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Morphological Characterization and Evaluation of Garlic (*Allium sativum* L.) Accessions Collected from Northern Highlands of Ethiopia

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Abstract

Seventy five germplasm collections of garlic (*Allium sativum* L.), three standard checks and three promising genotypes were evaluated for six quantitative characters using simple lattice square design at Chefe Donsa and Debre Zeit, Central part of Ethiopia. The main objective of the study was to asses and select better genotypes with high yield, quality and pest tolerant to next steps. Analysis of variance showed significant difference among the tested accessions for most of the quantitative traits considered in the study except weight of clove. The better performed accessions than best check were GOG-018/18 and GOG-067/18 found to be superior bulb yield followed by GOG-073/18, GOG-069/18, GOG-058/18, GOG-057/18, GOG-072/18, GOG-074/18, GOG-075/18, GOG-061/18, GOG-064/18, GOG-059/18, GOG-047/18, GOG-056/18, GOG-055/18, GOG-001/18, GOG-063/18, GOG-045/18, GOG-049/18, GOG-068/18, GOG-011/18, GOG-051/18, GOG-070/18, GOG-025/18 and GOG-046/18. So, these accessions will be promoted to the next breeding step. Cluster- IV and V were constituted by the most important garlic accessions that are characterized by the best bulb yield than the other clusters. All morphological characters were positively and significantly correlated with bulb yield.

Keywords: *Allium sativum* L; Accessions; Characterization; Quantitative traits

Introduction

Garlic (*Allium sativum* L.) is one of the main Allium vegetable crops known worldwide with respect to its production and economic value which requires good production and management practices [1]. It is used as a flavoring in many foods worldwide and without garlic; many of our popular dishes would lack the flavor and character that make them favorites. However, the quality and high yield garlic production is depend on production and management practices on both field and after harvested.

In spite of its importance (increasing of garlic production and productivity), garlic yield is low in many parts of the world, due to genetic and environmental factors affecting its yield and yield related traits. To overcome such production problems, great effort should have to be made in the selection and breeding of high yielding cultivars and the development of cultural techniques.

In Ethiopia the Alliums group (onion, garlic, and shallot) are important bulb crops produced by small and commercial growers. Garlic is one of the important vegetable crops in Ethiopia for local market and export [2]. It is also the most ancient cultivated herbs and vegetative propagated by cloves and widely cultivated spice crops used for food as well as medicinal purposes. These crops are produced for home consumption and as a source of income to many farmers, especially for those who have limited cultivated land or small holder farmers in many parts of the country [3].

Economic significance of garlic in Ethiopia is quite considerable; it is grown as spice and used for flavoring local dishes, and contributes to the national economy as export commodity. Garlic is produced mainly in the mid and high lands of the country and the bulk of garlic for domestic market is produced in homestead gardens of subsistence farmers and produced mainly as a cash.

Garlic is widely cultivated around home gardens, but nowadays, its production is practiced in some large farms [4]. In addition, it is one of the most important vegetables produced by small hold farmers mainly as a source of cash income and for flavoring the local stew called 'wot'. According to CSA (2017/18), in Ethiopia, garlic was cultivated on 19412.49 hectares of land and above 1.78 million quintal of yield was harvested. The average yield per hectare was 9.18 ton.

The Garlic germplasm has been collected from different sources maintained and attempt was made to characterize, clonal selection and released only six varieties for users in Ethiopia. This one of the great efforts has been made in the selection and breeding of locally adapted cultivars and the development of cultural techniques. Because many traits of garlic including bulb size, shape, maturity date, the percentage of thick-necked and double bulbs are influenced by the environment [5]. For the development of suitable varieties of garlic, it is essential to evaluate the characters of the available germplasm properly for selection. Garlic accessions that are new varieties with higher bulb yield and better bulb quality can be developed through selection from the rich source. This study was therefore, conducted to asses and advance better genotypes with high yield, quality and pest tolerant varieties.

Materials and Methods

The experiment was conducted at Debre Zeit Agricultural Research Center (DZARC) and Chefe Donsa research sub-station during 2019/20 main season. Seventy five garlic germplasm collections, three standard checks and three promising genotypes were used. The experiment was laid out in 9 × 9 simple lattice square design with two replications. The plot size was 2 m × 1.2 m=2.4 m. The spacing between double rows, rows and plants was 60 cm, 40 cm and 20 cm,

respectively. All agricultural management practices was carried out at the same time to all treatments such as weeding, watering, and hoeing. Fertilizers were also applied at the rate of 243 kg/ha NPS during planting and 130 kg/ha urea in split application once during planting and the second application was done after 45 days. Pesticides were applied like, Tilt (0.5 lit/ha for 3 times), Karate (0.3 lit/ha for 2 times) and Ridiomil gold (2.5 lit/ha for 1 time) per season as per manufacturer recommendation rates.

