KSÜ Tarım ve Doğa Derg 26 (2), 346-354, 2023
KSU J. Agric Nat 26 (2), 346-354, 2023
https://doi.org/10.18016/ksutarimdoga.vi.1091225

Postharvest Losses in Onion: Causes and Determinants

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ABSTRACT

Reducing post-harvest losses is a reasonable step towards food security globally. However, the lack of deep knowledge of the causes and determinants of postharvest loss poses a great challenge to strategies for alleviating postharvest loss. This study, therefore, identifies the causes and drivers of postharvest losses in onion, in Nigeria, to alleviate the menace. Data collected from 360 farmers between February and April 2021 were analyzed with descriptive statistics and a multiple regression model. Results showed that the primary causes of postharvest loss were rot, diseases and pests, drying, and bruises. While, poor storage facilities, poor transportation systems, long distances to marketing centers, poor agricultural extension services, and inadequate credit were secondary causes. The driving factors of postharvest losses in onion were extension services (β = -0.1269, $p < .05$), access to credit (β = -0.1054, $p < .05$), household size (β = -0.2650, $p < .01$), age of the farmer (β = 0.0557, $p < .05$), level of education (β = -1.0500, $p < .01$), farm size (β = 0.3801, $p < .01$), distance to market (β = 0.2187, $p < .05$), output (β = 0.1180, $p < .01$), and length of storage after harvest (β = 0.0635, $p < .05$). These findings call for improved transportation systems in agrarian areas, overhauling of extension services, making credit facilities available to farmers at affordable interest rates, and developing efficient post-harvest management technologies by research institutes.

Agricultural Economics

Research Article

Article History
Received : 22.03.2022
Accepted : 29.09.2022

Keywords
Onion
Post-harvest loss
Causes
Determinants
Food security

To Cite: Falola A, Mukaila R, Uddin II RO, Ajewole CO, & Gbadebo W 2022. Postharvest Losses in Onion: Causes and Determinants. *KSÜ J. Agri Nat 26* (2), 346-354. https://doi.org/10.18016/ksutarimdoga.vi.1091225.

INTRODUCTION

Achieving self-sufficiency in food production is a major challenge confronting many developing nations, especially sub-Saharan Africa. This challenge is not only a result of the inability of such countries to meet their target in terms of agricultural production but also due to the food losses along their supply chains (FAO, 2011; Nicastro and Carillo, 2021). Food and Agricultural Organization (2011) identified five stages of food loss – agricultural production, postharvest, processing, distribution, and consumption. Food losses at production involve those due to spillage during harvest operation and mechanical damage. Postharvest losses involve spoilage during handling and storage that reduce crop value (Kumar and Kalita, 2017). Food losses at processing entail those at both domestic and industrial processing stages. Losses at the distribution stage entail those at the market system while those at the consumption level mostly involve food waste at the household consumption stage (FAO, 2011). This study specifically focuses on the onion value chain from the farmers' perspective rather than consumers, retailers, and processors' perspective. This is because farmers bear most of the monetary loss and double as producers and distributors of onion to the market in many developing countries (Delgado et al, 2021).

The postharvest loss could be seen from two perspectives – quantitative and qualitative (Sheahan and Barrett, 2017). The quantitative approach measures the postharvest loss in terms of the reduction in the physical count of food commodities in time and space. The qualitative approach measures the postharvest loss in terms of reduction in nutrients, viability, aesthetic properties, and nutritional properties of food items (Sheahan and Barrett, 2017). One-third of the food produced to feed the growing population is lost globally (Nicastro and Carillo, 2021). Thus, postharvest loss has been a bane to food security in many developing nations, including Nigeria. Estimates of postharvest food losses in developing countries from pest infestation, spoilage, and

mishandling are put at over twenty-five percent (Kulwijila, 2021). This implies that about one-quarter of food produced for human consumption never reaches them. Besides, postharvest losses have prevented the effect of the possible increase in yield due to agricultural innovations to be felt on the income of the small-scale farmers in such countries (Delgado et al., 2021). Aidoo et al. (2014) noted that fresh vegetables suffer a high postharvest loss than cereals due to their high perishability nature. One of such vegetables is onion.

