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Genetic variability, heritability and genetic advance studies for yield and its contributing traits in Garlic *(Allium sativum)*

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Abstract

A field investigation was carried out to estimate the genetic variability, heritability and genetic advance in the garlic. The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) in all the characters. The highest GCV associated with high heritability of with good genetic advance, was observed for weight of 10 uniform cloves followed dry weight of bulb. The lowest variability associated with low heritability and low genetic advance as percent of mean was observed for number of leaves per plant. Simultaneously, fresh weight of bulb, weight of 10 uniform cloves, dry weight of bulb and volume of bulb observed with high heritability coupled with moderate genetic advance. These traits were also governed by preponderance of additive gene effects and selection for these characters also rewarding to improve bulb yield. High heritability accompanied with low genetic advance observed for circumference of bulb, sulphur content (%), dry weight of leaves and fresh weight of leaves. It is indicative of non-additive gene action. The moderate to high heritability is being exhibited due to favourable influence of environment rather than genotype and selection for such traits may not be rewarding. Low heritability coupled with low genetic advance was found for number of leaves per plant, neck thickness, total soluble solids (TSS) and vitamin C were highly influenced by environmental effects and selection would be ineffective. High heritability in association with high genetic advance observed for plant height, number of cloves per bulb, bulb weight, and moderate heritability coupled with highest genetic advance observed for bulb yield. It indicates that most likely the heritable is due to the preponderance of additive gene effects and the potential of selection for these characters to improve bulb yield.

Key words: *Genetic variability, heritability, genetic advance, garlic, Allium sativum*

Introduction

Garlic (*Allium sativum* L.*)* is the second most important bulb crop after onion. It is an important spice crop belonging to family Alliaceae. It is hardy and grown extensively in Chittorgarh, Baran, Jodhpur, Jhunjhunu, Udaipur, Kota, Dungarpur, Bundi, Jaipur and Sikar districts of Rajasthan during *rabi* season. The economic yield is obtained from its underground bulb, which is consisted of bulblets, popularly known as cloves. Garlic is used in flavouring foods, preparing chutneys, pickles, curry powder, tomato ketchup etc. It contains a clourless as well as odourless water soluble amino acid called allin. Garlic contains volatile oil known as 'diallyl-disulphide', Which is the major flavouring component in garlic. Beneficial use of garlic extract has been found against many fungi and bacteria. Besides the nutritive value of garlic and its use in various forms, it is included in Indian system of medicine as carminative and gastric stimulant to help in digestion and absorption of food. Allicin present in aqueous extract of garlic reduces blood cholestrol concentration in human blood. Garlic oil or its juice is recommended to inhale in cases of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and redness of eyes.

Evaluation of genotypes to assess the existing variability is considered as preliminary step in any crop improvement programme. To initiate an effective improvement programme in any crop, the first and foremost step is to build up a comprehensive germplasm. Information on the magnitude of variation in the available genetic material and the part played by the environment on the expression of plant characters are prime importance for the appraisal of the and magnitude of possible improvement. The prediction of genetic advance is a prerequisite for crop improvement breeding programs especially when large populations are subjected to selection. Facilitated by obtaining phenotypic and genotypic coefficients of variation in the absence of which field evaluation of every genotype would be physically less feasible. Hence there is need to study variability. Variability for different traits in the source population is a prerequisite for crop improvement since all attempts of breeding and selection would be futile unless major portion of variability is heritable. Further, estimate of genetic advance and heritability would give the best picture

of the extent of improvement expected from selection and reliability of selection based on phenotype. Garlic is an sexually sterile diploid vegetable bulb crop and its genotypes has tremendous variability for bulb weight, number of cloves per bulb, weight of 10 uniform cloves, weight, shape, taste etc. Inspite of being on important crop for cool season in plains, the research work on garlic is very scare. In order to pursue an effective breeding programme, the present investigation was made to estimate the genetic variability, heritability and genetic advance in the garlic.

