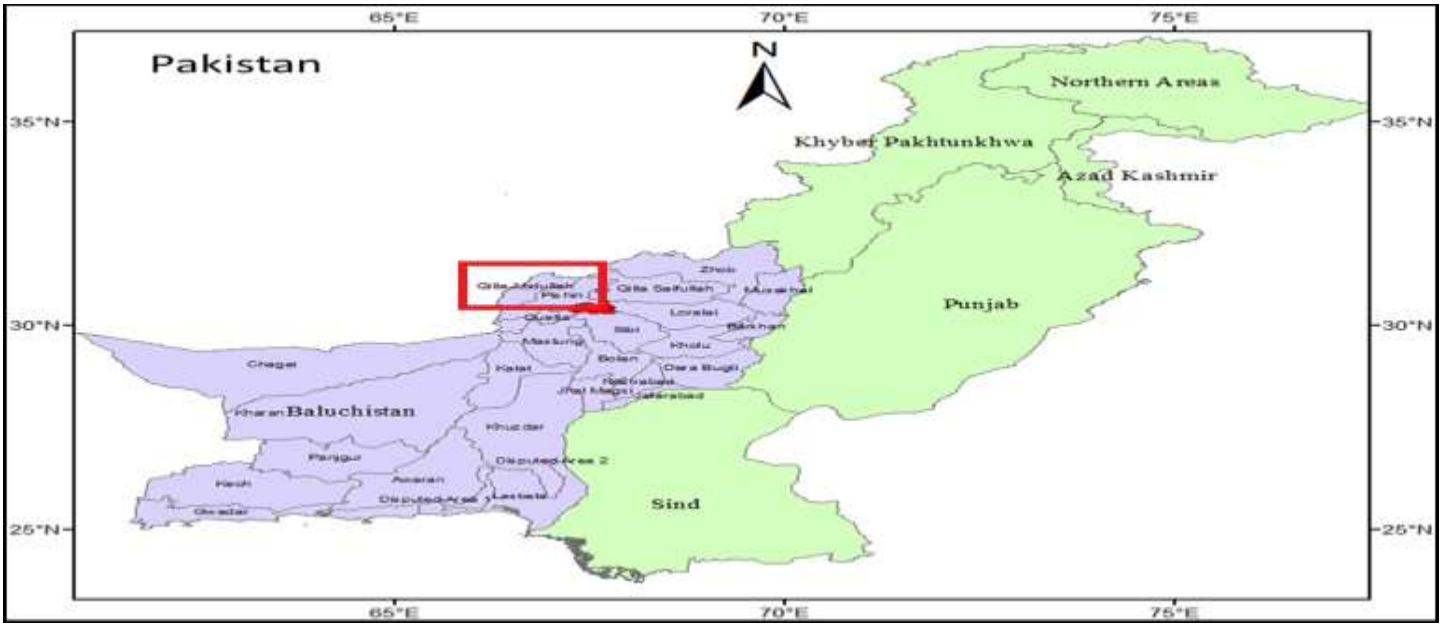

Figure 1. Map of district Pishin and Killa Abdullah.

Sampling technique and sample size

The multistage sampling technique was applied to select a sample of growers in the

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study area in the light of pertinent literature (Hamdullah *et al.*, 2021). In the first stage, District Pishin and Killa Abdullah were chosen purposively on basis of grapes production. In the 2nd stage, 4 major producing Tehsils were selected from two selected districts. In the third stage, the 2 union councils were chosen from each selected tehsil. In the final stage, farmers were randomly selected in the selected Union council. A random sample of 180 progressive farmers was drawn keeping in view the limited available resources, time, and financial constraints. The sample size within the Union council was drawn by applying the proportional allocation sampling technique (Cochran, 1977).

$$n_i = \frac{n}{N} N_i$$

In the above equation;
n; The total size in all the UCs
N= denotes the total population of growers
Ni; denotes the entire population of grapes growers in the ith UC
ni; is the sample drawn from the ith UC
i; (1,2,3…..8) = UC.

Table 1. Sample size and sampling technique.

District	Tehsil	Union councils	Total growers	Sampled growers
Killa Abdullah	Gulistan	Adbul Rehamzai	88	16
		Abdullah khan	128	23
	Killa Abdullah	Gulistan	156	28
		Pir Alizai	80	15
Pishin	Pishin	Shiekhalzi	102	19
		Malikyar	120	22
	Huramzai	Manzari	148	27
		Hurramzai	162	30
	Total		983	180

Source; Author's survey estimates, 2021.

