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Adaptation Trial of Improved Garlic (*Allium sativum* L.) Varieties in North Shewa Zone, of Oromia Region

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Abstract: Garlic (Allium sativum L.) belongs to the family Alliaceae and is the second most widely used Allium next to the onion. North shewa has considerable potential in agroecology which is suitable for garlic production. However, the lack of improved and adaptable varieties of this crop is the major production constraint in the study area. A field experiment was conducted for one year (2021) during the cropping season on farmers' land in Jidda, Wachale, Yaya Gulale, and Degam districts. The objective of the study was to identify adaptable, high-yielding, and diseases tolerant garlic varieties for the study areas and similar agroecology. The treatments were arranged in a randomized complete block design with three replications. The treatments consisted of five garlic varieties (Bushoftu, Kuriftu, Tsedey 92, HL, and Chefe) and one local check. The result of the study showed significant differences among varieties for all the recorded traits. Among the varieties, Local check gave the highest yield (9.96 tons ha^{-1}) followed by Kuriftu (6.94 tons ha^{-1}) and Tsedey 92 (6.37 tons ha^{-1}), respectively. Therefore, the result of this research can be used as good information for the future garlic variety development program at the national level. Considering the most desirable yield and yield component parameters, the local cultivar is recommended to the producers in the North Shewa Zone of the Oromia Region. Further research on the collection, characterization, and evaluation of the local cultivars should be conducted for national use.

Keywords: Adaptation, Bulb Yield, Garlic, Varieties

1. Introduction

Garlic (Allium sativum L.) belongs to the family Alliaceae and is the second most widely used Allium next to onion [16]. Garlic is among the most important bulb vegetable crops used as a seasoning or condiment of foods because of its pungent flavor. Garlic adds a taste to foods as well as helps to make them more palatable and digestible [7]. Garlic is one of the best-studied medicinal plants that have antibacterial and antiseptic properties [9].

These crops are also produced for home consumption and as a source of income for many peasant farmers in many parts of the country [5]. In Ethiopia, the total area under garlic production in 2019/20 reached 8,344.47 ha and the production is estimated to be 1,525,946.34 Qt [3]. The production is spread throughout the country both under irrigation and rain-fed conditions in different agro-climatic regions [2]. The low yield of this crop is due to many biotic and a biotic factors such as lack of high-yielding varieties, non-availability of quality seeds, imbalanced fertilizer use, lack of irrigation facilities, lack of proper disease and insect pest management and other agronomic practices, low storability, and lack of proper marketing facilities [12]. North shewa has a great potential to produce garlic under rain fed, and irrigation. However, due to the lack of improved and adaptable garlic varieties with their improved agronomic practices, the farmers use only the local cultivar in their traditional production. Even if the area is very suitable and the crop is very important commercially, farmers' income generation from garlic and productivity is still unsatisfactory. There are no research efforts made concerning the adaptability of garlic varieties in the study area. Therefore, the objective of this study was to identify adaptable, high-yielding, and diseases tolerant garlic varieties for the study areas and similar agroecology.

2. Materials and Methods

2.1. Study Area

The multi-location yield evaluation was conducted on four locations at Fitche Agricultural Research Center sub-sites (Jidda, Wachale, Yaya Gulale, and Degam) in North shewa, Oromia, Ethiopia, during the 2021/22 main cropping season.

Breeding Materials and Experimental Design

The treatments consisted of five improved garlic varieties and one local check (Table 1). The trial was carried out in a randomized complete block design (RCBD) having three replicates in a gross plot size of 3.6m2 (1.8m and 2m) with a spacing of 1m between replicates and 0.5m between plots. All treatments were assigned randomly to the experimental plots. Spacing between rows 30 cm apart and 10 cm between plants' was split and applied in the form of Urea half at planting and the other half 30 days after planting while all the NPS was applied at the time of planting.

