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Research article

The rise and fall of onion production; its multiple constraints on pre-harvest and post-harvest management issues along the supply chain in northwest Ethiopia

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ABSTRACT

Food and nutrition security is not only addressed by increasing production alone, it should also ensure by reducing food loss. Onion has a great contribution to both economic and health issues, however, its production and productivity in the country is low. Thus, the study was initiated to identify multiple constraints on onion production and postharvest handling practices and to determine the extent of postharvest loss along the supply chain in northwestern Ethiopia. The survey was conducted on production, marketing, and consumption at farm, wholesale, retailer, and consumers level. The multistage sampling procedure was employed. The present results revealed that sex, age, educational level, production experience, land covered by onion, and household size has a significant influence on onion production. Sex, age, education level, active household size, selling experience, amount purchased, and storage duration have a significant association with onion production and postharvest loss. Major onion production and post-harvest loss constraints were high perishability, nature of the crop, market, linkage problem and low market price, lack of awareness of using post-harvest technologies, absence of better storable varieties, shortage of fertilizer access, disease and insect pests. The whole purchased produce never reached the consumer's hands. The total postharvest loss of onion at the farmer, wholesale, retail, and consumer level was found to be 29.775%, of which the higher proportion of losses (35.5%) was observed at the farmer's level. Based on the findings of the present study, onion producers were challenged by timely and adequate supplies and unfair, high cost of major production inputs, and high post-harvest loss. Therefore, producers and handlers in each supply chain need to be trained on affordable and applicable postharvest technologies. In addition, continuous capacity-building training, improving infrastructures, and input access along the supply chain should be designed and implemented to improve better crop management and postharvest handling practices. Moreover, marketing cooperatives working on onion postharvest handling and marketing systems should be functional to absorb surplus production and ensure continuous supply to the market. Thus, meaningful interventions in the development and implementation of policy on sustainable production, handling practices, and supply of onion should be designed.

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1. Introduction

Feeding a global population of 10 billion by 2050 is expected to become one of the greatest challenges of this time, which will require a 70% increase in food production [1,2]. Food and nutrition security continues to pose a challenge to African countries taking into consideration the fast-rising population growth coupled with decreasing natural resources such as land and the stress posed to water resources by climate change [3]. An increase in malnutrition has occurred in different parts of the world. Food and nutrition security is not only addressed by increasing production alone, it should also ensure that by reducing food loss. At this time, the most urgent need is to increase production with proper postharvest management of onion in a sustainable manner and improve farm income to insure household food and nutritional security. Onion is one of the more intensively consumed and most important cash-generating crop for farmers around northwestern Amhara [4]. Even though the crop has a great contribution to both in economic and health issues, its production and productivity are not scaled to the required level. Its production trend is not consistent, raises over in a certain period of time and falls in another period of time. Thus, farmers are not yet benefited from onion production. There are a number of factors associated for this low levels of onion production. These factors are improper agronomic practices, cost of production inputs, lack of adequate storage facilities, limited access to improved seeds, high cost of transport, fluctuation of market price and lack of sufficient capital, and postharvest losses [5].

Onion post-harvest loss begins from production and it is inevitable after harvesting particularly during storage. Its postharvest losses are incurred at each channel in the supply chain that the produce passes through. Therefore, identifying major constraints for onion is important to alleviate the existing problems along the supply chain and to design intervention strategies. Though, there are limited studies on onion production and postharvest handling constraints along the supply chain.

Thus, detecting multiple factors that determining the rise and fall of the production and postharvest handling of onion from the farm to the consumers in the study area would give direction to farmers and concerned bodies to improve problems in the production and continuous supply. Thus, this study was initiated;

- To investigate the farmer's knowledge and management practices in onion production and handling.
- To identify major onion production and postharvest handling constraints in supply chains in northwestern Ethiopia.
- To determine the extent of postharvest loss of onion along the supply chain

Consequently, the findings of the present study focused to answer the onion production and postharvest handling constraints along the supply chain. In addition, the study provided valuable information to onion traders, processors, consumers, and policymakers to support them in developing onion production and postharvest handling strategies and policies.

This article contains four sections. The first section (introduction) deals with the background information of the study, and explains the rationale of the study, research gaps, and research objectives. The second section deals about the materials and methods section which includes the study area description, data collection methods, and the statistical methods for data analysis to achieve study objectives. The third section explains the major findings of the present study. The fourth section outlines the major results of the study and provides recommendations and future research areas.

1.1. Hypothetical framework

According to Abedullah et al. [6] Achoja and Obodaya [7]; Mukaila et al. [8], Debebe [9] large family members contribute in the operation of farm activities of onion and to manage its losses after harvest, as additional and cheaper labor source. Thus, it was possible to hypothesize that household size positively influence onion production, post-harvest loss reduction, and supply to the market. The experience in years that the household would have engaged in onion production and selling improves the household's abilities in production and postharvest management operations. As a result, it was possible to hypothesized that farmers and traders with longer period farming and selling experience are expected to have better skill on production and post-harvest management. Experienced farmers have better administrative abilities that they can exert to their production and handling [10]. As a result, it was hypothesized that as the age of the farmers increased, the probability of capability of farming and increasing the yield also increased. Education enhances farmer's, traders and consumer's ability and decisions to accept and practice new ideas and technologies. Furthermore, formal education positively influences farmer's and trader's willingness to produce better and to reduce extent of postharvest loss [11].

The higher production costs decrease the farmers ability to supply surplus onion bulbs for market Agumas [12]. As a result, we hypothesized that the cost of farm inputs like fertilizer, pesticides, and fuel was negatively influence the production of onion. Improved seed varieties would contribute to crop yield 5 to 30% [13]. It was hypothesized that hybrid seed production is positively correlated with onion production. According to Falola et al. [14] an increase in the volume of onion harvested and purchased increased post-harvest loss. As a result, when the farmers harvested and purchased a larger volume of onion bulbs, there is a possibility of high postharvest loss. According to Kader [15], the produce deterioration rate increases as the time it stays in the market increases. The number of days to finish selling has a positive relation with the proportion of spoilage of onion.

2. Methodology

2.1. Study area description

The study was conducted in three potential onion-producing districts and six *kebeles* of north-west Amhara, Ethiopia. Major onion-

producing kebeles are namely: Mecha district (*Kudmi and Enguti kebeles*), Fogera district (*Shina and Kuhar Micael kebeles*), and Bahir Dar Zuria district (*Yigoma, and Sebatamit kebeles*) from August 2021–March 2022. The three districts Fogera, Mecha, and BahirDar zuria are geographically located between 11°58 N latitude and 37°41 E longitude, 11°05′ N to 11°38′ N, and 37°00′ E to 37°23′ E and 29° 27′ 34″, 35° 58′ 40″ East of longitude and 13° 38′ 19′, 12° 1′ 37" North of latitude respectively (Fig. 1).

2.2. Data types, sources, and collection methods

To achieve the study objectives, primary data were collected through face-to–to-face interviews with key informants and supply chain actors, direct field observation, and market observations. Data on socio-demographic and socio-economic characteristics, onion production practices, and constraints related to farmers' onion production, utilization, marketing, harvesting, postharvest handling practices, postharvest loss, and their interaction with the respective actors were collected from the respondents.

To collect primary data, a structured questionnaire was used by Elahi [16], through key informant interviews, farmers, wholesalers, retailers, consumers, direct field observations, and market assessment. The structure of the questionnaire was designed as both open-ended and close-ended. The close-ended questions were designed to list or select a suitable response and they were coded. The open-ended questions were prepared by letting the respondents freely explain any of their ideas. Before the interviews, the respondents have informed and convinced about the purpose of the study and each respondent had asked for their agreement before the interview. In addition, respondents were given the right to drop the questions which are uncomfortable for them and replace them with other voluntary respondents and their responses were kept strictly confidential [17].

Secondary data were collected by using document analysis techniques, district agricultural offices, and a systematic review of peer-reviewed literature. The questionnaire for the interview prepared in the English language was translated into the local language of respondents, Amharic to avoid the language barrier. The questionnaires used for the interview consisted of socio-demographic and socio-economic characteristics of households, questions on farming knowledge and practices, questions on access to production inputs, harvesting, and postharvest handling practices, and access to market information. During the field observation (physical observation), an onion production and handling practice was observed to determine the type and causes of postharvest loss at the time of harvesting. In addition, onion production, agronomic management, major disease and insect pests, and harvesting and postharvest handling activities were also observed to have more reliable information about the existing onion handling practices in the supply chain.

By excluding personal information (the name of respondents), the collected data were encoded in the Statistical Package for Social Sciences (SPSS) for further analysis. The data were checked for possible outliers before running for statistical analysis. Preliminary descriptive analysis was carried out to identify inconsistencies and irregularities in data entry, which were then corrected by cross-checking the questionnaires.

2.3. Sampling technique and sample size determination

A reconnaissance survey was carried out with district horticulture experts to get an overview of onion production status. The survey was conducted on supply chains of onion production, marketing, and consumption at the farm, wholesale, retail, and consumers level to identify its major production and postharvest handling constraints.

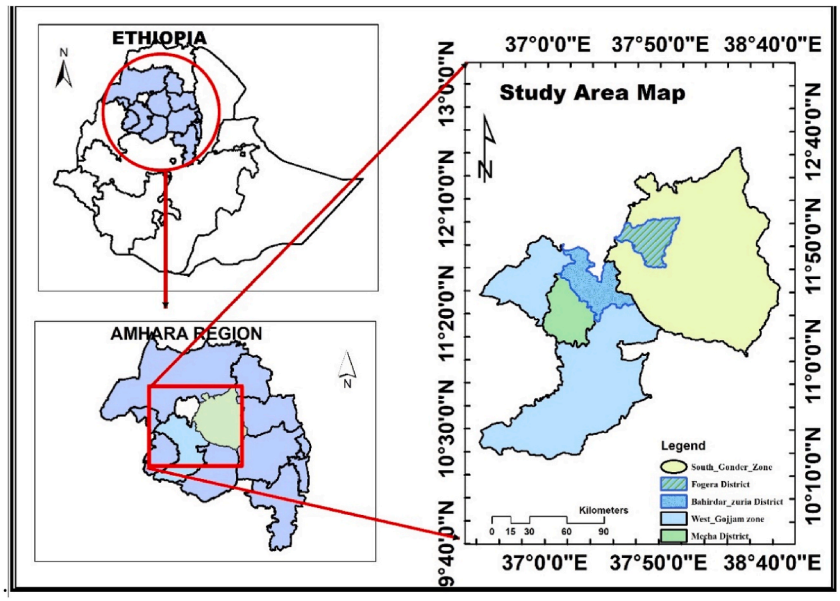


Fig. 1. Location map of the study areas.

Based on the previous studies, Elahi et al. [16] and Abbas [18], the multistage sampling procedure was employed with *kebeles* and farmers to select representative respondents to gather primary data and to reach out to target respondents from the large population size.

At the first stage of the sampling procedure; from major onion-producing *kebeles*, two highly potential onion-producing *kebeles* were selected purposely for their high onion production and marketing flow for many major market centers of the country. In the second stage of the sampling procedure, onion-producing households were randomly selected among each kebeles for an interview purpose.

In the third stage, for supply chains at wholesalers, retailers, and consumers, Bahir Dar, Woreta, and Merawi cities were also purposely selected as they are well known for large volumes of wholesale and retail trade of onions. The retailers chain was including roadside sellers, town market displayers, and other small-scale traders. Yamane's [19] sampling formula with a 7% precision level was applied to draw the sample sizes of the households; as

$$n = \frac{N}{1 + N(e)^2} \quad [1]$$

Where; n is the required sample size, N is the target population size (total number of onion-producing households), and e is the precision level (7%). In order to minimize the sample size, it is obliged to use the level of precision to be 7%. Consequently, the representative sample proportional sample size $n = \frac{N}{1+N(0.07)^2} = X$ onion growers were randomly selected and interviewed.