Onions (*Allium cepa* L.) are major vegetable crops farmed primarily as food for home use and export in many parts of the world, especially the bulb types. They are highly valued for their herbs, nutritional values, and flavor because of their richness in fiber, minerals, protein, vitamins, calcium, iron, ascorbic acid, insulin, Sulphur, and calories (Bektaş and Küsek, 2021; Slimestad et al., 2007). Onions also have interesting technological properties and health benefits such as antithrombotic, hypolipidemic, prebiotic, antimicrobial, anticarcinogenic, and antioxidant properties that made them have been revered not only for their culinary use but also for their therapeutic properties (Bektaş and Küsek, 2021; Nasri et al., 2012). It as well plays a significant role in the livelihood of people who are involved in its production and value chain both in rural and urban areas of developed and developing countries. However, it is replete with a reasonable amount of postharvest loss, like many other vegetables. Onion production in Nigeria is over 1.1 million tons which makes it the largest onion producer in West Africa (Ministry of Foreign Affairs, 2021). However, Nigeria had a significant share in onions lost in Africa and the world.

Over the years, many studies have been carried out on the intensity of postharvest losses in onion production and its cost implications on the farmers (Emana et al., 2017; Gorrepati et al., 2018; Sharma, 2016). While these studies have focused on the losses incurred by onion farmers, studies that specifically focus on the determinants of these losses are lacking. Several studies have argued that mitigating post-harvest loss is a reasonable pathway to food security and income generation among farmers (Mlambo et al., 2017; Ng'ang'a et al., 2016; Tesfaye and Tirivayi, 2018; Shee et al., 2019). However, a lack of relevant information on the causes and the socio-economic factors responsible for these losses poses a serious challenge to using relevant mitigation strategies (Affognon et al., 2015; Prusky, 2011). Most often, the cost involved in managing the postharvest losses is borne by the farmer (Delgado et al, 2021). Therefore, to formulate relevant policies that will make farmers achieve profit maximization goals, there is the need to minimize postharvest losses. This can be achieved when the factors that lead to this menace are identified. Therefore, the main aim of this study is to identify the drivers of postharvest loss in onion production in Kaduna State, Nigeria. Specifically, the study describes the socioeconomic characteristics of onion farmers, determines the causes of postharvest loss in onion production, and identifies the determinants of postharvest losses in onion.

MATERIAL and METHOD

Study Area

The study was carried out in Kaduna State, Nigeria. The state is located in northwest Nigeria at coordinates 10°20'N 7°45'E and has a landmass of 46,053km² (Wikipedia, n.d). The state has 23 Local Government Areas. Kaduna state is one of the top onion-growing states in Nigeria with Zaira, Giwa, and Kaduna South as leading LGAs with onion production in the state. It is worthy of note that there is no well-defined demarcation among value chain actors for onions in the state, as the farmers largely double as marketers (involved in onion distribution) in the study area.

Sampling Techniques and Data Collection

The population for the study was made up of onion farmers. A three-stage sampling technique was used to select the respondents. First, a purposive selection of three LGA - Zaira, Giwa, and Kaduna South – was made, due to the preponderance of onion farmers in the areas. In the second stage, six communities from each LGAs were selected, randomly. After this, 20 onion farmers were randomly selected in each of the selected communities, making a total of 360 respondents. The field survey was conducted between February and April 2021.

Primary data were collected from onion farmers using a semi-structured questionnaire and personal interviews. Data collected include information on farmers' socioeconomic characteristics, postharvest losses, and perceived causes of the losses.

