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Genetic Variability, Heritability and Genetic Advance in Garlic (*Allium sativum* L.) Germplasm

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ABSTRACT

A set of one fifty genotypically diverse genotypes of garlic were studied for assessment of genetic variability, heritability and genetic advance for fifteen yield contributing and economically important traits at Vegetable Research Station, Junagadh Agricultural University, Junagadh, during rabi 2016-17. The analysis of variance revealed significant difference among the genotypes for the traits, number of leaves per plant, leaf length (cm), leaf width at middle portion (cm), bulb polar diameter (cm), bulb weight (g), number of cloves per bulb, clove weight (g), clove length (cm), bulb yield (kg/ha) and pseudo stem height (cm). Based on the mean performance, the genotypes RGP-498, RGP-501, RGP-487, RGP-619 and RGP-114 were identified as most promising genotypes for bulb yield per plant. In general, estimates of phenotypic coefficient of variation (PCV) were found higher in magnitude than corresponding genotypic coefficient of variation (GCV) for all the traits studied. The higher magnitude of coefficient of variation at genotypic as well as phenotypic levels was observed for bulb yield followed by bulb weight, while high heritability was observed for clove weight. The highest genetic advance was recorded for bulb yield, while clove weight had high heritability coupled with moderate genetic advance as per cent of mean. It is suggested that selection for these traits will directly increase bulb yield per plant, in garlic crop.

Key words: *Garlic, Genetic variability, Heritability, Genetic advance, Yield.*

INTRODUCTION

Garlic (*Allium sativum* L.) belonging to the family *Amaryllidaceae* is second the most widely cultivated crop of *Allium* group next to onion. Garlic has been originated from Central Asia and it is grown throughout the world. "*Allium*" is the largest and the most important representative genus of the Alliaceae family that comprises 700 species, widely distributed in the Northern hemisphere, North America, North Africa, Europe and Asia[21].

Garlic has a chromosome number of 2n=2x=16. It is an herbaceous annual bulb producing crop. The edible underground stem is the composite bulb made up of numerous smaller bulbs called cloves. Leaves have solid thin blades. Garlic is an obligate apomitic crop hence vegetative reproduction occurs.

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Even though some varieties produce flowers but these flowers do not set seeds. There are some varieties which produce vegetative bulbs on the top called bulbils. They are also used for propagation in some cases.

Garlic contains at least 33 sulfur compounds, several enzymes and minerals along with 17 amino acids. Garlic has higher concentration of sulfur compounds than any other *Allium* species which is responsible for both garlic's pungent odor and many of its medicinal effects. The most abundant sulfur compound in garlic is alliin (S-allylcysteine sulfoxide), which is present at 10 and 30 mg/g in fresh and dry garlic, respectively[12].

Recent genetic studies revealed that garlic displays a wide range of variation under various ecological conditions and some germplasm have adapted to specific environments through artificial and natural selection. Garlic germplasm normally show wide variations in characteristics such as bulb weight, coat layer, leaf length, growth habit and stress resistance[13, 23]. So, evaluation of garlic genetic resources both by morpho-agronomic traits or molecular markers will make us to understand the variation between accessions and select out those with our interested character for breeding program. 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 future breeding programmes.

Keeping all these facts in view, an attempt was made to assess the variability of important bulb yield contributing traits along with the indicate of variability *i.e.* genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), heritability in broad sense and genetic advance as per cent of mean.

MATERIAL AND METHODS

The present investigation was carried out during *rabi* 2016-17 at Vegetable research Station, Junagadh Agricultural University, Junagadh. The experimental material comprised of 150 genotypes along with four checks namely GG - 4, G - 282, GJG – 5 and GAG – 6 collected from Directorate of Onion and Garlic Research (DOGR), Rajgurunagar, Pune through Vegetable Research Station, Junagadh Agricultural University, Junagadh. The experiment was laid out in Augmented Randomized Block Design (ABRD). Each genotype was accommodated in a plot of 1.5 × 1.0 m size by keeping 15 × 10 cm distance between two rows and two plants, respectively. All the recommended cultural practices were adopted to raise a healthy crop. Data were recorded on randomly selected ten plants with respect to 15 characters namely plant height (cm), number of leaves per plant, leaf length (cm), leaf width at middle portion (cm), days to maturity (days), bulb equatorial diameter (cm), bulb polar diameter (cm), bulb weight (g), number of cloves per bulb, clove weight (g), clove length (cm), bulb yield (kg/ha), total soluble solids (%), neck thickness (cm) and pseudo stem height (cm). The data were analyzed to estimate genotypic and phenotypic coefficient of variation using the formula given by Burton and DeVane[4], heritability and genetic advance by Allard[2] and genetic advance as per cent of mean by using the formula given by Johnson *et al*.[7].