Materials and Methods

The present investigation comprised of 25 genotypes of garlic collected from different parts of India. The genotypes were sown in randomized block design with three replications at Horticulture Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University Bikaner during *rabi* season 2009-10. Each genotype was planted in a double rows plot of 5 m length, maintaining row to row and plant to plant spacing 15 cm and 10 cm, respectively. Cloves of healthy bulbs 8-10 mm in diameter are dibbled at 5-7.5 cm deep keeping their growing ends upwards. All the recommended package of practices was given to raise a good crop. Observations on ten randomly selected plants from each replication were recorded for plant height at 90 days after sowing, number of leaves per plant, fresh weight of leaves (g), dry weight of leaves (g), number of cloves per bulb, weight of 10 uniform cloves (g), fresh weight of bulb (g), dry weight of bulb (g), neck thickness (cm), circumference of bulb (cm), volume of bulb (cc), total soluble solids (°brix), sulphur content (%), vitamin C (mg per 100 g), bulb weight (g) and bulb yield (qt /ha). Data recorded were subjected to statistical analysis. Genotypes coefficient variation (GCV) and phenotypic coefficient variation (PCV), broad sense heritability, genetic advance, were computed by the methods suggested by Al-Jibouri *et al.* (1958) and Devey and Lu (1959).

Results and Discussion

Genetic variability, heritability and genetic advance for sixteen characters in twenty five varieties / lines of garlic were studied. Analysis of variance revealed significant differences among the genotypes for all the sixteen characters studied (Table 1). Mean performance of all genotypes and GCV, PCV and genetic advance parameters for all the studied traits were given in Table 2 & 3, respectively. On the basis of per se performance, plant height was maximum (60.70 cm) in Bikaner local followed by Jobner local (58.40) and Vidisha local (58.37). The smallest plants (36.33 cm) were measure in Baran local. Maximum number of leaves per plant (10.13) was noted in G- 1 which was at par with Ladwa local and Jobner local and minimum leaves per plant (8.57) was recorded in Mahadev. Number of cloves per bulb was recorded highest in Bikaner local (38.27) followed by Ladwa local and Jobner local. Weight of 10 uniform cloves was highest in G-282 followed by Mahadev and Buccani local. Ladwa local was found maximum in fresh weight of bulb (31.60 g) followed by G-41 and Bikaner local. Buccani local contained highest dry weight of bulb (16.50 g) and was at par with Vidisha local and Phule Baswant. Neck thickness was maximum in G 51 followed by G-282, G- 41, G-50 and Amleta local. Ladwa local followed by Phule Baswant and Ooty- 1 was found with highest circumference of bulb. The maximum total soluble solid (TSS) (43.17 %) was observed in G41 and was at par with Mahadev, Vidisha local genotypes. Genotype Buccani local and G-323 were found with maximum sulphur content (%). G282 and Phule Baswant were also reported second highest in sulphur content. Vitamin C content was maximum in G282 followed by Vidisha local, G-1 and Phule Baswant. The highest bulb weight was recorded in Ladwa local (32.13) followed by G- 1 and Punjab garlic (30.13). The highest bulb yield (qt/ha) was recorded in G 1 (151.40) followed by Rulayata local, G 282, G- 323. Maximum range was recorded for bulb yield (82.60 - 151.40 q/ha) followed by plant height (36.33- 60.70 cm), number cloves per bulb (16.03- 38.27), bulb weight (12.50- 3213 g) fresh weight of bulb (14.97-31.60 g) and volume of bulb (12.37- 24.00 cc) indicating maximum variability present in these traits which showed a greater scope for selection among the existing genotypes while the low range was observed for sulphur content (0.31-0.35%). Singh and Chand (2004) were also found that bulb yield per hectare, followed by bulb weight and number of cloves per bulb, exhibited maximum diversity.

The magnitude of PCV as expected was greater than the corresponding GCV for all the characters indicating importance of environment in expression of characters. The GCV does not offer full scope to estimate the heritable variation and, therefore, estimation of heritability becomes necessary. In the present study, all the traits expressed low to high heritability which ranged from 21.81 per cent (number of leaves per plant) to 98.23 per cent (Plant height) suggesting thereby the major role of genetic constitution in the expression of these character and such traits are considered to be dependable for breeding point of view. The highest GCV (23.03) associated with high heritability of (86.29) with good genetic advance, was observed for weight of 10 uniform cloves followed dry weight of bulb (GCV = 2.522).

