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Evaluating Local Garlic (Allium sativum L) Accessions using Multivariate Analysis Based on agro-morphological Characters in Southern Tigray, Ethiopia

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ABSTRACT
To assess the diversity and trait association of eight local garlic accessions, a study was conducted in southern Tigray, Ethiopia using Randomized Complete Block Design with three replications during 2014 cropping season. Cluster analysis using Ward's method classified the eight accessions into three clusters. Cluster I and III were equally with three number of accessions while, cluster II contains two accessions. The three principal component analysis with Eigen value greater than one explained 81% of the variability in the data set. Using the first principal component and the second principal component indirect selection could be effective using all accessions except accessions three and eight. The accessions by trait biplot showed that traits under study have positive association signifying narrow angle between them.
Key words: cluster analysis, principal component, garlic accessions

Introduction

Garlic (Allium sativum L,) belongs to the family Alliaceae and is the second most widely used Allium next to onion (Rubatzky and Yamaguchi, 1997). It is originated from the northwestern side of the Tien-Shan Mountains of Kirgizia in the arid and semi-arid areas of central Asia. Garlic is one of the most ancient cultivated herbs, and vegetatively propagated from cloves. This mode of clone propagation allows the production of a uniform crop that preserves quality traits, such as flavour and the nutritive properties of the plant. Maintaining of vegetatively propagated crops in the gene bank requires more efforts than generatively propagated crops. Cryopreservation is the most efficient technique for these crops (Keller et al., 2007) and it is a modern and effective method for plant germ plasm storage.

The highlands of Ethiopia are the most populated areas of the country containing the majority of the agricultural work force required for the sector. With the continuing increase in population and decline in size of farm land holdings, the major labor force has to move to the labor intensive cropping system to sustain rural development and food production. The highland areas of south Tigray is potential for cultivation of garlic. Many farmers in the particular zone widely cultivates this crop and used as the main source of income (MoARD, 2010).
A total of 10,690.41ha of land was under garlic production in Ethiopia, taking up about 6.64% land area covered by all vegetable crops at country level and yielding about 128440.94 tons cultivated by small scale farmers, contributing about 7.42% to the total country level all vegetable crop production (CSA, 2012).
Most of the conditions that are suitable for the production of onions are also suitable for garlic. The suitable growth temperature for garlic is 13 to 24 °C. The plants are also influenced by temperature and day length. Long days and high temperatures during the growing season encourage bulb formation. Garlic is sensitive to moisture stress throughout the growing season. Any period of dry soil conditions, especially during bulbing will result in yield reductions. Where enough rainfall is not available, then irrigation is a requirement for this crop to provide satisfactory yields. Garlic grows best in well drained fertile soils that are high in organic matter.
The optimum soil pH for garlic is between 5.5 and 7 http://www.nda.agric.za/docs/Brochures/prodGuideGarlic.pdf.
Garlic is used as a seasoning in many foods worldwide, without garlic many of our popular dishes would lack the flavor and character that make them favorites. Garlic's volatile oil has many sulfur containing compounds that are responsible for the strong odor, its distinctive flavor and pungency as well as for its healthful benefits (Salomon, 2002).

Estimating genetic diversity and determining the relationships among germplasm collections enhances efficient germplasm collection, management (Nisar et al., 2008) and genetic improvement (Geleta et al., 2005). Future of breeding programs depends on the availability of genetic variability to increase productivity. Morphological characterization is the first step in the description and classification of germplasm collections (Smith et al., 1991). This study was therefore conducted with the objective of assessing the genetic diversity of local garlic accessions using morpho-agronomic characters among eight accessions collected from southern Tigray of Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted at Zata Kebele, Ofla Woreda, southern Zone of Tigray in 2014 production season. The experimental site is located at $12^0$30 N latitude and 39^0 17' E longitude at an elevation of 2376 meter above sea level. Zata Kebele is located about 650 km away from Addis Ababa to the north part of the country and about 156 km to the south of Mekelle town. Maximum and minimum temperature ranges from 26.36^0C and 11.71^0C, respectively. The mean annual rainfall of the area is 766.9 mm (AARC annual report, 2013).