Data acquisition and data sources

Mainly primary cross-sectional data was utilized for this study. Secondary resources such as; Government reports and trusted websites were also utilized. In order to collect data about grapes and post-harvest losses of grapes, a well-designed, interesting, and smooth interview schedule was advanced to collect data from the growers. The questions were arranged in such a way that farmers can easily understand and answer accurately. The survey was carried out in districts Pishin and Killa Abdullah from November-December, 2021. The respondents were encouraged and assured that the information gathered will be used for research purposes only. That's why they responded willingly and provide accurate data which will lead to significant results.

The research aimed to evaluate the quantitative evidence of losses. In the previous literature, different authors have utilized different economic models to evaluate the socio-economic factors influencing post-harvest losses. They have made estimations on various levels. However, in our case, we have focused on the growers who were well

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informed about the magnitude of losses from farm to end consumer. They have revealed the actual magnitude and thus the analyses were conducted on the aggregate level. Based on the practical experiences the model was designed by (Maloba *et al.*, 2017; Addo *et al.*, 2013; Mebratie *et al.*, 2015). Thus, in this research work, most of the significant determinants were taken into consideration as suggested by the pertinent literature. The study employed a linear multiple regression model to analyze the data following the footprint of renowned researchers (Di Bari *et al.*, 2004; Divya *et al.*, 2014; Kulwijila, 2021). In this study, the model is estimated at the farm producer level to drive reliable results.

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The general form of the model is given below:

$$y_{\mathrm{i}} = \underset{\circ}{\beta} + \beta^1 X^1 + \beta^2 X^2 + \beta^3 X^3 \ldots . + \beta n X n + e_{\mathrm{i}}$$

Where

y_{i} is the post-harvest losses of ith farmer

X is the independent variable i.e. determinants of post-harvest losses

$\beta_{\circ}$ is the intercept of the model

β_1 to βn n are the estimated parameters

e_{i} is the random error term

Following the literature, the Empirical model for post-harvest losses of grapes and the factors responsible for these losses is given below. The data were analyzed using STATA 12.

$$\begin{aligned} Post - Harvest\ losses_{\mathrm{i}} &= \beta_{\circ} + \beta^1 age + \beta^2 Education + \beta^3 Experience + \beta^4\ Area\ under\ grapes \\ &+ \beta^5 Distance\ farm\ to\ Market + \beta^6 D^1 Harvesting\ time \\ &+ \beta^7 D^2 Maturity\ index + \beta^8 D^3 Harvesting\ tool \\ &+ \beta^9 D^4 Means\ of\ Transportation + \epsilon \end{aligned}$$

Where;

Post-harvest losses dependent variable of i*th* grapes grower (kg/ ton)

$\beta_{\circ}$ Intercept of the model

Age of the grower

Education of the grower

Experiences of the grower

Area under grapes

Distance from market to farm

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D_1 Dummy for harvesting time morning OR evening (Morning=1 and evening=0)
D_2 Harvesting tool cutter OR saw (cutter=1 saw=0)
D_3 Means of or reefer truck OR transportation truck (reefer truck=1 simple truck=0)
D_4 Maturity index color OR size (Color=1, size=0)
$\beta_1 - \beta_9$ Estimated parameters
ϵ_i Random error term

Post estimation diagnostics

Histogram, VIF variance inflation factor, and Bruesch pagan test were conducted to check the model for the issue of normality, multicollinearity, and heteroscedasticity.

Results and Discussion

Post-harvest losses of grapes in the selected districts and union councils

According to results presented in the table 2 compares the mean post-harvest losses and mean percentage of post-harvest losses between the two districts and among the union councils in the respective district. The average post-harvest losses in the district of Pishin were 227 kg/Ton or 22.72%. Within the respective district, losses ranged from 19% to 27%. The minimum losses were suffered by grapes growers in UC Sheikhalzai whereas the maximum losses occurred in UC Huramzai. Likewise, the average post-harvest losses in District Killa Abdullah were 243 kg/Ton or 24.32%. The variation in the magnitude of losses ranged from 20% to nearly 29% among the selected UCs within the district. Our estimations are almost the same as that of (Aujla *et al.*, 2011) who reported that post-harvest losses in the same region are (16% to 23%). However, the losses in the entire surveyed area range from 18% to 28.54%. The least losses suffering UC among all UCs was Sheikhalzai (18.84%) while the most affected UC was Pir Alizai (28.54%) based on the data analysis. The average Post-harvest losses in the entire study area were 235 kg/ton or 23.52%. Post-harvest losses in Killa Abdullah were more dominant in comparison to district Pishin. It is evident from the district profiles of the district that Pishin is comparatively more developed than Kill Abdullah based on demographic aspects. The literacy rate in Pishin is higher than in Killa Abdullah. In this way growers in Pishin are more educated than farmers in Killa Abdullah. Therefore, we can say that the latest or innovative techniques are more likely to be adopted by growers in Pishin than in Killa Abdullah. Indeed, socioeconomic factors can influence post-harvest losses thus the pertinent literature reveals that losses are more common in developing nations than in developed nations Post-harvest losses in fruits and vegetables are reported to range from 20% to 40% (Barry *et al.*, 2008; Kumrul *et al.*, 2010; Atanda *et al.*, 2011; Ngowi and Selejio, 2019). In the same way losses of grapes are said to be ranging from 20% to 53% in developing nations (Rajabi *et al.*, 2015; Kughur *et al.*, 2015).