2.2. Experimental Materials

Table 1. *Description of five garlic varieties and one local check selected for the trial.*

No	Varieties	Year of released	Breeder/Maintain
1	Chefe	2015	DebreZeit Agricultural Research center
2	Kuriftu	2010	DebreZeit Agricultural Research center
3	Holeta	2015	DebreZeit Agricultural Research center
4	Tsedey 92	1999	DebreZeit Agricultural Research center
5	Local		Farmers of the study area

Source =Ministry of Agriculture and Natural Resources [10]

2.3. Treatments and Experimental Design

The treatments consisted of five garlic varieties and one local check (Table 1). The trial was carried out in a randomized complete block design (RCBD) having three replicates in a gross plot size of 3.6m2 (1.8m and 2m) with a spacing of 1m between replicates and 0.5m between plots. All treatments were assigned randomly to the experimental plots. The experimental field was prepared following the conventional tillage practice using an oxen plow. Cloves of medium-sized (2 -3 g) were planted by hand in rows 30 cm apart and with 10 cm between plants within rows. N was split applied in the form of Urea half at planting and the other half 30 days after planting while all the NPS was applied at the time of planting.

2.4. Data Collection

Data were recorded on plant height, number leaf per plant, bulb diameter, number of cloves per bulb, Clove weight, and bulb weight from a sample of 10 representative plants while days to maturity, stand count, and bulb yields were collected on plot base. Also, disease data were collected by scale (1 to 5).

2.5. Data Analysis

Analysis of variance was carried out using Gens tat discovery 15th edition software for the parameters studied following the standard procedures Gomez, KA. [6]. Means that showed significant differences were compared using the Least Significant Difference (LSD) test at a 5% significant level.

3. Results and Discussion

A combined analysis of variance showed the presence of highly significant (P≤0.01) differences among the treatments for the plant height, stand count, days to maturity, bulb diameter, number of cloves per plant bulb weight, and Clove weight; the significant difference (P≤0.05) for number leaf per plant and bulb yield. (Table 2). The presence of significant differences among treatments indicates the presence of genetic variability for each of the characters among the tested treatments.

Table 2. *The mean squares for different sources of variation and the corresponding CV (%) for the parameter studied.*

S.V	DF	PH	SC	DM	NLP	BD	NCPB	BW	CW	BY
Loc	3	144.32**	103.25**	417.38**	9.84**	446.69**	80.42**	6313.34**	8.35**	222.86**
Rep	2	14.38	5.79	1.62	2.58*	2.19	1.94	18.34	1.24	0.03
Trt	5	255.05**	113.53**	203.63**	1.70*	25.36**	56.31**	1343.16**	3.97**	64.19*
Loc*Trt	15	35.04**	21.50**	24.78**	0.45	3.83*	21.88**	241.85**	0.93*	14.82*

Keys: *, **: significant at 5% and 1% respectively, S. V=source of variation, Loc=Location, Trt = treatment, Rep = replication, Loc*Trt = Location by treatment, DF = degree of freedom, PH=plant height, SC=stand count, DM=days to maturity, NLP= number leaf per plant, BD=bulb diameter, BW=bulb weight, CW= Clove weight, BY=bulb yield

