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On Farm Evaluation and Demonstration of Onion (*Allium cepa* L.) Varieties Under furrow Irrigation at Dalo-mana District, Bale Low land southeastern Ethiopia

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ABSTRACT

Four varieties with one local varieties of onion were planted under a complete randomized block design experiment with four replications at farmers' field in Dalo Mana. The quantitative data on yield of onion varieties and, farmers perception on the varieties were collected. All the varieties were harvested at their maturity (80% tops down) and then graded and weighed into six categories of bulbs: small weight, double weight, thin weight, bolters weight, marketable weight and total weight. Inferential and descriptive statistical methods were used for data analysis where by two ways analysis of variance and ranking scales were applied. It was concluded that all the four varieties namely; Adam Red, Red bomby, Nafis, and Nasic contributed differently to the total yield, marketable yield and percentage marketable yield. Onion variety Nasic followed by Red bomby produced the highest marketable yield whereas Local variety gave the lowest marketable yield. Despite the fact that Local variety produced the highest total yield and has been a common and popular onion variety in Ethiopia, it was recommended that farmers should not use Local variety as it produced the lowest percentage (60%) of marketable yield. Based on the yield performance and the farmer's perception, Nasic followed by Red bomby varieties were found to be the best performing onion variety and therefore, government should promote these onion varieties for cultivation in Ethiopia. The effects of different planting dates on the yield of onion varieties can be considered for future research.

Keywords: Onion; FRG; On-farm; Evaluation; Cost; Benefit; Yield; Perception; Furrow; Varieties; Watering; Transplant.

1. Introduction

Onion is widely grown herbaceous biennial vegetable crop with cross pollinated and monocotyledonous behavior having diploid chromosomes number (Gebremeskel, et al., 2016). Globally it is one of the most important vegetable crops and its demand increasing worldwide (Bindu, B and Bindu, P., 2015). It is a recently introduced bulb crop in the agriculture community of Ethiopia and it is rapidly becoming a popular vegetable among producers and consumers. It is more widely grown in Ethiopia for local consumption and for flower export (Lemma, D and Shemelis, A., 2003). In Ethiopia, onion can grow between 500- 2400 meter above sea level, but the best growing altitude so far known is between 700-1800 m (Lemma, D and E. Herath, 1994). It is grown under wide range of climatic conditions but it succeeds best in mild seasons without great extremes of heat or cold or excessive rainfall. Optimum temperatures of 18 - 24°C Day and 10 -12°C nights are ideal for bulb production. Onion can grow in all types of soils. Highest yield was obtained from freely drained friable loam soil with PH of 6-6.8 (Lemma, D and Shemelis, A., 2003).

Onion has been grown mainly as food sources and used as cousins and value addition for different dishes. In Ethiopia, the consumption of the crop is very important in the food seasoning and in daily stews as well as in different vegetable food preparation uses (Muluneh, B et al., 2019). Also, the chemical flavonoids, anthocyanins, fructo-oligosaccharides and organo-sulphur compounds found in the onion is considered as medicinal and health benefits to fight different diseases including cancer, heart and diabetic diseases (Goldman, I.L., 2011).

In Ethiopia, the area under onion production is increasing from time to time mainly due to its high profitability per unit area and ease of production, and the increases of small-scale irrigation areas. The crop is produced both under

rainfed in the meher season and under irrigation in the off season. In many areas of Ethiopia, the off-season crop (under irrigation) constitutes much of the area under onion production (Fikre, M and Olani, N., 2010). According to (FAO-STAT. 2019) report a total of 99,968,016 tons of onion is produced worldwide. China is the largest onion producer country in the world with 24,966,366 tons production volume per year. In Africa, Egypt is the top onion producer country with 3,081,047 tons production and, Ethiopia ranked in 9th.