Model diagnostic tests

A histogram was created to test the symmetrical distribution of the error term. The test revealed error tern was zero at its mean and symmetrically distributed having constant variance. This implies that the random error term was normally distributed. Variance inflation factor (VIF) test for multicollinearity was held whose mean value was less than two which confirmed that there was no multicollinearity problem existed in the data set.

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For heteroscedasticity, the Bruesch-pagan/cook Weisberg test was performed which resulted in the calculated chi-square magnitude being 0.72 with P-value insignificant. Thus, it disclosed that the data set was free of heteroscedasticity.

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of Post-harvest losses Kg/Ton

Chi^2 (1)= 0.72

Prob > chi^2 = 0.3961

Table 2. Post-harvest losses of grapes in the selected districts and union councils.

Districts	Union Council	Obs	Mean Losses	%Age Losses
Pishin	Sheikhalzai	19	188.42	18.84%
	Malikyar	22	206.82	20.68%
	Manzari	27	241.48	24.15%
	Huramzai	30	272.00	27.20%
	Average Pishin	98	227.18	22.72%
Killa Abdullah	Abdul Rehmanzai	16	209.38	20.94%
	Abdullah Khan	23	216.96	21.70%
	Gulistan	29	261.03	26.10%
	Pir Alizai	13	285.38	28.54%
	Average Killa Abdullah	81	243.19	24.32%
Total		179	235.18	23.52%

Author's estimates; survey results, 2021.

Table 3 represents the descriptive statistics of the regress and regressors employed in the model. Total observations were 180 however one of them was dropped based on inaccurate and incomplete data. The mean post-harvest losses were recorded at 237 kg/ton with a standard deviation of 35. The mean age of the respondents was 37 years having a standard deviation of 9. In the same way, the average education and experience were 8 and 17 years, and the standard deviation was 5 and 9 years respectively. The area under the grapes orchard ranged from 1 to 10 hectares with an average of 4 hectares and a standard deviation of 2. The distance from farm to market varied to a large extent. The reason behind this variation was that there were mostly 4 market destinations for grapes grower i.e. Hazarganji market Quetta, Dera Ismail Khan Market Khyber Pakhtunkhwa, Karachi fruit market, and Islamabad fruit market. the closest market was Hazarganji Quetta while the far-off was Islamabad market Therefore, farm-to-market distance ranges from 70 to 895 km, and the mean distance remained 464 Km. Four dummy variables were utilized in the model.

- D_1 Grapes harvesting time 0 for evening and 1 for morning time.
- D_2 Grapes ripening, or maturity index was determined on two features i.e. size and color. Those who preferred size were coded with 0 and for color 1.
- D_3 Grapes were plucked from the belly using two tools i.e. traditional Saw and cutter. Those who used Saw were coded with 0 and 1 for the cutter.

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- D_4 Grapes after packing were transported by two means i.e. simple trucks and reefer trucks. For the simple truck code set was 0 and for the reefer truck 1.

In addition to these, some other variables were not taken in the analysis. For instance, in the entire study area, corrugated cotton was used as a packaging material. Likewise, Gender, traditional packed house, pre-cooling, storage facilities, credit access facilities, and time spent on grapes reaching markets were alike. Therefore, it was understood that no significant effect of these variables could be extricated. Therefore, these factors were excluded from the data analysis. The data were analyzed using STATA 12.

Table 3. Descriptive statistics of the variable.