. Based on this, a totally 197 respondents from onion farmers, 15 wholesalers, 50 retailers, and 50 consumers were selected and interviewed as participants in the onion supply chain. Moreover, a key informant discussion was also conducted with agricultural office managers, development agents, and agricultural officers to augment the information supplied by respondents (Table 1).

Respondents from the consumer chain were interviewed considering the market nearness and vicinity of the study area. They were interviewed about their daily experience with the quality and handling of the onion together. Key informant interviews were conducted.

2.4. Conceptual framework

As can be illustrated in Fig. 2, based on literature and empirical evidence that the interrelationships of key variables involved in the study. Precisely, Institutional, Production, Socioeconomic and Demographic variables, Farm and Market related variables, are considered.

Socioeconomic variables are age, educational level, sex, and household size. Production variables access to improved onion varieties, access to fertilizer, and access to herbicides, and pesticides. Institutional factors like access to credit, participation in training, membership in cooperatives, farmer and farm-related variables (like land allocated to onions, onion farming experience), and market factors like (lagged onion market price, distance to nearest market, selling experience) influenced on market participation. Market participation leads to the level of participation (amount of onion sales) which, turn increased the household income.

2.5. Data analysis

To meet the objective of the study, the SPSS (Statistical Package for Social Science) software 16.0 version was used for data entry and analysis. Microsoft Excel computer program was also used to draw graphs and error bars. A descriptive statistic was also used that included to describe the socio-demographic and socio-economic profile and postharvest handling activities using frequency, mean and percentage, etc. Furthermore, inferential statistics (using the Chi-square test) was implemented to explore the significant association between socio-demographic and socio-economic aspects and onion production and postharvest management determinants. In addition, mean comparison techniques such as ANOVA and independent sample-t test were employed to compare the differences in onion production and postharvest management constraints among the supply chain actors or handling practices.

Table 1
Sample distribution in the selected districts and kebeles.

District	Kebeles	Total onion producing households	Number of proportional sampled (7%)
Mecha	Kudmi	300	12
	Engutti	300	12
Fogera	Shina	1058	40
	Quhar Michael	850	33
Bahir Dar Zuria	Yigoma	1715	65
	Sebatamit	920	35
	Total	5143	197

Source: District agricultural office, 2021

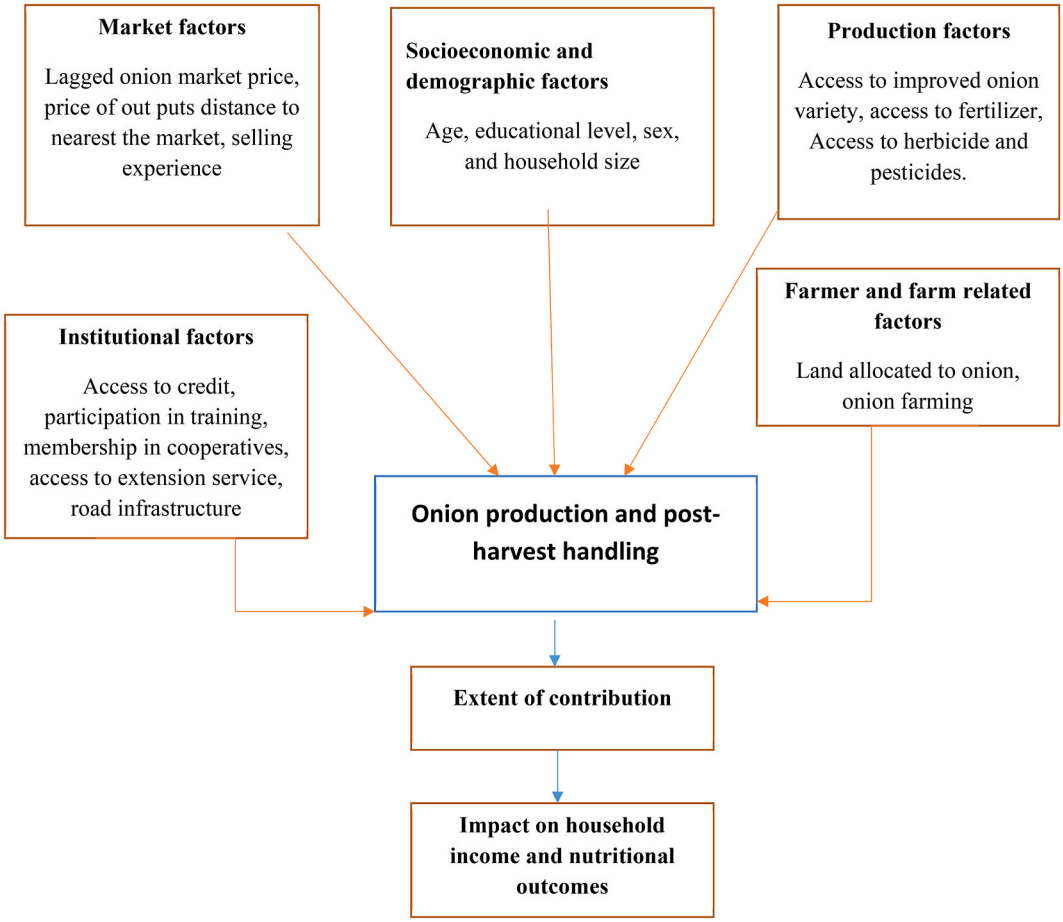


Fig. 2. Conceptual framework of the onion supply chain
Source: Own conceptualization.

3. Results and discussion

3.1. Socio-demographic characteristics

The result of the present finding indicated that male-headed households are the dominant chain actors in producers (98.5%) and

Table 2
Socio-demographic characteristics of onion supply chain actors in the study area.

Questioners	Status	Producer (N = 197)		Wholesaler N=(15)		Retailer N=(30)		Consumer N=(50)	
		Freq	%	Freq	%	Freq	%	Freq	%
Sex	Male	194	98.5	**15**	**100**	5	15.2	3	6
	Female	3	1.5	-	-	25	75.8	47	94
Marital status	Married	187	94.9	12	80.0	18	60.0	34	68
	Single	7	3.6	3	20.0	8	26.7	8	16
	Widowed	3	1.5			2	6.7	4	8
	Divorced	0	0			2	6.7	4	8
Educational status	Illiterate	37	18.8					7	14
	Read and write only	83	42.1				26.7	7	14
	1–6	31	15.7	1	6.7		10	4	8
	7–9	20	10.2	7	46.7		33.4	3	6.0
	10–12	18	9.1	7	46.7		20	16	32
	College level	1	0.5				10	8	16
	Higher education	7	3.6					5	10

Source: Own survey (2022) Where % = Percentage, Freq = Frequency

wholesalers levels (100%). While female-headed households are dominant in retailers (75.8%) and consumers (94%) chains. Implying that the majority of the onion-producing and wholesaling households in the study area are male-headed (Table 2). The present finding is in line with Gebrselassie [20], indicated that female farmers were discouraged owing to demands on their scarce time, price fluctuations, working capital, and difficulties selling onions and other high-value crops in Ethiopia. Similarly, based on the study conducted on the banana value chain in Uganda by Kikulwe [21] at the wholesale chain, all traders in the study area were male headed. Yeshiwas and Tadele [22] also reported in the fruit and vegetable retailing business in Debre Markos town, the dominant traders (85%) are females. Regarding the educational status of respondents, from 197 respondents in the producer's chain, five respondents (3.6%) were attending higher education and 18 respondents (9.1%) were attending grade 10-12. While 37 (18.8%) respondents are illiterate, and 83 (18.8%) respondents can read and write. On the other hand, the dominant supply chain actors in wholesalers, retailers, and consumers level are attained their secondary school (grade 10–12 (Table 2). Among supply-chain actors, wholesalers and retailers were attaining the minimum of primary school which showed educated youths prefer and compete for marketing of onion.

In addition, results show that the average age of the household head was 44, 43, 37, and 38 years for producers, wholesalers, retailers, and consumers, respectively (Table 3). Therefore, this is an indication of onion production and marketing in the study area is dominated by adult and educated persons with a strong labor force. As age is the primary demographic feature used to characterize the working capabilities of the respondents. Similar results were reported by Mossie [23] and Teklebrhan [24] who reported the average age of onion producers is around 44 years.

The results also showed that the average household number of the respondents in the study area was 5.7,4.67,4.93, and 4.8 for producers, wholesalers, retailers, and consumers, respectively (Table 3). The minimum number of family members actively working on cultivating, harvesting, and weeding activities are 1 and the maximum is 8 per household. The availability of high household size has a positive impact on the amount of onion production and handling, and it also reduces the production and marketing cost as they use family labor sources during onion production for marketing. Previous studies, for instance, CSA [25] and Abera [26] confirmed that the average household size in the East Shewa Zone of Ethiopia was ranged from 5.4 to 5.5 (~6) family members per household.

3.1.1. Socio-demographic characteristics and their association with onion production

The Chi-Square analysis was used to determine the significance of certain variables on onion production. The present study indicated that sex ($X^2 = 89.125$ and $p = 0.009$**), age ($X^2 = 2957.97$ and $p = 0.000$***) educational level ($X^2 = 406.61$ and $p = 0.04$*) had a significant influence on onion production. Household size ($X^2 = 622.6$ and $p = 0.000$**), production experience ($X^2 = 1212.57$ and $p = 0.000$**), land covered by onion ($X^2 = 894.4$ and $p = 0.000$**) has also had significant effect on onion production (Table 4). Likewise, independent variables such as sex, marital status, education level, active household size, production experience, and land covered by onion ($X^2 = 1101.73$ and $p = 0.000$**) were found to be very highly significantly associated with the dependent variable onion yield. However, marital status ($X^{2=}112$ and $p = 0.686$) was not significantly associated with the dependent variable onion yield. As expected educational level, household size and production experience positively influence onion production.

3.1.2. Socio-demographic characteristics and their correlation with postharvest management along the supply chain

Chi-square test on postharvest loss at different supply chains indicated that independent variables such as sex, age, education level, active household size, selling experience, amount purchased and storage duration have significant associations with postharvest loss at producers and consumers levels. However, at the retailer's level, selling experience and storage duration are significantly associated (Table 5). As expected age, educational level, household size, production experience, amount of onion bulbs harvested/purchased positively influence onion production and postharvest loss along the supply chain. The present finding is in line with the results of Kereth [27]; Adugna [28]; Yeshiwas and Tadele [22] who reported the spoilage percentage of harvested fresh commodities increases as selling time increases, as their exposure to fluctuating environmental condition. Masood [29]; Yeshiwas and Tadele [22] also reported similar results as the age and sex of traders did not significantly influence the postharvest loss of fruit and vegetables at wholesalers. In contrast to the present finding, Abera [26], reported that gender has a significant contribution to the postharvest loss of tomatoes.

At the wholesaler's level, variables are not significantly associated with postharvest loss. At the consumer's level, age, total household size, amount harvested/purchased, and storage duration were significantly influenced by onion postharvest loss. While the educational level and marital status did not significantly influence the loss of onions (Table 5). The result is probably due to the majority of respondents at the consumer level being educated.

3.2. Farmers knowledge on onion production practices in the study areas

The present result indicated that households in the study districts have diversified income sources. However, a mixed type of

Table 3
Mean of age of the households and household size of onion producers in the study area.

Indicators	Producer N = 197	Wholesaler N = 15	Retailer N = 30	Consumer N = 50
	Mean _ SD	Mean _ SD	Mean _ SD	Mean _ SD
Age of the household head (year)	44.7 ± 8.728	43.33 ± 8.812	37.56 ± 6.806	38 ± 9.88
Total household size (number)	5.7 ± 1.704	4.67 ± 1.63	4.93 ± 1.617	4.8 ± 1.89

Table 4
Chi-square results for socio-demographic/economic factors and onion production by farmers.