Experimental design and the treatments

Eight different garlic accessions were collected from different garlic growing areas of Tigray region Table 1. The experiment was arranged in a randomized complete block design with three replications . A plot size of 4.2 m^2 was used with 7 rows and 15 plants per row. Row to row and plant to plant spacing was 0.30 and 0.10 m, respectively.

Table 1. Geographical origin of the accessions

Accessions Code	Source of accessions	Soil type	Rain fall mm/year	Altitude (m)	Year of release
1	DZARC/EIAR				1999/00
2	DZARC/EIAR				1999/00
3	Around Bora	Silt-clay loam	828.1	1799	-
4	Around Bora	Silt-clay loam	828.1	1799	-
5	Bora	Silt loam	845	1890	-
6	Bora	Silt loam	845	1890	-
7	Brki	Silt loam	600	2200	-
8	Brki	Silt loam	600	2200	-

Data Collected

Different morphological and agronomical traits were measured that includes:

Plant height (PH): Height of 10 sample plants per plot were measured in cm from the soil surface to the tip of the mature leaf in the plant

Leaf number per plant: leaf number was recorded as average leaves count of ten plants per plot at physiological maturity and expressed as number of leaves per plant

Number of cloves per bulb: Mean clove numbers produced from single bulb. It was measured at harvest and expressed as number clove of per plant

Days to maturity: Number of days from planting to the date of maturity

Total yield: Mean weight of garlic bulb produced from middle row, it was recorded at harvest by weighting the cloves and weighed in kg/plot and converted into qt/ha.

Bulb length: The height of ten sample mature bulb per plot measured in cm

Bulb diameter: The average size measured at the widest point in the middle portion of the mature bulb expressed in cm

Statistical analysis

The collected data were subjected to cluster analysis based on the phenotypic mean cluster analysis was computed using ward method by XLSTAT, 2015 software. Principal component analysis and genotype by trait biplot was performed using Past software (Hammer et al., 2001).

Results and discussion

Cluster analysis

The clustering analysis was done using the mean value of seven traits of garlic accessions. Using the ward method and divided into three major clusters (Figure 1). This result is in agreement with Panthee et al. (2006) that had found three major clusters in garlic using morplogical traits. Accession 3,1and 8 was located in the first cluster and accession 4 and 5 fall in the second cluster while, accession 6, 2 and 7 categorized in the third cluster. The clustering has no association between clustering pattern and source of collection.

