Vegetable Science (2012) 39 (1) : 86-88

Studies on variability, heritability and genetic advance in garlic (*Allium sativum* L)

RK Singh, BK Dubey, SR Bhonde and RP Gupta

Received : July, 2011 / Accepted : April, 2012

Among the spices grown in India, garlic (*Allium sativum* L.) is undoubtebly one of the important crops of alliaceae after onion and propagated vegetatively. It is also used as flavor agent and in pharmaceutical preparation due to its high valid medicinal properties like antimicrobial, antidiabetic and anticarcinogenic action. Garlic has higher nutritive value than other bulb crops (Pandey, 1989) and has good export potential as fresh bulb as well as in the dehydrated form (Gupta and Singh, 1998). During 2009-10, the garlic was grown on an area of 107.69 thousand hectare and estimated production was approximately 593.10 thousands MT. The average productivity of garlic in India is 5.00 t/ha, which is quite low as compared to other garlic growing countries. To meet out the domestic requirement and to fulfill the export demand, selection of suitable variety for growing under different agro-climatic condition is necessary. As this crop is propagated vegetatively, the clonal selection is an important breeding method and very scanty work has been done on the association between different traits, which are prerequisites for executing a selection programme for complex quantitative yield. With a view to develop high yielding garlic varieties the National Horticultural Research and Development Foundation (NHRDF), Nashik collected a good numbers of germplasm across the country and abroad and conducted field experiment to assess the potential of genetic resources to identify cloves having high bulb yield with large sized cloves, less number of clove per bulb and other desirable traits.

The experiment was carried out at NHRDF, Salaru, Karnal in during subtropical climate with minimum and maximum temperature ranging between 2^0C to 42^0C 2006-07 and 2007-08 using thirty two divers germplasms along with five checks *viz*., G-1, G-41, G-50, G-282 and G-323, selected from more than three hundred collected germplasms from different region. The experiment was laid out in randomized block design with three replications. Cloves were selected for uniformity in size and planted in first fortnight of October in bed of 3.0 x 1.5 m with the spacing of 15 x 7.5 cm. Recommended cultural operations were carried out to ensure a healthy crop growth and development. Harvesting was done as per the maturity of different lines. The observations were recorded on ten randomly selected plants in each replications for all the characters viz.-plant height (cm), number of 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), number of cloves per bulbs, weight of 50 cloves (g), and marketable yield (q/ha). The pooled data of 2006-07 and 2007-08 were analyzed statistically for variance using the standard procedure by Gomez and Gomez, (1984). The genotypic and phenotypic coefficient of variations was calculated as suggested by Burton and De Vane EH (1953). Heritability in broad sense and expected genetic advance as percent of mean was worked out with the method suggested by (Johnson *et. al.,* 1955).

All the characters showed significant variances, indicating sufficient diversity among the germplasms. A wide range of variability (Table-1) was recorded for marketable yield (62.40 q/ha to 183.58 q/ha), weight of 50 cloves (41.66 g to 86.66 g), number of cloves per bulb (14.0 to 43.93), weight of 20 bulbs (432.0 g to 767.0 g), and clove diameter (0.91-1.40 cm). These high ranges of variation among different lines could be utilized by breeders for the improvement of desired traits. The mean data (Table 1) indicated that, the maximum marketable yield (183.58 q/ha) was recorded for advance line G-384 followed by G-41 (177.28 q/ha) and G-189 (164.20 q/ha). The maximum 20 bulbs weight (767.0 g) and weight of 50 cloves (86.66 g) was observed for check G-282 and G-

RK Singh, BK Dubey, SR Bhonde and RP Gupta
National Horticultural Research and Development Foundation, Chitegaon Phata, Post- Darna Sangavi, Dist-Nashik, 422 003, Maharashtra
E mail: singhrknbpgr@yahoo.com

