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POSTHARVEST LOSSES OF BULB ONION (*ALLIUM CEPA L.*) IN SELECTED SUB-COUNTIES OF KENYA

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ABSTRACT

Inappropriate postharvest practices such as unsuitable harvesting methods and inadequate curing in bulb onion lead to losses. Postharvest losses in bulb onion contribute to food and nutrition insecurity. Although Kenya has suitable environmental conditions for bulb onion production, its productivity is low, which is attributed to pre- and postharvest factors. Information on bulb onion postharvest losses and their causes in the country is scanty which limits development of postharvest losses reduction strategies. Therefore, this study was carried out in three major bulb onion growing sub-counties of Kenya namely Mt. Elgon, Buuri and Kajiado East to determine postharvest practices, causes and factors influencing postharvest losses of bulb onion. A multi-stage sampling design was used to select the study areas and a total of 166 respondents were randomly selected. Face-to-face interviews were conducted using a structured questionnaire to collect information on postharvest handling practices, postharvest loss levels and their causes at farm level. Data were subjected to descriptive and logistic regression analysis using Statistical Package for Social Scientists (SPSS) software version 2.0. Results indicated that 68% of the respondents were males and with an average age of 40 years in the three sites. Forty eight percent of the respondents used leaves toppling, and 25% used drying of upper leaves as maturity indices. About 42% of the respondents used machete (*panga*) as a harvesting tool which significantly ($P<0.05$) influenced postharvest losses. Seventy seven percent of the respondents indicated that up to 30% postharvest losses occurred at farm level. Forty percent of the respondents indicated that bulb onion rots caused 10 % loss at farm level. The level of education, and mode of transport (bicycles and donkeys) significantly ($P<0.05$) influenced postharvest losses. It was concluded that the postharvest losses at farm level was 30% and were mainly caused by rotting. Socio-economic characteristics and postharvest handling practices influenced bulb onion losses at farm level. Development of postharvest losses reduction strategies on bulb onions focusing on alleviating rotting through appropriate postharvest handling practices at farm level was recommended.

Key words: Bulb onion, causes, farm level, handling practices, postharvest losses, rotting

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INTRODUCTION

Onion (*Allium cepa L.*) is a herbaceous biennial plant belonging to the family *Amaryllidaceae* and genus *Allium* [1]. Bulb onion also known as common onion is grown globally as a commercial crop and is used widely either as a vegetable in form of salad or as a component in meal preparation. Onion is a source of vitamin C, Vitamin B_6, potassium, magnesium, polyphenols and phytonutrients and its medicinal value is highly acclaimed [2,3].

Bulb onion is grown globally in about 170 countries. China ranks first with over 18 million tons of bulb onion produced, followed by India (11 million) and USA (about 3.2 million) tons annual production [4]. In 2018, bulb onion ranked first among aromatic crops including coriander (7,070MT), spring onion (35,340MT), rosemary (8,270MT) and garlic(3,113MT) in Kenya in terms of volume produced, area under production, and income generated [5]. During the same year, the area under production was 7,005 ha, from which 105,585MT valued at Kenya Shilling (KES) 4.1 billion was produced. Although the country has favorable environmental conditions for bulb onion production its productivity is low. This is attributed to bulb onion poor quality, inappropriate pre- and postharvest handling practices. Inappropriate postharvest handling practices in crops such as harvesting techniques, sorting, curing, packaging and poor storage facilities leads to postharvest losses [6]. In developing countries especially in Southern and Eastern Africa information on physical postharvest losses levels is scanty where previous research concentrated mainly on maize [7]. However, an estimation of 40 to 50% losses in horticultural crops has been reported in sub-Saharan Africa and these are attributed to high temperatures, poor quality packages, poor field sanitation and time taken to reach market [8]. Postharvest losses can be defined as degradation in both quantity and quality of food structure from harvest to consumption [9]. Postharvest losses in crops lead to food and nutrition insecurity and wastage of natural resources [10]. Fruits, vegetables and aromatic crops have a short postharvest life mainly because they have high moisture content (95%) [11].

Wilting and shriveling, mechanical injury, pathological and biological incidences are major causes of postharvest losses in horticultural crops including bulb onion [12], which occur during harvesting, transportation, marketing and storage [13, 14]. In Kenya, postharvest factors have been associated with bulb onion low productivity, though information on level of postharvest losses is scanty. In other countries such as India postharvest losses of about 35-40 % have been reported [15], while 31.49% losses occurred during various postharvest operations that included handling and storage in Philippines [16]. Information on bulb onion level of postharvest losses and causes is the first step in identifying of the postharvest losses reduction strategies.

