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Genetic variability, heritability and genetic advance in garlic (*Allium sativum* L.) genotypes

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Abstract
The present investigation on "Genetic variability, heritability and genetic advance in garlic (*Allium sativum* L.) Genotypes" was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, during the Rabi season of 2020-2021. The experimental material for the study comprised of twenty-five genotypes. These genotypes were sown in Randomized Block Design in three replications to estimate the genetic variability, heritability and genetic advance. Analysis of variance indicated the presence of considerable amount of variability among the genotypes for all the traits studied. On the basis of mean performance Gulbarga local was found to be best performing genotype with highest bulb yield per hectare (6.3 t/ha). Higher estimates of PCV and GCV were observed for number of cloves per bulb followed by average bulb weight, clove width, dry weight of plant, bulb yield per hectare, neck diameter of bulb and fresh weight of plant, indicating the presence of high variability, therefore, simple selection would be helpful for improvement of these characters. High heritability estimates coupled with high genetic advance recorded for fresh weight of plant, dry weight of plant, harvest index and bulb yield per hectare which suggests that these traits can aid in simple selection which could be helpful for further crop improvement.

Keywords: Garlic, variability, heritability, genetic advance

Introduction
Garlic (*Allium sativum* L.) is second widely cultivated vegetable crop after onion, under the genus *Allium*, belongs to family Alliaceae and having chromosome number 2n (2x) = 16. The wild species *Allium longicuspis* Regel is considered as closest relative and ancestor of garlic. It is native to Central Asia and Southern Europe especially Mediterranean region. It is being grown in India and China in larger areas.

The major garlic growing countries in the world are China, India, Bangladesh and Myanmar. In the world it is grown in an area of 1.6 million hectares with production of 30.7 million tonnes and productivity of 19.18 tonnes per hectare (Anon., 2019a). India is the second largest garlic producing country in the world with production of 2836 thousand metric tonnes from 354 thousand hectares area (Anon., 2019b). Major garlic producing states in India are Madhya Pradesh, Gujarat, Uttar Pradesh, Rajasthan, Assam, Punjab, Maharashtra, West Bengal and Haryana. In Karnataka, it is grown in an area of 4.01 thousand hectares with production of 26.55 thousand metric tonnes and productivity of 6.62 tonnes per hectare (Anon., 2019c).

Garlic cultivars are sterile and propagated vegetatively by cloves. However they exhibit greater morphological variation between clones and thus genetic improvement is limited only to clonal selection. The effectiveness of this improvement programme therefore largely depends upon the magnitude of interclonal variability and further the heritability of this variability being carried forward into subsequent generations. Thus, the information on the native and magnitude of genetic variability present in the genetic stocks, heritability and genetic advance among various traits are of considerable use in selecting the suitable genotypes to include in future breeding programmes. The amount of work done on the genetics of the most important quantitative character i.e. yield is meager. Therefore, the study was undertaken to estimate the genetic variability present in the germplasm of garlic.

Material and Methods
The present investigation on "Genetic variability, heritability and genetic advance in garlic (*Allium sativum* L.) Genotypes" was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *rabi* 2020-21.

Twenty-five genotypes were collected and evaluated using randomized block design (RBD) with three replications. The selected cloves of each genotypes were dibbled at 15 cm apart from row to row and 7.5 cm from plant to plant by keeping growing ends of cloves upward direction. All the recommended package of practices was followed for garlic as per the package of practices for horticulture crops (Anon., 2013). Five plants were selected randomly from each replication and data were recorded for the characters *viz.*, plant height (cm), number of leaves per plant, leaf length (cm), leaf width (cm), fresh weight of plant (g/plant), dry weight of plant (g/plant), neck diameter (mm), dry matter content of plant (%), pseudo stem length (cm), harvest index (%), days to maturity, average bulb weight (g), bulb polar diameter (mm), bulb equatorial diameter (mm), number of cloves per bulb, clove length (cm), clove width (cm) and bulb yield (t/ha).