Data Analysis

Data analyses were carried out with descriptive statistics and multiple regression analysis. Descriptive statistics involving frequency distribution tables, mean, and charts were used to summarize the socioeconomic characteristics of the farmers and to identify the main causes of postharvest loss in onion production. To identify the major causes of postharvest loss in onion production, responses from the respondents were ranked on a five-point scale using the scoring order very high (5), high (4), moderate (3), low (2), and very low (1). A weighted average index was then estimated

$$\text{WAI} = \frac{\Sigma F_i W_i}{\Sigma F_i} = \frac{\text{WI}}{\Sigma F_i} \quad (1)$$

Where: WI = weighted index, i = weight, W = weight of each scale and F = frequency (Falola and Achem, 2017).

A multiple regression model was used to identify the major factors that influence postharvest losses in the study area. Since no econometric theory specifies an exact mathematical relationship between postharvest loss and its potential determinants, four functional forms namely double log, exponential, semi-log and linear models were fitted. But the double-log function gave the best fit based on relevant econometric criteria discussed in this study. These include the signs of the coefficients in line with *a priori* expectations, the number of significant variables, F-statistics, and the value of the coefficient of multiple determination. The model is expressed as:

$$LnPL = b_0 + b_1LnAg_1 + b_2LnEd_2 + b_3LnHS_3 + b_4LnFE_4 + b_5LnAC_5 + b_6LnEC_6 + b_7LnMF_7 + b_8LnFS_8 + b_9LnTH_9 + b_{10}LnO_{10} + b_{11}LnD_{11} + b_{12}LnLS_{12} + \mu \quad (2)$$

Where Ln represents natural logarithm, PL = Postharvest loss (kg), Ag_1 = age of farmer (years)

Ed_2 = educational level (years), HS_3 = Household size (number of people in the household), FE_4 = farming experience (years), AC_5 = access to credit (amount measured in Nigerian Naira), EC_6 = extension services (number of agricultural extension contacts), MF_7 = membership of farm-based organizations (member = 1, non-member = 0), FS_8 = farm size (hectares), TH_9 = time of harvest after maturity (days), O_{10} = output (kg), D_{11} = distance to market (km), LS_{12} = length of storage after harvest (days) and μ = error term.

RESULTS and DISCUSSION

Demographic and Institutional Features of Onion Farmers

The socio-economic characteristics of the respondents are presented in Table 1. Most of the onion farmers were males, indicating male dominance in the enterprise. They had an average age of about 44 years which agrees with Ağır and Akbay (2022). This shows that the majority of the farmers were still in their economic active and productive age. Due to energy requirements in small-scale agriculture, the age of the farmers is an important factor that could influence labor availability, physical capacity and productivity (Gbigbi 2021; Mukaila et al., 2020). Thus, the onion farmers could be described as farmers with the required energy needed for efficient production. Most of the farmers were married and had large households, which suggests that onion production is a major means of catering for the family (Table 1). Besides, the rural farmers in most African countries have a larger household size to serve as family labor in their agricultural production activities (Achoja and Obodaya, 2019; Mukaila et al. 2021). Thus, the onion farmers could have household members who could serve as family labor at their disposal. There was a low level of literacy among the respondents, which agrees with the findings of Aidoo et al. (2014). High postharvest loss is common among farmers with no formal education (Obayelu et al., 2021).

The majority of the farmers engaged in onion production as their primary occupation (Table 1). Membership of farm-based organizations was low among the respondents, which could hinder their access to credit facilities. The majority of the respondents were operating on a small scale with an average farm size of 2.8 hectares (Table 1). Onion production is an age-long venture in the study area as the respondents possessed some levels of farm experience (an average of 13.6 years). Most of the respondents did not have access to extension services. Most of the farmers fund their farm business mainly with personal savings while a few fund their operations with credit from banks, cooperatives society, friends and relatives, and local money lenders. This implies a low level of access to external finance, especially commercial banks, by the onion farmers. This could limit their level of cultivation, as external finance increases farmers' level of investment (Falola et al., 2022).