Despite research findings on postharvest handling practices on horticultural crops including bulb onion in Ethiopia [17], limited information is available on bulb onion handling practices in Kenya. It is important to identify appropriate postharvest handling practices in bulb onion that can be employed to maintain its quality. This will improve bulb onion productivity contributing to enhanced food and nutrition security and farmers' incomes. Therefore, this study was carried out in three major bulb onion

growing sub-counties of Kenya namely Mt. Elgon, Buuri and Kajiado East to determine postharvest handling practices, causes and factors influencing postharvest losses of bulb onion.

MATERIALS AND METHODS

Data collection tool preparation

A structured questionnaire was developed to collect data at farm level. Data collected include: socio-economic characteristics (gender, age and primary level of education (8years), secondary level of education (12 years) and tertiary level of education (>12years), land size), bulb onion harvesting techniques, postharvest handling practices and causes of postharvest losses. The questionnaire was pre-tested using an expert review methodology [18]. Three experts including a sociologist, statistician and postharvest physiologist revised the questionnaire and their comments were included. The questionnaire was then administered through face-to-face interviews with farmers.

Study sites selection

A multi-stage sampling design was used to select the study areas according to Basavaraja *et al.* [19] with slight modification. Two stages were used in the selection of sub-counties as study sites. First selection of three major bulb onion growing Counties in Kenya and secondly one sub-county in each County. In the first stage Bungoma, Meru and Kajiado Counties with annual bulb onion production of 5,682, 4,421 and 2,415 tons, respectively were selected [20]. In the second stage, one sub-county with the highest bulb onion production level per the chosen Counties was selected using information provided by County Agriculture Officers. The three sub-counties selected as study sites were Kajiado East in Kajiado County, Buuri in Meru County and Mt. Elgon in Bungoma County.

Farmers selection and data collection

At farm level, lists of bulb onion farmers from the three selected sub-counties were generated with the assistance of County Agriculture Officers. From the lists, farmers were randomly selected using systematic sampling procedure [21] and were contacted to avail themselves for interview.

From the sub-counties, 166 respondents (47 in Kajiado East, 56 in Buuri and 63 in Mt. Elgon) were selected and interviewed. The survey was conducted during the months of June, July and September 2018 through face-to-face interviews with an adult person present in the farm during the time of visit.

Data analysis

Data obtained from 166 respondents were coded and analyzed using Statistical Package for Social Scientists (SPSS) software version 2.0 for descriptive analysis and the results were expressed as percentages in charts. Logistic regression analysis was employed to determine factors influencing postharvest losses of bulb onion at farm level. The model used was statistically significant at Chi-square = 46.619 and $P<0.05$ as given below:

$$\text{Logit}(p) = \beta 0 + \beta 1\, X1 + \beta 2\, X2 + \beta 3\, X3 + \beta 4\, X4 + \beta 5\, X5 + \beta 6\, X6 + \beta 7\, X7 + \beta 8\, X8 + \beta 9\, X9 + \beta 10\, X10.$$

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Where logit (p) is postharvest losses (dependent variable), β is population regression coefficient, X1 is secondary level of education, X2 is tertiary level education, X3 is land size under bulb onion, X4 is use of machete as harvesting tool, X5 is curing, X6 is sorting, X7 is toppling of leaves as maturity indices, X8 is use of bicycle as transport mode, X9 is use of donkey as transport mode, and X10 is distance to market > 5km.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

Demographic characteristics of a population which includes sex, age and education level may affect agriculture negatively or positively [22]. Results indicated that majority of respondents interviewed were males (68%). Similar findings have been reported in Northern Tanzania where majority of respondents involved in bulb onion production were males [23]. Bulb onion production activities such as land clearing and bed preparation as well as marketing were carried out by males who were also mainly hired as farm managers [23]. The results indicated that the average age of bulb onion growers in the three study sites was 40 years. This was contrary to the average age of Kenyan farmers of 60 years in 2018 as was reported by [24]. Bulb onion enterprise requires intensive labour [16], therefore, farmers aged 40yrs who are in their productive age were involved in the bulb onion production.