Water availability is the main limiting factor of crop productivity than all of the rests due to its paramount importance for normal plant growth and developments. Hence, due to its shallow root system and needs frequent irrigation water after a short interval, onion is susceptible to water stress as compared to other crops (Fitsum et al., 2016). Knowing a number of water requirements of onion based on the specific area is basically important to produce the optimum onion yields. Bossie et al (2009) elaborated that, knowing of the water requirement and the coefficient values of the crop can help to accurately plan and manage the irrigation water for onion production at different locations even an area where a water shortage is very critical. Therefore, assuming of high irrigation frequency and better scheduling method may be expected to increase the applied fertilizer use efficiency, reduces leaching effects and to improve onion yields by increasing bulb sizes (Serra and Currah, 2002). Knowing of the individual crop water requirements help to produce more than two times per annum to ensure the year-round production of onion in order to get a high return as well as to reduce the susceptibility of the crop to various diseases and insect pests.

In Ethiopia, during 2019/20 growing season 734,921 small house holders are engaged in onion production. The total area allocated to onion has reached 36,373.48 ha; total production of 273,858.986 tons and the national average productivity is7.53 tons ha^{-1} as compared with the world average productivity 19.25 tons ha^{-1} (FAO-STAT., 2019 and CSA (Central Statistical Agency, 2019). The main reason for this lower productivity of the crop is most probably due to lack of improved onion varieties/seeds, inappropriate agronomic practices such as (inappropriate fertilizer rate, inter and intra row spacing), diseases and insect pests, high cost of agricultural chemicals including fungicides, insecticides, and a little-given attention to the crop production and poor extension system (Yemane K et al., 2014, Melkamu, A et al., 2015, Gebremedin, G et al., 2018 and Dessie, G et al., 2020). The Successful onion production depends on the selection of varieties that are adapted to different climatic conditions imposed by specific environment (Pandey U. B., 1989). There is no systematic study has been conducted to assess the stability and adaptability of onion for cultivation in the study area. Hence, the present experiment was conducted to study the performance evaluation and adaptability of some improved onion varieties under irrigation at Dalo mana Districts, Erba small scale irrigation scheme.

1.1. Study Objectives

- To evaluation the adaptability of improved Onion varieties under irrigation at Dalo mana Districts.
- To demonstrate the adaptability of different Onion varieties under irrigation.

2. Materials and Method

2.1. Study Area Description

The study was conducted at Erba Small scale irrigation scheme, Dalo Mana District, which is located 110km to the capital city of Bale. It is located between 5°50'00'' to 6°50' 00''latitude and between 39° 35'00'' to 40° 35'00'' longitude (Figure 1). The altitude of the area is range from 800-3500 m above sea level with average annual rainfall range from 700 mm (Figure 2 and Table 1).

