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Studies on genetic variability and character Association in Garlic (*Allium sativum* L)

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Abstract

Genetic variability and character association analysis were estimated among sixteen genotypes of garlic for twelve characters comprised of bulb yield and its contributing characters in Randomized Block Design with three replications during *Rabi*-2014-15. Analysis of variance indicated presence of considerable variability for all the twelve characters. High GCV and PCV were observed for volume of bulb and weight of cloves. High estimates of heritability along with high genetic advance as per cent of mean was observed for volume of bulb and bulb yield indicating predominance of additive gene effects for these traits. The result from character association indicated that bulb yield had highly significant positive correlation with number of cloves per bulb, ascorbic acid and weight of cloves at both the levels.

Keywords: *Garlic, Variability, Correlation, Genetic advance, Heritability.*

Introduction

Garlic (*Allium sativum L.*) is the second most widely cultivated bulb crop, after onion. It is an important spice crop belonging to the family Alliaceae. The economic yield is obtained from its underground bulb, which is consisted of bulblets, popularly called as cloves. It has high nutritive value than other bulb crops. It is rich in protein, phosphorus, calcium, magnesium and carbohydrates. Ascorbic acid content is very high in green garlic (Pandey, 1997). Garlic contains a colourless as well as odourless water soluble amino acid called 'allin'. On crushing the clove, an enzyme allinase acts upon allin and breaks it down to produce allicin. Garlic contains volatile oil known as 'diallyl disulphide' which is the major flavouring component in garlic. It contains 0.1 per cent volatile oil and has good export potential as bulb as well as in the form of dehydrated products.

India ranks second after China in area (247.52 thousand hectare) and second in production (1259.27 thousand tonnes) of garlic with an average productivity of 5.09 tonnes per hectare (Gupta, 2014). The major garlic producing states of India are Madhya Pradesh, Odisha, Rajasthan, Karnataka, U. P. and Gujarat. India is one of the garlic exporting countries of the world. Genetic variability character association pattern and direct and indirect effects of the yield attributing characters on bulb yield is helpful for effective selection in crop improvement. Knowledge of association of different components together with their relative contributions has immense value in selection.

Materials and methods

The field experiment entitled "Genetic Variability, correlation and path coefficient analysis in garlic (*Allium sativum* L.)" was conducted at SKN College of Agriculture, Jobner (Jaipur) during rabi season of 2014-15. The experiment consists of sixteen genotypes of garlic viz., Mahadeva, Amleta, Malaypur, Kota Local, Ranikhet Local, Haldwani Local, G-1, G-41, G-50, G-189, G-282, G-323, G-384, Jaipur Local, Sonipat Local, Malakapuri. These genotypes were evaluated in randomized block design with three replications. Genotypes were sown in a plot of 1.05 m x 1.0 m size mentioning row to row distance 15 cm and plant to plant 10 cm. Cloves of healthy bulb were sown at 5-7.5 cm deepth keeping their growing ends upwards, on 3rd November, 2014. All the recommended package of practices were practiced to raise a healthy crop. Five competitive plants were marked in each plot per replication and observations were recorded on these plants. Observations were recorded on these plants for plant height (cm) at ninety days after sowing, number of leaves per plant, dry weight of bulb (g), number of cloves per bulb, weight of ten uniform cloves (g), bulb yield (q/ha), neck thickness (cm), circumference of bulb (cm), volume of bulb (cc), total soluble solids (%), sulphur content of bulb (%) and vitamin 'C' (mg/100g).

The genotypic and phenotypic coefficient of variations was done by the method as suggested by Burton (1952) and Johanson *et al.* (1955), heritability (broad sense)

by Johnson *et al.* (1955) and genetic advance by Lush (1940). The phenotypic and genotypic correlation coefficients were calculated as per the methods given by Singh and Choudhary (1985). The path coefficients were obtained by following the method of Dewey and Lu (1959).