The extent of Postharvest Losses in Onion

The extent or level of postharvest loss in onion in the study area is presented in Table 2. The larger proportion of the farmers experienced 21% to 30% postharvest loss in onion. This was followed by 21.1% of respondents who recorded 11% to 20% postharvest loss. About 17% of the farmers recorded 31% to 40% postharvest loss, 15.8% recorded not more than 10% postharvest loss, 13.9% experienced 41% to 50% postharvest loss while just 6.1% of the farmers recorded over 50% postharvest loss in onion production. On average, the farmers experienced a 23.9% postharvest loss in onion. This shows that postharvest loss is a serious challenge in onion production and the value chain. This further implies that about one-third of the total value of onion produced was lost. This is in tandem with Calica and Cabanayan (2018) who reported a 31.49% postharvest loss in onions in the Philippines.

Causes of Postharvest Loss in Onion

The major causes of postharvest loss in onion production are presented in Figure 1. The primary causes of postharvest loss in onion in the study area were rot, diseases and pests, drying, and bruises. Rot in onion, caused by fungi and bacteria, contribute immensely to postharvest loss in onion. This leads to leaf dieback and wilting, and consequently leaf and bulb decay. Diseases and pests such as black mold, Colletotrichum blight, Stemphylium leaf blight, purple blotch and damping-off also cause a serious postharvest loss in onions (Ji et al, 2018; Tolouee et al,

2010). The quality and quantity loss caused by diseases accounts for huge economic losses in agriculture (Günaçtı and Ay, 2021). Postharvest loss due to drying of onion leaves at a premature stage and drying of bulb reduce the quality and market price of onion. Bruising of onions commonly from poor transportation and packaging causes damage and postharvest loss of onion. This suggests that most of these primary causes of postharvest loss in onion production were during on-farm operations and/or storage.

Table 1. Demographic and institutional features of onion farmers

Variables	Category	Frequency	Percentage
Gender	Male	302	83.9
	Female	58	16.1
Age (years)	30 – 40	68	18.9
	41 – 50	232	64.4
	51 – 60	42	11.7
Mean = 44.3	Above 60	18	5.0
Marital status	Single	26	7.2
	Married	274	76.1
	Widowed	48	13.3
	Divorced	12	3.3
Household size	1 – 5	102	28.3
	6 – 10	202	56.1
	11 – 15	36	10.0
7.8	Above 15	20	5.6
Level of formal education	No formal education	198	55.0
	Primary	134	37.2
	Secondary	28	7.8
Primary occupation	Farming	352	96.7
	Others	8	3.3
Membership in farm-based organizations	Yes	252	70.0
	No	108	30.0
Extension Service	Yes	64	17.8
	No	296	82.2
Farm size (hectares)	1.1 – 2.0	28	7.8
	2.1 – 3.0	256	71.1
	3.1 – 4.0	40	11.1
	4.1 – 5.00	24	6.7
Mean = 2.8	> 5.00	12	3.3
Farming experience (years)	1 – 10	142	39.4
	11 – 20	150	41.6
	21 – 30	56	15.6
Mean = 13.6	Above 30	12	3.4
Major source of capital	Personal savings	286	79.4
	Friends and relatives	28	7.8
	Local money lenders	16	4.4
	Banks	8	2.2
	Cooperatives	22	6.1

Source: Field survey, 2021

Table 2. Extent of postharvest losses in onion in the study area

Percentage postharvest loss in onion	Frequency	Percentage
≤ 10	57	15.8
11-20	76	21.1
21-30	94	26.1
31-40	61	16.9
41-50	50	13.9
≥51	22	6.1
Total	360	100.0

Source: Field survey, 2021

Further investigations were made to determine the secondary causes of postharvest loss in onion as perceived by the respondents (Table 3). The most critical secondary causes of postharvest loss in onion in the study area, in decreasing order of importance, were lack of credit to carry out their operations at the right time, poor storage facility, lack of agricultural extension services to train them on mitigating the loss, poor transportation system and long distances to marketing centers. This finding is in tandem with the report by Aidoo et al. (2014) on the causes of tomato

postharvest loss in Ghana. A critical look at these causes reveals that most of them are issues that are beyond the control of the farmer. Issues within their control such as harvesting techniques, type of the varieties grown and time of harvest were adjudged to have a minimal or low impact on postharvest loss in onion in the study area.