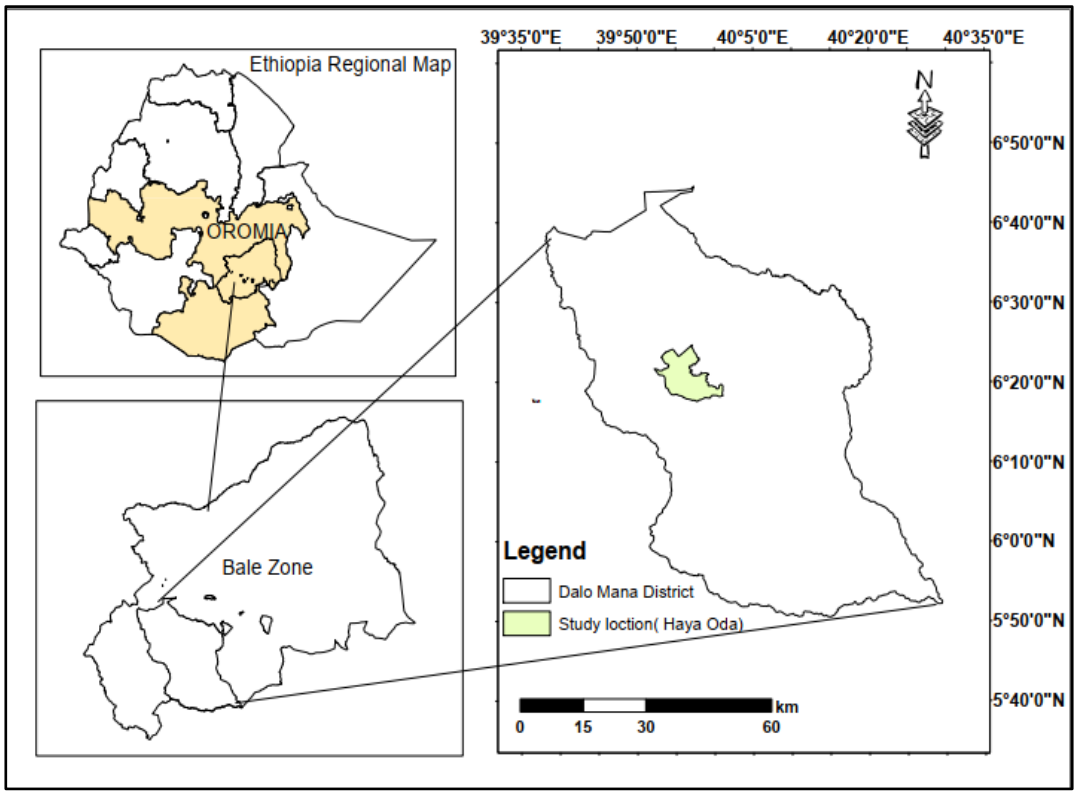

Figure 1. Location map study area

Table 1. Climate data of the study area

Month	Prc. mm/m	Tmp. min. °C	Tmp. max. °C	Tmp. Mean °C	Rel. Hum. %	Sun shine J m^{-2} day^{-1}	Wind (2m) m/s	ETo mm/m
Jan	7	17.3	32.0	24.6	25.9	23,823,238	2.2	175
Feb	1	17.9	32.8	25.3	23.4	25,402,854	2.2	171
Mar	25	18.7	32.7	25.7	28.8	24,392,502	2.7	200
Apr	173	19.7	29.8	24.8	45.8	19,605,267	2.2	148
May	297	19.4	27.9	23.6	55.3	18,233,228	2.2	130
Jun	93	18.7	27.1	22.9	48.5	15,089,503	3.3	129
Jul	105	18.7	26.2	22.5	49.9	12,851,623	3.5	129
Aug	63	19.2	28.0	23.6	42.6	15,037,553	3.1	147
Sep	71	19.7	29.5	24.6	37.1	17,760,263	2.4	148
Oct	528	18.8	26.5	22.7	60.1	16,371,995	1.6	112
Nov	28	17.3	28.8	23.1	42.2	20,549,970	1.9	135
Dec	1	16.9	30.4	23.7	29.9	21,825,436	2.1	156
Total	**1,392**							**1,780**