Result and discussion

Analysis of variance revealed significant differences among the genotypes for all the traits studied indicating significant variability in the materials (Table1). The range of variation was high for bulb yield (100.56-151.80 q/ha) followed by plant height at 90 DAS (41.32-71.22 cm), volume of bulb (22.26-47.26 cc), dry weight of bulb (15.73-30.66 g),number of cloves per bulb (17.06-26.44) and weight of cloves (9.20-17.80 g). A better idea can be gained by comparing the relative amount of coefficient of phenotypic and genotypic variance for the actual strength of variability. Comparison of coefficient of variation indicated that the phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the characters which indicated effect of environment on the character expression.Among all the characters high GCV and PCV were observed for volume of bulb (23.20 & 23.31) followed by weight of cloves (21.64 & 21.66) in comparison of other characters, indicating the presence of high amount of genetic variability for these traits and selection for these characters would be effective because the response to selection is directly proportional to the variability present in the experimental material. Moderated GCV and PCV were observed for dry weight of bulb, neck thickness, number of cloves per bulb, plant height at 90 DAS and bulb yield. These results are in broad conformity to earlier researchers (Korla *et al*., 1981; Shaha *et al.*, 1990; Dhar, 2002; Agrawal and Tiwari, 2004; Singh and Chand, 2004 and Singh *et al.,* 2012). With the help of PCV and GCV alone, it is not possible to determine the amount of variation which is heritable. The heritability along with genetic advance is more meaningful and help in predicting the resultant effect of selection on phenotypic expression. Estimates of heritability in broad sense was high for bulb yield, weight of cloves, number of cloves per bulb, volume of bulb, ascorbic acid, dry weight of bulb and TSS and high heritability along with high genotypic coefficient of variance was recorded for weight of cloves and volume of bulb. The heritability estimates along with genetic advance were more useful than heritability estimates alone in predicting the response to selection. Thus, high heritability along with high genetic advance as per cent of mean was observed for volume of bulb and bulb yield. In this condition selection will be more effective for these characters. Yield of a crop is the results of interaction of a number of inter-related characters. Therefore selection should be based on these component characters after assessing their correlation with yield.

Characters associated revealed the mutual relationship between two characters, and it is important parameter for taking a decision regarding the nature of selection to be followed for improvement in the crop under study. The phenotypic and genotypic correlation among yield and yield components in garlic are presented in Table 2. Significant correlation of characters suggested that there is much scope for direct and indirect selection for further improvement. In general, the estimate of genotypic correlation coefficient was higher than their corresponding phenotypic ones, therefore suggesting strong inherent association among the characters studied. In the present investigation, bulb yield showed significant positive correlation with number of cloves per bulb, ascorbic acid and weight of cloves. Although it showed positive and non significant correlation with sulphur content, TSS, circumference of bulb and dry weight of bulb. From these associations, it appears that higher bulb yield can be obtained by increasing these characters. Positive association of dry weight of bulb with yield of garlic was also observed by Kohli and Mahajan, 1993 and Baiday and Tiwari, 1995.

Yield is sum total of several component characters which directly or indirectly contributed to it. The information derived from the correlation studies indicated only mutual association among the characters. In the light of above findings, it may be concluded that improvement in the characters like number of cloves per bulb, ascorbic acid, dry weight of bulb, circumference of bulb and number of leaves per plant will help in improving the bulb yield in garlic. Therefore these characters should be considered for bulb yield in garlic breeding programme

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Table 1. Estimates of genetic parameters of variation for the different characters of garlic genotypes

Characters	Mean	Range	Genotypic Variance	Phenotypic Variance	Genotypic Coefficient of Variance	Phenotypic Coefficient of Variance	Heritability (%)	Genetic Advance	Genetic Advance as per cent of mean (%)
Plant height at 90 days after sowing (cm)	53.22	41.32 - 71.22	47.76	56.29	12.98	14.10	84.84	13.11	24.64
Number of leaves per plant	7.52	6.73 - 8.06	0.12	0.21	4.54	6.03	56.65	0.53	7.04
Number of cloves per bulb	21.61	17.06-26.44	8.82	8.88	13.75	13.79	99.40	6.10	28.23

