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Performance Evaluation of Garlic (*Allium sativum* L) Varieties for Yield and Yield Related Components at Chora, Gechi and Didessa Districts of Buno Bedele Zone, Southwestern Ethiopia

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Abstract

Garlic is one of the most important bulb crops grown in Ethiopia as it plays a crucial role in contributing to food security and livelihoods for the majority of farmers. However, one of the factors limiting poor yield is the absence of well-adapted cultivars across the possible agro-ecologies for garlic production and productivity. Therefore, the purpose of this experiment was to assess the adaptation and performance of enhanced varieties for the study in Oromia's western regions. During the 2023 agricultural season, the experiment was carried out in the districts of Buno Bedele zone (Chora, Gechi, and Didesa). Rain-fed conditions were employed to examine six (6) different types of garlic. Three replications of the RCBD (Randomized Complete Block Design) experimental design were used. The study's findings demonstrated that, for every attribute that was documented, there were notable variations across varieties. This indicates the potential to select high-yielding and better-adapted varieties for the region. To enhance local collections for future use, research on local cultivars should be done. Furthermore, agronomic practices such as proper planting timing, optimal spacing, seed quality selection, pest and disease management, and balanced nutrient application must be meticulously followed in order to boost garlic output. Even with indigenous varieties, the yields remain unsatisfactory, highlighting the urgent need for integrated efforts in variety improvement and farming practices. Future initiatives should also focus on farmer training, seed system improvement, and dissemination of best practices to maximize garlic production in diverse agro-ecological zones.

Keywords: Garlic, bulb yield, improved varieties, indigenous varieties, RCBD

INTRODUCTION

A broad range of adaptation and cultivation around the globe, including Ethiopia, garlic (*Allium sativum* L.) is the second most used Allium after onions (Pandey, 2012; Harnet and Yibrah, 2015) [1, 2]. As a significant spice and medicinal plant, garlic may be grown in all temperate to subtropical and tropical hilly regions. For more than 5000 years, people have recognized the tremendous use of garlic as a medicinal plant and cultivated spice. China, India, and Bangladesh are the top three producers of garlic [3].

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Ethiopia with diversified agro-ecological conditions is suitable for garlic production. Internationally, Ethiopia has ranked. Thus, the demanded of garlic in both locally and internationally [4]. Moreover, garlic is one among the most top economic crops of low income smallholder farmers of highland area of Ethiopia. Despite this, Ethiopia's agriculture productivity and production are low when compared to the yield of many other nations [4, 5].

The low production may be due to several abiotic and biotic factors, and unavailability of improved and high yielder varieties, garlic covered 30,946.22 ha of Ethiopia during the main cropping season of 2022, and 1,938,797.93 t were produced overall, with an average yield of 6.27 $t.ha^{-1}$. During the 2022 main cropping season, the study area's garlic coverage was 57.21 ha, and the total production was approximately 2291.21 t, much less than the national average.

The low yield of this crop might be due to many abiotic and biotic factors such as absence of common time of sowing that is suitable for higher yielding, lack of high-yielding cultivars, insufficient supply of high-quality seeds, uneven fertilizer application, inadequate irrigation systems, improper handling of insect and disease pests, and other agronomic procedures, poor storage capacity, and inadequate marketing facilities. Research on the adaptation of garlic types in the study region has not been conducted. Therefore, finding high-yielding, disease-tolerant, and adaptable garlic cultivars for cultivation in Buno Bedele and comparable agro-ecologies was the aim of this study [6, 7].

MATERIAL AND METHODS

Description of the Study Area

The field experiment was carried out during the 2023 cropping season at Chora, Gechi and Didessa districts on farmer's field.

Treatments and Experimental Design

The treatments consisted of six garlic varieties including one local variety (Table 1). Three replicates with a gross plot size of 4 m^2 (2 m by 2 m) and a spacing of 1 m between replications and 0.5 m between plots were used to organize the treatments in a Randomized Complete Block Design. The experimental plots were randomly assigned to each treatment [8]. Medium-sized (2–3 g) cloves were manually planted in rows 30 cm apart, with 10 cm separating each plant. 100 $kg.ha^{-1}$ of urea and 200 $kg.ha^{-1}$ of NPSB were used as fertilizers. Split urea was administered. Every relevant management technique was implemented in accordance with the crop's guidance (Table 1).