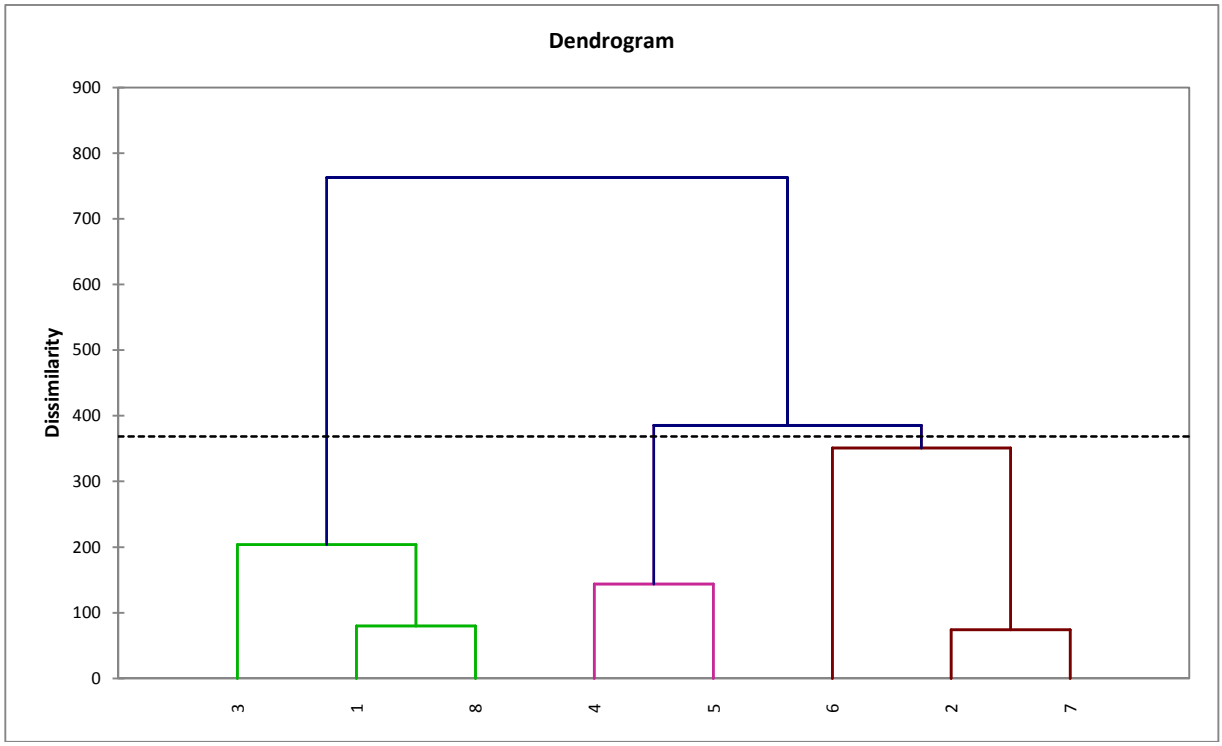

Figure 1: Dendrogram of eight garlic accessions studied in southern Tigray during 2014

The clusters mean showed difference for the seven characters of garlic accessions. The first lusters were with lower yield, lower plant height, short to days to maturity and lower number of clove per bulb. The second cluster was having a higher yield, longer plant height, medium in days to maturity and higher leaf number per plant. The third cluster were with medium yield, longer days to maturity and higher number of clove per bulb.

Table 2 mean of seven quantitative traits of garlic accessions studied in southern Tigray

Cluster	Yield (qt/ha)	Plant height (cm)	Days to maturity	Bulb diameter (cm)	Number of clove per bulb	Bulb length (cm)	Leaf number per plant
1	34.667	45.400	108.333	4.220	11.867	3.540	7.867
2	61.963	50.133	116.667	3.780	12.200	3.507	9.000
3	47.222	49.000	125.000	4.087	15.133	3.500	7.867

Principal Component Analysis

Principal component analysis was help full in identifying the most important characters in the study of association among traits. The three principal components captured 81% of the total variation in the data set (Table 3). The first principal component captured 36.88% having Eigen value of 2.582 since in forming first component the traits of width of clove, length of clove and yield had the highest positive coefficient, so this selection had the highest value in first component based on accessionss 2, 6 and 4 respectively. The second principal component also explained 27.34% with Eigen value of 1.914 in forming the second principal component the traits days to maturity, plant height , leaf number per plant and yield were with highest positive coefficient hence, selection based on accessions 7 is effective (Figure 2). The principal component three explained further 16.8% of the variability in the data set and having an Eigen value of 1.176 the leaf number was with higher positive coefficient and effective selection can be made using accessions 3 and 8.

Table 3 Principal component analysis Eigen value and total variability explained of the seven characters of garlic accessions.