Weight of cloves (g)	13.38	9.20-17.80	8.39	8.41	21.64	21.66	99.78	5.96	44.53
Dry weight of bulb (g)	20.51	15.73 - 30.66	13.45	14.63	17.88	18.65	91.91	7.24	35.32
neck thickness (cm)	0.88	0.66 – 1.24	0.02	0.02	14.61	15.83	85.15	0.24	27.77
Circumference of bulb (cm)	12.28	10.42 - 14.02	1.00	1.19	8.16	8.90	83.98	1.89	15.40
Volume of bulb (cc)	34.64	22.26 - 47.26	64.61	65.21	23.20	23.31	99.08	16.48	47.58
Total soluble solids (%)	41.79	39.77 - 43.19	1.00	1.11	2.39	2.52	89.91	1.95	4.67
Sulphur content (%)	0.33	0.31 - 0.35	0.00	0.00	2.63	4.07	41.93	0.01	3.51
Ascorbic acid (mg/100g)	11.05	9.57 - 11.48	0.21	0.22	4.13	4.28	93.49	0.91	8.24
Bulb yield (q/ha)	123.84	100.56 - 151.80	231.31	231.76	12.28	12.29	99.80	31.30	25.27

Table 2. Phenotypic (P) and genotypic (G) correlation coefficients between different characters in garlic

Characters		Plant height at 90 days after sowing(cm)	Number of leaves per Plant	Number of cloves per bulb	Weight of uniform cloves (g)	Dry weight of bulb (g)	Neck thickness (cm)	Circumference of bulb (cm)	Volume of bulb (cc)	Total soluble solids (%)	Sulphur content (%)	Ascorbic acid (mg/100g)	Bulb yield (q/ha)
Plant height at 90 days	P	1.0000	0.5021**	-0.4148**	-0.4213**	-0.1700	-0.0753	0.2728	0.3462*	-0.3432*	-0.3833**	-0.6045**	-0.4709**
after sowing(cm)	G	1.0000	0.5721	-0.4540	-0.4618	-0.1954	-0.0765	0.3131	0.3735	-0.4001	-0.5217	-0.6967	-0.5071
Number of leaves per plant	P		1.0000	-0.0327	0.1531	-0.0786	0.0365	0.4376**	0.3610*	-0.1000	-0.0106	-0.0572	-0.0794
	G		1.0000	-0.0648	0.2025	-0.0900	0.0589	0.6499	0.4661	-0.0831	0.1592	-0.1289	-0.0984
Number of cloves per bulb	P			1.0000	0.3881**	0.0403	-0.1737	-0.0203	-0.0662	0.2101	0.1812	0.3910**	0.8032**
	G			1.0000	0.3907	0.0473	-0.1897	-0.0256	-0.0696	0.2246	0.2795	0.4018	0.8070
Weight of cloves (g)	P				1.0000	0.1027	0.0120	0.0494	-0.2757	0.2683	0.1894	0.4507**	0.4865**
	G				1.0000	0.1041	0.0157	0.0574	-0.2773	0.2803	0.3159	0.4668	0.4872
Dry Weight of bulb (g)	P					1.0000	-0.1270	-0.1277	-0.1604	0.1051	0.4900**	-0.2212	0.0051
	G					1.0000	-0.1525	-0.1310	-0.1602	0.0810	0.8052	-0.2295	0.0068
Neck thickness (cm)	P						1.0000	0.4908**	0.4971**	0.1039	0.1270	0.4149**	-0.0457
	G						1.0000	0.5690	0.5470	0.1159	0.2199	0.4810	-0.0444
Circumference of bulb (cm)	P							1.0000	0.6873**	-0.1053	0.1103	0.1267	0.0462
	G							1.0000	0.7555	-0.1497	0.1346	0.1138	0.0529
Volume of bulb (cc)	P								1.0000	0.0767	-0.0709	0.0882	-0.0588
	G								1.0000	0.0785	-0.0931	0.0895	-0.0587
Total soluble solids (%)	P									1.0000	0.2237	0.2980*	0.1289
	G									1.0000	0.3773	0.3575	0.1363
Sulphur content (%)	P										1.0000	0.1504	0.1759
	G										1.0000	0.1737	0.2703
Ascorbic acid (mg/100g)	P											1.0000	0.5496**
	G											1.0000	0.5729

*Significant at p=0.05 or at 5 % and **Significant at p=0.01 or at 1%

Table 3 Phenotypic (P) and genotypic (G) path coefficients of various characters on bulb yield of garlic=