Data to be collected and analysis

Morphological traits were measured at various growth stages according to descriptors for garlic developed by International Plant Genetic Resources Institute [6]. These were Plant vigor, plant height, maturation date, number of clove/bulb, weight of clove, and bulb yield. Analysis of Variance (ANOVA) was performed and then the means of results were compared by LSD analysis. Statistical analysis was done using SAS version 9.00.

Results and Discussion

Bulb yield

Seventy five garlic accessions with three standard checks and three promising genotypes were evaluated in two locations. Significant differences were observed ($P<0.05$) between the tested genotypes for garlic bulb yield [7]. The variability between accessions is statistically significant for the morphological characters, which indicated the presence of wide spectrum of variability among the local garlic accessions.

In addition to that there were garlic accessions that surpassed standard check and promising genotypes in terms of yield. Combined mean bulb yield has revealed that the check HL was the highest yielding check [8]. However, check HL was surpassed by 26 accessions. This shows the possibility of screening genotypes among collections from North highland of Ethiopia which is higher yielding than the varieties already released by the national program.

Among the 26 accessions whose mean bulb yield was higher than that of the best check HL (4663.90 kg/ha), accession GOG-065/18 (7327.55 kg/ha) was superior from all evaluated accessions. Other accessions which were superior to the best checks are GOG-018/18, GOG-067/18, GOG-073/18, GOG-069/18, GOG-058/18, GOG-057/18, GOG-072/18, GOG-074/18, GOG-075/18, GOG-061/18, GOG-064/18, GOG-059/18, GOG-047/18, GOG-056/18, GOG-055/18, GOG-001/18, GOG-063/18, GOG-045/18, GOG-049/18, GOG-068/18, GOG-011/18, GOG-051/18, GOG-070/18, GOG-025/18 and GOG-046/18 as indicated. These accessions should be subjected to further testing and advanced towards breeding trials.

Growth and bulb yield related traits

The data with respect to growth and yield related traits were presented. The garlic accessions significantly differed ($P<0.05$) in terms of plant height, plant vigor, maturation date, number of cloves per bulb, but not for weight of clove. Among different genotypes evaluated, GOG-065/18 was tallest with plant height (64.90 cm) followed by GOG-072/18 (64.65 cm) and GOG-069/18 (62.90 cm) whereas, genotype GOG-008/18 (44.25 cm) was found shortest.

Among all the evaluated accessions GOG-008/18 was taken minimum days to maturity (116.50 days) followed by GOG-006/18 (117.00 days) and GOG-006/18 (117.25 days) while, the maximum days to maturity were recorded in GOG-072/18 and GOG-079/18 (135.25 days) followed by GOG-065/18 (135.00 days). However, the remaining genotypes took 117.25 days to 134.50 days with a mean of 128.08 days to maturity [9]. Thus, in addition to bulb yield evaluation and characterization of collected germplasm by using growth and yield related traits are provide a rapid, reliable and efficient tool of information to exploit genetic variability and to enhance the utilization of germplasm.

Mean performance and associations of characters for garlic accessions

The ranges and means of bulb yield and its related traits are clearly indicated in Table 1. The result showed that there was wide range of variation for most of the traits such as bulb yield (2003.00 to 7328.00 kg/ha) and the mean for this character was 4168.00. The maximum value plant height was exhibited 64.90 cm and the minimum value was 44.25 cm. Number of cloves per bulb (10.80 to 18.95) and clove weight (2.55 to 4.50 g) also showed differences among the germplasm. The range and mean in this study indicated the existence of variability among the tested accessions for the major characters studied and there is considerable potential for garlic improvement program in the future. The present findings are in agreement with the findings of who were reported wide range of variation for bulb yield and yield related characters of garlic genotypes.

No	Characters	Minimum value	Maximum value	Range unit	Mean
1	Bulb yield(Kg/ha)	2003	7328	5325	4168
2	Plant vigor (scale 1 to 5)	2	4	2	2.98
3	Maturity date (Days)	116.5	135.25	18.75	128.08
4	Plant height (cm)	44.25	64.9	20.65	55.56
5	No of cloves per bulb (No)	10.8	18.95	8.15	14.94
6	Weight of clove (g)	2.55	4.5	1.95	3.5

Table 1: Range and mean of quantitative characters for the 81 garlic germplasm accessions studied.

Correlation analysis helps in the evaluation of relationship existing between yield and its components. Significant positive correlation of bulb yield per hectare was observed with plant vigor, maturity date, plant height number of clove per bulb and bulb weight (Table 2). The more these variables are maximized the higher will be the yield. Choosing genotypes with high levels of these characteristics, and application of appropriate agronomical techniques will guaranty higher yield. The highest correlation was found positively among bulb yield with plant vigor (r=1) and bulb diameter (r=0.788), respectively. Thus, if the plant is vigorous, then higher yield could be expected. In the other hand, there was a relatively strong positive correlation (r=0.606) between plant height and maturity date, and between plant height and bulb yield (r=0.543).