Analysis of variance was computed as par the procedures given by Panse and Sukhatme (1961) [12] and genetic parameters such as mean, range, genotypic and phenotypic c as suggested by Burton and De vane (1953) [2]. Heritabilty and genetic advance were worked according to Johanson *et al.* (1955).

Result and Discussion

The nature and extent of genetic variability is one of the most important and essential criteria in any breeding programme. The knowledge of various parameters of variability i.e. phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), general mean, variation in range, genetic gain and heritability in broader sense are very much helpful in predicting the amount of variation present in a given set of genetic material. For all the observed characters, the estimates of PCV and GCV were worked out. The variation in coefficients of variability varies from character to character, either low or moderate and these are helpful in determining the extent of genetic diversity present among the genotypes. Broad sense, heritability is the parameter of tremendous significance to the breeder as its magnitude indicates the reliability with which a genotype can be recognized by its phenotypic expression. For estimating the real effects of selection, it is more important to study genetic advance along with heritability since only heritability is not enough. The estimates of genetic parameters *viz*., phenotypic coefficient of variation (PCV %), genotypic coefficient of variation (GCV %), heritability and genetic advance (GA) as per cent of mean for different traits of garlic genotypes.

A perusal of data presented in Table. 1 indicates that wide range of phenotypic variability existed in experimental material. Phenotypic coefficients of variability were higher in magnitude than genotypic coefficients of variability, though there is a very small difference in majority of cases. This implies, these traits were less influenced by environmental factors. The highest (> 20%) estimates of phenotypic coefficient of variation and genotypic coefficient of variation were recorded for number of cloves per bulb (GCV= 54.857%; PCV=57.543%), followed by average bulb weight (GCV= 36.121%; PCV=37.257%), clove width (GCV=36.101%; PCV=40.419%), dry weight of plant (GCV=33.555%; PCV=36.873%), bulb yield (GCV=32.429%; PCV=32.530%), neck diameter of bulb (GCV=31.771%; PCV=33.728%), fresh weight of plant (GCV=31.177%; PCV=33.236%). Moderate (10-20%) estimates of phenotypic coefficient of variation and genotypic coefficient of variation was registered for equatorial diameter of bulb (GCV=15.415%; PCV=16.305%) followed by harvest index (GCV=15.181%; PCV=15.216%), polar diameter (GCV=13.783%; PCV=15.412%), plant height (GCV=12.411%; PCV=13.692%), dry matter of plant (GCV=12.128%; PCV=15.340%) and leaf width (GCV=10.459%; PCV=14.878%). Lowest (< 10%) estimates of coefficients of phenotypic coefficient of variation and genotypic coefficient of variation were recorded for days to maturity (GCV=8.984%; PCV=9.735%), followed by leaf length (GCV=8.962%; PCV=12.491%), clove length (GCV=7.303%; PCV=14.570%), number of leaves per plant (GCV=4.510%; PCV=7.248%) and pseudo stem length (GCV=4.011%; PCV=8.887%).The observed higher estimates of phenotypic and genotypic coefficients of variation for above characters, indicates the existence of adequate variability among the genotypes for these traits. Thus, simple selection could be helpful for further crop improvement. The similar outcome of results were recorded for number of cloves per bulb (Yadav *et al.*, 2006 [22], Tsega *et al.*, 2011, Singh *et al.*, 2012 and Dubey *et al*., 2012); for bulb weight (Kar *et al.* 2014 and Rakesh *et al*., 2016); for clove width (Dhall and Brar, 2013, Singh *et al*., 2018) and for bulb yield (Yadav *et al*., 2012, Kumar *et al.*, 2017) [23, 20].