Table 3. *Combined mean for bulb yield and yield related traits.*

Treat	PH (cm)	SC	DM	NLP	BD (cm)	NCPB	BW (g)	CW (g)	BY (t/ha)	RDS
Local	67.06^{a}	24.58^{a}	152.60^{d}	8.58^{a}	20.03 ^{a}	19.31^{bc}	56.86 ^{a}	3.81^{a}	9.96^{a}	1.50
Kuriftu	60.28^{b}	23.75^{ab}	158.10^{b}	8.00^{ab}	19.08^{ab}	21.94^{a}	41.11 ^{b}	2.75^{b}	6.94^{b}	1.00
HL	61.25^{b}	22.50^{b}	159.60^{a}	8.28^{a}	18.33^{bc}	21.14^{a}	39.78 ^{b}	2.45^{b}	5.98^{d}	1.00
Tsedey 92	60.39^{b}	24.75^{a}	156.20^{c}	8.31^{a}	17.42^{cd}	20.69^{ab}	34.25 ^{c}	2.35^{b}	6.37^{c}	1.00
Chafe	54.42^{c}	17.50^{c}	150.10^{e}	7.47^{b}	16.47 ^{d}	18.28^{c}	30.61 ^{d}	2.55^{b}	3.72^{e}	2.00
Bushoftu	55.11^{c}	18.92^{c}	150.00^{e}	8.08^{a}	16.42 ^{d}	16.06^{d}	26.92 ^{e}	2.23^{b}	3.77^{e}	2.00
Mean	59.75	22.00	154.42	8.12	17.97	19.57	38.25	2.69	6.12	1.41
LSD 5 %	1.90	1.84	0.62	0.60	1.08	1.70	2.21	0.56	2.30	
CV %	3.90	10.20	0.50	8.90	7.40	10.60	7.00	25.30	4.60	

Keys: CV= Coefficient of Variation, LSD= Least Significant Difference. Means followed by different letters within columns are significantly different by Duncan's new multiple range test (P = 0.05). PH=plant height SC=stand count, DM= days to maturity, NLP= number leaf per plant, BD=bulb diameter, NCPB= number of clove per bulb, BW= bulb weight CW= Clove weight, BY (t/ha) =bulb yield tons per hectare, and RDS= Rust disease score (1-5)

3.1. Maturity Date

The current result showed that there was a significant difference among treatments, Chafe and Bushoftu varieties were early matured (150.10 and 150.00 days) respectively. Medium days to maturity were recorded by variety Local (152.60) followed by Tsedey92 (156.20) while Kuriftu and HL varieties were late maturity date (158.10 and 159.60 days) respectively. The five varieties thus differed significantly in date of maturity. A similar result was reported byYesigat, M.[19]. This extended growth period of this variety may incur additional cost and makes the land not to be ready for the next crop.

3.2. Plant Height and Number of Leaves Per Plant

The current study revealed that the highest plant height (67.06cm) was recorded from Local and the medium plant height (61.25cm) was recorded from HL followed by Tsedey92 (60.39cm) and Kuriftu (60.28cm) while the lowest plant height (54.42cm) was recorded from Chafe andBushoftu (55.11cm). The mean values show that a greater number of leaves per plant was noted in varieties Local (8.58), Tsedey 92 (8.31), HL (8.28), Bushoftu (8.08), and Kuriftu (8.00) respectively. While the smaller number of leaves per plant was recorded from variety Chafe (7.47). This result is in line with Ayalew, A. *et al* [1] who reported that the highest plant height and number of leaves per plant was recorded from local among tasted garlic varieties.

3.3. Bulb Diameter and Number of Cloves PerBulb

The mean values revealed that the maximum bulb diameter was recorded from Local (20.03cm) followed by Kuriftu (19.08cm) while the lowest bulb diameter (16.42cm) was recorded from the Bushoftu variety. On the other hand, the highest number of cloves per bulb was recorded from Kuriftu (21.94) followed by HL (21.14) while the lowest was from the Bushoftu variety (16.06). In contrast to the current finding research reported that the highest number of cloves per bulb was recorded from the local cultivar (12.75 cm) Yan W, Rajcan.[18]. This might be a variation between the two environments.

3.4. Clove Weight, Bulb Weight, and Yield

The mean values showed that the maximum clove weight (3.81g) was noted in the Local cultivar. Except for the local cultivar, all the other five varieties are statistically similar to each other. This result is in line with Muhammad*et al.* [14] who reported that the maximum clove weight was recorded from local among tasted garlic varieties.