Forty five percent of the respondents had attained primary education level, 37 % were educated up to secondary level and 15% had tertiary level of education , while the rest had no formal education. Education level influenced postharvest losses incurred at the farm level (Table 1). Secondary and tertiary level of education enhances farmers' ability to access postharvest management knowledge and skills especially during trainings. This enables the farmers to employ appropriate postharvest management techniques thus influencing postharvest losses negatively.

The average farm size owned by the respondents was 1.6 ha with 0.8 ha under bulb onion production. In the developing world, two-thirds of population live in rural areas with about 475 million farmers of small holder farms who own about two hectares [22]. In Kenya farmers owned an average farm size of 1.2 ha [22]; however, the results established that bulb onion producers in Kajiado East, Buuri and Mt. Elgon sub-counties owned an average of 1.6 ha with half of that under bulb onion production. Onion production in Kenya has gained popularity over the years due to its low supply and high demand in domestic markets [5]. This resulted to farmers opening up vast areas previously not engaged in bulb onion production to meet market demand, case in point were Kajiado East and Mt. Elgon sub-counties. The study showed land size under onion production influenced postharvest losses positively (Table1).

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Figure 1: Bulb onion crop in the field at Kajiado East sub-county

Postharvest management practices

Maturity indices

The respondents were aware of various bulb onion maturity indices as indicators of harvesting time. Toppling and drying of upper leaves were used as maturity indicators by a large proportion of respondents 48% and 25%, respectively (Figure 1). Only 11% of the repondents used bulb onion size as maturity indicator while 16% used number of days from planting as an indicator to harvest bulb onions (Figure 1). Maturity is defined as the stage at which the produce has developed consumers' favourable taste, appearance and exhibits acceptable shelf life [12]. Majority of farmers (60-70%) were aware of bulb onions maturity indicators. Drying and toppling of leaves in bulb onions were commonly used as maturity indicators since they are simple and can easily be identified [25] . Bulb onion size as maturity indicator was not used frequently since it depends on variety characteristics and the agronomic practices employed during production. Harvesting stage was likely to influence losses positively during postharvest handling of bulb onions (Table 1). Bulb onion harvested when the tops are still green and succulent would take a longer time to cure and also have a shorter shelf life [26]. However, the exact time to harvest bulb onion depends on agronomic practices, onion variety and climatic conditions [26]. Non-conformity to optimum harvesting stage may result to loss of quality, quantity and monetary returns [27].

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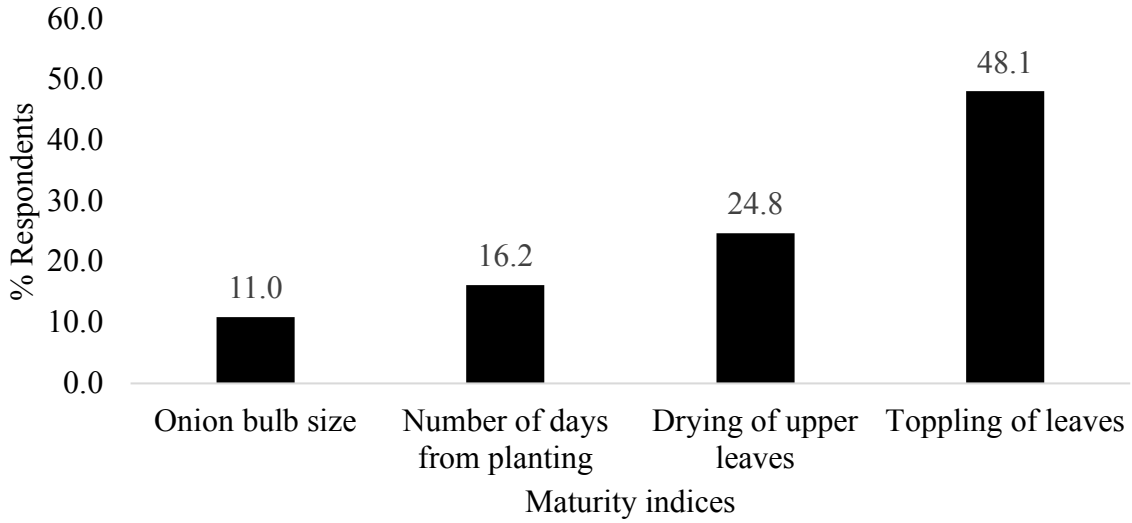

