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INTRA AND INTER CLUSTER STUDIES FOR QUANTITATIVE TRAITS IN GARLIC (*Allium sativum* L)

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ABSTRACT

Garlic is propagated vegetatively, the clonal selection is the important breeding method and very scanty work has been done on the association between different traits in garlic. Analysis of variance revealed significant divergence in fifteen garlic clone with checks i. e. Yamuna Safed (G-1), Agrifound White (G-41), Yamuna Safed-2 (G-50) and Yamuna Safed-3 (G-282) for different traits, indicating sufficient genetic diversity among the cultivars. Genotypes belonging to the cluster with maximum inter cluster distance were genetically more divergent. Therefore, it is suggested that based upon large cluster distances to select genotypes from all the clusters, which may lead to broad spectrum of favorable genetic variability for bulb yield improvement. Cluster-III had highest value of plant height (93.05 cm), bulb diameter (4.71 cm), bulb size index (16.08 cm^2), 20 bulb weight (700 g), clove diameter (1.75 cm), clove size index (4.43 cm^2), weight of 50 cloves (97.50 g) and gross yield (159.63 t ha^{-1}) and minimum neck thickness (1.45 cm) number of cloves per bulbs (17) days for bulb initiation (61.66 days) and days to harvesting (149.83). The traits total soluble solids contributed maximum (20.46%) toward genetic divergence followed by gross yield (16.37%), bolters (12.86%), marketable yield (11.11%), number of cloves per bulbs (10.52%), weight of 50 cloves (10.52%), days for bulb initiation (10.52%) and days for harvesting (4.09%). These traits were considered to be most important for genetic divergence, they contributed (96.45%) towards genetic divergence and selection of genotypes based on these traits will contribute to wider genetic diversity in the existing gene pool of garlic genotypes.

Key words: Garlic, Allium sativum, genetic divergence and D^2 analysis

INTRODUCTION

Among the spices grown in India, garlic (*Allium sativum* L.) is undoubtedly one of the important crops, propagated vegetatively and hence selection and use of

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diverse parents for its improvement through hybridization is difficult. Garlic consumed by almost all the sections of societies and highly placed for its flavor enhancing capacity and good export potential as fresh bulb as well as in the form of dehydrated product (Gupta and Singh, 1998). Lack of high yielding varieties is one of the main constraints in limiting the production and productivity. Garlic exhibits greater susceptibility to agro-techniques and environmental conditions and possesses a wide range of variability for bulb traits and yield attributes as well as the storability in spite of being vegetatively propagated crop. As this crop is propagated vegetatively, the clonal selection is the important breeding method and very scanty work has been done on the association between different traits which are prerequisite for executing a selection programme. Ministry of Agriculture, India estimate; the annual area under garlic during the year 2012-13 was 2.42 lakh ha and production was 12.28 lakh MT with average yield 5.07 t ha^{-1}. Among different states in India, Madhya Pradesh is the leading state accounting for more than 27% of area and 21% of production with average yield of 4.47 t ha^{-1}. The other major garlic growing states are Gujarat, Rajasthan, Orissa, Uttar Pradesh, Maharashtra and Tamilnadu. In India per hectare yield are highest in Kerala (19.0 t ha^{-1}) followed by Manipur (11.91 t ha^{-1}), Punjab (10.96 t ha^{-1}), Andhra Pradesh (10.38 t ha^{-1}) and West Bengal (9.79 t ha^{-1}) (Bhonde et al, 2012).

Diversity arises either due to geographical separation or due to genetic barriers to cross ability and it plays an important role in plant breeding. The knowledge of genetic diversity, its nature and degree of variability would be helpful for selecting desirable genotypes and cultivars for a successful breeding programme. Application of this method helps us for maintaining large number of germplasm and avoiding the duplicates. To meet the domestic requirement and fulfill the export demand, selection of suitable variety for growing under different agro-climatic condition is necessary. In this regards National Horticultural Research and Development Foundation (NHRDF), collected more than 400 germplasm from different garlic growing areas. Among of those 19 germplasm were selected including four checks on the basis of yield and yield contributing traits. The present study was therefore, conducted to determine the genetic divergence among 15 selected genotypes along with four checks i. e. Yamuna Safed (G-1), Agrifound White (G-41), Yamuna Safed-2 (G-50) and Yamuna Safed-3 (G-282) and factors influencing genetic diversity and variability of economic traits to identify suitable genotypes of garlic.