Data Collection

Growth and yield data was collected from six randomly selected and pre-tagged plants. The procedures applied to collect the data are presented as follows: Bulb diameter (cm), Bulb length (cm), Bulb weight per plant (g), Number of cloves per bulb and Total yield per hectare ($t.ha^{-1}$). Disease and insect pest score were recorded using (1–9) rating scale, where 1= No visible disease symptom, 3= resistant, 5= moderately tolerance, 7= susceptible and 9= highly susceptible. The disease was scored at weekly intervals starting from the first disease spot symptom appearance and was continued until the final stage when the disease attained maximum [9–13].

Table 1. Description of garlic varieties evaluated in the study.

Varieties	Year Release	Breeder Source
Holota	2015	Debre Zeit Agricultural Research center
Kuriftu	2010	Debre Zeit Agricultural Research center
Bushoftu	2015	Debre Zeit Agricultural Research center
Tsaday	1999	Debre Zeit Agricultural Research center
Chafe	2015	Debre Zeit Agricultural Research center
Local	-	

(MoA, 2016).

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Data Analysis

Every measured parameter was subjected to analysis of variance (ANOVA) in accordance with the factorial experiment in RCBD. The data was then subjected to ANOVA using SAS version 9.2 (SAS, 2014) procedures, and when the ANOVA revealed significant differences, the treatment mean comparison was conducted using the Least Significance Difference (LSD) test at a 5% probability level [14].

RESULTS AND DISCUSSION

A combined analysis of variance showed the presence of highly significant ($P<0.01$) differences among the varieties for the days to maturity, plant height, number of cloves per plant, bulb weight, marketable bulb yield and clove weight; and the significant difference ($P<0.05$) for number of bulb diameter and bulb length was observed (Table 2). Significant variations between the types suggested that each of the traits in the tested cultivar had genetic variability [15, 2, 16, 17].

Maturity Date

The findings indicated that garlic's days to maturity were significantly ($p<0.01$) impacted by the variety (Table 2). The range of days to maturity is 139.67 to 157.33 days. Kuriftu had the longest days (157.33), whereas the local variety reached early maturity at 139.67 days. It is possible that the six types' varying levels of ripeness are caused by genetic variations. observed a similar outcome, stating that the Tsedey 92 garlic variety matured later than Bishoftu [18].

Bulb Diameter (cm)

The current result showed that there was significance difference ($p<0.05$) among varieties. Hence, local variety recorded the highest Bulb diameter (5.60 cm) and lowest bulb diameter (4.01 cm) was recorded in Bushoftu variety. Numerous researches discovered that garlic types differed significantly in bulb width). Variations in bulb characteristics, including bulb size, among cultivars may be the cause of this outcome [19].

Length of Bulb (cm)

Garlic variety bulb length had a substantial ($p<0.05$) impact (Table 2). A maximum bulb length of 4.60 cm was reported by the local variety, and 3.87 cm by Holota local. But the Chafe variety produced the shortest, measuring 3.05 cm (Table 2). This variance may result from the fact that different types can differ in terms of bulb form, bulb length, and bulb color.

Bulb Weight (g)

Garlic varieties show a significant variation ($p<0.05$) in mean bulb weight. Thus, highest bulb weight (29.67 g) recorded by local varieties and Chafe variety recorded the lowest bulb weight (24.05 g) compared to other varieties. Similarly, Ayalew *et al*. reported that the maximum bulb weight (49.72 g) and yield (16.56 $t.ha^{-1}$) were recorded from local cultivars as compared to five garlic varieties [7].

Table 2. Combined Mean square values on phonological and yield component response garlic varieties in 2023 cropping season.

Source of Variation	DF	DM	BD	BW(g)	NCPP	MY	BY
Replication	2	14.16ns	1.98ns	0.61ns	0.99ns	1.78ns	1.47ns
Varieties	5	571.43**	1.87*	1.59*	110.20**	129.67**	121.68**
Location	2	39.45**	0.25*	1.25*	10.78**	10.57**	11.15**
Varieties*Location	10	26.42ns	0.11ns	0.02ns	0.48ns	0.48ns	0.63ns
Error	52	16.21	0.41	0.21	8.11		10.88

*DF= degree of freedom, DM=Days to maturity, BD=Bulb Diameter , BW=Bulb weight, NCPP=Number of clove per plant, *=significant differences,**= Highly significant and ns=Non-significant*

This outcome, however, differs from that of a study which found that the local, Kuriftu, and Tsadey 92 cultivars produced the best bulb yields, at 16.16, 11.78, and 5.57 t/ha, respectively. This could be a difference between the two settings, that the variation in bulb weight among garlic varieties may be explained by the vigorous growth (production of more leaves), which aided in the synthesis of more photosynthates and increased accumulation of carbohydrates and other metabolites. These factors ultimately determined the weight of bulbs per plant [20, 21, 1, 14, 22].