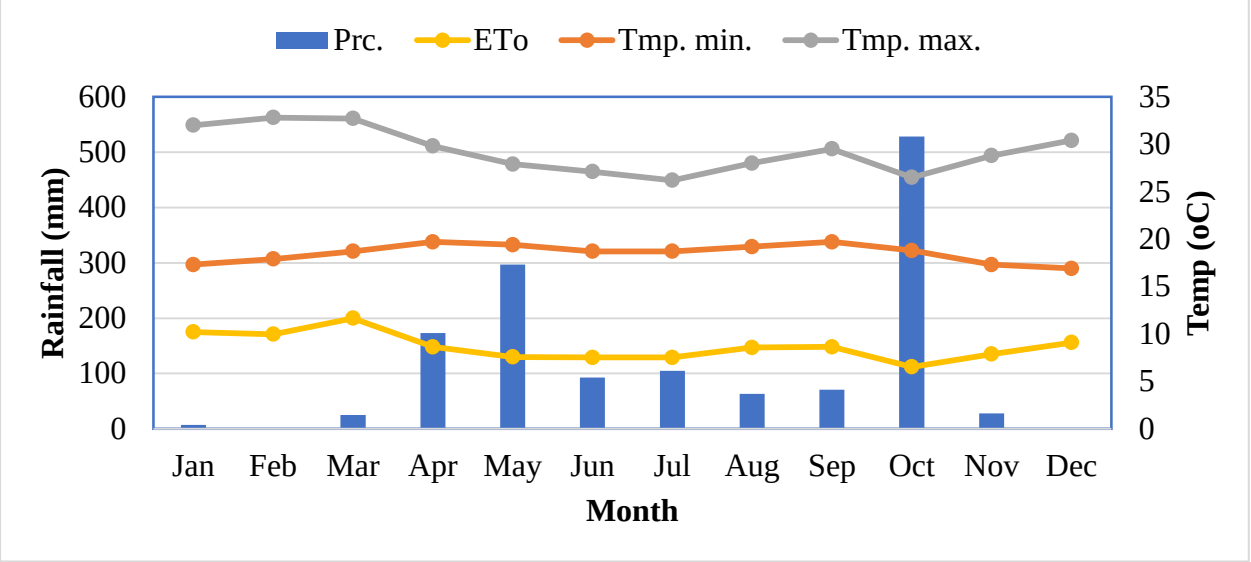

Figure 2. Monthly rainfall, temperature and ETo of the study area

2.2. Experimental Materials, Design and Procedure

A total of four improved onion varieties were collected from Melkasa Agricultural Research Center/MARC and one local cultivar from the study area. The varieties were arranged in Randomized Complete Block Design (RCBD) with three replications on plot size of 10m x 10m = 100m^2. The spacing between rows, ridges and plants were 40cm, 20cm, and 5cm respectively. The spacing between plots and adjacent replications were 1m and 1.5m, respectively (Nikus, O., & Mulugeta, F, 2010). The two middle rows were used for data collection. Fertilizer application was made as per the specific recommendation for the location, in which NPS as a source of phosphorus was applied at a rate of 150 kgha^{-1} and Urea as a source of nitrogen was applied at a rate of 100 kg ha^{-1}. NPS was applied once during transplanting period in the rows, while urea was applied in split application half at during transplanting period and half at 45 days after first application as a side dress application. All other agronomic practices such as weeding, cultivation and spraying chemicals were kept uniform for all treatments in each plot.

2.3. Site and Farmer Selection

The site was selected at Erba small scale irrigation which is PASIDP II target area found in Dalo Mana district and also farmer selection for establishing Farmer Research Group (FRG) was carried in collaboration with office of agriculture and the farmers themselves. Two FRGs, with 20 members were established at the irrigation scheme. From one FRG, two trial farmers were selected by considering farm accessibility, farmers' willingness to host the trial and their prior history (model farmers will got priority). Accordingly, it was demonstrated on four (4) farmers' field.

2.4. Approach used

Training was organized for the selected experimental farmers and respective DAs concerning on onion production and management systems under Irrigation. Then, seed bed preparation, seed sowing, land preparation and transplanting were done jointly with researchers (extensionists and agronomist), farmers and extensions agents in each district. Close supervision and monitoring were undertaken through joint action of stakeholders. Finally, field day was organized for different stakeholders including farmers to create awareness on selection of performed

varieties, and boost the dissemination of the varieties through farmers to farmers. Different extension materials such as leaflets and manuals of training were delivered to the farmers during the field day and training for the participant farmers, extension agents, and agricultural office experts. Moreover, the outputs gained from the study were communicated on a field day program, mass media, and written materials.

2.5. Irrigation water management

The furrow irrigation method was used to irrigate for improved onion cultivars. Water application depth and irrigation scheduling were determined using CROPWAT.8 model. The crop data, crop type, planting date, growth stage, maximum rooting depth, Kc values, depletion fraction, and yield reduction coefficient were used as inputs to the model.