Heritability is defined as the ability of a paricular trait to get transmitted from one generation to another. The magnitude of heritability indicates the reliability with which a genotype can be recognized by its phenotypic expression thus making heritability a parameter of utmost significance to breeders. Higher the variation in heritability among the different genotypes for a particular trait greater will be the chances for its improvement by selection. Hence heritability studies are of great significance to know whether the variability for a particular trait is heritable or the extent t1o which it is being affected by the environmental factors. Johnson *et al.* (1955) [8] stated that heritability estimates along with genetic advance provides better chance for selection than either of the parameters alone. The heritability of different traits under study is categorized as high (> 60%), moderate (31-60%) and low (0-30%). The estimates of heritability (broad sense) ranged from 0.406 to 99.539% for various characters under investigation (Table 1). Heritability was maximum for harvest index (99.539%) followed by bulb yield (99.384%), average bulb weight (93.997%), number of cloves per bulb (90.882%), equatorial diameter of bulb (89.377%), neck diameter of bulb (88.734%), fresh weight of plant (87.990%), days to maturity (85.149%), dry weight of plant (82.811%), plant height (82.164%), polar diameter of bulb (79.985%), clove width (79.772%) and dry matter of plant (62.506%). Moderate estimates of heritability was observed for leaf length (51.481%), leaf width (49.422%) and number of leaves per plant (38.725%). While, lower estimates of heritability was observed for pseudo stem length (20.371%) and clove length (0.406%). The observed results on high heritability are in a consonance with the earlier workers for the characters *viz*., plant height, maturity duration, bulb weight, bulb diameter, number of cloves per bulb, yield (Panthee *et al.*, 2006 and Gupta *et al.*, 2007) [13, 6]; for dry weight of plant (Tsega *et al*., 2011) [20] and for neck thickness (Gupta *et al.* 2007, Dubey *et al*. 2012, Singh *et al*. 2018) [6, 5, 18].

Genetic advance is defined as increase in performance of a

particular trait achieved through selection annually or intensification in performance of a particular trait achieved through selection annually. The highest genetic advance was recorded for fresh weight of plant (63.851%), dry weight of plant (42.958%), bulb yield (27.596%) and harvest index (20.271%) which is given in Table 1. Moderate values of genetic advance were recorded for days to maturity (19.126%), number of cloves per bulb (15.499%), plant height (12.936%), dry matter of plant (12.807%) and average bulb weight (10.640%). Low estimates of genetic advance were recorded for equatorial diameter of bulb (9.828%), polar diameter of bulb (7.635%), leaf length (5.869%), neck diameter of bulb (3.831%), clove width (0.764%), number of leaves per plant (0.365%), leaf width (0.284%), pseudo stem length (0.253%) and clove length (0.024%). These observed results on high genetic advance are in line with previous researchers for the characters like bulb yield (Panthee *et al*., 2006, Jabeen *et al*., 2010) [13, 7]; dry weight of plant (Tsega *et al*., 2011) [20]; number of cloves per bulb (Sandhu *et al*., 2015) [15].

Genetic advance as per cent of mean (Genetic gain) is the percentage of population mean. The data pertaining to genetic gain presented in Table.1 showed the preponderance of low (0-10%), medium (10-20%) and high (>20%) genetic gain for different characters under study. Maximum genetic advance as per cent of mean was observed for number of cloves per bulb (107.73%), average bulb weight (72.142%), bulb yield per hectare (66.598%), clove width (66.421%), dry weight of plant (62.903%), neck diameter of bulb (61.652%), fresh weight of plant (60.244%), harvest index (31.20%), equatorial diameter of bulb (30.021%), polar diameter of bulb (25.394%) and plant height (23.174%). Moderate values of genetic advance as per cent of mean was noticed for dry matter of plant (19.752%), days to maturity (17.077%), leaf width (15.147%) and leaf length (13.247%). Lowest values of genetic advance as per cent of mean was registered for number of leaves per plant (5.782%), pseudo stem length (3.729%) and clove length (0.959%). It is shown in the Table 1. These results are in consistent with works of Gupta *et al.* (2007) [6] and Dhall and Brar (2013) [4] for bulb weight and number of cloves per bulb; Vatsyayan *et al.* (2015) [21] and Bhatt *et al.* (2017) [1] for bulb weight, cloves per bulb and bulb yield; Tsega *et al*. (2011) [20] for dry weight; Khar *et al.* (2015) [10] for plant height, average weight of bulbs, equatorial diameter of bulb and yield per hectare.