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance for different characters is presented in Table 1. The mean sum of square due to genotype were significant for the characters number of leaves per plant (cm), leaf length (cm), leaf width at middle portion (cm), bulb polar diameter (cm), bulb weight (g), number of cloves per bulb, clove weight (g), clove length (cm), bulb yield (kg/ha) and pseudo stem height (cm). Significant mean sum of squares due to bulb yield and attributing characters revealed existence of considerable variability in material studied for improvement of various traits.

Mean performance of genotypes

Mean performance of top genotypes compared with the best check is presented in Table 2. A wide range of variation in mean performance of genotypes were present for all characters under study.

The mean values with respect to the characters revealed that, the genotype RGP-498 was the highest bulb yielder followed by RGP-501, RGP-487, RGP-619 and RGP-114. The genotype RGP-108 had the highest bulb weight and it was also a top genotype for economic traits like clove weight and bulb polar diameter. The genotype RGP- 619 had the highest number of cloves per bulb, while the genotype RGP- 162 had the highest clove length. Plant height and total soluble solids was highest in case of RGP- 461, while RGP-288 had the maximum number of leaves per plant. The genotype RGP- 454 had the highest leaf length, RGP- 257 had the maximum leaf width at middle portion. The genotype RGP-160 was found to be early maturing when compared to other genotypes. RGP- 224 had the highest neck thickness, while RGP-26 was found to have maximum pseudo stem height. These genotypes might be utilized as potent parents in a breeding programme for improving bulb yield and its components. These findings are akin to the findings of Bhatt *et al*.[3], Raja *et al*.[16] and Yeshiwas and Negash[24].

Genotypic and Phenotypic coefficient of variation

The assessment of GCV, PCV and heritability helps in estimating the contribution of genes and environment in the expression of any trait, while facilitating a plant breeder for better and effective selection. In the present investigation, all the studied traits recorded a higher PCV over the GCV indicating major role of environment in the expression of traits (Table 3). Among all the characters studied, the maximum genotypic and phenotypic coefficient of variation was observed for bulb yield followed by bulb weight indicated the presence of wide variation for these characters under study to allow selection for individual traits. High genotypic and phenotypic coefficient of variation in garlic for the characters bulb yield and bulb weight was reported by Singh *et al*.[19], Dhall and Brar[6, 22], Vatsyayan *et al*.[22], Kar *et al.*[8], Bhatt *et al*.[3], Chotalia and Kulkarni[5], Kumar *et al*.[9] and Kumar *et al*.[10]. Moderate estimates of phenotypic coefficient of variation was observed for leaf width at middle portion, bulb equatorial diameter, clove weight, and neck thickness. Low genotypic and phenotypic coefficient of variation was observed for plant height, number of leaves per plant, leaf length, days to maturity, bulb polar diameter, number of cloves per bulb, clove length, total soluble solids and pseudo stem height. Low phenotypic and genotypic coefficient of variation indicated that variation present in these characters is minimum and further improvement of these characters is difficult.

Heritability

Heritability in a broad sense is important to the breeder since it indicates the possibility and extent to which improvement is possible through selection. High heritability was observed for the character clove weight. This indicates that good correspondence between genotypic and phenotypic values and there by low environmental effect on the expression of clove weight. High heritability for the character is controlled by polygenes which might be useful for the plant breeders for making effective selection. High heritability for clove weight was reported by Singh *et al.*[19], Dhall and Brar[6,22], Vatsyayan *et al.*[22], Sandhu *et al.*[17], Kumar *et al.*[11], Sharma *et al.*[18], Bhatt *et al*.[3] and Chotalia and Kulkarni[5].