Variable	Obs	Mean	Std. Dev.	Min	Max	Units
Post-harvest Losses	179	237.04d	35.48	170	290	Kg/Ton
Age	179	37.15	9.39	25	58	Year
Education	179	8.36	4.51	0	16	Year
Experience	179	17.78	9.14	5	38	Year
Area under Grapes	179	4.04	2.03	1	10	Hectare (Ha)
Distance farm-MKT	179	463.98	336.64	70	895	Kilometer (KM)
D_1Harvesting Time	179	0.84	0.36	0	1	Dummy
D_2 Maturity Index	179	0.94	0.24	0	1	Dummy
D_3 Harvesting Tool	179	0.55	0.50	0	1	Dummy
D_4 Means of Trnsptn	179	0.88	0.32	0	1	Dummy

Author's estimates; survey results, 2021

Estimates of Multiple regression analysis

Table 4 represents the estimation of multiple regression analysis. R-squared magnitude is 93 which interprets the measure of goodness of fit of the model. It implies that 93% of the variation in the regress is due to regressors utilized in the model. The major socio-economic factors revealed an inverse but significant influence on post-harvest losses. The age variable is negative but statically significant at a 1% level of significance. It revealed that an increase in age by 1 year can reduce post-harvest losses by 0.33 kg ceteris paribus. Our findings were not in line with Kulwijila (2021) who reported no significant relation. Though we can say that a person aged more has higher experiences, this could be the reason. Education is statically significant at a 1 % level of significance. It shows that an increase of 1 year in education can decline the post-harvest losses by 1.1 kg/ ton. In general, it can be perceived that education increase may be associated with more suitable post-harvest management techniques. Our results are similar to that of Umer *et al.* (2021) who found a significant effect of education on post-harvest losses. He reported 0.137 reductions in losses with an increase of one year of education. In the same way, Experience was statistically significant but had negative behavior concerning grapes post-harvest losses. The magnitude of experience was 0.34 which reveals that if an individual's experience is increased by one year the losses of grapes will decrease by 0.34 kg. The findings are alike to that of Kulwijila (2021) who found that increase in experience is related to a decline in the post-harvest losses of grapes. Likewise,

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comparable results were elucidated by Ahmed *et al.* (2015) and Mebratie *et al.* (2015). They found that Post-harvest losses have significant inverse relation and unveiled that the higher the experience lower the losses of Kinnow fruit and Banana after harvesting.

Distance has a vigorous relationship with commodities transportation specifically perishable commodities are more vulnerable to long-distance. Due to their low shelf life, they suffer damages in shipping. The results of distance from orchard to market had positive and statistically significant relation. The results revealed that with a distance of 1 km the post-harvest losses increase by 0.05 kg per ton. Kulwijila (2021) reported equally similar results that distance had a statically significant and positive influence on post-harvest damages. The study found increase in distance from farm to market increase the losses. Likewise, Ayandiji *et al.* (2011) stated the same results that far-flung markets badly influenced the tomato crop in Nigeria. Murthy *et al.* (2009) argued that about 50% of post-harvest losses occur during shipment to distant markets in form of loose and damaged berries. The author estimated that 7%-11% of losses are caused by shipment to distant markets. In our case, far-flung market destinations and sub-standard communications routes badly influence the quality of fruits in the form of mechanical damages and long shipment time for such perishable commodities. The mean shelf life of fruits ranges from 3 to 4 days so long-distance shipment and inappropriate handling damage fruits up to 20% before reaching the end consumer Dessalegn *et al.* (2016). Consequent to transportation losses Subrahmanyam (1986) is of the view that these losses can only be minimized by increasing the per-unit cost of transportation and marketing.

In general, most of the post-harvest losses occurred during handling the grapes as compared to socio-economic factors. The results revealed that growers who harvested their grapes in the evening suffered losses of 22 kg/ ton more than the growers who carried their harvesting in the morning. Our findings were in line with that of Ahmed *et al.* (2015) with slight variation in the magnitude. The author found morning losses 0.28 times fewer losses suffered during evening harvest. It is evident from the literature that harvesting grapes in the morning are likely to reduce post-harvest losses. Our findings are also in conformity with Gangwar *et al.* (2007), who reported morning time for harvesting is beneficial comparatively. The same recommendations were being made by Sharma and Singh (2011) that harvesting in the early morning is more suitable to lessen the harm.

Growers were cognizant of and practiced two measures (i.e. color and size of grapes) to decide whether grapes are ready to pluck or not. This study found that growers who considered size as maturity index suffered losses of 25 kg more than the growers who considered color as maturity index. Pertinent literature also had found color factor as maturity index is more suitable as significant criteria under which bunch color remains uniform. The color index is said to be more appropriate in colored varieties (Sharma and Singh, 2011). The dummy for the harvesting tool was statistically significant but inversely on the post-harvest losses. The results revealed that growers who used traditional Saw to detach a bunch from the belly suffered 4.7kg/ton more than those who used modern cutters or sharp scissors. Similar results were found by Umer *et al.* (2021) who reported that sharp tools for picking were effective to reduce losses as compared to traditional

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picking methods. Mencarelli *et al.* (2005) also emphasized that a skilled picker can also play a role in the reduction of losses.