Variable	Chi-square value (X^2)	d.f	*P*-value
Sex	89.125a	60	0.009**
Age	2957.97	2520	0.000***
Educational level	406.61	360	0.04*
Marital status	112.026	120	0.686ns
Household size (number)	622.6	413	0.000***
Production experience (year)	1212.57	960	0.000***
Land covered by onion (ha)	1101.73	480	0.000***

Where, NS=Non significant, *, **and*** significance difference at 5%, and 1% probability levels, respectively. ha = hectare.

farming which includes the production of cereal crops, vegetable crops, and rearing animals was found to be the major source of income. Among vegetable crops production, onion is the primary source of income which shared 86.6% of households followed by tomato (8.1%), potato (4.1%), head cabbage (0.5%), pepper (0.5%), and papaya (Table 6). Around 64% of respondents produce onions on their farms. While 22.8% of respondents were producing onion on their family land, 8.6% obtained by gift, 3% inherited from their relatives, and 1.5% of onion farmers were produced by renting the land. Relatively Farmers produce their onions on rental land are covered a larger area (Table 6). In contrast to the present study, Baloch [30] reported 31.6% of onion farmers have ownership and the remaining 68.4% produce onions on rental land.

The study result also indicated that the majority of onion producers 172 (87.3%) produce onion once per year by using irrigation while 25 (12.7%) of the respondents produce twice per year by using irrigation in the study area. The total average cultivated area was 1.09 ha with a standard deviation of 0.47 ha. While the minimum land allocated for onion was 0.5 ha and the maximum 3 ha. The land average allocated for onion was 0.49 with a standard deviation of 0.297 ha. While the minimum land allocated for onion was 0.125 ha and the maximum was 2 ha (Table 6). This implies that onion farming becomes a promising venture.

3.2.1. Nursery management practices

The result revealed that all respondents in the study area produced onions by transplanting. The transplanting stage of seedlings was 30 days after seed sowing and extends up to 60 days after seed sowing. Among respondents, 56 (28.6%) and 54 (27.6%) are transplanting their seedlings at 45 and 50 days after sowing, respectively.

Trimming seedlings 3–4 days before transplanting and during transplanting to make them grow thicker and stronger is a common practice in the study area. In addition, extremely vigorous seedlings (older than 60 days), extra seedlings after transplanting, and when seedlings are ready before the main field preparation (Table 7). About 125 (63.5%) respondents were trim their seedlings before transplanting while 72 respondents (36.5%) did not trim the top of the seedlings. Farmers trim their seedlings to produce suitable and uniform seedlings for transplanting, to avoid lodging of vigorous grown seedlings, to hasten field establishment after transplanting, to initiate/rejuvenate new leaf regrowth, and to avoid pre-translating bulb development.

The present survey result also indicated that the planting distance between irrigation furrows, between plants, and between rows varies from one farmer to another. About 36 respondents (18.6%) were transplanting their seedlings through broadcasting. Broadcasting type of transplanting was widely practiced in the Fogera district. The reason they broadcast is, they believe that this type of transplanting demands less labor during planting and weeding, is simple to irrigate, and is used to save water and labor. The minimum planting distance between the irrigation furrow, row, and plant is 10 cm, 10 cm, and 3 cm, respectively. While the maximum is 60 cm, 40 cm, and 7 cm between furrows, rows, and plants, respectively. The majority of farmers were transplanting their seedlings by using 5 cm spacing followed by 3 cm spacing. Three (3) cm intra-row spacing is very narrow for onions, which increases the number of unmarketable small bulbs. A similar result was presented by (Olani and Fikre [31]; Habtamu [32] who indicated 6 cm is the optimum intra-row spacing to obtain the highest marketable bulb yield of onion with the maximum number of medium-sized bulbs.

3.2.2. Irrigation access, sources and its problems

In the study area, onion production was entirely carried out by using irrigation. All respondents (197) in the study area were produced their onions by using irrigation. However, the access to irrigation was varied from one farmer to the other. From the total respondents, 77 (77%), in the Bahir Dar Zuria district, and 4 (16.7) at Mecha district were accessing sufficient irrigation water. They apply irrigation water 7 days–14 days' intervals and 7 days–16 days intervals at Bahir Dar Zuria district and Mecha district, respectively. However, at the Fogera district all respondents did not get sufficient irrigation water. They apply irrigation water every 15 days at an early stage (up to one month of transplanting) and every 7–10 days one month after transplanting. The longer irrigation interval at Fogera district was because the soil is vertisol, the better capacity to hold water (Table 8). Agumas [12] reported similar result in Fogera district, onion producers are suffered by irrigation water shortage.

As illustrated in Fig. 3, onion producers in Bahir Dar Zuria district were using rivers and dams such as Andassa, Abay, Tikurit, Yeshmet, and Yizana as major irrigation sources. In Mecha district, the only irrigation source was Koga Dam. While at Fogera district, the major irrigation sources are the Gumara river, Ground water, and the Guanta river. There is sufficient irrigation water at the Andassa district, moreover, at this district there is flooding due availability of excess water. However, at Fogera and Mecha districts frequently encounter a shortage of irrigation water especially in March–April in relation to the use of irrigation. The reasons for the shortage of Fogera were the high cost of fuel and its shortage in the market for groundwater users, increasing the number of onion growers by irrigation, and increasing production of teff and wheat by using irrigation. In Mecha the district, the major reason raised

Table 5
Chi-square results for postharvest loss of onion and Socio-demographic factors at supply chains.

Variable	Producer			Wholesalers			Retailers			Consumers		
	X^2	d.f	Pvalue	X^2	d.f	Pvalue	X^2	d.f	Pvalue	X^2	d.f	Pvalue
Sex	99.87	66	0.005**	No statistics are computed because sex of the respondents is a constant.			16.000 a	15	0.709ns	4.331	11	0.959
Age	3561.55	2772	0.000***	138.7499	130	0.284	2.586E2a	240	0.195ns	3305.60	220	0.000**
Educational status	406.6	354	0.028**	38.750a	30	0.131	81.944a	90	0.715ns	70.694a	66	0.324ns
Marital status	122.11	132	0.72ns	11.875	10	0.294ns	40.602a	45	45.487a	45.487a	33	0.072ns
Total household size	554.48	462	0.002**	63.54a	60	.353ns	107.22	90	0.104ns	157.35	88	0.000**
Producing/Selling experience	1212.32	1056	0.001**	75.417a	70	0.308	175.41a	135	0.011*			
Amount harvested/purchased	10743.73	3960	0.000**	1.238E2a	100	0.05*	71.825	60	0.141ns	22.312E2a	132	0.000**
Storage duration				55.417a	50	0.278ns	48.018a	32	0.034*	2.654E2a	156	0.000**

NS=Non significant, *, **and*** significance difference at 5%, and 1%, probability levels respectively.

Table 6
Income sources and annual onion production cycle and by using irrigation.

Questioners		Frequency	Percentage
Main income sources	Vegetable production	43	21.8
	Cereals Production	2	1.0
	Mixed	152	77.2
Comparative income source from vegetables	Onion	171	86.8
	Tomato	16	8.1
	Potato	8	4.1
	Cabbage	1	0.5
	Pepper	1	0.5
Means of land acquisitions	Owned	126	64.0
	Gift	17	8.6
	Family	45	22.8
	Rented	3	1.5
	Inherited	6	3.0
Onion production cycle per year	Once	172	87.3
	Twice	25	12.7
Onion production per year by using irrigation	Once	172	87.3
	Twice	25	12.7
Land covered by onion in ha	Mean SD	Minimum	Maximum
	0.49175 ± 297221	.125	2.000

Source: own survey (2022)

Table 7
Seedling management practices in the study districts.

Questioners	Status	Producer (N = 197)	
		Frequency	%
Stage of transplanting	30 Days	8	4.1
	35 Days	12	6.1
	40 Days	48	24.4
	45 Days	56	28.4
	50 Days	54	27.4
	55 Days	13	6.6
	60 Days	6	3.0
Practice of trimming seedlings	Yes	125	63.5
	No	72	36.5

Where, % = Percentage.

Table 8
Irrigation practices in the study districts.

Questioners		B/Dar zuria (N = 100)		Mecha (N = 24)		Fogera (N = 73)	
		Freq	%	Freq	%	Freq	%
Access to sufficient irrigation water	Yes	77	77.0	4	16.7	0	0
	No	23	23.0	20	83.3	100	100
Irrigation frequently in days' interval	7	49	49.0	10	41.7		
	8	17	17.0				
	10	13	13.0	9	37.5	25	34.2
	12	12	12.0	3	12.5	1	1.4
	13	6	6.0			1	1.4
	14	3	3.0				
	15			1	4.2	10	13.7
	16			1	4.2		
	15 days Early and 10 days MAT					14	19.2
	15 days Early and 7 days MAT					14	19.2
	15 days Early and 8 days MAT					8	11.0

Where, Freq = frequency; % = Percentage; MAT = Months After Transplanting.

was the delayed release of water from the source/dam.

3.2.3. Access to production inputs

3.2.3.1. Hybrid variety production practice. Use of better quality varieties is the basic input and foundation for better yield and longer

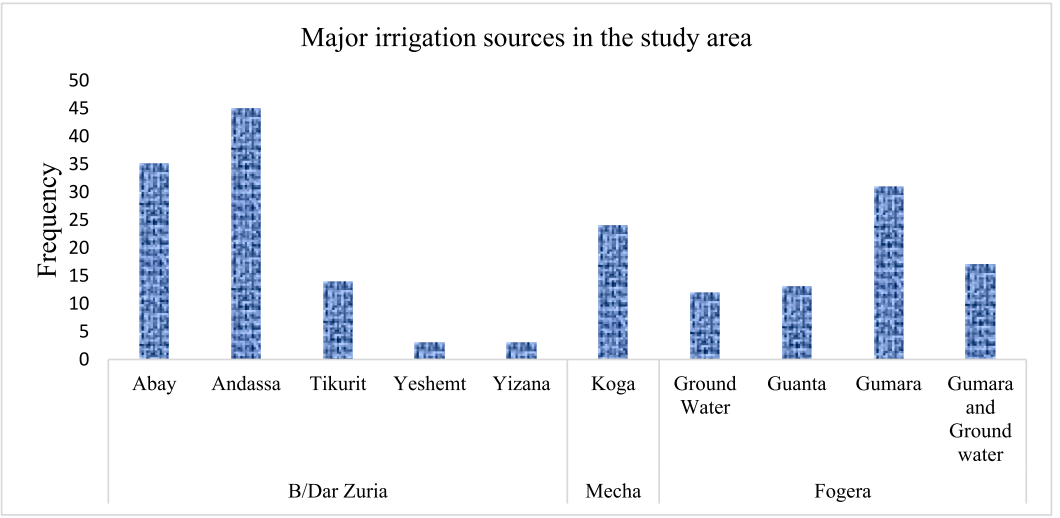


Fig. 3. Major irrigation sources of onion in the study area.

storage periods. Additionally, hybrid crops can play an important role in supporting global food security. They produce higher yields and are often more resistant than non-hybrid varieties to disease and climate stress. In the study area, farmers were experienced in adopting hybrid onion varieties. The present assessment results indicated that hybrid onion variety production was started in the study area. From the total respondents, 26 (13.2%) produce hybrid onion varieties such as Jambar, Russet, and Red Coach. These varieties are under production in a large area as well as in the demonstration plot (Table 9). On the other hand, 171 respondents (86.8) were not producing hybrid onion varieties due to the high seed cost, lack of extension advise, and lack of awareness, respectively (Table 9). As expected hybrid seed access and production is positively correlated with onion production and post-harvest handling.

It has been three years since farmers were started growing the hybrid onion varieties. During 2011E.C/2018G.C 7.69% of respondents were starting hybrid onion variety production, while during 2013E.C/2020G.C which is 80.76% (Fig. 4a). The trend indicated that in the presence of better awareness and better extension advice, more farmers can produce hybrid onion varieties. Hybrid onion variety producer respondents explained that they will not be stopping the production of this variety. As they are high yielders and stored for a long period.