MATERIALS AND METHODS

The experiment was carried out at National Horticultural Research and Development Foundation, (NHRDF) Salaru, Karnal during 2005-06 and 2006-07. Nineteen diverse genotypes including four checks (released varieties) namely Yamuna Safed (G-1), Agrifound White (G-41), Yamuna Safed-2 (G-50) and Yamuna Safed-3 (G-282) (table-1) were evaluated in randomized complete block design with three replications. Uniform size cloves were selected and planted during the first

fortnight of October in bed of 3.0 m x 1.5 m with a spacing of 10 cm x 7.5 cm. The climate of Karnal is subtropical with minimum and maximum temperature ranging between 2^0 to 45^0C and favorable for garlic cultivation during Rabi season. Recommended dose of chemical fertilizer such as 100 kg N, 50 kg P_2O_5 and 50 kg K per hectare) were adopted to ensure a healthy crop growth and development. Harvesting was done as per maturity of different genotypes. Observations were recorded on 10 randomly selected plants in each replications for all the characters viz.-plant height (cm), leaves per plant, neck thickness (cm), bulb diameter (cm), bulb size index (cm^2), weight of 20 bulbs (g), clove diameter (cm), clove size index (cm^2), cloves per bulbs, weight of 50 cloves (g), bolters (%), total soluble solid (%), dry matter (%), days for bulb initiation, days for harvesting, gross yield (t ha^{-1}) and marketable yield (t ha^{-1}).

Pooled data of 2006-2008 were analyzed statistically as suggested by Mahalanobis, (1936). "$D^{2"}$ statistics was used to find out generalized distance between the genotypes as per Rao, (1952). The D^2 values were determined to have clustering which was done following Tocher's method. The clusters were grouped in to four divergence classes (DC) on the basis of mean (M) and standard deviation (S).

RESULTS AND DISCUSSION

On the basis of D^2 values, all the 19 genotypes were grouped in three clusters (Table-2). Cluster I was largest consisting of 17 genotypes. Cluster II and III had one genotype each. The genotypes belonging to same status or origin were grouped in to different cluster and the genotypes belonging to different origin were grouped in same cluster. The grouping pattern of the genotypes suggested no parallelism between genetic divergence and geographical distribution of genotypes. Singh et al. (2011), Singh et al, (2012), Lokhande et al. (1987), Mohanty (2001) and Mohanty and Prusti (2002) also reported that genotype diversity was independent of geographical region.

Intra and inter cluster D^2 values and corresponding genetic distance are presented in table-3. The highest inter cluster value (D^2) and genetic distance was noted for cluster-I (852.88), (29.20) while other clusters II and III had zero intra cluster value. Clusters with single genotype (II and III) indicated their independent identity and importance due to various unique characters possessed by them. The intra cluster values were less than inter cluster values indicating the homogenous and heterogeneous nature of the genotypes within and between the clusters. Inter cluster distance (D^2) is the main criterion for selection of genotype. The genotypes belonging to the cluster with maximum inter cluster distance are genetically more divergent. Therefore, it is suggested that selection of genotypes should be based upon large cluster distances, which may lead to broad spectrum of favorable genetic variability for bulb yield improvement.

Estimates of cluster means for different traits are the measures of inter cluster divergence and degree of homogeneity in these clusters. Cluster mean was worked out and presented in table-4, indicating that the different clusters were superior in respect of various traits.

Cluster-III had highest value of plant height (93.05 cm), bulb diameter (4.71 cm), bulb size index (16.08 cm^2), 20 bulb weight (700 g), clove diameter (1.75 cm), clove size index (4.43 cm^2), weight of 50 cloves (97.50 g) and gross yield (159.63 t ha-1) and minimum neck thickness (1.45 cm) cloves per bulbs (17) days for bulb initiation (61.66 days) and days to harvesting (149.83) (Table-3). Cluster-II was promising for highest number of leaves per plant (7.60) and minimum bolters (11.38%). Cluster I showed highest cloves per bulb (38.57), total soluble solids (38.11%), dry matter content (40.22%) and marketable yield (134.89 t ha-1). The largest cluster-I had more and less average values for most of the traits like yield and yield contributory traits. Any attempt to strengthen the existing gene pool with introduction of garlic materials and their evaluation for desirable traits like resistance to insect pest and disease, adoptability, yield and quality is relevant for improving the potentiality of garlic crop.