2.6. Types of data and method of data collection

Primary and secondary source quantitative and qualitative data were collected from the study area. The number of farmers participated in demonstration, training and field day, date of planting, maturity date, disease and insects' effects, agronomic parameters (plant height, bulb weight, bulb diameter), farmers' preferences and bulb yield (t/ha) were the major types of data collected. Besides, types of advisory services gained by the farmers and frequency of (land preparation, supervision made, and weeding practices) were collected from experimental farmers and also socioeconomic profiles, demographic, crop profiles and climatic information were collected from research reports, district agricultural offices reports, internet and other written materials.

2.7. Method of Data Analysis

The collected qualitative and quantitative data were analyzed, the quantitative data were analyzed using R software and the qualitative data were analyzed by using description, narration, interpretation, and argumentation.

2.8. Economic Analysis

Economic analysis of the Irrigation system was computed, based on investment, operation and production costs (CIMMYT, 1988). In this research, a partial budgeting approach based on economic evaluation of the product was used. To assess the economic viability of the Furrow Irrigation method under, both fixed and operating costs were calculated (Kuscu et al., 2009). The net income for each treatment was computed by subtracting all the production costs from the gross incomes. All calculations were undertaken, based on a unit area of 1 ha, according to Cetin et al. (2008).

3. Results and Discussion

3.1. Soil physio-chemical properties of the study area

The soil properties of the study area reveal critical insights for onion cultivation. At a depth of 0-20 cm, the soil pH is 6.56 (Table 2), which is conducive for onion growth, as onions typically thrive in slightly acidic to neutral pH levels (5.8 to 6.8). The organic matter (OM) content is measured at 2.89% (Table 2), providing a rich nutrient base essential for the healthy development of onions (Shubham S et al., 2025). In terms of soil texture, the top layer consists of clay with a bulk density of 0.98 g/cm³ (Table 3), which can retain moisture effectively, yielding suitable field capacity (35%) and permanent wilting point (18%) (Table 3). These properties suggest that the soil in the

study area has favorable conditions for successful onion farming, as indicated by the balanced pH, adequate organic matter, and appropriate moisture retention capabilities (Demir, Z. 2024; Abayneh E et al, 2003).

Table 2. Some soil chemical properties of the study area

Soil Depth	pH	OM (%)	OC (%)	P(mg/Kg)	EC (ds/m)
0-20	6.56	2.89	1.68	2.15	0.02
20-40	6.4	2.52	1.23	2.13	0.03
40-60	6.5	1.89	0.98	2.21	0.03

NB: **OM**: Soil organic matter, **OC**: Soil Organic Carbon, **P**: Soil available phosphors and **EC**: Soil electrical conductivity.

Table 3. Some soil physical properties of the study area

Soil Depth	Soil texture class	BD(g/cm^3)	FC (%)	PWP (%)
0-20	clay	0.98	35	18
20-40	clay	1.1	37	19
40-60	clay	1.1	37	20

NB: **BD**: Bulk density, **FC**: Soil Field capacity and **PWP**: Soil Permanente wilting point.

3.2. Agronomic traits of the Onion varieties

The combined Analysis of variance (ANOVA) showed that significant differences between improved onion varieties in terms of their maturity date, both marketable and unmarketable bulb yield in t ha^{-1}, bulb length in cm, and bulb weight in gm were observed. Significant difference was observed between onion varieties for plant height in cm, total bulb yield in t ha^{-1} and average bulb diameter, Bulb weight in gm (Table 4). Many authors reported that there was significant variation between improved onion varieties for both agronomic and bulb yield. According to (Germew, A., et al., 2010 and Neeim, S et al., 2019) report significant variation was observed between improved onion varieties for marketable and unmarketable bulb yield tha^{-1}. Similarly, (Gebremedin, G et al., 2018) stated that significant difference between improved onion varieties was observed for marketable bulb yield. Additionally, (Gebremedin, G et al., 2018, Germew, A. et al., 2010, Neim, S et al., 2019 and Addis Sh., 2020) also stated non-significant difference for bulb size/diameter was reported among improved onion varieties. Non- significant difference for total bulb yield among onion varieties was reported by (Addis Sh., 2020).