High values of PCV as well as GCV were recorded for weight of 10 uniform cloves, dry weight of bulb, number of cloves per bulb and bulb weight which revealed the great extent of variability present in characters. Earlier, Shri Dhar (2002) was also reported high magnitude of phenotypic (PCV) and genotypic (GCV) coefficients of variation were recorded for bulb yield, weight of 50 cloves and number of cloves per bulb. The lowest variability (GCV= 3.12) associated with low heritability (21.81%) and low genetic advance as percent of mean (5.66) was observed for number of leaves per plant. High heritability in association with high genetic advance observed for plant height, number of cloves per bulb, bulb weight, and moderate heritability coupled with highest genetic advance observed for bulb yield. These findings were in accordance with the findings of Raj Narayan and Khan (2002), Singh and Chand (2004), Khar *et al*. (2005) and Jabeen *et al.* (2010). It indicates that most likely the

Table 1. Analysis of variance for bulb yield and other traits in garlic

Source of variation	d.f	Plant height at 90 days after sowing (cm)	No. of leaves per plant	Fresh weight of leaves (g)	Dry Weight of leaves (g)	No. of cloves per bulb	Weight of 10 uniform cloves (g)	Fresh weight of bulb(g)	Dry weight of bulb(g)
Replication	2	0.15	0.91	0.47	0.19	4.32	0.14	3.60	1.18
Genotypes	24	86.40**	0.56*	9.40**	1.39**	91.13**	29.62**	69.90**	18.68**
Error	48	0.51	0.31	0.98	0.18	2.25	1.49	4.63	1.02

*, ** Significant at 5 % and 1 % level of significance, respectively

Source of variation	d.f	Neck thickness (cm.)	Circumference of bulb (cm)	Volume of bulb (cc)	TSS (%)	Sulphur content (%)	Vitamin C (mg/100g)	Bulb weight (g)	Bulb yield (q/ha)
Replication	2	0.000004	0.52	0.38	4.42	0.00005	0.02	6.35	110.79
Genotypes	24	0.0055**	3.63**	31.69**	10.17**	0.00043**	1.90**	84.98**	997.56**
Error	48	0.0026	0.70	2.92	2.98	0.00007	0.52	2.33	133.11