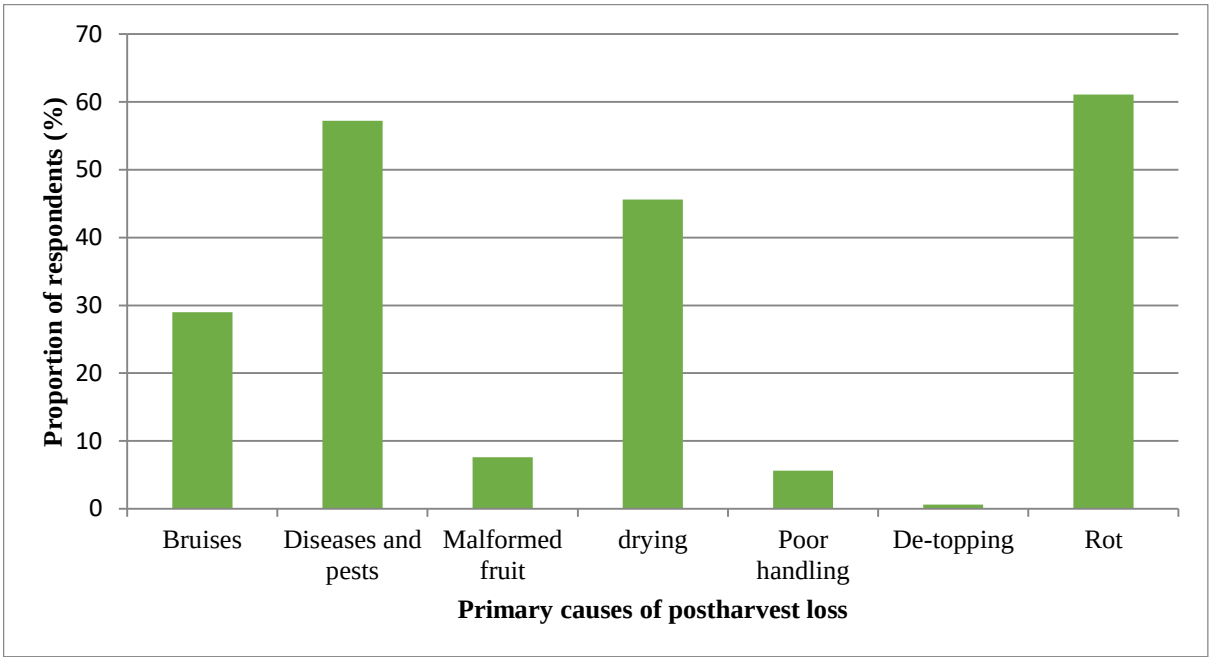

Figure 1. Primary causes of onion postharvest loss in the study area
Source: Field survey, 2021

Table 3. Secondary causes of postharvest loss in onion

Secondary Causes	Very high(5)	High (4)	Moderate (3)	Low (2)	Very low (1)	WI	WAI	Rank
Lack of credit facilities	196 (54.4)	130(36.1)	18 (5.0)	12 (3.3)	4 (1.1)	1582	4.39	1st
Poor storage facility	140 (38.9)	130(36.1)	58 (16.1)	32 (8.9)	0 (0.0)	1458	4.05	2nd
Lack of agricultural extension services	174 (48.3)	90 (25.0)	24 (6.7)	64 (17.8)	8 (2.2)	1438	3.99	3rd
Poor transportation system	86 (23.9)	48 (13.3)	90 (25.0)	106 (29.4)	30 (8.3)	1134	3.15	4th
Long distance to market	64 (17.7)	98 (27.2)	46 (12.8)	94 (26.1)	58 (16.1)	1096	3.04	5th
Type of variety used	48 (13.3)	42 (11.7)	84 (23.3)	168 (46.7)	18 (5.0)	1014	2.82	6th
Bad weather	52 (14.4)	60 916.7)	24 (6.7)	126 (35.0)	98 (27.2)	922	2.56	7th
Poor harvesting technique	14 (3.9)	24 (6.7)	36 (10.0)	174 (48.3)	112(31.1)	734	2.04	8th
Untimely harvest	8 (2.2)	12 (3.3)	68 (18.9)	160 (44.4)	112(31.1)	724	2.01	9th