Table 4. Combined mean value of agronomic traits of Onion variety on selected scheme at Dalo mana District

Variety	Ph(cm)	BD (cm)	BW (gm)	TY(t/ha)	MBY(t/ha)	UBY(t/ha)
Adama red	49.3^{b}	4.75^{b}	104.03^{abc}	36.33^{b}	35.24^{b}	1.19^{b}
Nasic	49.2^{b}	5.2^{a}	108.6^{ab}	41.33^{a}	39.95^{a}	1.39^{ab}
Red bomby	54.8^{a}	5.05^{ab}	110.55^{a}	40.67^{a}	39.45^{a}	1.18^{b}
Nafis	49.3^{b}	4.8^{b}	102.58^{bc}	34.33^{b}	33.23^{b}	1.1^{b}
Local	40.3^{c}	3.97^{c}	98.7^{c}	24.33^{c}	22.5^{c}	1.83^{a}
Mean	**48.56**	**4.75**	**104.89**	**35.4**	**34.07**	**1.34**
CV	**2.5**	**3.4**	**3.8**	**4.48**	**4.68**	**18.53**
LSD(0.05)	**2.27****	**0.3****	**1.04**	**2.98****	**3****	**0.46**

NB: BD=Bulb Diameter, Ph=Plant height, BW=Bulb Weight, TY=Total Yield, MBY= Marketable bulb yield, UBY= Unmarketable Bulb yield and ** highly significant.

3.2.1. Maturity Date

Improved onion variety Nafis matured at (110.67 days) followed by Bombay Red (107.83 days), Nasik Red (106.0 days) and Adama Red (105.67 days). The variation of maturity date between improved onion varieties might be due to their inherent genetic difference. Similarly (Yemane K et al., 2014) and (Gebremedin, G et al., 2018) reported that significant difference among onion varieties for maturity date.

3.2.2. Plant Height

Plant height raged from 40.3cm to 54.8cm with a mean of 48.56 cm. The highest plant height was recorded from variety Red bomby (54.8cm) while the lowest was the local variety (40.3cm) (Table 4). The presence of significant difference between improved onion varieties in plant height was reported by (Gebremedin, G et al., 2018). The variation of Plant height between improved onion varieties might be due to their inherent genetic difference and location.

3.2.3. Marketable, Unmarketable and Total Yield

The highest marketable bulb yield was obtained from variety Nasic (39.95 tha^{-1}) followed by Red bomby (39.45 tha^{-1}), Adam Red (35.24 tha^{-1}) and Nafis (33.23 tha^{-1}) while the lowest marketable bulb yield was gained from Local variety (22.5 tha^{-1}) (Table 4). The difference due to bulb yield might be genetic variation among onion varieties and irrigation method. The finding results also in agreement with (Yemane K et al., 2014) reported higher marketable bulb yield was obtained from variety Nasic (34.36 t ha^{-1}) and lower from Adama Red (28.45 t ha^{-1}). Similar (Dessie, et al., 2020) also reported that the marketable lower bulb yield was obtained on variety Adama Red. The two varieties Bombay Red and Nasic gave maximum unmarketable yield 1.39 and 1.18 tha^{-1} respectively (Table 4 and Figure 3). Local variety gave minimum unmarketable yield 1 tha^{-1}.