*, ** Significant at 5 % and 1 % level of significance, respectively

Table 2. Mean values for different metric characters of garlic genotypes

S. No.	Genotypes	Plant height at 90 days after sowing (cm)	No. of leaves per plant	Fresh weight of leaves (g)	Dry Weight of leaves (g)	No. of cloves per bulb	Weight of 10 uniform cloves (g)	Fresh weight of bulb (g)	Dry weight of bulb (g)	Neck thickness (cm.)	Circumference of bulb (cm)	Volume of bulb (cc)	TSS (%)	Sulphur content (%)	Vitamin C (mg/100g)	Bulb weight (g)	Bulb yield (q/ha)
1.	G-282	52.33	9.03	9.30	3.66	22.83	17.87	25.37	11.50	0.94	13.37	19.83	41.00	0.344	11.557	24.77	140.00
2.	Mahadeva	55.66	8.57	9.70	3.60	20.67	17.77	25.73	12.07	0.93	11.83	18.30	43.17	0.339	11.053	25.57	129.83
3.	Ringus Local	49.07	8.93	7.50	2.43	29.67	8.70	19.30	6.90	0.84	11.23	15.43	37.33	0.325	9.357	19.17	92.70
4.	Kota Local	55.56	9.67	8.20	3.88	22.97	15.87	25.43	11.70	0.90	12.82	19.20	40.33	0.337	10.700	25.50	124.70
5.	Buccani Local	56.80	9.60	9.93	4.43	22.40	17.33	29.37	16.50	0.91	12.19	24.00	42.50	0.345	10.993	29.50	131.17
6.	Rulayata Local	53.10	9.70	8.73	2.90	18.43	7.90	20.83	8.43	0.90	11.54	14.70	41.67	0.336	11.247	21.00	143.90
7.	G-41	50.60	8.77	10.97	4.29	23.60	12.83	30.27	12.53	0.94	12.43	23.47	43.17	0.341	11.003	29.70	120.27
8.	G-323	57.17	9.30	10.30	3.51	26.40	14.43	26.73	11.73	0.90	13.35	18.27	42.33	0.345	11.113	27.50	140.13
9.	Rajgarh Local	44.17	9.53	7.33	3.11	18.67	10.70	15.43	7.70	0.84	11.52	15.90	41.50	0.315	9.953	14.73	97.87
10.	G-50	52.58	9.43	11.30	4.83	23.47	14.30	26.73	9.90	0.94	12.80	16.57	42.33	0.337	11.320	26.73	128.90
11.	G-1	51.37	10.13	8.67	3.54	25.43	12.77	22.37	11.73	0.92	12.14	17.63	39.00	0.346	11.407	31.87	151.40
12.	Amleta Local	43.63	9.63	6.00	2.37	23.60	9.43	21.57	9.14	0.94	11.88	15.00	41.67	0.342	11.313	22.37	128.00
13.	Baran Local	36.33	9.33	7.67	2.71	16.03	8.43	14.97	6.05	0.81	8.76	12.73	39.83	0.316	9.477	12.50	93.30
14.	Bikaner Local	60.70	9.30	13.63	4.23	38.27	12.90	30.23	11.10	0.84	13.11	20.77	41.50	0.311	9.377	28.63	82.60
15.	Vidisha Local	58.37	9.33	9.07	3.83	17.53	16.57	28.47	15.13	0.93	12.53	20.67	43.00	0.336	11.427	27.90	130.83
16.	Phule Baswant	56.63	9.26	9.07	3.67	30.47	16.37	25.93	13.07	0.90	13.60	16.80	41.17	0.344	11.093	26.80	122.83
17.	Punjab Garlic	51.33	8.73	9.33	2.43	26.30	15.27	28.50	7.27	0.89	13.34	22.33	41.67	0.310	10.483	30.13	109.53
18.	Ooty-1	54.77	8.90	8.53	2.74	16.37	16.53	19.50	10.05	0.88	13.40	15.93	41.17	0.326	11.200	20.83	111.43
19.	Dausa Local	49.13	9.43	8.53	2.75	29.53	9.43	17.63	9.37	0.82	11.12	12.37	38.00	0.317	9.523	17.33	89.23
20.	Jobner Local	58.40	9.97	11.17	3.64	32.40	9.20	16.23	10.27	0.85	12.30	18.20	40.17	0.318	9.330	15.97	100.90
21.	Khandar Local	53.60	8.70	10.30	3.24	30.43	11.93	22.20	9.30	0.84	11.80	14.00	38.50	0.323	9.237	22.37	109.57
22.	Bhima Omkar	55.17	9.83	7.73	3.12	20.40	15.53	24.47	12.50	0.88	11.82	22.93	40.00	0.335	10.937	24.40	114.70
23.	Ladwa Local	57.07	10.00	10.27	4.25	30.53	12.57	31.60	11.30	0.92	14.35	21.27	36.50	0.344	10.893	32.13	122.60
24.	Jhalrapattan Local	54.67	9.74	9.60	3.45	24.00	13.47	24.07	13.60	0.91	12.71	18.37	41.17	0.339	10.630	25.20	132.07
25.	G-51	54.50	9.61	13.40	4.15	27.70	14.33	26.90	10.47	0.95	12.57	18.20	38.50	0.343	11.387	27.03	122.87
	Mean	52.91	9.38	9.45	3.47	24.72	13.30	23.99	10.77	0.89	12.34	18.11	40.69	0.33	10.64	24.39	118.85
	CV (%)	7.36	5.91	10.47	12.08	6.07	9.18	8.96	9.38	5.71	6.77	9.43	4.24	2.46	6.80	6.26	9.71
	CD at 5%	0.68	0.53	0.94	0.40	1.42	1.16	2.04	0.96	0.05	0.79	1.62	1.64	0.01	0.69	1.45	10.94