Among hybrid onion producers, 9 (4.56%) respondents were preferred the Jambar variety followed by Russet which is preferred by 8 (4.06%) respondents. While 9 (4.56%) respondents were preferring all existing varieties such as Jambar, Russet, and Red coach. These varieties are preferred due to the reason that longest storage period, better yield advantage, and high market demand (Fig. 4b).

3.2.3.2. Access to hybrid variety seed supply. Access to quality seed is essential to increase crop productivity. In the study area, 34 (17.3%) respondents have sufficient access to hybrid seed varieties. However, 163 (82.7%) respondents have no information about the accessibility or inaccessibility of seeds. For the hybrid onion variety, the producer's main seed sources are local markets and Non-Governmental organizations (NGO) as (Table 10). As the extension agents and district agriculture officers explained SNV project is the major hybrid seed/seedling source for farmers.

3.2.3.3. Access to fertilizer and pesticide supply. The present study indicated that farmers were not timely and adequately obtaining fertilizers from formal suppliers such as cooperatives. Twelve respondents (6.1%) obtained fertilizers from cooperatives, while 185

Table 9
Names of varieties grown by onion producers.

Questioners	Options	Frequency	%
Growing hybrid onion varieties	Yes	26	13.2
	No	171	86.8
Name of varieties	Jambar	9	
	Red Coach	7	
	Russet	17	
Under production	Under production	26	
	At demonstration plot	4	
Not producing hybrid varieties	High cost of the seed	55	27.9
	Lack of extension advice	53	26.9
	Lack of awareness	63	32.0

Where, % = Percentage.

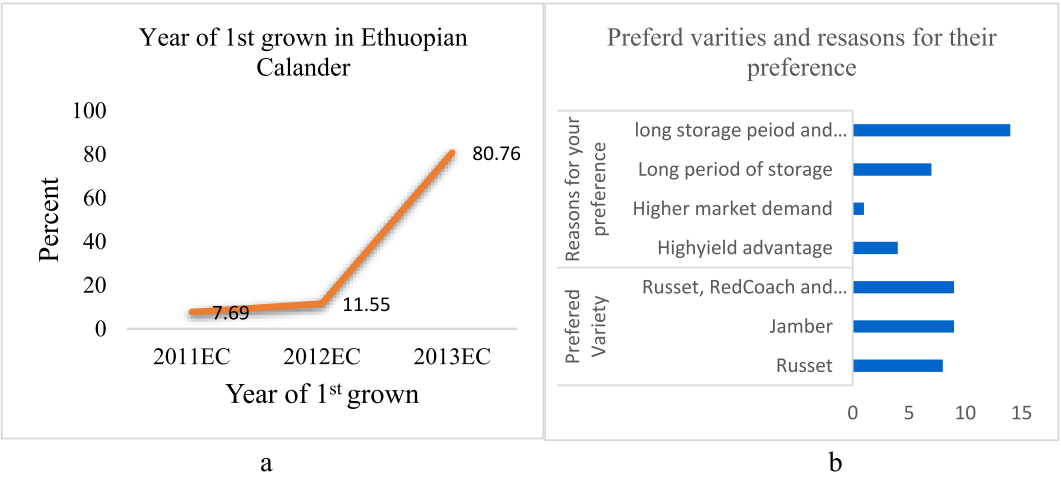


Fig. 4. a. Year of first grown in Ethiopian Calendar
b. hybrid variety preferred by farmers.

Table 10
Access to hybrid seed varieties.

Questioners		Frequency (N = 197)	%
Sufficient access for hybrid varieties	Yes	34	17.3
	No/DHI	163	82.7
Sources of hybrid onion seed	Market	10	5.1
	NGOs	16	8.1
Way of getting seeds	Purchase	11	5.6
	Gift	15	7.6

Where, % = Percentage.

(93.9%) purchased from the local markets at the high prices due to the inadequacy of fertilizers access they received from cooperatives. The farmers also purchase insecticides and pesticides from suppliers at the nearby markets (Table 11). The reasons for inadequate access to fertilizers are supply shortage from the source and sometimes there is delay and unfair distribution from the cooperatives, and unfair price also added in urea fertilizer. To achieve maximum yield, the shortage of fertilizer is a great bottleneck for onion producers in the study area. For the existing problems, farmers have used different solutions to get better yields. Among the alternative solutions used by farmers, whatever the crop and area covered they were addressing, the amount they get, using organic fertilizers, addressing the amount we get and using organic, and some farmers purchase before pick time and store them for late use (Table 11).

Timsina [33] described that increased fertilizer application rate can increase crop yields up to the optimum level and improve global food security, and inadequate application rate can decrease crop yields. Brewster [34] also indicated that maximum yields of onion can only be obtained with adequate fertilizer application.

3.2.3.4. Fertilizer and pesticide application rate. High and better yield can only be achieved with the adequate application of fertilizers and pesticides. Raising the recommended level to the optimum of nitrogen also maintains a high significant level of increments in the

Table 11
Fertilizer and pesticide access in the study area.

Questioners		Frequency (N = 197)	%
fertilizer access timely and adequately	Yes	2	1.0
	No	192	97.5
Sources of fertilizer	Cooperatives	12	6.1
	Local market and Cooperatives	185	93.9
Source of pesticide	Local market	197	100
Reasons for inadequate access	Supply shortage, high cost urea	197	100
Alternatives to solve the problem	Addressing the amount we get and using organic	30	15.1
	Purchasing from merchants by high price	179	90.5
	Purchasing before and storing	31	15.7
	Purchasing form local market use of organic fertilizers	9	4.6
	Use of organic fertilizers	14	7.1

Where, % = Percentage.

total yields, and average bulb size and reduces the percentage of bolting [35]. In the study area, all respondents were applying chemical fertilizer/synthetic fertilizers (NPS/B and Urea), and organic fertilizers such as compost and animal manure during onion production. However, the quantity of fertilizer and chemicals applied varied across the respondents. The mean application rate of NBS/B is below the recommended rate. Among the total respondents, 153 (77.7%) respondents used both NPS/B and Urea, 28 (14.2%) respondents used only NPS/B fertilizer and 14 (7.1%) applied NPS/B, Urea, and organic fertilizers together. In the study area, NPS/B is the major source of nutrients for onion production. However, the majority of reposndants193 (98%) applied above the recommended rate (Table 12). The respondents also explained that soil fertility is reduced every year, thus the land needs a high amount of fertilizer, without applying a high rate of fertilizers, we did not expect a better yield. The minimum amount of Urea and NPS/B fertilizer rates were 25 kg per hectare while the maximum application rate was 500 kg/ha for NPS/B and 350 kg/ha for Urea (Fig. 5). According to the district agriculture office, the recommended rate of fertilizer application for onion cultivation is 200 kg DAP and 100 kg Urea per hectare, respectively. Thus, the mean of Urea is increased by 5.04% from the recommendation and the mean of NPS/B is decreased by 29.5% from the recommendation. The main reasons for improper application of fertilizers and chemicals were due to the reduction of land fertility, the recommended amount of fertilizer does not provide high yield, the increasing cost of fertilizer, awareness problem, shortage of supply, reduction of agro-chemical effectiveness, and to obtaining maximum yield (Figs. 5a–c).

3.2.4. Major constraints for onion production

The current survey result indicated that the aveage yield of onion in the study area was 16 tons/ha, which is better than Amhara National Regional State (11.67 t/ha) reported by CSA [36]. Nevertheless, producers in the study area were producing onion yields below the world average of 19.7 tons/ha [37]. As explained in Fig. 6 onion production (1993E.C-2013E.C) in area coverage per hectare and yield quintal per hectare. Area coverage per hectare shows a significant increasing trend with a slight fluctuation. However, the productivity of onions shows an entirely decreasing trend [38]. Thus, as all respondents explained in the investigation area, 100% of onion producers were challenged with multiple production constraints from input access to harvesting and postharvest handling practices. Due to these reason, the yield of onions is decreasing rate. A similar trend was explained by Getu and Ibrahim [39] who indicated improper application of agronomic practices in the adequate application of fertilizers, high cost of inputs, and weak market linkage are the major constraints that hinder onion productivity. As expected, cost of farm inputs like fertilizer, pesticides, and fuel was negatively influence the production of onion and its supply to market.

The present field survey results combined with group discussion and key informant survey indicated the major constraints. Among the constraints are high postharvest loss, market linkage problems, low market price, lack of awareness of how to extend the shelf life of onions (rotting, sprouting), absence of better storable varieties, and low price during pick harvesting time, shortage of fertilizer access and high price, absence of storage room, poor access to road, disease and insect pest, lack of awareness on storage methods, interference of brokers in market information, rain at maturity period, irrigation water shortage, lack of pure seed, fuel shortage, labor cost, less extension support, similar planting calendar and pesticide supply and safety problem (supply of expired products) (Fig. 7). These results are in line with, the study conducted by Almaz [40] who indicated that the onion and tomato value chain is complicated by a lack of production and marketing skills.

3.2.4.1. Disease and insect pests. In the study area, diseases and insect pest infestation were very high. As a result, the major diseases found were powdery mildew (*Leveillula taurica*), Downy mildew (Mech in local language), and Black fungus and Thrips (*Thrips tabaci*) are the major insect pests that hinder onion production. The type of disease was diagnosed by farmers and district extension officers. Different kinds of disease protection chemicals were used by farmers, among the pesticide/insecticide chemicals, Omaxis was used as a preventive chemical, Redomil Gold was used to control powdery mildew, Ajanta and Prostar were used to manage Thrips. During chemical application, the farmers were not wearing safety clothes (Table 13).

3.2.4.2. Market price. Farmers grow onion for market supply and to get cash. However, due to its perishability nature, production is seriously affected by price fluctuations every year. The present result indicated that the minimum lagged price of onion at pick harvesting time was one birr per kilogram, however, the minimum lagged price during offseason was 13 birr/kg, and the maximum lagged price during the pick harvesting period was 7 birr/kg and the maximum lagged price was 33 birr/kg. Thus, there is a great onion market price difference within a year. The farmers are not benefited from the increased price (Table 14). This was due to farmers' lack better storage facilities for late selling, lack of better storable varieties, planting onions at similar planting times, rain at harvesting,

Table 12
Type of fertilizers used by respondents in the study area.

Questioners		Frequency (N = 197)	%
Use of fertilize	Yes	197	100.0
Type of fertilizer used	NPS/B	28	14.2
	NPS/B and Urea	153	77.7
	NPS/B, Urea Organic	14	7.1
	NPS and organic	2	1.0
properly application of recommended fertilizer and chemical rate	Yes	4	2.0
	No	193	98.0

Where, % = Percentage.