Moderate estimates of heritability was found in the characters like bulb weight, number of cloves per bulb, bulb yield, leaf width at middle portion, leaf length and pseudo stem height. Heritability was low in the characters like number of leaves per plant, bulb polar diameter, clove length, neck thickness, plant height, bulb equatorial diameter, total soluble solids and days to maturity. Low heritability for these traits suggested that environmental effects constituted major portion of total phenotypic variation and hence direct selection for these characters would be less effective.

Genetic advance

In the present investigation, the highest genetic advance was recorded for bulb yield. While remaining all the traits had low genetic advance. Thus for the character bulb yield,

further selection in the next generations would be useful. High genetic advance for bulb yield was reported by Chotalia and Kulkarni[5] and Yeshiwas and Negash[24].

Relative comparison of heritability along with genetic advance as per cent of mean over the characters indicated that the character clove weight had high heritability coupled with moderate genetic advance as per cent of mean indicated that the genotypic variations for such character is probably due to predominance of additive gene action and selection pressure could profitably be applied on this character for improving the bulb yield. Similar results of high heritability with moderate genetic advance as per cent mean was reported by Panse *et al*.[14], Sharma *et al.*[18] and Yeshiwas and Negash[24]. Genetic advance as per cent of mean was moderate for bulb weight, clove weight and bulb yield. Low heritability with low genetic gain was reported for number of leaves per plant, days to maturity, bulb equatorial diameter, bulb polar diameter, clove length, total soluble solids and neck thickness. It may be inferred that these traits were regulated by non additive gene action and presence of high genotype × environment interaction.

Table 1: Analysis of variance for fifteen characters in garlic

Source of variation	d.f.	Plant height (cm)	Number of leaves per plant	Leaf Length (cm)	Leaf width at middle portion (cm)	Days to Maturity (days)	Bulb Equatorial diameter (cm)	Bulb Polar diameter (cm)	Bulb weight (g)
Block (B)	4	2.20	1.20*	15.73*	0.01	5.64	0.20	0.06	2.24
Entries (E) (Including checks)	153	19.35	0.76*	10.83*	0.04*	9.81	0.20	0.09*	10.81*
Check (C)	3	2.90	0.76	18.14*	0.04*	24.18	0.09	0.15*	4.04
Germplasm accessions (G)	149	19.27	0.74*	10.64*	0.03*	9.57	0.21	0.08*	10.83*
Accessions Vs Checks	1	80.73*	3.89*	17.77*	0.58*	2.13	0.08	1.23*	27.64*
Error	12	9.14	0.27	3.17	0.01	7.98	0.11	0.03	1.92

Source of variation	d.f.	Number of cloves per bulb	Clove weight (g)	Clove length (cm)	Bulb yield (kg/ha)	Total soluble solids (%)	Neck thickness (cm)	Pseudo stem height (cm)
Block (B)	4	6.54*	0.06*	0.01	1763502	6.50	0.0002	2.88
Entries (E) (Including checks)	153	7.82*	0.05*	0.03	3290134*	5.13	0.006	4.36*
Checks (C)	3	16.26*	0.02	0.01	10734635*	2.02	0.006	9.08*
Germplasm accessions (G)	149	7.70*	0.05*	0.03*	3160721*	5.20	0.006	4.29*
Accessions Vs Checks	1	0.72*	0.06*	0.08*	239098.9	4.10	0.036*	1.26
Error	12	1.49	0.01	0.01	614764.8	3.22	0.003	1.12

* Indicates significant level at 5%.

Table 2: Mean performance of best genotypes of garlic with respect to characters as compared with check