Table 1. Mean performance of different advance line for different traits

Advance lines	Plant height (cm)	Leaves/ plant	Neck thick ness (cm)	Bulb dia meter (cm)	Bulb size index (cm^2)	Weight of 20 bulbs (kg)	Clove dia meter (cm)	Clove size index (cm^2)	Cloves /bulb	Wt. of 50 cloves (g)	Marketabl e yield (q/ha)
G-002	90.00	8.90	1.66	4.60	15.16	0.633	0.98	2.55	38.93	50.00	143.45
G-004	90.65	8.13	1.44	4.50	14.65	0.710	1.25	3.31	40.46	61.66	147.53
G-023	90.60	8.73	1.66	4.46	14.61	0.622	1.08	2.71	32.66	55.00	137.90
G-035	89.80	8.66	1.56	4.57	14.84	0.560	1.16	3.05	27.53	65.00	131.48
G-072	99.10	8.73	1.64	4.55	14.50	0.605	1.10	2.71	40.06	53.33	140.12
G-176	88.90	9.20	1.41	4.73	15.44	0.703	1.24	3.24	24.23	64.66	154.44
G-182	92.80	8.73	1.63	4.40	14.02	0.600	1.08	2.87	36.66	51.66	123.58
G-189	90.90	8.93	1.62	4.61	15.45	0.685	1.07	2.97	41.80	58.33	164.20
G-192	89.20	8.76	1.46	4.73	16.16	0.717	1.02	2.63	36.50	51.66	148.27
G-200	92.58	8.13	1.45	4.27	13.38	0.663	1.30	3.46	21.23	66.66	129.01
G-222	90.95	8.06	1.42	4.53	14.49	0.667	1.18	3.24	28.23	60.66	138.76
G-255	91.24	8.36	1.51	4.44	14.02	0.693	1.14	2.70	40.46	53.33	145.55
G-264	92.68	9.86	1.46	4.47	14.60	0.707	1.10	2.63	35.50	53.33	162.71
G-294	88.63	8.20	1.56	4.41	14.24	0.540	1.05	2.75	21.00	71.66	120.12
G-302	91.96	8.60	1.53	4.75	16.49	0.727	1.37	3.57	24.00	86.66	138.51
G-304	91.68	8.33	1.48	4.54	15.22	0.717	1.25	2.95	38.70	55.00	149.13
G-305	90.42	8.93	1.50	4.84	16.55	0.730	1.24	3.09	29.16	60.00	148.76
G-324	93.53	8.86	1.52	4.55	15.42	0.685	1.12	2.90	34.06	53.33	154.19
G-342	92.76	8.73	1.68	4.48	13.90	0.615	1.10	2.70	18.80	80.00	102.65
G-351	88.83	8.73	1.56	4.35	14.59	0.607	1.16	2.93	14.26	85.00	105.80
G-360	87.83	8.73	1.53	4.33	13.56	0.432	1.16	2.99	17.20	76.66	62.40
G-366	93.43	7.73	1.41	4.37	15.89	0.720	1.31	3.57	25.93	76.66	136.29
G-368	94.70	9.00	1.66	4.52	14.55	0.592	1.08	2.55	33.93	55.00	128.14
G-369	91.85	8.86	1.48	4.25	13.09	0.627	1.24	3.27	20.10	65.66	98.27
G-376	89.80	8.86	1.58	4.58	15.14	0.633	1.06	2.76	26.53	83.33	145.49
G-378	90.00	8.80	1.59	4.68	14.98	0.542	1.13	2.89	20.66	81.66	104.93
G-384	98.76	9.13	1.66	4.84	17.18	0.732	1.32	2.98	25.06	70.00	183.58
G-1 ©	90.30	9.03	1.39	4.63	15.87	0.657	0.97	2.63	39.73	54.33	137.15
G-41 ©	95.06	9.63	1.51	4.74	17.17	0.723	1.21	3.25	35.16	76.66	177.28
G-50 ©	94.93	8.80	1.60	4.48	14.56	0.627	0.913	2.03	42.93	41.66	126.97
G-282 ©	87.93	8.60	1.55	4.73	16.96	0.767	1.40	3.58	20.26	85.00	151.66
G-323 ©	90.22	9.06	1.51	4.70	15.39	0.710	1.21	3.30	26.60	68.33	140.86
RANGE	87.83-94.93	7.73-9.86	1.39-1.68	4.25-4.85	13.09-16.96	0.432-0.767	0.91-1.40	2.03-3.58	14.26-43.93	41.66-86.66	62.40-183.58
S EM+-	1.08	0.124	0.036	0.121	0.448	0.022	0.050	0.192	2.12	3.39	10.45

302 respectively. The highest bulb diameter (4.84 cm) was noted for G-384 and G-305. It is concluded from mean data the advance line G-384, G-189, G-305 and G-282 can be used in garlic crop improvement programme.