	P1	P2	P3	P4	P5	P6	P7
Yield	0.359	0.294	-0.441	-0.456	-0.484	-0.381	-0.051
Plant height	0.271	0.513	0.294	0.487	-0.014	-0.319	0.488
Days to maturity	0.082	0.547	-0.501	0.178	0.229	0.59	-0.104
Bulb diameter	0.539	-0.182	-0.13	0.142	0.599	-0.36	-0.388
Number of clove per bulb	0.448	-0.303	0.065	0.469	-0.57	0.309	-0.252
Bulb length	0.525	-0.23	0.11	-0.412	0.173	0.389	0.555
Leaf number per plant	0.157	0.416	0.659	-0.337	0.002	0.169	-0.475
Eigenvalue	2.582	1.914	1.176	0.776	0.343	0.208	0.001
Variability (%)	36.886	27.341	16.807	11.085	4.899	2.972	0.01

Accessions by trait biplot analysis

The traits were represented by vector while, the accessions represented by points .The angle between traits approximate the relationship among them the lower the angle the positive and strong correlation the traits had between them however, if the angle is wider the reverse is true (Yan et al., 2007).The seven traits were categorized tentatively in to two groups (Figure 2). Accessions 2 and 4 were with higher number of principal component one and two and had higher days to maturity, Plant height, leaf number per plant and yield. Accessions 3, 1, 8 and 5 were followed with lower principal component one and principal component two as well and they were low responsive to all of the traits in the study.

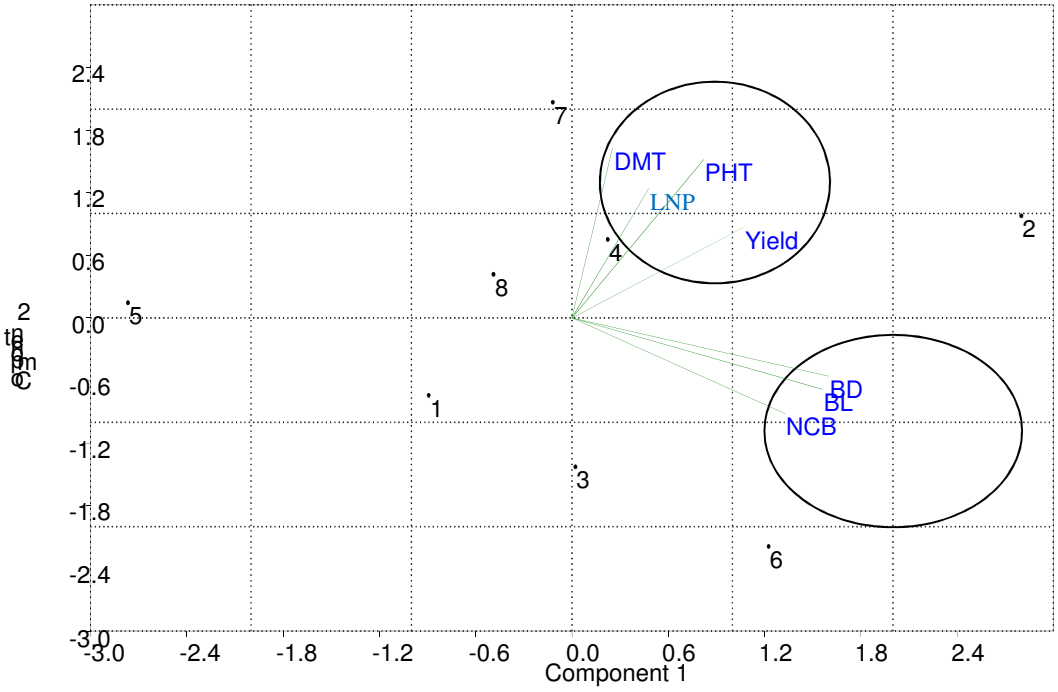

Figure 2. Accessions by trait biplot analysis

NB**:** DMT**=** Days to maturity**,** PHT**=** Plant height, LNP= leaf number per plant, NCB= number of cloves per bulb, BL= length of bulb and BD= bulb diameter

Conclusions

Study was conducted to determine the trait association of local garlic accessions using cluster analysis, principal component analysis and accessions by trait biplot analysis. Using the cluster analysis the garlic accessionss were categorized into three major clusters. The association of traits using the principal component analysis 81% were

captured using the three principal component having Eigen value greater than one. Using the accessions by trait biplot analysis 3, 1, 8 and 5 were with lower principal component one and two and indirect selection is not effective for any of the traits in the study.

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