Note: Figures in parenthesis are in percentages.
Source: Field survey, 2021

Determinants of Postharvest Loss in Onion

Table 4 shows the determinants of postharvest loss in onion in the study area. The coefficient of multiple determination (R^2) is 0.6854, implying that the explanatory variables in the model explain about 69% of the total variations in the postharvest loss in onion production. The results reveal that the significant factors influencing postharvest loss in onion production in the study area were age, educational level, household size, distance to market, farm size, access to credit, access to extension services, output, and length of storage after harvest.

The age of a farmer was significant ($p < 0.05$) and positively related to postharvest loss in onion production. This suggests that older farmers are likely to incur more postharvest loss than young ones. This may be due to the fact that the older a farmer is, the less innovative or energetic he is likely to become (Girei et al, 2016). *Ceteris paribus*, young farmers are likely to have the required physical strength to carry out postharvest management, thereby minimizing postharvest loss than their old counterparts. Also, the

young farmers are usually more innovative and more likely to adopt improved postharvest management practices than their older counterparts (Falola et al, 2017).

The level of education of the respondents was very highly significant ($p < 0.01$) and negatively related to postharvest loss. This implies well-educated farmers have lower post-harvest losses than those with less education. Education has been reported to enhance the ability of an individual to make better, meaningful and more accurate decisions (Akanbi et al., 2020). It can also enhance the adoption and use of improved technologies that may guide against postharvest loss. This result is in line with many similar studies (Kikulwe et al. 2018; Shee et al. 2019).

The household size of the respondents was significant ($p < 0.01$) and negatively affected postharvest losses in onion production. This suggests that farmers with large household sizes tend to incur less postharvest loss. This could be due to the relatively high availability of family labor to such farmers which makes postharvest management practices much faster and more efficient. Aidoo et al. (2014) reported a similar finding that household size influenced postharvest loss in tomato production.

Table 4 further shows that access to credit influences postharvest losses in onion production negatively ($p < 0.05$). This result implies that the more access farmers have to credit, the lower the level of postharvest losses they incur. On the other hand, those who have little or no access to credit are likely to incur more postharvest losses. Managing postharvest loss could involve high financial costs which may be difficult for farmers who do not have much financial strength to undertake. This may not be untrue about the onion growers in the study area, especially given the fact that most of them finance their farm operations with mainly personal savings (See Table 1).

A similar relationship existed between access to extension services and postharvest loss in the study area. Those who had more agricultural extension contacts had less postharvest loss than those who did not. This could be due to the possibility of receiving training on postharvest loss by the former group of farmers than the latter ones. A similar finding was reported by Shee et al. (2019) that access to extension services lowered postharvest losses of sweet potato and maize value chains in Uganda.

The results also show that the larger the farm area put under cultivation, the more postharvest loss and vice versa. This could be due to the low level of modern storage facilities to store and preserve the harvested onions. Similarly, an increase in the output of onion also increased postharvest loss. This may also result from a lack of proper storage due to poor storage facilities. It may also be due to the high labor requirement needed to carry out the harvesting on time which may be lacking or not within the reach of the farmer. The same explanation may be responsible for the positively significant influence of the length of storage on postharvest loss in the study area.