The extent of variability with respect to eleven quantitative characters in different advance lines of garlic measured in terms of range, variance, genotypic coefficient of variations (GCV), phenotypic coefficient of variations (PCV), along with heritability (h^2), genetic advance and genetic advances as percent of mean are presented in Table 2. All the characters exhibited considerable variations. In the present investigation phenotypic coefficient of variations (PCV) was higher than the genotypic coefficient of variations (GCV) for all the traits indicating that environmental factor influencing their expression and their susceptibility to environmental fluctuations. Genotypic and phenotypic coefficients of variations were high for weight of 50 cloves, number of cloves per bulbs, marketable yield and clove size index. Similar results for some important traits are reported by Godhani and Singh (2000) and Dhar (2002). Narrow differences between phenotypic and genotypic coefficient of showed less environmental interference on the expression of traits. The traits exhibited high phenotypic and genotypic coefficient of variations are of economic importance and there is scope for improvement of these traits through selection.

Heritability in broad sense ranged from (43.90 to 95.00%). High value of heritability was recorded for plant height (95.00%) followed by cloves per bulbs (90.90%), leaves per plant (90.30%), weight of 50 cloves (89.60%), weight of 20 bulbs (86.90%), marketable yield (77.80%), bulb size index (77.60%) and neck thickness (77.60%). Remaining characters showed moderate heritability. High heritability for above characters clarified that, they were least effected by environmental modifications and selection based on phenotypic performance would be reliable. The findings are in consonance with observation of Korla *et. al.*

Table 2. Range, mean, coefficient of variation, heritability and genetic advance for different traits in garlic

Character	Range	CV	Sem+-	G. Mean	Variance		Coefficients of variation		Heritability (%)	Genetic Advance	GA as percent of mean
					ÓG	ÓP	PCV (%)	GCV (%)			
PLANT HEIGHT	21.70	1.41	1.08	94.16	33.71	35.47	6.32	6.16	95.00	11.66	12.38
LEAVES PER PLANT	2.26	1.74	0.124	8.71	0.21	0.240	5.61	5.34	90.30	0.911	10.45
NECK THICKNESS	0.293	2.88	0.036	1.54	0.007	0.009	5.99	5.25	76.80	0.146	9.49
BULB DIAMETER	0.587	3.24	0.121	4.55	0.017	0.039	4.34	2.87	43.90	0.179	3.92
BULB SIZE INDEX	4.45	3.65	0.448	15.03	1.042	1.34	7.70	6.78	77.60	1.85	12.31
WEIGHT OF 20 BULBS	0.300	4.10	0.022	0.64	0.005	0.005	11.35	10.58	86.90	0.132	20.33
CLOVE DIAMETER	0.457	5.29	0.050	1.15	0.010	0.014	10.32	8.86	73.70	0.180	15.67
CLOVE SIZE INDEX	1.833	7.90	0.192	2.97	0.141	0.196	14.89	12.62	71.80	0.656	22.04
CLOVES PER BULBS	28.66	8.68	2.12	29.95	68.00	74.77	28.87	27.53	90.90	16.20	54.08
WEIGHT OF 50 CLOVES	45.00	6.41	3.39	64.75	148.48	165.72	19.88	18.81	89.60	23.76	36.69
MARKETABLE YIELD Q/HA)	121.17	9.48	10.45	134.94	575.87	739.80	20.15	17.78	77.80	43.61	32.32

PCV: Phenotypic coefficient of variation, GCV: Genotypic coefficient of variation, ÓG: Genotypic variance, ÓP: Phenotypic variance

(1981), Mehta and Patel (1985), Jabeen *et al.* (2010) and Tsega *et. al.* (2010).

The heritability estimates along with genetic advance are more useful than the heritability values alone for selecting the best individual. From the present investigation, the genetic advance as percent of mean ranged from (3.92 to 54.08%). High estimates of genetic advance was showed by cloves per bulbs (54.08%) followed by weight of 50 cloves (36.69%), marketable yield (32.32%) and weight of 20 bulbs (20.33%), while rest of the traits showed moderate to low genetic advance. High values of heritability, GCV and genetic advance as percent of mean were observed for cloves per bulbs, weight of 50 cloves, marketable yield, and weight of 20 bulbs, suggesting that these all traits are genetically controlled by additive gene action (Panse, 1957) and can be improved through mass selection, family selection and other modified selection. High heritability coupled with low genetic advance as percent of mean with low GCV were observed for all the traits suggesting that these traits were governed by no additive gene action and high genotype-environment interaction. These results are also in agreement with Padda *et. al.* (1972) regarding number of cloves per bulb, gross yield and weight of bulbs.

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