Clove Number Per Bulb (Count)

The current result showed that the clove number was affected by the variety. The Kuriftu variety had the fewest cloves per bulb (7.00), while the local check had the most (13.67). This outcome is consistent with the findings that out of the garlic varieties tested, the local variety had the most cloves per bulb. Additionally, it was noted that the local cultivar (12.75 cm) produced the most cloves per bulb. Furthermore, numerous authors have noted variations in the quantity of cloves per bulb across various garlic cultivars [23–27].

Marketable Bulb Yield ($t.ha^{-1}$)

The combined data analysis showed that the garlic plants' varietal effect had a substantial ($P<0.01$) impact on marketable production. The local variety produced the most bulbs per plot (3.8 $t.ha^{-1}$), followed by the Holota local. Varieties' varying genetic compositions can also be blamed for the variations in yield [28].

Unmarketable bulb yield ($t.ha^{-1}$)

The garlic types had a highly significant ($P<0.01$) impact on unmarketable yield. The unmarketable yield of variety Holota local was much greater (1.10 $t.ha^{-1}$), whereas the unmarketable yield of local was significantly lower (0.12 $t.ha^{-1}$). This suggested that locals performed better in terms of yield and adaptability. Mohammed et al. (2021) showed similar results for certain garlic varieties [19].

Disease Incidence

The main potato disease seen during the trial period was garlic rust. As a result, all kinds exhibited moderately susceptible (40 ms) reactions to the disease (Table 3).

In Ethiopia, similar studies revealed that garlic rust is the major threat, which reduces production potential of garlic significantly; and severity and yield losses of 80 and 48.5% were noted, respectively (Table 3).

Table 3. Combined mean marketable yield and yield related parameters of Garlic varieties tested during 2023 cropping season.

Varieties	DM (Day)	BL (cm)	BD (cm)	BW (g)	MY ($t.ha^{-1}$)	UMY ($t.ha^{-1}$)	NCPP (No.)	Disease (LR)
Holota Local	152.67^{b}	3.87b	4.49b	27.02b	1.90^{b}	1.10a	9.33^{b}	40Ms
Kuriftu	157.33^{a}	3.13c	4.17b	26.76b	1.17^{b}	1.00a	7.00^{c}	40Ms
Bushoftu	152.33^{b}	3.09c	4.01b	25.03c	1.50^{b}	0.33b	7.11^{c}	40Ms
Tsaday	151.00^{c}	3.10c	4.11b	24.10c	2.10^{b}	0.20b	8.67^{c}	40Ms
Chafe	151.00^{c}	3.05d	4.33b	24.05c	1.17^{c}	0.20b	7.33^{c}	40Ms
Local	139.67^{d}	4.60a	5.60a	29.67a	4.75^{a}	0.12c	13.67^{a}	40Ms
LSD (%)	2.41	0.65	1.05	1.23	1.28	0.14	1.98	
CV (%)	2.59	13.92	19.62	13.66	27.26	24.11	13	
P-Value	**	*	*	**	**	**	**	

*DM=Days to maturity, BL=Bulb length, BD=Bulb diameter, BW=Bulb weight, NCPP=Number of clove per plant, BY=Bulb yield, LSD (0.05) =least significant differences and CV (%) = coefficient of variation, LR= Leaf rust, Ms=moderately susceptible, **= highly significant and NS=Non significant.*