The present result showed that the bulb weight and yield were affected by the variety. Significantly the highest bulb weight (56.86 g) and yield (9.96t/ha) were recorded from the Local cultivar while the lowest bulb weight (26.92 g) from the Bushoftu variety and bulb yield (3.72 tons ha^{-1}) from the Chafe variety. This result is in line with Mohammed *et al.* [13] The current outcome showed the possibility of bulb yield increment by using local cultivar and Kuriftu, respectively. However, the overall yield was lower compared to the national average yield. Similarly, Ayalew, A. *et al* [1] reported that the maximum bulb weight (49.72g) and yield (16.56 tons ha^{-1}) were recorded from local cultivars as compared to five garlic varieties. However, this result varies from the study conducted by Ayalew, A. *et al* [1] reported that the highest bulb yield was recorded at 16.16, 11.78, and 5.57t/ha from local, Kuriftu, and Tsadey 92 varieties respectively. This might be a variation between the two environments.

The average environment is defined by the average values of PC1 and PC2 for all environments and it is presented with a circle Purchase, JL. [15]. The average ordinate environment (AOE) is defined by the line which is perpendicular to the AEA (average environment axis) line and passes through the origin. This line divides the varieties into those with higher yields than average and those with lower yields than average. By projecting the varieties on the AEA axis, the varieties are ranked by yield; where the yield increases in the direction of the arrow. In this case, the highest yield varieties are Local, Kuriftu, and Tsedey 92. On contrary, Chafe and Bushoftu varieties recorded the lowest bulb yield (Figure 1).

The variety ranking is shown on the graph of a variety called the "ideal" variety (Figure 1). An ideal variety is defined as one that is the highest yielding across test environments and it is completely stable in performance that ranks the highest in all test environments; such as Local, Kuriftu and Tsedey Farshadfar, E. *et al and* Yan, W. [4, 17]. Even though such an "ideal" variety may not exist in reality, it could be used as a reference for variety evaluationMitrovic, B *et al* [11]. A variety is more appropriate if it is located closer to the "ideal" variety Kaya, Y. *et al*, and Farshadfar, E. *et al* [8, 4] So, the closer to the "ideal" variety in this study was Local (Figure 1). The ideal test environment should have large PC1 scores (more power to discriminate variety in terms of the genotypic main effect) and small (absolute) PC2 scores (more representative of the overall environments). Such an ideal environment was represented by an arrow pointing to it (Figure 2). Actually, such an ideal environment may not exist, but it can be used as an indication for variety selection in the Mets. An environment is more desirable if it is located closer to the ideal environment. Therefore, using the ideal environment as the center, concentric circles were drawn to help visualize the distance between each environment and the ideal environment Yan W, Rajcan.[18]. Accordingly, (Jida), which fell into the center of concentric circles, was an ideal test environment in terms of being the most representative of the overall environments and the most powerful to discriminate varieties (Figure 2).