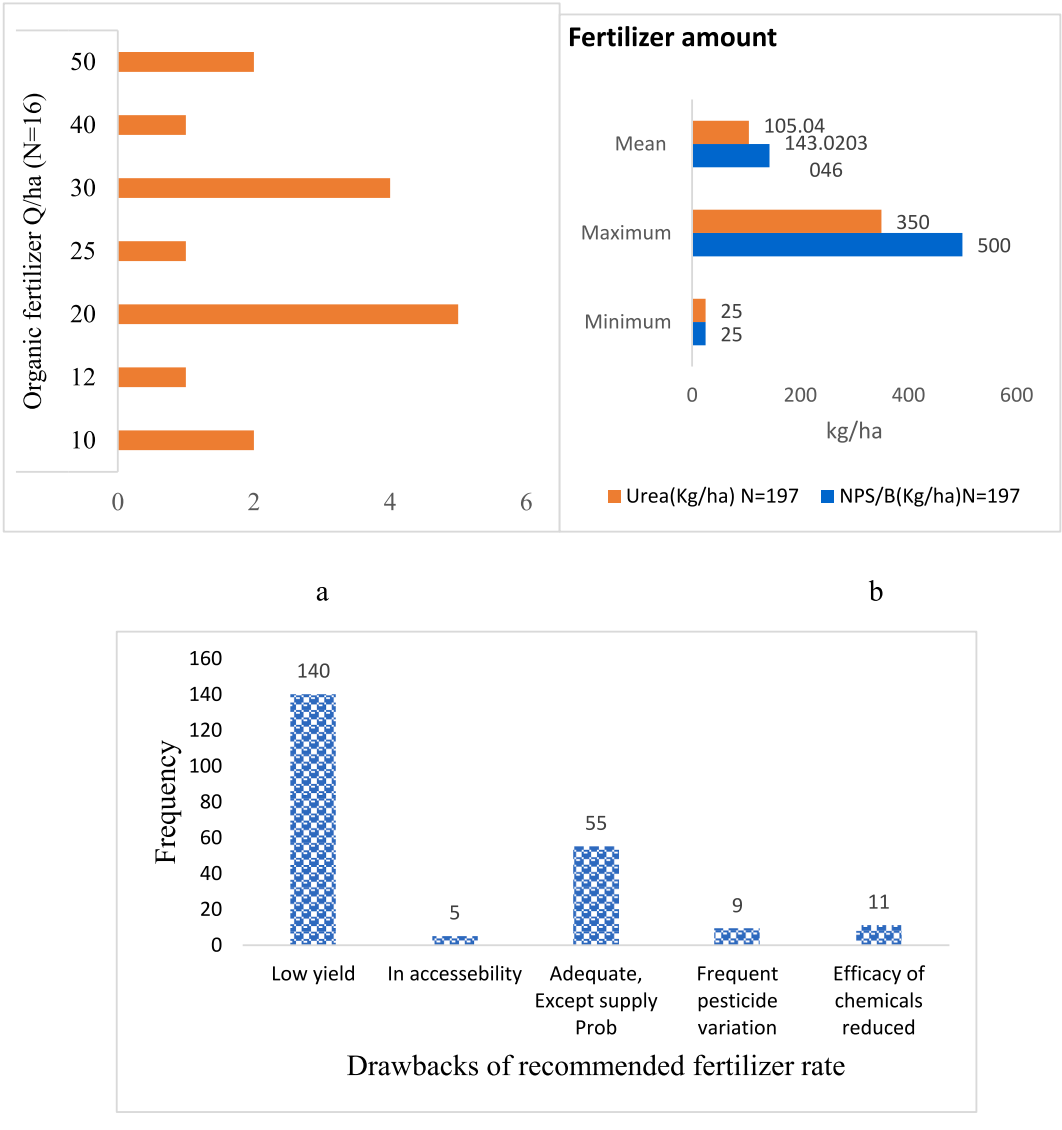


Fig. 5. a. Amount of fertilizer applied
b. Amount of fertilizer applied
c. Drawbacks to recommended fertilizer rate.

disease, and insect pests affecting the farmers to extend shelf life. These results are in line with the findings of Almaz [40] who reported onion production is affected by price fluctuations and unfair prices.

3.2.4.3. Brokers. In the study area, there are middlemen (brokers) that are information providers in the chain, mainly between farmers and wholesalers. The broker also checks the quality of the onion bulbs and supervises the harvest process. In addition, they are major actors to determine the price between farmers and wholesalers. Also, they have the great role of bargaining the price between farmers and wholesalers. However, the respondents in the study area indicated that brokers were blocking the market information and setting the selling price by themselves to underestimate the selling price of onion. In some cases, they created a problem by collecting the produce by credit and taking to a limited client, cheating selling weight, and wrong price information. Brokers are aware of the harvested onion cannot be stored for a long period of time, they put pressure on producers to sell their onions at low prices. In general, because of the aforementioned reasons, farmers are not storing onions for a long period of time (Table 15).

3.2.4.4. Access to credit. Credit facility access enhances the financial capacity of onion producers which enables them to purchase required production inputs such as improved varieties of seed, chemical fertilizers, pesticides, insecticides, fuel, etc. As a result, access

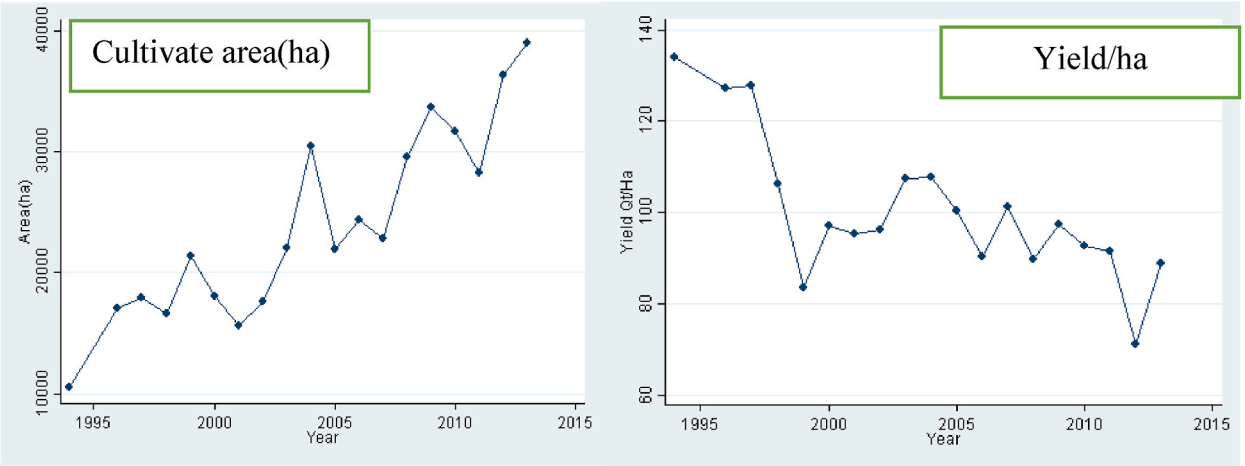


Fig. 6. Onion production trend in Ethiopia (1993-2013E.C)
Source; CSA [389].

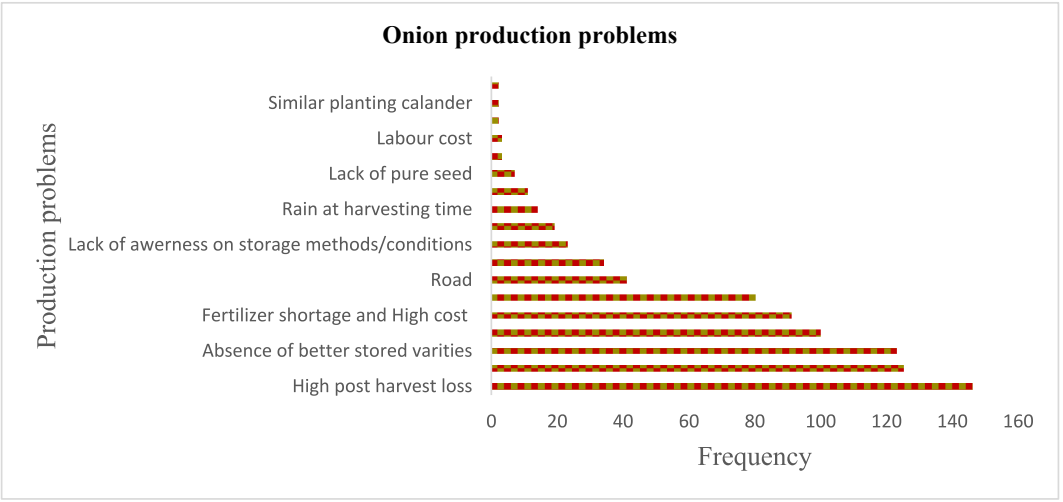


Fig. 7. Major onion production constraints in the study area.

Table 13
Major diseases in the study area.

Questioners		Frequency (N = 197)	%
Major diseases	Mech	44	22.3
	Powdery Mildew	151	76.6
	Black fungus	30	15.2
Major insect pests	Thrips	197	100.0

to credit in the study area was not well practiced, as a result, the farmer's areas purchased all farm inputs in cash.

3.3. Harvesting and postharvest handling practices in supply chains

3.3.1. 1.Post-harvest handling practices at farm level

3.3.1.1. Harvesting. The stage of maturity is one of the most important factors determining crop quality and storability/shelf life. Furthermore, harvesting immature onion bulbs can lead to bruising, hastened sprouting time, and the highest weight loss. Onions are usually harvested when the neck of onion bulbs fails down to the ground. Manual harvesting is the most common practice in the study

Table 14
Onion price in the study area.

Indicators	Producer N=(197)		
	Minimum	Maximum	Mean _ SD
The market price of onion at its pick harvesting season in 2013?Birr/q	0.1	7	1.9 ± 1.009
The market price of onion per quintal at its off season (summer) in 2013	13	32	21.62 ± 5.59574
	Frequency (N = 197)		**%**
Comparatively price evaluate in the price for two seasons	Increasing	197	100
Benefiting from the increased price	Yes	4	2.0
	No	193	98.0

Table 15
The role of brokers/middle man.

Questioners		Frequency (N = 197)	%
Availability of brokers	Yes	197	100
Selling price decision	Yourself	1	0.5
	Brokers	179	90.9
	Market demand and supply	9	4.6
	By negotiation	8	4.1
Role of brokers with regard to selling price	Bargaining the market	32	
	Contact the sellers and buyers	2	
	Underestimation of the price	180	
	Credit	17	
	Block the link b/n farmers and merchant	15	
Problems created by brokers with regard to onion market	Took to limited client, cheating selling weight, Wrong price information	197	100.0

area. The majority of onion producers 120 (60.9%) responded that onion harvesting is based on bulb maturity (leaf color changed from deep green, to light green or yellowish). While the remaining 8 (4.1%) and 69 (35%) respondents harvest their bulbs based on market price alone and on both maturity and market price. In the study area, almost all onion producers harvested their produce at any time of the day by digging with human power by using a hoe (*Ankassie, Mekotkocha*) which damages bulbs during digging and hastens the spoilage rate of bulbs.

Onion bulbs are susceptible to high storage losses as they contain a high amount of water. Once harvested, their internally stored food and water decline over time. As a result, bulbs are subject to sprouting, rotting, and shrinkage losses during storage. Curing techniques help to improve the shelf life (storage quality) of onion, which in turn increases the return from onion production and stabilizes the market situation. In the present study, most of the farmers don't practice curing/drying after harvesting which reduces the shelf life of harvested onions and thus increases the postharvest losses. The survey result also indicated that curing practice for five days was applied by 7 (3.6%) respondents. The remaining respondents 33.5% and 62.9% were avoiding the top of the bulb at the time of selling and immediately after harvest, respectively (Table 16). Different types of maturity indices were used by farmers in the study area. Among the indices, are leaf drooping/drying, leaf color change, neck fail, 90–120 days after transplanting, market demand, bolting, high pungency of leaves during leaf cutting, and bulb crack of the soil (Fig. 8).

Different types of cultural practices such as toppling, applying irrigation water at the time of harvesting, stopping irrigating fields, and reducing irrigation frequencies were applied before harvesting (Fig. 9). Toppling was applied to increase bulb weight, strength, and bulb quality, better bulb filling, and to increase bulb weight by translocating food from the leaf part to the bulb and to stopping further vegetative growth. Applying irrigation water at the time of harvesting was applied to soften the soil at harvesting, increase bulb weight, improve bulb color/shiny/, increase, get better color, and increase yield and bulb quality. Stopping and reducing irrigation

Table 16
Harvesting practices of onion in the study area.