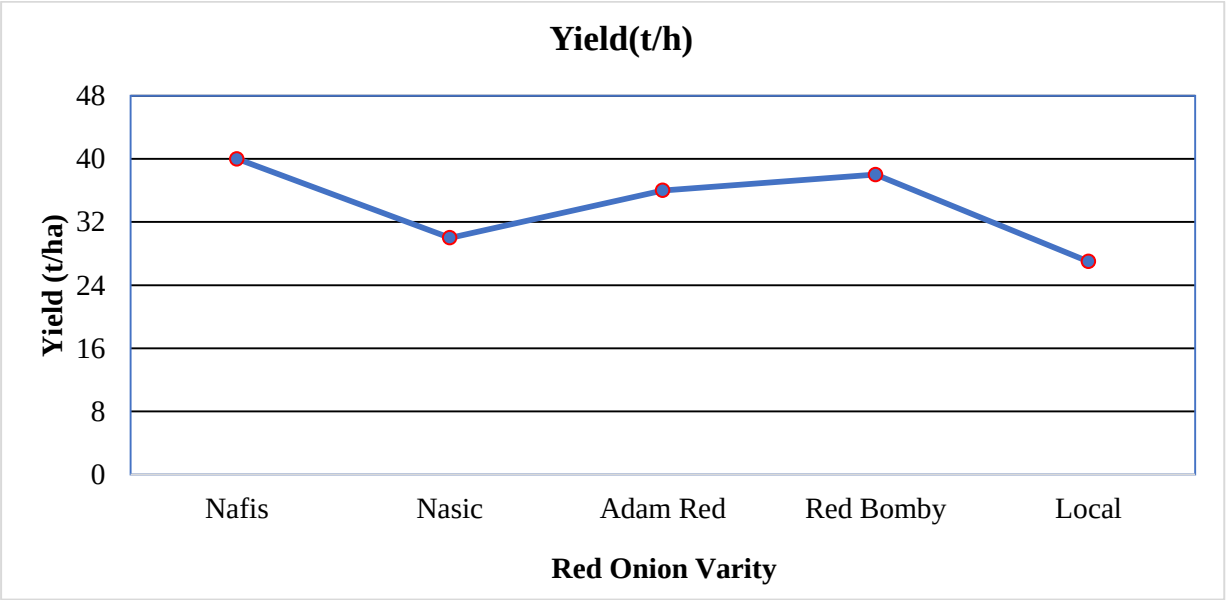

Figure 3. Combined Mean yield of Onion variety

Significant difference between improved onion varieties on marketable yield was reported by (Gebremedin, G et al., 2018). This finding result also in line with (Yemane K et al., 2014). According to (Neim, S et al., 2019) report

lower bulb yield was measured from Adama Red (3.45 t ha^{-1}). Similarly (Geremew, A et al., 2010) reported that the lowest marketable and total bulb yield was measured from variety Adama Red (15.82 and 19.22 t ha^{-1} respectively). Additionally (Geremew, A et al., 2010) also stated that the higher and lower unmarketable yield was recorded from variety Bombay Red and Adama Red 8.98 and 0.36 tha^{-1}.

3.2.4. Bulb diameter and average Bulb weight

Bulb diameter and bulb weight were ranged from 3.97 to 5.2cm and 98.7 to 110.5gm respectively. The wider bulb diameter was recorded from variety Nasic (5.67cm) while the narrow bulb diameter was gained from local variety (3.97cm) followed by Adama Red (4.75 cm) (Table 4). The present result is similar with Geremew, A *et al*., (2010) reports. Minimum bulb diameter was observed from Adama Red (5.08 cm). Similarly (Dessie G., 2020) reported that the largest bulb diameter was recorded on Bombay Red variety at Fogera districts. Bombay Red showed that the maximum bulb weight (110.5 g) followed by Nasic (108.6 g), while the minimum bulb weight (98.7gm) was observed from local variety (Table 4).

3.2.5. Farmers' perceptions

The onion varieties were evaluated by farmers' set preference criteria (Figure 4). The criteria used for the evaluation by farmers were: yield, tolerance to disease and insect, bulb size, bulb color (deep red color is the most preferred), storability, and market preference. The analysis of preference weight scores, as given in Table 5, for each characteristic of the onion varieties resulted that Nasic was preferred by most of the farmers criteria except average bulb size. Similarly, Bomby red is ranked second. In reference to the average bulb size, Nasic is the most preferred by farmers due to significance importance of the Nasic Red variety in markets where average bulb size is preferred by consumers.