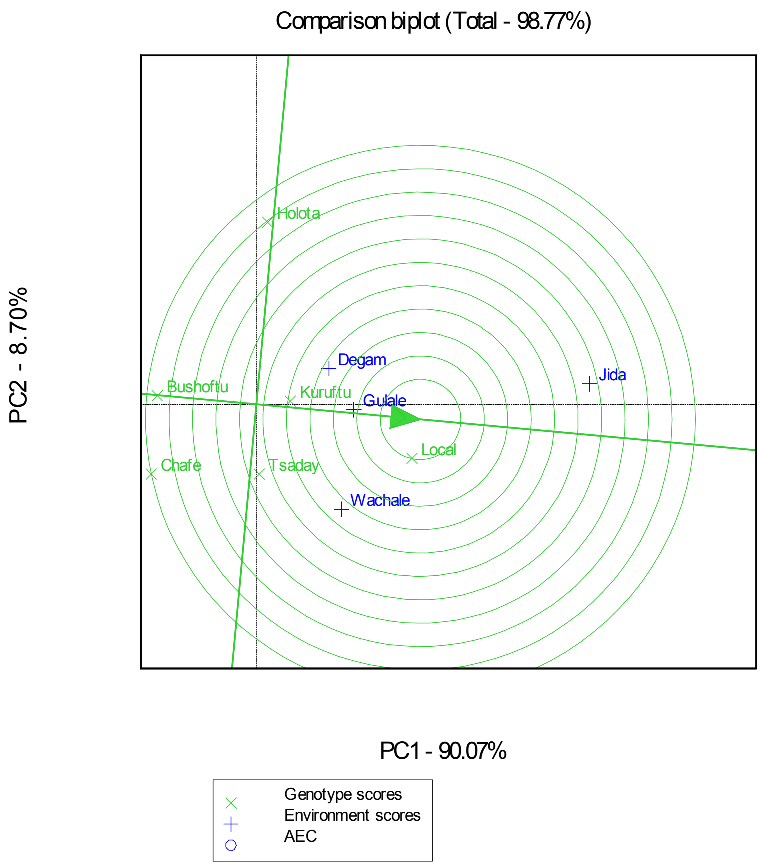

Figure 1. *GGE bi-plot comparison of varieties for their yield potential and stability.*

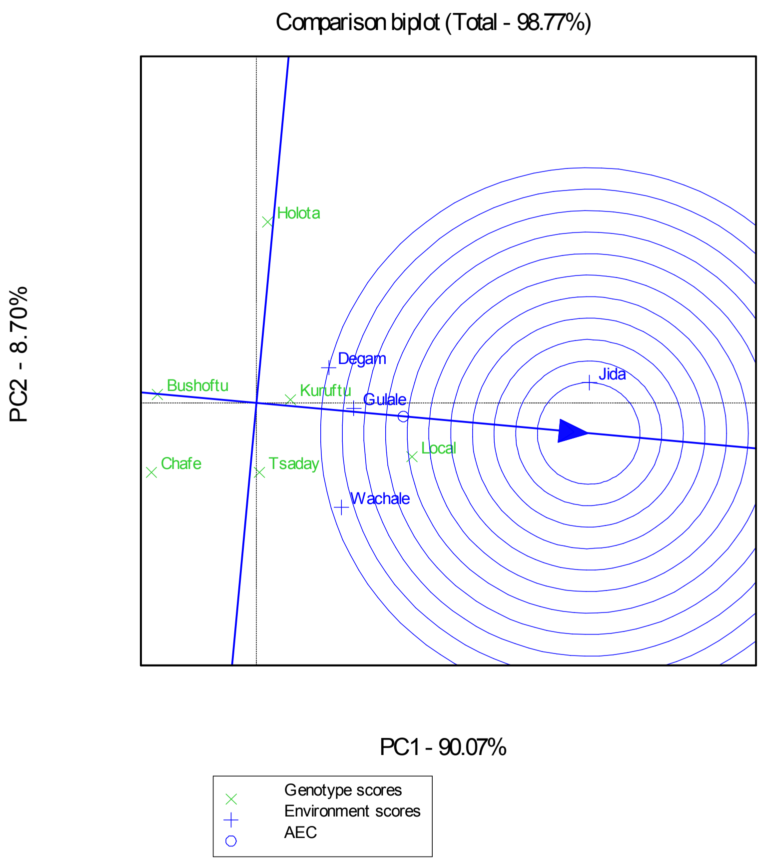

Figure 2. *GGE bi-plot based on tested environments-focused comparison for their relationships.*

4. Conclusions

As indicated in the result there was significant differences among the varieties for all parameters. The local variety was superior in most of the desired parameters for garlic. This research work proved that the improved and released varieties of garlic were not compared with the local cultivar which was under production in the study area before they get released. Therefore, the result of this research can be used as good information for the future garlic variety development program at the national level. Finally, considering the most desirable yield and yield component parameters, the local variable should be recommended to the producers in the North Shewa Zone of the Oromia Region. Further research on the collection, characterization, and evaluation of the garlic cultivars which are under production in the study area and the nearby districts with similar agro-ecologies should be conducted to make this variety be registered and released at the national level.

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