Questioners		Frequency (N = 197)	%
Criterion to harvest onion	Maturity	120	60.9
	Market price	8	4.1
	Both	69	35.0
Harvesting time	Anytime/the whole day	197	100.0
Harvesting material used	Pulling by hand	9	4.6
	Digging by hoe/*Ankassie*	176	89.3
	Both	12	6.1
Time of top removal	5 days after harvest	7	3.6
	at the time of selling	66	33.5
	Immediately after harvesting	124	62.9

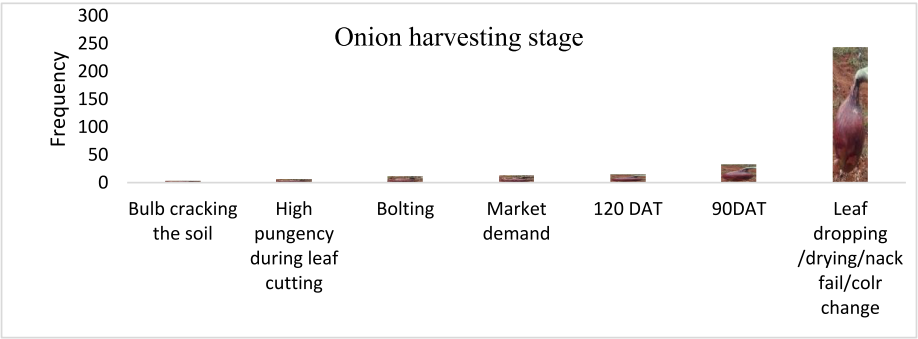


Fig. 8. Harvesting stage of onion.

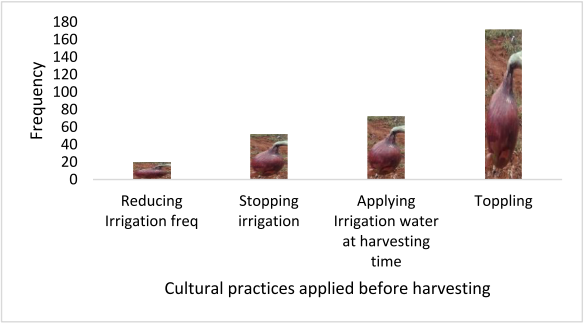


Fig. 9. Cultural practices applied before harvesting.

frequencies were applied to avoid bulb rotting and sprouting, to harden/strengthen the bulb skin to hasten maturity time.

3.3.1.2. Transportation. Onion whole sellers, local collectors, and retailers in the study area were purchasing the produce from producers and transported by using different methods of transportation. Among different transportation mehods, using open truck is the main transportation method, when the farmers sold at the farm. While *animal driven gari* and human labor were used when farmers delivered the produce to the market. All onion producers were facing a market problem (Table 17). Worku and Ülkü [41] reported similar practices as the primary mode of transportation to deliver the onions harvested to the nearest market place was by using cart (62.8%) followed by truck (19.7%) and labor (17.5%).

Moreover, the road access in the study area is poor, and not suitable and causes vibration of bulbs during transportation. The vibration leads to bruising, mechanical damage, and high postharvest loss on the bulbs. Idah et al. [42] explained that vibration during transport because of road roughness is one of the major causes of postharvest losses of fruits and vegetables.

3.3.1.3. Market problem and storage. Because onion bulbs produced are harvested at a relatively similar time, the market is over-saturated and resulting in lower market prices. Farmers in the study area are not storing their onion bulbs for a long period. They rather prefer to sell their produces immediately after harvest with current market prices which are mostly unsatisfactory/low. However, to get the better market price, only 35 (17.8%) respondents were storing their produce for five days to two months for late

Table 17
Marketing problems in onion produce.

Questioners		Frequency	%
Type of transport used	*Animal driven gari*	59	
	Human labor	24	
	Open Track	127	
Presence of market problems with regard to onion price	Yes	197	100.0
Storing onion bulbs for late selling	Yes	35	17.8
	No	162	82.2
Storage duration N = 35	5 days	7	3.6
	6 days	12	6.1
	1 week	10	5
	2 weeks	3	1.5
	2 month by renting storage room	2	1

selling at a better price. The remaining 162 (82.2%) respondents were not storing their produce. Because the existing varieties are not stored well, awareness problem, shortage of storage technologies/methods, improper care during harvesting, lack of storage room, and poor storage period. Bezabih [43] reported that over 30% of postharvest losses of vegetables in Ethiopia were registered mainly due to poor handling practices, marketing, storage and transport.

3.3.1.4. Handling practices and its losses. Inadequate postharvest management of fresh onion results in a large amount of losses. Improper handling, poor application of agronomic practices, lack of sorting and cleaning, improper packaging materials, diseased and damage during harvesting, lack of appropriate transportation, and storage facilities are the main problems for postharvest loss. The present survey results as indicated in Fig. 10 revealed that during 2013E.C/2020G.C cropping season unsuitable bulbs from harvested produce range from 2% to 100% (when the farmers left harvesting when the market price is low).

The present survey result also revealed that in the study area, due to improper handling and packaging, onions often suffered from mechanical damage during transportation and storage and there is large postharvest loss (Table 18). It was also possible to observe during the assessment period that onion handling during packing and loading was rough as the harvested bulbs are heaped in strong sunlight and packaged in 100 kg weight content burlap sacks and waiting for trucks in strong sunlight and harsh conditions. In addition, loaders walk on top of packaged produces, pack too high amount, and overloading of vehicles, which causes mechanical damage and increased the extent of losses at all levels of the supply chain. The reason for the use of all-purpose burlap sacks and as a major packaging materials was their accessibility and low cost. However, such kind of packaging material does not properly ventilate the air in the onion bulbs and causes sprouting and rotting. Kader and Rolle [44] explained that using sack container for fruits and vegetables creates high heat because of metabolic reaction which ultimately hastens mechanical damage and microbial attack.

The respondents explained that around 124 farmers practice measure to minimize loss after harvest. Among the strategies to reduce the loss, of immediate sale, delay to top removal, adjusting planting time, planning to produce hybrid varieties, and constructing a storage room (Fig. 12).

In the study area during marketing, all 100% of respondents were packing their produce in a burlap sacks. While during home storage majority 44.7% and 44.2% of respondents were spread on the ground and packed by using jute/burlap sacks, respectively. The remaining 6.1 and 5.1% of respondents stored their bulbs on-field storage and shelf, respectively (Table 18).

3.3.1.5. Marketing component. The present finding indicated that the majority of farmers 94.3% were selling their onions to wholesalers while 5.6% were to (local collectors/brokers). The remaining 3%, 1.5%, and 1% were sold their produce to cooperatives, retailers, and consumers, respectively. The majority of farmers were preferring their customers due to large volume purchases. About 31.5% of farmers responded that there were established cooperatives to collect harvested onion bulbs, but they are not well functional. If they get functional cooperatives, around 94.5% of respondents are voluntary to sell their produce to marketing cooperatives. All respondents believe that engaging in onion farming is a profitable venture, except for market problems and poor storage period of varieties.

3.3.2. Post-harvest handling practices at wholesaler and retailer level

3.3.2.1. Selling experience and marketing practices. The survey results from the whole sellers and retailers chain in the study area indicated that the experience of selling onion ranged from 5 to 15 years for wholesalers and 4 years–13 years for retailers (Figs. 13a and b). Even if the experience of the wholesalers and retailers was a long time, the survey observation confirmed that there is a knowledge gap in their produce handling. As expected onion traders with longer period of selling experience are expected to have better skill on

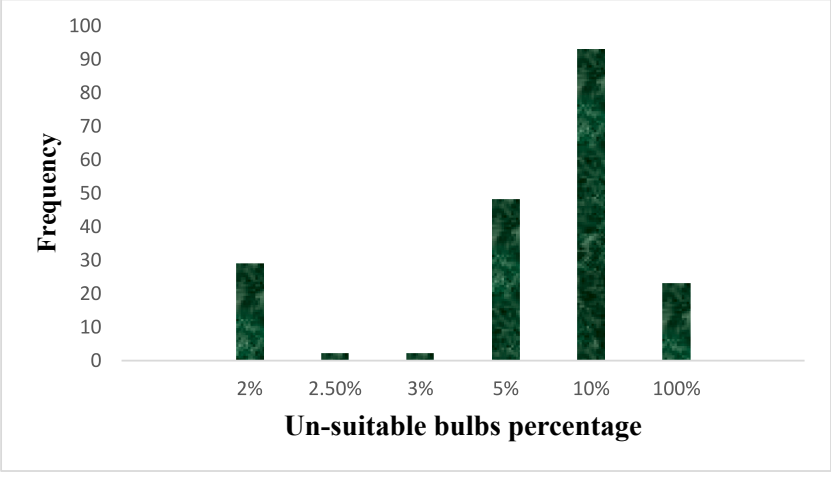


Fig. 10. Handling practices of onion.

Table 18
Post-harvest handling practice of onion at farm level.

Questioners		Frequency (N = 197)	%
Presence of loss after harvest	Yes	197	100.0
Type of container you are using during marketing	burlap sack 100kgweight	197	100.0
Type of container or storage material you are using during home storage for home consumer late selling	Jute/burlap bag	87	44.2
	Spread on ground	88	44.7
	Shelf	10	5.1
	Filed	11	6.1
Customers to sell your onion	Cooperatives	6	3.0
	Wholesalers	177	94.3
	Local collectors	11	5.6
	Retailers	3	1.5
	Consumers	2	1.0
Reasons you prefer selling to this buyer	Better price	2	1.0
	Large volume of purchase	166	84.3
	No option	29	14.7
Availability of marketing cooperative for onion to collect harvested bulbs	Yes	62	31.5
	No	135	68.5
interest to sell your onion through cooperatives?	Yes	188	95.4
	No	9	4.6
Do you believe onion farming is a profitable venture?	Yes, except market problem and poor storage period of varieties	197	100
How do you get information about buyers/transporters?	Through brokers	197	100.0

post-harvest management.

Hundred (100) % of wholesalers were collect onion bulbs from producers and local collectors. While 50% of retailers were collected from wholesalers, and the remaining 50% from both producers and wholesalers. Around 73.3% of whole sellers and 100% of retailers were evaluating sample bulbs before purchasing. However, during bulb collection, they face some bulb quality problems such as damaged bulbs, diseased, rotten, undersized, sprouted, and immature bulbs (Table 19).

Moreover, a hundred percent (100%) of the respondents explained that there is a loss of onion during the selling/storage process. On average, 4.5% of onion bulbs are not suitable for selling at wholesalers, and 13.93% of onions at retailers (Table 20).

The reason for the use of all-purpose burlap sacks and as a major packaging materials was their accessibility and low cost (Table 21). However, such kind of packaging material does not properly ventilate the air in the onion bulbs and causes sprouting and rotting. Kader and Rolle [44] explained that using sack container for fruits and vegetables creates high heat because of metabolic reaction which ultimately hastens mechanical damage and microbial attack.Where, Freq = frequency.

3.3.2.2. Causes of postharvest loss and strategies to minimize the number of rejected bulbs. The result revealed that at the retailer level, all respondents indicated that there is postharvest loss. The major causes for loss are bruising, sprouting, damage during harvesting and transport, decay, disease, mechanical damage, damage during harvesting, transportation, perishability nature, rooting, mechanical damage and shriveling (Fig. 11). To minimize the amount of rejected bulbs, wholesalers and retailers should avoid damage during harvesting better-stored varieties harvest dried bulbs need Sudan-type onions (long time stored onion varieties) for proper disease management. Falola et al. [14] who reported are bruising, sprouting, rotting, disease, damage during harvesting, are major causes for post-harvest loss of onion.

Table 19
Onion handling information of wholesalers and retailers.

Questioners		Wholesalers (N = 15)		Retailers (N = 30)	
		Frequency	%	Frequency	%
Source to collect onion bulbs	Producers/local collectors/	15	100.		
	Wholesalers			15	50
	Wholesalers and producers			15	50
Presence of quality problem	Yes	15	100.0	30	100.0
Type of problems	Damaged	4	39.9	19	63.3
	Size (under size)	4	26.7	19	63.3
	Diseased	4	26.6	10	33.3
	Sprouting	4	26.7	9	30
	Decay	3	20	28	93.3
	Immature bulbs	6	40	7	23.3
	Shriveling			2	6.7
Evaluation of samples of the onions before buying them	Yes	11	73.3	30	100
	No	4	26.7		

Table 20
Total quantity of bulbs not suitable for loss in percentage.