Figure 2: Proportion of respondents who used various maturity indices to harvest bulb onion (n=166)

Figure 3: Immature harvested bulb onion

Harvesting tools

A large proportion of respondents (59%) harvested bulb onion using hands while 41% of repondents used machete. Use of machete as a harvesting tool significantly ($P<0.05$) influenced postharvest losses of bulb onions at farm level (Table 1). Harvesting of bulb onion should be done appropriately to minimize mechanical injuries such as bruises. The results in Table 1 indicated that harvesting technique such as use of machete in

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bulb onions increased occurrence of postharvest losses, similar findings were also reported in Ethiopia [28]. Use of machete causes bruises on bulb onions leading to rotting. To ensure reduction of postharvest losses in bulb onions proper harvesting methods such as hand-lifting should be employed since it reduces bruising on the crop [28].

Postharvest handling practices

The respondents carried out various postharvest handling practices at farm level. Sixty nine percent of the respondents carried out sorting at farm level. A greater proportion (82%) of the respondents indicated that they were grading bulb onions at farm level to remove the immature and small sized ones**.** Majority of the respondents graded according to size (66%) while 31% used colour. The results indicated that a large proportion of respondents (75%) did not cure bulb onions while 59% of those who cured did it for less than ten days. Curing and sorting of bulb onions reduced occurrence of postharvest losses as also reported by Kitinoja *et al.* [8]. After harvesting, curing hardens bulb onion outer scales, reduce skin cracks and make the neck narrow, thus reduce pathogenic decay [29]. Bulb onion cured at 30˚ C for nine days narrowed bulb neck and reduced rotting by 80% [30]. It is recommended that curing bulb onion should be done under temperature range of 25˚C to 30˚C and relative humidity of 65% to 75% [31]. Sorting of bulb onion involves removal of injured and rotting onions, lack of sorting before packing promoted spread of diseases to healthy bulb onion leading to losses [11]. Proper curing and sorting should be employed in bulb onion handling to minimize postharvest losses.

Level of postharvest losses

Bulb onion postharvest losses estimates were based on previous season crop and were recorded in a range of percentage losses. Postharvest losses were experienced during handling of bulb onions at farm level. The results indicated that majority of the respondents (59%) encountered losses at farm level. Thirty seven percent of the respondents who experienced losses indicated 5-10% losses, 21% repondents registered 11-20% losses while 19% indicated 21-30%. Ten percent of the respondents experienced more than 50% postharvest losses (Fig. 2). Overall majority of respondents (77%) registered 5-30% bulb onion at the farm level. In India and Philippines bulb onion postharvest losses of about 35-40 % and 31.49% respectively have been reported [15,16] . Immature harvesting, use of machete as harvesting tool and inadequate curing are likely to influence postharvest losses positively at farm level (Table1).

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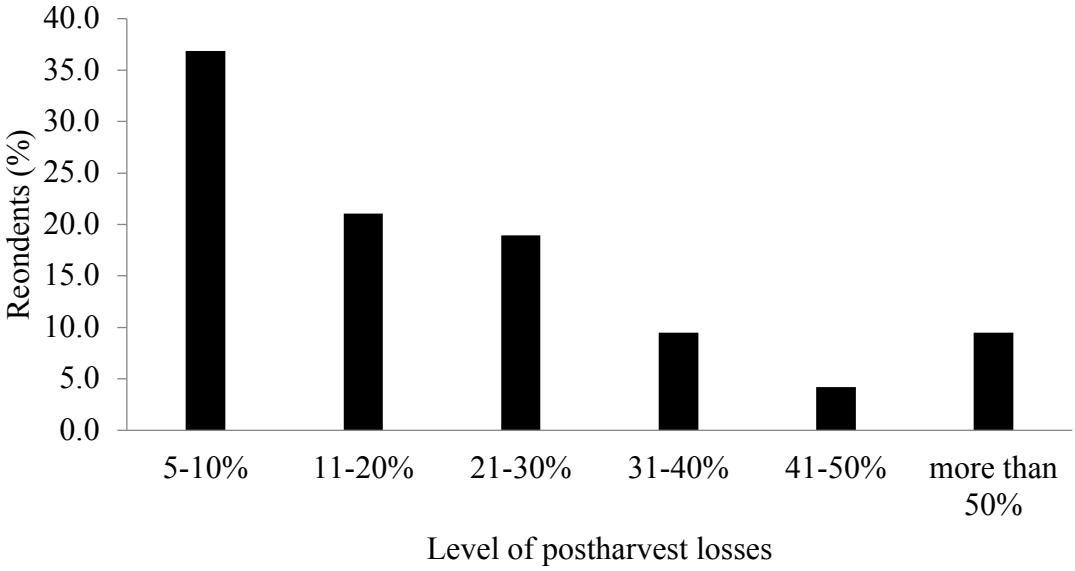