The characters contributing maximum to the D^2 values are to be given greater emphasis for deciding the cluster for the purpose of further selection. The study revealed that total soluble solids contributed maximum (20.46%) toward genetic divergence followed by gross yield (16.37%), bolters (12.86%), marketable yield (11.11%), cloves per bulbs (10.52%), weight of 50 cloves (10.52%), days for bulb initiation (10.52%) and days for harvesting (4.09%). All above mentioned traits were considered to be most important for genetic divergence and they contributed (96.45%) towards genetic divergence in this present investigation. Similar findings for contribution towards marketable yield and gross yield were also reported by Khar et al. (2006) in garlic and Mehta et al. (2005) in onion. The result of the present study will help to avoiding duplicates and minimizes the cost of maintenance of garlic germplasm. This also indicates that there is good scope for selection of varieties for desirable traits and cultivation in different part of India for higher productivity.

Therefore it is suggested that based upon large cluster distances to select genotypes from all the clusters, which may lead to broad spectrum of favorable genetic variability for bulb yield improvement.

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Table 1: Details of genotypes used in experiment and their source of collection

SN	Genotype	Source of collection
1	G-4	Calcutta, West Bengal
2	G-176	Rajkot, Gujarat
3	G-189	NBPGR, New Delhi
4	G-192	NBPGR, New Delhi
5	G-200	NBPGR, New Delhi
6	G-222	NBPGR, New Delhi
7	G-255	NBPGR, New Delhi
8	G-284	Mandsaur, Madhya Pradesh
9	G-302	Rajkot, Gujarat
10	G-304	IARI, New Delhi
11	G-305	Karnal, Haryana
12	G-324	NBPGR, New Delhi
13	G-366	Indore, Madhya Pradesh
14	G-368	Dindigul, Tamil Nadu
15	G-369	Kota, Rajasthan
16	Yamuna Safed G-1(C)	Azadpur, New Delhi
17	Agrifound White G-41(C)	Nalanda, Bihar
18	Yamuna Safed-2 G-50 (C)	Karnal, Haryana
19	Yamuna Safed-3 G-282(C)	Dindigul, Tamil Nadu

Table 2: Distribution of 19 garlic genotypes in different clusters as obtained by multivariate analysis

Cluster	Genotypes	Name of genotypes
I	17	G-4, G-222, G-176, G-189, G-1, G-284, G-255, G-200, G-304, G-50, G-192, G-41, G-324, G-305, G-368, G-366, and G-369
II	01	G-302
III	01	G-282

Table 3: Intra and inter cluster D^2 value and distance ($\sqrt{D^2}$) in garlic genotypes

Clusters	I	II	III
I	852.88 **(29.20)**	2285.42 **(47.81)**	5053.38 **(71.09)**
II		0.00 **(0.00)**	2070.12 **(45.50)**
III			0.00 **(0.00)**

Table 4: Cluster mean for different traits in garlic genotypes

Characters	Clusters			
	I	II	III	% Contribution
Plant height (cm)	92.20	87.33	93.05	0.00
Number of leaves/plant	7.14	7.60	7.13	0.00
Neck thickness (cm)	1.48	1.50	1.45	0.00
Bulb diameter (cm)	4.57	4.70	4.71	0.00
Bulb size index (cm^2)	14.62	13.86	16.08	1.17
Weight of 20 bulbs (g)	601.47	620.00	700.00	0.00
Clove diameter (cm)	1.08	1.18	1.75	0.00
Clove size index (cm^2)	2.70	3.06	4.43	2.33
No. of cloves/bulbs	38.57	25.66	17.00	10.52
Weight of 50 cloves (g)	45.80	59.66	97.50	10.52
Bolters (%)	17.92	11.38	15.25	12.86
Total soluble solids (%)	38.11	34.96	35.65	20.46
Dry matter (%)	40.22	36.82	38.06	0.00
Days for bulb initiation	65.88	67.00	61.66	10.52
Days for harvesting	158.86	151.66	149.83	4.09
Gross yield (t ha^{-1})	165.57	117.28	159.63	16.37
Marketable yield (t ha^{-1})	134.89	81.23	122.42	11.11