	Min.	Max.	Mean	Std. Dev.
Whole sellers	2%	7%	4.5	1.43
Retailers	5%	25%	13.93	7.65

Table 21
Handling and marketing practices.

Questioners		Wholesalers (N = 15)		Retailers (N = 30)	
		Freq	%	Freq	%
Do u sell all you bought	No	15	100.0	30	100
Are there any storage possibilities for onions at the market?	Yes	15	100.0	30	100.0
How many days does it take to finish selling your onion bulbs? ___ days	4			6	20.0
	5	2	13.3	12	40.0
	6	3	20.0	7	23.3
	7	7	46.7	4	13.3
	8	3	20.0	1	3.3
If it is discarded, what do you do?	Throwing	15	100.0	30	100
What measures do you undertake to reduce the number of rejected bulbs?	Sorting, ventilated	15	100	25	83.3
	Spreading during night			2	6.7
	Nothing			3	10.0
At what date interval do you buy new onions from suppliers? ____ days	4 days			1	3.3
	5 days			3	10.0
	6 days			18	60.0
	every week	3	20	8	26.7
	depends on market demand	11	73.3		
	up on finishing	1	6.7		
How do you store bulbs for selling?	Jute bag	6	40.0	30	100
	heaping on the floor	6	40.0		
	Wooden box	3	20.0		
What type of packaging material do you use for the transport of onions to the market?	Jute/Burlap sack	15	100.0	30	100

Table 22
Amount of price deduction in birr.

	Minimum	Maximum	Mean	Std. Dev.
Producer				
Whole sellers	3	5	4.8	0.561
Retailers	2	5	4.41	0.795

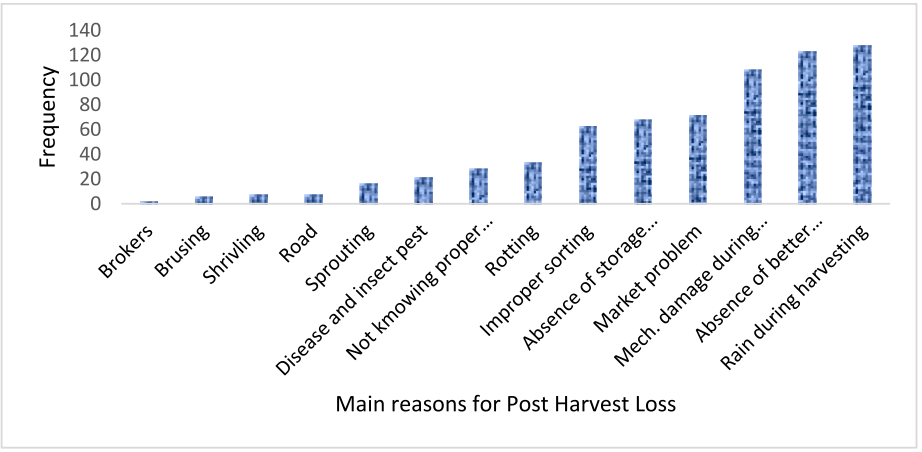


Fig. 11. Main reasons for the postharvest loss of onion.

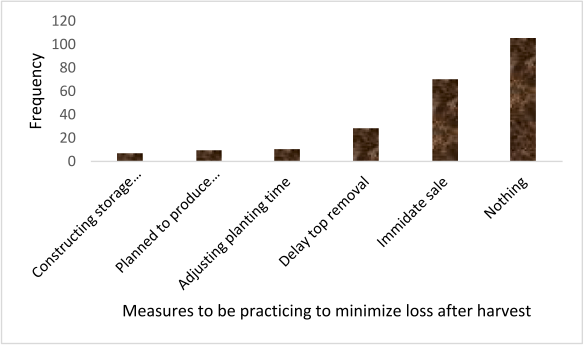
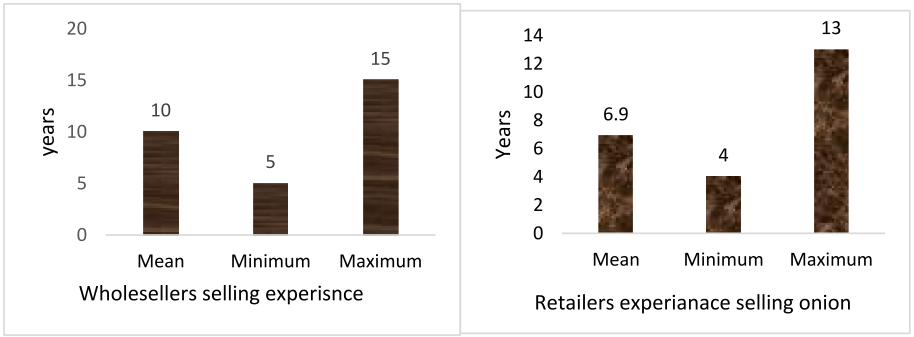


Fig. 12. Measures that farmers are practicing to minimize loss after harvest.



a b

Fig. 13. a. Experience in selling at the wholesaler
b.Experience in selling at the retailers.

3.3.2.3. Amount bought and storage period. The survey result indicated that wholesalers bought 10 quintals to 70.2 quintals at a time, and retailers bought 0.25 quintals to 1 quintal at a time. Majority of traders during selling process store the bulb by spreading it on the floor heaping the bulb on the ground/floor, and using wooden boxes (Figs. 14a, and b).

The traders also indicate that the demand for onion is year-round, but they face an onion supply shortage from May to October. Because there is no practice of storage of bulbs for late selling and there is no production during this months/production seasonality. During these seasons, the price of onion increases above 3 fold compared with pick harvesting seasons such as February to March at pick harvesting season, the price falls because of the large supply as all farmers plant at similar planting times.

3.3.2.4. Mode of transportation of onions. In this study, there were different modes of transportation used by the traders of onion from farm to marketing chain. The majority of the onion wholesalers (86.7%) transport their produce from the farm to the local markets by using an open FSR truck. While 13.3% of wholesalers used open ISUZU trucks. The difference between the transportation methods is the amount of onions load. FSR trucks can load 50-80quintal fresh onions, while Isuzu trucks can load 40-60quinatls. 36.7% of retailers were transporting onion by using *careta*, 30% by using *hand gari*, 23.3% by using *animal-driven gari*, and 13.3% by using the motor. As Rehman [45] explained that ultimate care should be given to the transportation of the produce to avoid mechanical injury and damage and deterioration of the produce.

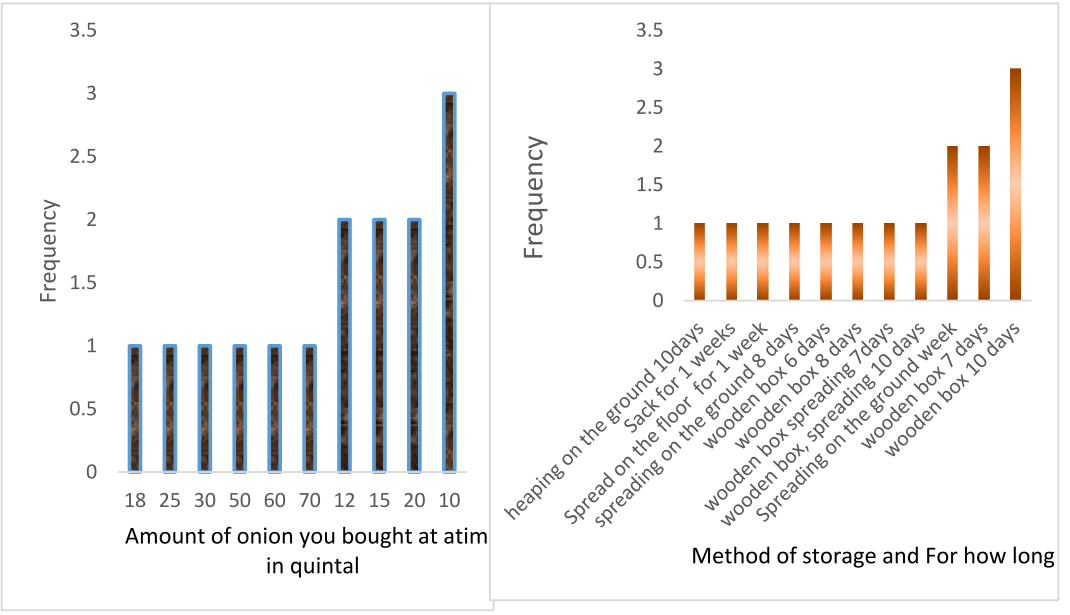
For wholesalers, on loading of the transportation process, there is postharvest loss, caused by bruising, crashing, mechanical damage, and high heat generated in the bulbs. Retailers during transportation, they did not record any loss of bulbs because short-distance transport and small volume transportation (Table 23). In addition, retailers during storage were frequently ventilating the bulbs, sorted, discarded the rotten bulbs, and sold them at relatively discount prices.

About 80% of wholesalers indicate that they have no contact with farmers, all contacts are through brokers, and the remaining 20% of farmers can have contact with farmers. The wholesalers do not have any information about the onion varieties they bought. They got information about transportation trucks also through brokers (Table 24).

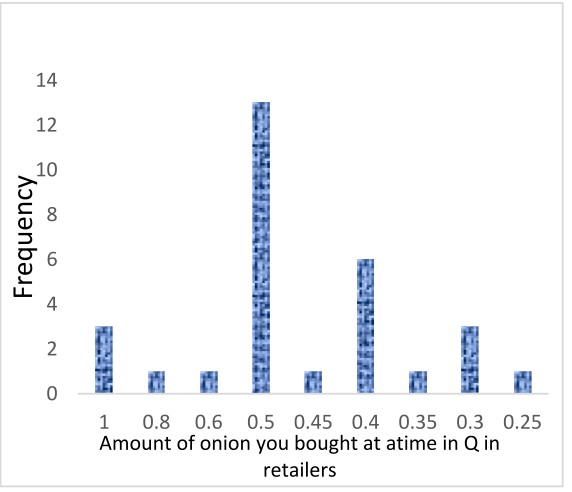
3.3.3. Post-harvest handling practices at consumer's level

Consumers are the final most affected bodies both financially and in getting quality and enough quantity of safe produce. The survey result indicated that about 23 consumers are facing quality problems such as sprouting, undersize, bruising, and decay, especially during the rainy season (Figs. 15a and b). Generally, during this season it is hard to find quality onion bulbs.

On average, the amount of onion bulbs purchased from the market by consumers ranges from, 1 kg to 50 kg at a time. All purchased



a



b

Fig. 14. a. Amount bought and method of storage at wholesaler level
b. Amount bought and method of storage at retailer's level.

produces are not used/utilized. Depending on the storage method and initial quality of the bulb, they face shriveling, sprouting, bruising, and rotting. Consumers were storing bulbs for up to 5 days to 3 months. The majority of consumers 28% and 24% stored bulbs spread on the ground and the polyester plastic bag, respectively. The remaining respondents were stored on hode/*zenbil*, basket, plastic rake, spreading on the shelf, spreading under the bed, and dried by sunlight (Table 25).

The survey result also indicated that consumers who purchase a large quantity of onion were going to purchase from wholesalers and consumers who want to buy a small quantity was purchasing from retailers. About 40% of respondents purchased from retailers, 26% were from wholesalers, 12% were from producers, and 22% were from both wholesalers and retailers, Customer preference is price discount from large volume, wholesalers and there is a chance to select bulbs from retailers. Customers who need fresh and unmixed bulbs were purchased from producers and retailers. In addition, nearness to access is another criterion to select customers. Consumers purchased too much amount bulbs during the low price and surplus supply period (Tables 22 and 26).