Character	Genotypes	Mean value	Compared check
Plant height (cm)	RGP-461 RGP-82	54.00 55.90	G-282 (45.60)
Number of leaves per plant	RGP-288 RGP-429 RGP-487 RGP-610 RGP-573, RGP-605 & RGP- 117	13.90 8.90 8.70 8.60 8.40	GJG-5 (6.90).
Leaf length (cm)	RGP-454 RGP-82 RGP-330 & RGP-21 RGP-461 RGP-602	43.70 36.10 35.90 35.50 35.00	GJG-5 (29.81).
Leaf width at middle portion (cm)	RGP-257 RGP-108 RGP-487 RGP-122 RGP-7	2.34 1.56 1.55 1.49 1.47	GAG-6 (1.06)
Days to maturity (days)	RGP-160 RGP- 278 RGP-523 RGP-178 RGP-334, RGP-461 & RGP-475	121.00 124.00 124.00 124.00 124.00	GG-4 (125.20)
Bulb equatorial diameter (cm)	RGP-247	7.77	GAG-6 (2.97)
Bulb polar diameter (cm)	RGP-108 RGP-513 RGP-403, RGP-134 & RGP-272 RGP-528 RGP-60	4.03 3.95 3.92 3.91 3.88	GAG-6 (3.31)
Bulb weight (g)	RGP-108 RGP-513 RGP-501 RGP-575 RGP-134	23.60 22.66 22.40 21.82 20.92	GAG-6 (13.49).
Number of cloves per bulb	RGP-619 RGP-162 RGP-487 RGP-396 RGP-224	25.20 25.00 23.20 23.10 22.60	GG-4 (18.10)
Clove weight (g)	RGP-108 RGP-513 RGP-401 RGP-272 RGP-528	2.12 1.80 1.68 1.66 1.54	GG-4 (0.99)
Clove length (cm)	RGP-162 RGP-606 RGP-513 RGP-528 RGP-309	2.66 2.60 2.56 2.55 2.53	GG-4 (2.04)
Bulb yield (kg/ha)	RGP-498 RGP-501 RGP-487 RGP-619 RGP-114	10000.00 9985 .00 9605.00 9200.00 9180.00	GG-(4 6680.00)
Total soluble solids (%)	RGP-461	47.37	GAG-6 (42.35)
Neck thickness (cm)	RGP-224 RGP-7 RGP-327	0.68 0.66 0.63	GG-4 (0.48)
Pseudo stem height (cm)	RGP-26 RGP-178 RGP-461 RGP-103 RGP-56	24.20 23.20 23.00 22.80 22.40	G-282 (19.40)

Table 3: Mean performance, range and variability parameters for 15 characters in garlic

Characters	Mean	Range		Genotypic Variance	Phenotypic Variance	Genotypic Coefficient of Variation (%)	Phenotypic Coefficient of Variation (%)	Heritability in broad sense (%)	Genetic Advance	GA as % mean
		Min	Max							
Plant height (cm)	44.79	32.5	55.9	2.025	11.170	3.18	7.46	18.12	1.25	2.79
Number of leaves per plant	7.13	5.2	13.9	0.092	0.366	4.26	8.49	25.18	0.31	4.40
Leaf length (cm)	29.06	19.9	43.7	1.494	4.661	4.21	7.43	32.05	1.40	4.83
Leaf width at middle portion(cm)	1.10	0.76	2.34	0.005	0.014	6.22	10.92	32.42	0.08	7.29
Days to maturity (days)	128.95	124.0	134.0	0.320	8.295	0.44	2.23	3.85	0.23	0.18
Bulb equatorial diameter (cm)	2.98	2.51	7.77	0.018	0.133	4.55	12.21	13.88	0.10	3.49
Bulb polar diameter (cm)	3.30	2.65	4.03	0.010	0.043	3.08	6.30	23.87	0.10	3.10
Bulb weight (g)	13.33	7.88	23.0	1.781	3.704	10.01	14.44	48.08	1.91	14.30
Number of cloves per bulb	17.21	10.6	25.2	1.242	2.729	6.48	9.60	45.53	1.55	9.002
Clove weight (g)	1.01	0.46	2.12	0.009	0.016	9.62	12.33	60.90	0.16	15.47
Clove length (cm)	2.05	1.69	2.66	0.003	0.017	2.94	6.42	21.05	0.06	2.78
Bulb yield (kg/ha)	5046.54	950.0	10000.0	509191.3	1123956.0	14.14	21.01	45.30	989.40	19.60
Total soluble solids (%)	42.31	29.93	47.37	0.396	3.617	1.49	4.49	10.94	0.43	1.01
Neck thickness (cm)	0.47	0.28	0.68	0.001	0.003	5.28	12.23	18.61	0.02	4.69
Pseudo stem height (cm)	18.70	13.0	24.2	0.633	1.756	4.25	7.08	36.05	0.98	5.26

CONCLUSION

On the basis of above studies, it can be concluded that due weightage should be given to bulb yield, bulb weight and clove weight while imposing selection for genetic improvement of bulb yield in garlic.

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