Dummy means of transportation were highly significant and had a positive influence on losses. The magnitude of means of transportation was 9.54 which implies that growers who transported their grapes through simple trucks suffered losses of 9.54 kg/ton more than those who used reefer trucks. In general, small and medium farmers cannot afford or avail of services of reefer vehicles due to lack of credit facilities and others. A large number of researchers like Umer *et al.* (2021) have conveyed that means of transportation such as road infrastructure, vehicles, etc. play a vital role in post-harvest losses. Additionally, the area under the grapes orchard was statistically insignificant. The reason could be that more or less cultivated areas might not assist in post-harvest management. Nonetheless, it would vary from locality to locality where the post-harvest management innovative techniques are introduced and followed. Moreover, the post-harvest losses might be more influenced by demographics rather than orchard size. However, our findings were dissimilar to Umar et al. 2021 who found a positive relationship between area under cultivation and losses.

Table 4. Estimates of multiple regression analysis.

Regressors	Coefficient	Std. Err.	t	P>|t|
Age	-0.332	0.094	-3.52	0.001
Education	-1.134	0.334	-3.4	0.001
Experience	-0.343	0.105	-3.26	0.001
Area under Grapes	-0.196	0.373	-0.53	0.600
Distance farm-MKT	0.053	0.005	11.64	0.000
D_1 Harvesting Time	-22.322	2.393	-9.33	0.000
D_2 Maturity Index	-25.446	3.728	-6.83	0.000
D_3 Harvesting Tool	-4.739	2.482	-1.91	0.058
D_4 Means of Trnsptn	9.542	2.510	3.8	0.000
Constant	278.066	6.935	40.1	0.000
Number of Obs	179	R-squared		0.9306
F(9, 169)	251.7	Adj R-squared		0.9269
Prob > F =	0.000	Root MSE		9.5954

Author's estimates; survey results, 2021

Literature reported various other factors that are contributing to post-harvest losses. As mentioned earlier, some of the essential variables were excluded from the analysis. The reason behind this was that in both districts those practices were common. As packaging material was corrugated cartons throughout the study area. Only males were practicing farming due to ritual constraints. Pre-cooling was not familiar across both districts. Even growers were not aware of the significance of pre-cooling which is a recommended technique to overcome the losses. Similarly, lack of credit facilities poses challenges to farmers to procure new types of equipment, rent reefer vehicles for transportation, and other requisite inputs. Grapes storage was infrequent for growers. In the same way,

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growers were using traditional pack houses where ventilation of air was poor. Likewise, improper handling, poor transportation, and climatic factors like temperature, rainfall, and humidity are factors responsible for post-harvest losses in grapes (Negi and Anand, 2015; Bishnoi *et al.*, 2018).

Post-harvest losses remain one of the highly concentrated research subjects in the agricultural sector. However, techniques for estimation of post-losses show a wide discrepancy through the different countries, depending on the crops and post-harvest management techniques. Based on different scenarios researchers have put to use different techniques for estimations (Ayandiji *et al.*, 2009; Gangwar *et al.*, 2007; Murthy *et al.*, 2007). There are only a few that attempted to evaluate different determinants of post-harvest losses, However, this piece of research focused econometric techniques to calculate the losses after harvest and the factors responsible for these losses.

Conclusion and Recommendations

The study was executed to estimate the post-harvest losses of grapes and also the causal factors that contribute to losses. Post-Harvest losses in the study area were ranging from 19% to nearly 29%. District Killa Abdullah suffered more losses than district Pishin. The linear multiple regression analysis disclosed that socioeconomic factors i.e. age, education, and experience were the principal factors in reducing the post-harvest losses. As the increase in the variables was found to decline in the losses of grapes. However, the main operational factors such as harvesting time, maturity index, a picking tool, and means of transportation were found to have more impact as compared to socioeconomic determinants. The picking tool cutter was found more beneficial to reduce losses. Similarly, morning time, and reefer truck for shipment of grapes were key factors that could reduce post-harvest losses to a large extent. Most of the recommended and beneficial post-harvest handling practices were not common in both districts. Generally, both districts fall in the backward and deprived province of a developing nation which is why innovative and modern techniques are not common. Growers should use cutters as picking tools rather than saws, which will help reduce the amount of loss. Agricultural extension and other agencies should train growers who understand post-harvest management practices. Governments and other financial institutions should arrange credit facilities for grape growers so that they can procure the necessary types of equipment required for post-harvest management.

Conflict of Interest

The authors have not declared any conflict of interest.

Authors Contributions

All the authors contributed equally in the manuscript.

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