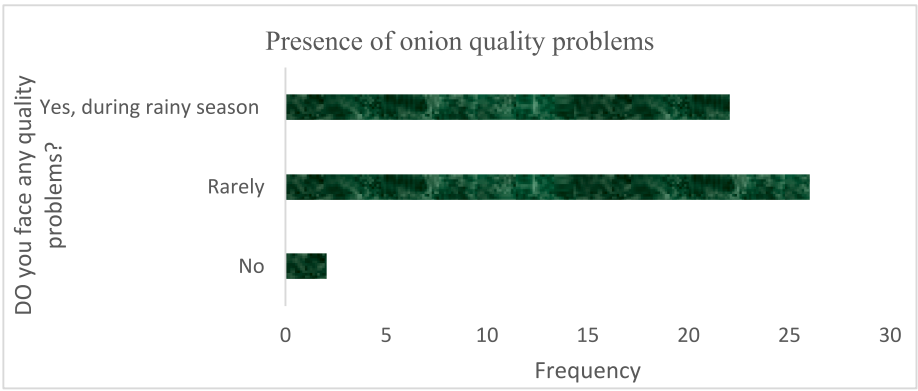
According to Yigzaw [46], instead of damping/culling damaged, wilted, and over-ripen fruits and vegetables everywhere, they might be used as animal feed in a scientific way and should be used as preparing compost to use plants as organic fertilizer, and other

Table 23
Methods of transportation at wholesalers and retailers chian.

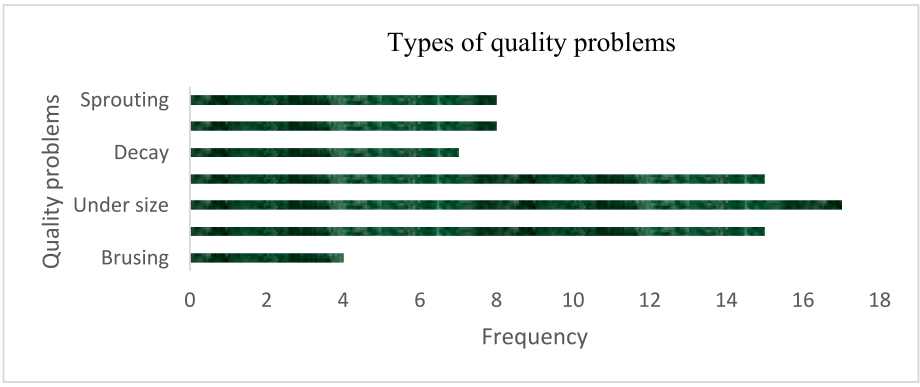
Questioners		Wholesalers (N = 15)		Retailers (N = 30)	
		Freq (N = 197)	%	Freq (N = 197)	%
What type of transportation you are using?	Open FSR truck	13	86.7		
	Open ISUZU truck	2	13.3		
	Animal driven Gari			7	23.3
	Hand Gari			8	30
	Careta			11	36.7
	Motor			4	13.3
At what time you transport from the farm to you?	Any time	15	100.00	30	100
Is there any loss during transportation?	Yes	15	100.00		
	No			30	100
If yes common causes for loss during transportation?	Bruising	11	73.4		
	Crushing/Mechanical Damage	3	20.1		
	High heat	1	6.7		

Table 24
Communication of wholesalers.

Questioners		Frequency (N = 15)	%
Do you have contact with farmers?	Yes have direct contact	3	20.0
	All contact goes through brokers	12	80.00
What onion-varieties you bought?	Don't have information	15	100.0
How do the wholesaler find trucks for onion transportation?	Drivers	1	6.7
	Through brokers	14	93.3



a



b

Fig. 15. a. Presence of onion bulb quality problems
b. Quality of onion bulbs.

Table 25
Onion handling practices at consumer's level.

		Frequency	Percent
Why don't you use the bulbs	Bruising	8	16
	Rotting	26	52
	Sprouting	28	56
	Shriveling	8	16
mechanism used to reduce loss of onion during storage	Applying cold charcoal ash	4	8
	Ventilating by Spreading on the ground	34	68
	Sorting	10	20
	Nothing	10	20
	Sun drying	3	6
How long you store onion bulbs?	5 days - 2 weeks	2	4.0
	1 week	16	32
	2 week	21	42
	1 month	3	6
	2 month	7	14
	3 months	1	2.0
How do you store bulbs for consumption?	Basket	3	6
	Drying on the sun	2	4.0
	Ground/spread on the ground	14	28
	Hod/*Zenbil*	8	16.0
	Plastic rake	5	10
	Polyester plastic bag	12	24
	Spreading on shelf	3	6.0
	Spreading under bed	2	4.0

Table 26
Market information.

		Frequency	Percent
From where do you buy onions and why do you buy onions from that certain place?	Wholesalers and retailers	11	22
	Producers/farmers	6	12
	Retailers	20	40
	wholesaler's	13	26
Do you ever buy too much or too little amount of onions?	No	14	28
	Yes, too little during supply shortage too much during low price and during surplus	36	72

energy sources. The present result is in line with the findings of [46].

3.3.4. Post-harvest handling practice in vegetable marketing cooperatives chain

In the study area (Andassa, Kudmi, and Fogera), there are established fruit and vegetable marketing cooperatives. However, except ocooperative at Fogera, all the others are not functional. In South Gonder, Fogera district, *Kuahir micael* kebele, there are marketing cooperatives for onion producers. The name of the cooperative is *Lomidir*. The member of s small-scale farmers is total of 240; males 221 and females 19. They have functional working guidelines. During the pick harvesting season, they have sufficient onion produce, sometimes beyond their capacity to absorb but no input during the off-season.

Attractive color sorted, marketable-size onions are ranked first and received first. Weekly, they can receive 12 tones and deliver to wholesalers and Addis Ababa and hotels. They practice storage methods such as spreading on the bed/shelf and putting on a burlap sack. The cooperatives purchase the produce from their members two times per week, especially on rest days. This cooperative is suffering from the absence of a sufficient places to store the commodity and storage room technology, at least on shelves.

Table 27
Average postharvest loss of onion at farm, wholesale, retail, and consumer level.

Supply chain	Average Loss (%)	Share in total (%)
Produces	10.58	35.5
Wholesaler	5.9	19.81
Retailer	8.27	27.77
Consumer	5.025	16.87
Total	29.775	100

Losses were estimated as the difference between the quantity harvested/purchased and quantity sold in relation to the total quantity harvested/purchased.

3.3.5. Extent of losses in supply chains

As explained in Table 27 the total postharvest loss of onion at the farmer, wholesale, retail, and consumer level was found to be 29.775% of which the higher proportion of losses (35.5%) was observed farmer level followed by at retail level while the 27.77% loss and 19.81 at wholesaler level in the present study losses along the supply chain mostly affect the farmer and retailer. The lowest loss (16.87%) was observed at the consumers level. The highest proportion of post-harvest loss at the farm level was due to improper pre- and post-harvesting factors such as disease and pest, mechanical damage during harvesting, and rain at harvesting time, wholesalers were buying selected and quality bulbs.

The high percentage loss observed at the retail level, could be accounted for by the cumulative effect of improper handling from packaging, and transportation at the wholesaler and to the retail level. Whole sellers were sold to retailers in mass without sorting damaged and diseased and unwanted bulbs. On the other hand, retailers were selling quality bulbs by sorting and avoiding damaged bulbs. The present finding shows that postharvest loss is a serious challenge in onion production and the supply chain.

The present result is in line with the findings of Bezabih [43] losses along the supply chain mostly affect the farmer and retailer. Falola et al. ([14] reported that onion farmers experienced a 23.9% postharvest loss in Nigeria. Calica and Cabanayan [47] also reported about 31.49% postharvest loss in onions in the Philippines.

4. Conclusions and recommendations

The salient findings of the present result indicated that sex, age, educational level, production experience, land covered by onion, and household size has a significant influence on onion production. Sex, age, education level, active household size, selling experience, amount purchased and storage duration have significant associations with onion production and postharvest loss. Different agronomic and cultural practices were applied by onion producers. Major onion production constraints were high post-harvest loss, market linkage, and low market price, lack of awareness to use post-harvest technologies, absence of better storable varieties, shortage of fertilizer access, disease, and insect pests. The whole purchased produce never reached the consumer's hands. There is a loss within each supply chain. Similarly, onion traders were facing quality problems such as damaged bulbs, diseased, undersized, sprouted, cultivate area/ha, and immature bulbs. The total estimated postharvest loss of onion at the farmer, wholesale, retail, and consumer level was found to be 29.775%, of which the higher proportion of losses (35.5%) was observed at the farmers level (production chain). Based on the findings of the present study, onion producers were challenged by timely and adequate supplies and the unfair and high cost of major production inputs. The existing problems and perishability nature of the crop aggravate onion post-harvest loss. Therefore, producers and handlers in each supply chain need to be trained on affordable and applicable postharvest technologies. In addition, continuous capacity-building training, improving infrastructures, and input access along the supply chain should be designed and implemented to improve better crop management and postharvest handling practices. Moreover, marketing cooperatives working on onion postharvest handling and marketing systems should be functional. The information from the current study could be used as a basis to improve onion production practices, scale up hybrid onion varieties cultivation minimize the postharvest losses of onion by policymakers to implement appropriate policies that improves the livelihood of farmers by increasing productivity, improving storage period and minimize its postharvest losses along the supply chain.

Thus, meaningful interventions in the development and implementation of policy on sustainable production, handling practices and supply of onion should be designed. Therefore, the present study depends on cross-sectional data, implementing spatial and temporal data might be required to draw a sound conclusion.

Authors contributions statement

Yebirzaf Yeshiwas: Conceived and designed the study; Analyzed and interpreted the data; Wrote the paper.
Melkamu Alemayhu: Conceived and designed the study; Contributed analysis tools or data; Wrote the paper.
Enyew Adgo: Analyzed and interpreted the data; Wrote the paper.

Funding statement

The authors declare that they have received funds for data collection from European Union's Horizon 2020, Healthy Food Africa.

Data availability statement

Data collected during the study are available from the corresponding author upon the request.

Declaration of competing interest

I, the undersigned author of the above-mentioned case report, hereby declare the following:

1. I have obtained written informed consent from the patient for the publication of this case report, any accompanying data and images. Where consent was obtained from someone other than the patient, I confirm that this proxy was authorised to provide consent on the patient's behalf.

2. Where the patient is a minor, we followed local laws on the age and circumstances under which they may consent for themselves. If they were not of legal age to consent, consent was obtained from an authorised proxy i.e. the parents or legal guardian. If the minor has reasonable understanding of the informed consent and implications, signature was also obtained from the minor.
3. Where the patient provided consent themselves, I confirm that they had capacity to do so, and any mental or physical disabilities were taken into consideration in the process of informing and obtaining written consent.
4. Where the patient has died, I confirm that the consent given still allows for publication.
5. I confirm that all content presented in this case report, associated data and images have been anonymized to the best possible extent.
6. The original signed and dated consent form is held by the treating institution and will be retained according to institutional policies and procedures.
7. The informed consent form (please **do not** include with your submission) includes the patient's name, age, medical history, diagnosis, treatment, and any other relevant information.
8. The patient/authorized proxy have been fully informed of the purpose of this case report, the potential risks and benefits of publication, and the consequence of disclosing their personal information.
9. The patient or authorized proxy has been given the opportunity to ask questions regarding publication of the case report, has had their questions answered fully and has approved the final version of the manuscript, all associated data and images prior to publication.
10. The patient or legal guardian(s) has been informed that their consent and participation in the publication of this case report is entirely voluntary. They have been informed that they have the right to withdraw their consent at any time.
11. I confirm that at least one of the authors of this paper was involved in the care of the patient.
12. I confirm that my article complies with the local law on consent and privacy.

By signing this declaration form, I acknowledge that I have read and understood the information provided above, and I attest to the accuracy of this declaration. I understand that any false or misleading information may result in the rejection of the case report or other disciplinary actions.

Acknowledgments

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e15905.

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