Figure 4: Percentage of respondents indicating different levels of bulb onion postharvest losses at farm level (n=96)

Causes of postharvest losses

Various causes of bulb onion postharvest losses were reported by the respondents at farm level. Fifty one percent of the respondents indicated that bulb onion postharvest losses occurred due to rotting while 48% reported sprouting, 18% shriveling and 8% reported size while 3% reported other causes including theft and peeling off of outer scale (Figure 3). In similar findings, rotting, sprouting and shriveling were reported as the major physical post-harvest losses of bulb onion at farm level in India and Ethiopia [13,32]. Physical losses in bulb onion could be influenced by immature harvesting, inappropriate harvesting techniques such as use of machetes as a harvesting tool, limited curing and lack of sorting. The results indicated that 10% of total postharvest losses which occurred at farm level were through rotting. This was in agreement with studies in Philippines where it was established that rotting caused the highest postharvest losses at farm level [16].

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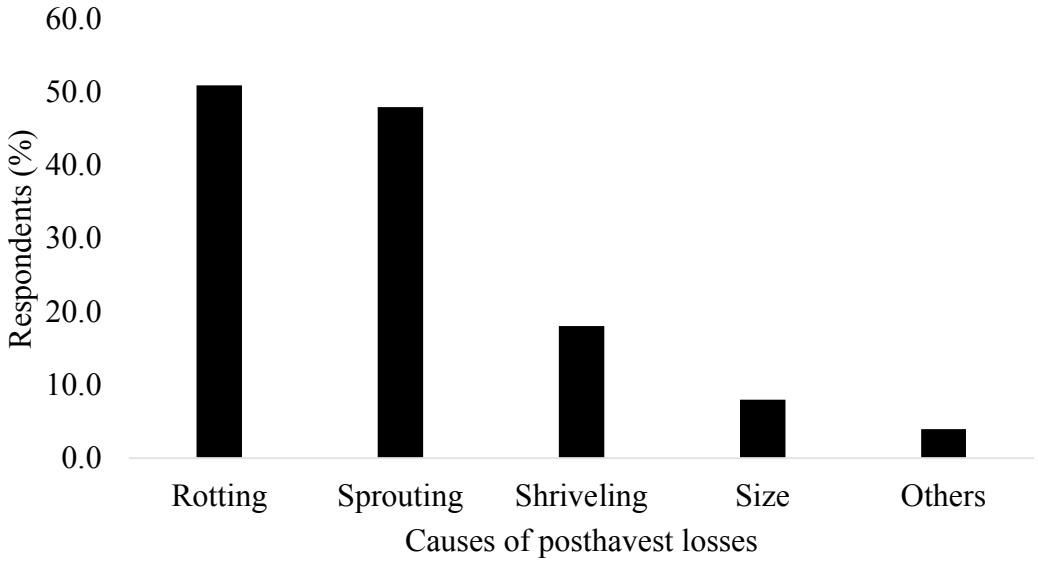

Figure 5: Percentage of respondents indicating different causes of postharvest losses in bulb onion

Factors influencing postharvest losses at farm level

Logistic regression modelling results (Table 1) indicated that secondary (12 years) and tertiary education (>12 years) levels significantly (P<0.05) reduced postharvest losses of bulb onion at farm level. Farmers who had secondary and tertiary education levels were associate with Odds Ratio (OR) of 0.057 and 0.079, respectively. Farmers' level of education is important in influencing occurrence of bulb onion postharvest losses at farm level. Similar findings were reported where number of years in education influenced postharvest losses in sweet potato [33]. Land size under bulb onion production significantly (P<0.01) influenced postharvest losses at farm level. Farmers with large land size under bulb onion production were likely to encounter postharvest losses (OR: 1.636) as shown in Table 1. With increased land size under onion production farmers were unable to employ proper postharvest handling practices leading to increased postharvest losses.