During group discussion, it was remarked that seeds shortage of improved varieties, disease and insect, the high price of chemicals and market price fluctuation are the major challenges hindering onion production and productivity in the areas. The farmers identified purple blotch as a major disease affecting onion production. A similar result was also reported by Yetayh et al. (2019).

Table 5. Ranking of Onion varieties based on farmers preferred criteria (N=40)

Variety	**Farmers Criteria**						**Average**
	Market preference	**Bulb Yield**	**Tolerance to disease**	**Color**	**Storability**	**Bulb size**	
Nafis	3	4	2	3	2	2	2.8
Bombay Red	4	4	3	4	4	4	3.8
Nasic	4	5	4	3	4	5	4
Adam Red	5	2	2	4	2	3	3
Local	3	1	1	2	1	22	1.6

Scores: 5 = Best; 4 = Very good; 3 = Good; 2 = Average; 1 = Not good (Source: Authors focus group)

Figure 4. Performance of Red Onion on selected farmers at Dallo Mana (Herba) photo during Mini Field Day

3.2.6. Financial analysis

The benefit of each variety was calculated by including the costs of fertilizer, seed, chemicals, land preparation, Watering and labor. The financial feasibility of the innovation was computed using the benefit-to-cost ratio (BCR) and net profit. Nasic had the highest benefit- cost ratio the study areas (Table 6). For every one ETB invested in the production of onion, the farmers earned a higher net income from Nasic variety. In the financial feasibility analysis, land was considered as a fixed cost; taking into account land rent. The profitability relates directly to the productivity and use of improved variety as well as good management practice compared with the local variety. Thus, farmers gained the high-profit if they cultivated Nasic using associated production practices followed by Bomby red onion.

Table 6. Financial feasibility of improved onion variety production at Erba scheme

Item	Nafis	Adama Red	Nasic	Bomby Red	Local Variety
Yield (Kg/ha)	20,000	27,100	33,200	31,700	16,400
Price (ETB/Kg)	25.00	25.00	25	25.00	25.00
Fixed Cost	25000	25000	25000	25000	25000
Variable cost	141365	141365	141365	141365	141365
Total cost	166365.00	166365.00	166365.00	166365.00	166365.00
Total return	500000.00	677500.00	830000.00	792500.00	410000.00
Net return	333635.00	511135.00	663635.00	626135.00	243635.00
BCR=TR/TC	**3.0**	**4.07**	**4.98**	**4.76**	**2.46**

4. Conclusion and Recommendation

Nasic and Bombay Red with improved management practices gave the highest yield per unit area on a farmers' field. The yield gaps result indicates that the farmers need to use, variety and the recommended practices (Improved Irrigation water management), to increase their onion productivity and production. Similarly, the host farmers fetched the highest financial returns from the technology. The selected varieties were also the most preferred because of their market preference, higher yield, preferred bulb color, average bulb size, relative tolerance to insects, relative tolerance to disease and storability. Therefore, it is advisable to grow Nasic and Bomby red by

replacing local verity on large-scale production to increase the production and productivity of onion that improve the livelihood of farmers in the study area and similar agro- ecologies in Bale lowland areas.

4.1. Future Suggestions

- Encourage farmers to cultivate Nasic and Bombay Red varieties to replace local options, leveraging their superior traits.
- Promote improved irrigation water management to address yield gaps and optimize production.
- Equip farmers with knowledge about the benefits of the selected varieties, including market preference and disease resistance.
- Foster cooperation among farmers to share knowledge and experiences, facilitating better adoption of best practices.

Declarations

Source of Funding

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Competing Interests Statement

The authors declare that they have no conflict of interest.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis, and manuscript writing equally.

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