Table 1: Mean, coefficient of variation, heritability (broad sense), genetic advance and genetic advance as per cent of mean for various character of garlic genotypes

Sl. No.	Characters	Mean	Range		Variance		Coefficient of variation		Heritability (Per cent)	Genetic advance (%)	Genetic advance as per cent of mean (Genetic Gain) (%)
			Min.	Max.	Genotypic	Phenotypic	Genotypic	Phenotypic			
1	X_1	55.822	44.83	68.57	47.996	58.415	12.411	13.692	82.164	12.936	23.174
2	X_2	6.308	5.67	7.13	0.081	0.209	4.51	7.248	38.725	0.365	5.782
3	X_3	6.787	6.37	8.03	0.074	0.364	4.011	8.887	20.371	0.253	3.729
4	X_4	1.875	1.37	2.13	0.0385	0.0778	10.459	14.878	49.422	0.284	15.147
5	X_5	44.309	35.77	53.23	15.769	30.632	8.962	12.491	51.481	5.869	13.247
6	X_6	30.065	21.96	36.32	17.172	21.47	13.783	15.412	79.985	7.635	25.394
7	X_7	32.738	23.61	43.1	25.467	28.494	15.415	16.305	89.377	9.828	30.021
8	X_8	14.749	6.67	28.07	709.601	754.917	36.121	37.257	93.997	10.64	72.142
9	X_9	14.387	6.00	32.00	62.284	68.533	54.857	57.543	90.882	15.499	107.73
10	X_{10}	2.512	1.70	2.67	0.034	8.282	7.303	14.57	0.406	0.024	0.959
11	X_{11}	1.151	0.53	2.03	0.173	0.216	36.101	40.419	79.772	0.764	66.421
12	X_{12}	64.972	36.22	85.87	97.28	97.73	15.181	15.216	99.539	20.271	31.20
13	X_{13}	6.213	3.00	12.56	3.897	4.391	31.771	33.728	88.734	3.831	61.652
14	X_{14}	112	89.33	119.33	101.235	118.891	8.984	9.735	85.149	19.126	17.077
15	X_{15}	105.987	59.33	189	1091.855	1240.887	31.177	33.236	87.99	63.851	60.244
16	X_{16}	68.293	32.67	123.67	525.133	634.131	33.555	36.873	82.811	42.958	62.903
17	X_{17}	64.842	48.61	81.57	61.838	98.932	12.128	15.34	62.506	12.807	19.752
18	X_{18}	4.14	1.9	6.39	1805.803	1816.994	32.429	32.53	99.384	27.596	66.598

Note:

X_1- Plant height (cm)
X_2- Number of leaves per plant
X_3- Pseudostem length
X_4- Leaf width (cm)
X_5- Leaf length (cm)
X_6- Polar diameter of bulb (mm)
X_7- Equatorial diameter of bulb (mm)
X_8- Average bulb weight (g)
X_9- Number of cloves per bulb
X_{10}- Clove length (cm)
X_{11}- Clove width (cm)
X_{12}- Harvest index (%)
X_{13}- Neck diameter of bulb (mm)
X_{14}- Days to maturity
X_{15}- Fresh weight of plant (g)
X_{16}- Dry weight of plant (g)
X_{17}- Dry matter of plant (%)
X_{18}- Bulb yield per hectare (t/ha)

Conclusion

From the present investigation, it is indicates that characters like bulb yield per hectare, average bulb weight, number of cloves per bulb, equatorial diameter of bulb, neck diameter of bulb, fresh weight of plant, days to maturity, dry weight of plant, plant height, polar diameter of bulb, clove width and dry matter of plant recorded high heritability and genetic gain. Thereby denoting that direct selection for these characteristics could lead to improvement in recognition of superior genotypes in garlic. Thus, the findings of the study are significant in the improvement of garlic as it throws light on the spectrum of variability in the crop. It is expected that from these garlic varieties can be obtained to increase the production and productivity substantially.

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