Characters	BIY	VI	MAD	PH	NOC	WOC
BIY	1					
VI	0.788***	1				
MAD	0.499***	0.473***	1			
PH	0.543***	0.413***	0.606***	1		
NOC	0.232*	0.247*	0.479***	0.354**	1	
WOC	0.281*	0.247*	0.060 NS	0.179 NS	0.466***	1
BIY: Bulb Yield (Kg/ha), VI; Plat vigor rate: 1 to 2=poor (weak plant with little foliar growth), 3=average (acceptable foliar growth), and 4 to 5=high (excessive amounts of foliar growth), MAD: Maturity date (No.), PH: Plant Height (cm), NOC: Number of Cloves per bulb (No.), WOC: Weight of clove (g)						

Table 2: Simple correlation between values of the garlic germplasm accessions for different traits.

Clusters analysis

Cluster analysis was confirmed the presence some variation among genotypes. Based on the method of the clustering is applied a cut-off point to the dendrogram of the UPGMA (Unweighted Pair Group Method with Arithmetic Mean) method at a dissimilarity.

Clustering based on six morphological traits was shown as a dendrogram of dissimilarity representing the closest accessions in homogeneous groups. It sorted the 81 garlic accessions into five main groups (Figure 1).

Similar report was indicated by who three clusters identified from twenty garlic accessions. The accessions were grouped in to Cluster I were the largest with 32 accessions (39.50%) followed by cluster II with 31 accessions (38.27%), cluster III with 9 accessions (11.11%), cluster IV with 5 accessions (6.17%) and cluster V with 4 accessions (4.94%) of the total (Table 1).

These were indicating that garlic accessions of the same cluster group were at least morphologically similar. The clusters-IV and V were constituted by the most important garlic accessions that are grouped by the higher bulb yield than the other clusters.

The clustering pattern of the accessions revealed the existence of genetic diversity in the garlic accessions for the characters studied.

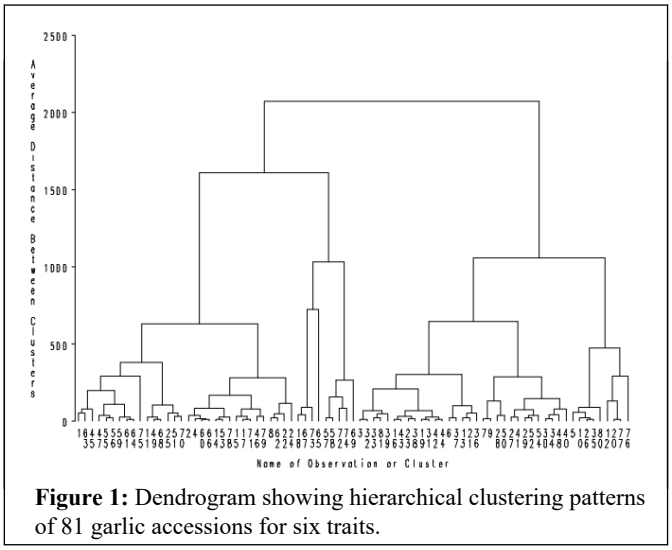

Figure 1: Dendrogram showing hierarchical clustering patterns of 81 garlic accessions for six traits.

Conclusion

The study was carried out to asses morphological variation among garlic accessions and to screen superior garlic genotypes, collected from Northern highlands of Ethiopia. The result showed a significant difference among the garlic genotypes for almost all the traits. The genotypes GOG-065/18 , GOG-018/18, GOG-067/18, GOG-073/18, GOG-069/18, GOG-058/18, GOG-057/18, GOG-072/18, GOG-074/18, GOG-075/18, GOG-061/18, GOG-064/18, GOG-059/18, GOG-047/18, GOG-056/18, GOG-055/18, GOG-001/18, GOG-063/18, GOG-045/18, GOG-049/18, GOG-068/18, GOG-011/18, GOG-051/18, GOG-070/18, GOG-025/18 and GOG-046/18 were also found promising for yield traits. The ranges of mean values for most of the characters were large, showing the existence of variations among the tested accessions. In

addition, the morphological traits of the characters of garlic had positive correlations among each other. All characters were exhibited positive and significant correlation with bulb yield Viz., plant vigor, maturity date, plant height, number of clove per bulb and bulb weight.

The result will be helpful for researchers to comprehensively understand the genetic background of the garlic collection and more easily select the target accessions, especially those with high bulb yield, best quality and pest tolerant characteristics. The garlic germplasm should be properly conserved and could serve as raw material for the in future garlic genetic improvement program. More of the observed variability for very important traits in garlic quality attributes and disease resistance related significantly should be exploited in order to improve the productivity of garlic.

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