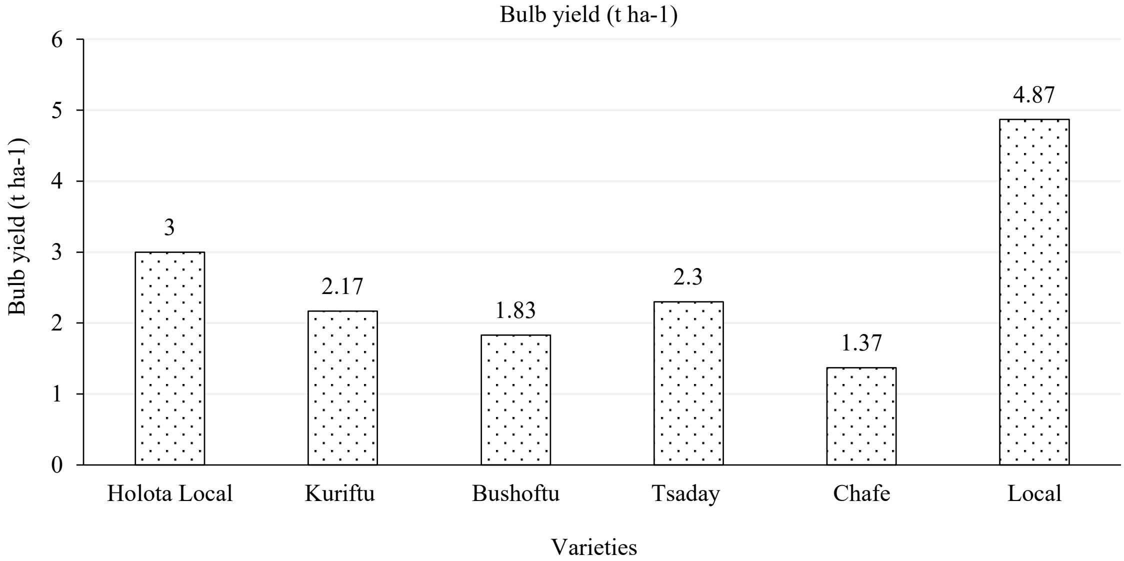

Figure 1. Combined mean yield of Garlic varieties tested during 2023 cropping season.

Table 4. Correlation Bulb diameter, Number of clove par bulb, bulb weight and bulb yield on garlic varieties.

	BL	BD	NCPP	BW	MY	BY
BL	1					
BD	0.36*	1				
NCPP[1]	0.39**	0.46**	1			
BW	0.44**	0.39**	0.65**	1		
MY	0.63**	0.59**	0.87*	0.72**	1	
BY	0.56**	0.65**	0.76**	0.95***	0.97*	1

***Note:** BL=Bulb Length, BD=Bulb Diameter NCPP= Number of clove per plant, BW=Bulb weight, MY=Marketable yield ,BY=Bulb Yield,*=Significant, **=Highly significant and ***Very highly Significant at 5, 1, and 0.1%, respectively.*

Bulb Yield (t.ha $^{-1}$)

The present result showed that the bulb yield was affected by the variety. Significantly the highest bulb yield (4.67 t.ha^{-1}) were recorded from local variety while the lowest yield (1.37 t.ha^{-1}) from Chafe variety. However, the overall yield was lower compared to the national average yield. Similarly, Ayalew *et al*. reported that higher bulb yield (16.56 t.ha^{-1}) was recorded from local cultivars as compared to five garlic varieties (Figure 1) [7].

Correlation Analysis

Pearson correlation indicated a significant and positive relationship between bulb yield of garlic with many parameters such bulb length (r=0.56**), bulb diameter (r=0.65**), number of cloves per bulb (r=0.76**) and bulb weight (r=0.95**), and Marketable bulb yield (r=0.97**) (Table 4). The current finding agree with the report of Jilani *et al*. and Ademe *et al*. [17, 3]. Zakari *et al*. also reported that the increase in yield contributing parameters and other positively correlated characters increased tuber yield (Table 4) [28].

CONCLUSION

An experiment was conducted for 1 year during 2023 cropping season under rain fed condition at three locations (Chor, Gechi and Didessa districts) to evaluate and recommend improved varieties for the study area. The result showed that number of cloves per plant and bulb yield were highly significant

($p<0.01$) while bulb diameter and Average bulb weight showed non-significant ($P>0.05$) effect. The highest bulb yield was obtained from Local variety (4.87 $t.ha^{-1}$) followed by Holota Local (3 $t.ha^{-1}$), while the lowest marketable bulb yield was obtained from Kuriftu variety (1.37 $t.ha^{-1}$). The local variety was superior to the others in most of the desired parameters for garlic. This research work proved that the improved and released varieties of garlic were not competent with the local cultivar which has been under production in the study area. Therefore, the findings of this study can be used as good source of information for the future garlic variety development program at regional and national level. In conclusion, considering the most desirable yield and yield component parameters, the local cultivar is recommended to the producers in Buno bedele Condition. Further research on the collection, characterization, and evaluation of the garlic cultivars targeting the study area and similar agro-ecologies. Moreover, Agronomic practice like planting date, spacing and fertilizer recommendation is needed to increase the production of garlic in the area.

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