Table 3. Estimates of genetic parameters of variation for the different characters of garlic genotypes

Characters	Mean ±S.Em	Range	Genotypic variance	Phenotypic variance	Coefficient of variance		Heritability (%)	Genetic Advance	G.A. as % of mean
					Genotypic	Phenotypic			
Plant height at 90 days after sowing (cm)	52.91±0.24	36.33-60.70	28.63	29.14	10.11	10.20	98.23	10.92	6.25
No. of leaves per plant	9.38±0.18	8.57-10.13	0.09	0.39	3.12	6.68	21.81	0.28	5.66
Fresh weight of leaves (g)	9.45±0.33	6.00-13.63	2.81	3.79	17.73	20.59	74.17	2.97	18.25
Dry Weight of leaves (g)	3.47±0.14	2.37-4.83	0.41	0.58	18.36	21.98	69.78	1.10	30.17
No. of cloves per bulb	24.72±0.50	16.03-38.27	29.63	31.88	22.02	22.84	92.94	10.81	13.30
Weight of 10 uniform cloves (g)	13.30±0.41	7.90-17.87	9.38	10.87	23.03	24.79	86.29	5.86	18.20
Fresh weight of bulb(g)	23.99±0.72	14.97-31.60	21.76	26.38	19.44	21.41	82.47	8.73	12.31
Dry weight of bulb(g)	10.77±0.34	6.05-16.50	5.89	6.91	22.52	24.39	85.22	4.61	19.94
Neck thickness (cm.)	0.89±0.02	0.81-0.95	0.002	0.004	3.48	6.69	27.14	0.03	20.46
Circumference of bulb (cm)	12.34±0.28	8.76-14.35	0.98	1.67	8.01	10.49	58.38	1.56	10.11
Volume of bulb (cc)	18.11±0.57	12.37-24.00	9.59	12.51	17.10	19.53	76.67	5.59	13.05
TSS (%)	40.69±0.58	36.50-43.17	2.40	5.38	3.80	5.70	44.58	2.13	3.59
Sulphur content (%)	0.33±0.008	0.31-0.35	0.001	0.003	3.33	4.14	64.56	0.02	40.69
Vitamin C (mg/100g)	10.64±0.24	9.24-11.56	0.46	0.98	6.38	9.32	46.84	0.96	9.19
Bulb weight (g)	24.39±0.51	12.50-32.13	27.55	29.88	21.52	22.42	92.19	10.38	13.21
Bulb yield (q/ha)	118.85±3.85	82.60-151.40	288.15	421.26	14.28	17.27	68.40	28.92	4.52

heritable is due to the preponderance of additive gene effects and the potential of selection for these characters to improve bulb yield.

Simultaneously, fresh weight of bulb, weight of 10 uniform cloves, dry weight of bulb and volume of bulb observed with high heritability coupled with moderate genetic advance. These traits were also governed by preponderance of additive gene effects and selection for these characters also rewarding to improve bulb yield. High heritability accompanied with low genetic advance observed for circumference of bulb, sulphur content (%), dry weight of leaves and fresh weight of leaves. It is indicative of non-additive gene action. The moderate to high heritability is being exhibited due to favourable influence of environment rather than genotype and selection for such traits may not be rewarding. Low heritability coupled with low genetic advance was found for number of leaves per plant, neck thickness, total soluble solids (TSS) and vitamin C were highly influenced by environmental effects and selection would be ineffective. Shri Dhar (2002) also reported high estimates of heritability for all the studied traits except bulb diameter and number of leaves. Out of 16 characters studied, weight of 10 uniform cloves and dry weight of bulb showed high GCV and heritability coupled with high genetic advance as per cent of mean which showed that these two characters might be under control of additive gene effect and therefore, they are more reliable for effective selection.

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