The results indicated use of machete as harvesting tool, curing and sorting significantly (P<0.05) influenced postharvest losses of bulb onions at farm level (Table 1). Farmers using machete during harvesting were likely to encounter postharvest losses with a positive coefficient of 2.633 and Odds Ratio (OR) of 13.922 (Table 1). Use of machete in harvesting bulb onion is more likely to incur losses compared to using hands. Farmers practicing curing and sorting were unlikely to encounter losses (OR. 0.283 and OR 0.133 respectively) (Table 1). Inadequate curing and sorting may lead to spread of diseases infection leading to postharvest losses due to decaying [8].

Use of bicycles and donkeys as transport mode from the farm to the market significantly influenced postharvest losses in bulb onions (P<0.05). Farmers who used bicycles as a mode of transport were more likely to encounter postharvest losses than the ones using donkey (OR: 48.53, 0.024), respectively. Bulb onions transported to the market using bicycles were piled on each other thus causing mechanical damage. While

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farmers using donkeys as mode of transport hang the packs on donkey's sides and, therefore, the produce is protected from compression (Fig. 6).

Distance from farm to the market significantly ($P<0.01$) increased postharvest losses in bulb onion. Bulb onion transported for more than 5km to the market were more likely to encounter losses (OR: 68.94) (Table 1). In developing countries market location is far from farms and majority of roads are inaccessible, thus traders use various modes of transport in order to reach the markets in good time [34]. Taking bulb onion to markets situated away from farms at more than 5Km exposed the produce to postharvest losses due to market delays. Other findings reported that during bulb onion transportation 3% postharvest losses occurred in Philippines [16]. Therefore, use of appropriate transport mode is important in minimizing postharvest losses.

Figure 6: A donkey transporting bulb onions from farm to the market

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CONCLUSION

The survey in major bulb onion growing regions of Kenya indicated that at farm level majority of farmers experienced 5- 30% bulb onions postharvest losses. These losses were influenced by demographic and economic factors such as education level and land size under bulb onion production. Use of machete as a harvesting tool and bicycles as transport mode increased occurrence of losses while use of donkeys in bulb onion transportation, and curing and sorting on-farm reduced incidences of postharvest losses. At farm level the major causes of bulb onions postharvest losses were mainly rotting followed by sprouting and finally shriveling. The study recommended that postharvest reduction strategies in bulb onion should focus on decreasing occurrence of rotting at farm level. Also, to reduce postharvest losses at farm level farmers should be trained on appropriate postharvest handling practices such as bulb onion maturity indices, harvesting mode, sorting, curing, packaging and transportation.

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Table 1: Logistic regression for factors influencing bulb onion postharvest losses at farm level

Variable	Coefficient	Standard error (S.E)	Wald Statistic	P-Value	Odds (OR)	Ratio
Primary education (8years)	-1.196	2.018	.351	0.553	0.302	
Secondary education (12years)	-2.867	1.185	5.855	0.016*	0.057	
Tertiary education (>12 years)	-2.536	1.270	3.983	0.046*	0.079	
Land size	-.016	.055	.087	0.768	0.984	
Land size under onion production	.492	.299	2.714	0.099***	1.636	
Use of machete as a harvesting tool	2.633	1.042	6.382	0.012*	13.922	
Curing	-1.267	.417	9.243	0.002*	0.282	
Sorting	-2.017	.997	4.094	0.043*	0.133	
Grading	.654	1.133	0.334	0.563	1.924	
Storage	-1.109	1.008	1.210	0.271	.330	
Toppling of leaves as maturity indices	1.902	.521	13.322	<.001**	6.699	
Human as a mode transport	.698	2.122	.108	0.742	2.009	
Bicycle as a mode transport	3.882	1.594	5.933	0.015*	48.534	
Motor bike as a mode transport	-.522	1.185	.194	0.660	0.593	
Donkey as a mode transport	-3.746	1.797	4.348	0.037*	0.024	
Distance of the farm to the market (≥5km)	4.233	1.041	16.549	<.001**	68.940	

*Significant at 5 % level, **1 % level, ***10%

2 Log likelihood=70.748, Cox & Snell R^2=0.601, Nagelkerke R^2=0.806, Power of correct prediction =56.7%, Chi-square value = <.001

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