Distance to market also influenced postharvest loss in onions production positively ($p < 0.05$). This implies that the longer the distance covered from the farm to the market, the higher the postharvest loss in onion production, *ceteris paribus*. This could be a result of poor road network in the rural areas which contributed to and/or resulted in the postharvest loss.

Table 4. Determinants of postharvest loss in onion

Variables	Coefficient	Standard error	t-value	p-value
Age of farmer	0.0557**	0.0282	1.9762	0.042
Education	-1.0500***	0.1455	-7.2142	0.000
Household size	-0.2650***	0.0930	-2.8513	0.005
Farming experience	0.0823	0.7843	0.1049	0.295
Access to credit	-0.1054**	0.0532	-1.9797	0.049
Extension services	-0.1269**	0.0616	-2.0589	0.040
Membership in a farm-based organization	0.8897	0.1236	7.2004	0.472
Farm size	0.3801***	0.0907	4.1900	0.000
Time of harvest after maturity	0.0785	0.7463	0.1052	0.293
Output	0.1180***	0.0189	6.2463	0.000
Distance to market	0.2187**	0.1102	1.9853	0.038
Length of storage after harvest	0.0635**	0.0318	1.9967	0.043
Constant	13.9243	1.1657	11.9449	0.000
R^2	0.6854			
Adjusted R^2	0.6531			
F-value	17.02			

***, **, * - Significant at 1%, 5% and 10% respectively
Source: Authors' computations, 2021

CONCLUSION

This study reveals that the major causes of postharvest losses in onion are rot, diseases and pests, drying, bruises, lack of credit to carry out their operations at the right time, poor storage facilities, lack of agricultural extension services to train them on mitigating the loss, poor transportation system and long distances to marketing centers. Meanwhile, the factors associated with high levels of postharvest loss are the age of the farmer, farm size, output, distance to market and length of storage. Educational level, household size, extension services and access to credit are associated with the low level of postharvest losses. It can be inferred that most of the primary causes of postharvest losses are during off-farm operations and storage periods. Moreover, most of the causes of postharvest loss in onions are issues that are beyond the control of the farmer. Therefore, measures that will address postharvest losses in onion production should be put in place. The Ministry of Agriculture in collaboration with relevant research institutes should develop efficient technologies that will prolong the shelf life of onion thereby minimizing postharvest losses in onion production. Such technologies should be such that they inhibit the growth of pests and provide an efficient storage system. Meanwhile, there is a need for the Ministry of Agriculture and allied agencies to overhaul extension services among onion farmers in the study area. This could be through employing more agricultural extension workers and/or the introduction of extension education programs on efficient post-harvest management practices through regular extension contacts. This will improve the technical knowledge and skills of the farmers and make them handle postharvest activities perfectly. Also, measures that will solve the problems of poor transportation in the study area should be taken. These may include the rehabilitation and construction of feeder roads and provision of buses by the Ministry of Transportation or in collaboration with private transport companies. This will ease the conveyance of onions from the farm to the market by farmers.

Moreover, financial institutions such as banks and other lending institutions should make credit facilities available to the farmers to carry out postharvest handling practices effectively. The provision of such credit facilities should be timely and at affordable interest rates, as these will encourage farmers to obtain them and safeguard against high postharvest losses. Young individuals should be encouraged to practice agriculture (including onion production), as this study has revealed that age has a positive influence on postharvest loss. This could be by making agriculture attractive to them through the provision of farm inputs at a subsidized rate and a favorable environment. This is more so important, especially in African agriculture, where agricultural production (including postharvest management practices) is largely carried out with manpower, which usually diminishes with age, due to the lack of mechanical power or the inability of many farmers to afford it. In the same vein, well-educated individuals should be encouraged to go into agriculture, as this study has shown that education reduces postharvest losses in onion.

ACKNOWLEDGEMENTS

The authors appreciate the onion farmers and extension agents in the study area for their cooperation during the field survey.

Statement of Conflict of Interest

The authors declare that they have contributed equally to the article.

Author's Contributions

The contribution of the authors is equal.

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