Characters		Plant height at 90 days after sowing (cm)	Number of leaves per plant	Number of cloves per bulb	Weight of cloves (g)	Dry weight of bulb (g)	Neck thickness (cm)	Circumference of bulb (cm)	Volume of bulb (cc)	Total soluble solids (%)	Sulphur content (%)	Ascorbic acid (mg/ 100g)	Correlation with bulb yield
Plant height at 90 days after sowing(cm)	P	0.0781	-0.0849	-0.2628	-0.0893	-0.0058	0.0083	0.0078	0.0352	0.0525	-0.0138	-0.1962	-0.4709
	G	-0.0649	0.0113	-0.3105	0.0007	-0.0626	0.0034	0.0955	-0.0806	0.0072	0.1719	-0.2784	-0.5071
Number of leaves per plant	P	0.0392	-0.1691	-0.0207	0.0325	-0.0027	-0.0040	0.0124	0.0367	0.0153	-0.0004	-0.0186	-0.0794
	G	-0.0371	0.0197	-0.0443	-0.0003	-0.0288	-0.0027	0.1982	-0.1006	0.0015	-0.0525	-0.0515	-0.0984
Number of cloves per bulb	P	-0.0324	0.0055	0.6335	0.0822	0.0014	0.0190	-0.0006	-0.0067	-0.0321	0.0065	0.1269	0.8032
	G	0.0295	-0.0013	0.6840	-0.0006	0.0152	0.0085	-0.0078	0.0150	-0.0040	-0.0921	0.1606	0.8070
Weight of cloves (g)	P	-0.0329	-0.0259	0.2459	0.2119	0.0035	-0.0013	0.0014	-0.0280	-0.0410	0.0068	0.1463	0.4865
	G	0.0300	0.0040	0.2673	-0.0015	0.0334	-0.0007	0.0175	0.0599	-0.0050	-0.1041	0.1865	0.4872
Dry weight of bulb (g)	P	-0.0133	0.0133	0.0256	0.0218	0.0340	0.0139	-0.0036	-0.0163	-0.0161	0.0176	-0.0718	0.0051
	G	0.0127	-0.0018	0.0324	-0.0002	0.3206	0.0069	-0.0400	0.0346	-0.0015	-0.2653	-0.0917	0.0068
Neck thickness (cm)	P	-0.0059	-0.0062	-0.1100	0.0026	-0.0043	-0.1097	0.0140	0.0505	-0.0159	0.0046	0.1346	-0.0457
	G	0.0050	0.0012	-0.1297	0.0000	-0.0489	-0.0450	0.1736	-0.1181	-0.0021	-0.0724	0.1922	-0.0444
Circumference of bulb (cm)	P	0.0213	-0.0740	-0.0129	0.0105	-0.0043	-0.0538	0.0284	0.0698	0.0161	0.0040	0.0411	0.0462
	G	-0.0203	0.0128	-0.0175	-0.0001	-0.0420	-0.0256	0.3050	-0.1631	0.0027	-0.0443	0.0455	0.0529
Volume of bulb (cc)	P	0.0270	-0.0611	-0.0419	-0.0584	-0.0055	-0.0545	0.0195	0.1016	-0.0117	-0.0025	0.0286	-0.0588
	G	-0.0243	0.0092	-0.0476	0.0004	-0.0514	-0.0246	0.2305	-0.2159	-0.0014	0.0307	0.0357	-0.0587
Total soluble solids (%)	P	-0.0268	0.0169	0.1331	0.0568	0.0036	-0.0114	-0.0030	0.0078	-0.1529	0.0080	0.0967	0.1289
	G	0.0260	-0.0016	0.1536	-0.0004	0.0260	-0.0052	-0.0457	-0.0169	-0.0179	-0.1243	0.1428	0.1363
Sulphur content (%)	P	-0.0299	0.0018	0.1148	0.0401	0.0167	-0.0139	0.0031	-0.0072	-0.0342	0.0359	0.0488	0.1759
	G	0.0339	0.0031	0.1912	-0.0005	0.2582	-0.0099	0.0411	0.0201	-0.0068	-0.3295	0.0694	0.2703
Ascorbic acid (mg/100g)	P	-0.0472	0.0097	0.2477	0.0955	-0.0075	-0.0455	0.0036	0.0090	-0.0456	0.0054	0.3245	0.5496
	G	0.0452	-0.0025	0.2749	-0.0007	-0.0736	-0.0217	0.0347	-0.0193	-0.0064	-0.0572	0.3996	0.5729

Residual effect : Phenotypic = 0.4959 and Genotypic = 0.4974

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