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Genetic variability and path analysis for yield and yield related traits in garlic (*Allium sativum* L.)

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ABSTRACT
The experiment was conducted in Augmented Block Design at Main Experimental Station of Department of Vegetable Science, Narendra Deva University of Agriculture, Narendra Nagar (Kumarganj), Faizabad (U.P.) during Rabi 2015-16.Genetic variability, correlation and path analysis were carried out in eighty genotypes/hybrid of Garlic for bulb yield and yield related traits. The analysis of variance revealed highly significant differences among all the characters. The higher magnitude of coefficient of variation observed for width of leaf, length of clove, diameter of clove, weight of clove, number of cloves per bulb, neck thickness of bulb and bulb yield per plant, at phenotypic as well as genotypic levels. High heritability coupled with high genetic advance in percent of mean was recorded for width of leaf and weight of clove. The bulb yield per plant had highly significant and positive correlation with length of bulb, number of cloves per bulb and total soluble solids indicated that selection for these traits would be effective for the improvement of bulb yield per plant. The maximum positive direct effect on bulb yield per plant was exerted by number of cloves per bulb, weight of clove, total soluble solids, length of bulb, neck thickness of bulb, width of leaf and number of leaves per plant. The maximum inter-cluster distance was observed between cluster VII and cluster VIII which suggested that members of these two clusters are genetically very diverse to each other.
Keywords: *Correlation, Genetic Advance, Heritability, Garlic, Variability.*

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INTRODUCTION

Garlic (*Allium sativum* L.) belongs to family Alliaceae is one of the most important crop of Allium group next to onion grown throughout the world. Garlic is a major spice and is regularly consumed almost in every home, not only for culinary purposes but also in home remedies and also used in processing companies, indicating its importance and fairly high demand in the market. Garlic shows wide morphological and agronomic variations in colour, size of bulb, plant height, flowering, number and size of the cloves, days to harvesting, resistance to storage capacity, dormancy and adaptation to agro-climatic situations [11]. Despite the importance of crop, so far very limited breeding work has been done. As a first step of systemic breeding programme, collection and evaluation of germplasm is required. The adequacy of germplasm collection is determined by the amount of genetic variability present in the germplasm. However, yield is a complex character and its direct improvement is difficult. A crop breeding programme aimed at increasing the plant productivity requires consideration not only on yield but also its components that have direct or indirect influences on yield. Knowledge in respect of nature and magnitude of association with different component characters is a prerequisite to bring the improvement in desired direction.

MATERIALS AND METHODS

Geographically the experimental site (Kumarganj, Faizabad) falls under humid sub-tropical climate and is located at 26.47° N latitude and 82.12° E longitude at an altitude of 113 meter above the mean sea level. Geographically, it falls in the north east gangetic alluvial plains of eastern U.P. region. The Experimental

field had sandy loam soil, low in organic carbon, nitrogen, medium in phosphorous, potash and slightly alkaline (pH-8.0) in nature. The mechanical mixture of soil was 64.4 % sand, 27.8 % silt and 11.3 % clay.
The experimental material of garlic used in the present study were, the collections from different places of Uttar Pradesh. Eighty genotypes have been used in the present study. The experiment was laid out in augmented block design.
The observations were recorded on five randomly selected plants of each row. Average of data from the sampled plant of each treatment was used for statistical analyses in order to draw valid conclusions. The following observations were recorded during the course of experimentation on following characters- Plant height (cm), Number of leaves per plant, Length of leaf (cm), Width of leaf (cm),Neck thickness of bulb (cm), Diameter of bulb (cm),Length of bulb (cm), Bulb yield per plant (g), Number of cloves per bulb, Weight of clove (g), Length of clove (cm), Diameter of clove (cm), Total soluble solids (%).
The analysis of variance for augmented block design was carried out by [13]. The coefficient of variation for different characters was calculated as suggested by [3]. Heritability and genetic advance was calculated by [1]. The correlation coefficient among different traits is evaluated by the formula of [15]. The path analysis was calculated by suggestion of [5] and genetic divergence analysis was done by [10].

RESULTS AND DISCUSSION

The analysis of variance for the design of experiment indicated that the mean squares due to genotypes were highly significant for most of the characters indicating a wide genetic variability among the genotypes.

Table 1: Analysis of variance (Augmented design) for twelve characters in garlic germplasm.

S. N.	Characters	Source of variation		
		Blocks	Checks	Error
		d.f. (6)	d.f. (2)	d.f. (12)
1	Plant height (cm)	3.26	42.93**	6.30
2	Number of leaves per plant	0.48	1.03*	0.23
3	Length of leaf (cm)	1.08	20.62**	1.88
4	Width of leaf (cm)	0.06	0.18*	0.03
5	Neck thickness of bulb (cm)	0.05	0.15**	0.02
6	Diameter of bulb (cm)	0.08	0.27*	0.06
7	Bulb yield per plant (g)	1.45	19.33**	1.30
8	Number of cloves per bulb	2.85	80.59**	1.06
9	Weight of clove (g)	0.05	0.13**	0.01
10	Length of clove (cm)	0.13	0.41**	0.06
11	Diameter of clove (cm)	0.02	0.27**	0.03
12	Total soluble solids (%)	1.41	11.47**	1.69

***, ** Significant at 5% and 1% probability level, respectively**

The assessment of PCV, GCV 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, for all the studied traits we recorded a higher PCV over the GCV indicting towards the major role of environment the expression of traits. The estimates of phenotypic coefficient of variation (PCV) were higher than the genotypic coefficient of variation (GCV) for all the characters. Both PCV and GCV were high for width of leaf, length of clove, diameter of clove, weight of clove, number of cloves per bulb, neck thickness of bulb and bulb yield per plant in the genotypes. Similar results were reported by [6,7, 8, 12].
The higher magnitude of heritability coupled with high genetic advance in per cent of mean was recorded for width of leaf and weight of clove, neck thickness of bulb, number of cloves per bulb, length of clove and diameter of clove. It indicated that these traits are governed by additive gene action and phenotypic selection would be effective for improvement of these traits. Similar results have been reported by [19], [12], [6, 7, 8, 18].

Table-2: Estimates of range, general mean, genotypic and phenotypic coefficient of variation, heritability, genetic advance and genetic advance in percent of mean for twelve characters in garlic.

Parameters / Characters	Range		General mean	Genotypic coefficients of variation (%)	Phenotypic coefficients of variation (%)	Heritability (%)	Genetic advance	Genetic advance in percent of mean
	Min.	Max.						
	1	2	3	4	5	6	7	8
Plant height (cm)	70.60	35.00	57.57	7.35	5.97	65.93	5.84	9.99
Number of leaves per plant	9.60	4.60	7.72	9.39	6.85	53.12	0.77	10.30
Length of leaf (cm)	41.20	22.80	33.07	7.71	6.76	76.84	4.51	12.21
Width of leaf (cm)	3.01	0.88	1.64	20.71	15.58	56.60	0.34	24.15
Neck thickness of bulb (cm)	2.10	1.01	1.46	19.85	15.64	62.04	0.33	25.38
Diameter of bulb (cm)	4.34	2.24	3.63	10.49	7.54	51.64	0.39	11.16
Bulb Yield per plant (g)	29.12	15.16	22.64	11.79	10.69	82.16	4.57	19.96
Number of clove per bulb	26.60	11.10	20.40	27.16	26.63	96.13	10.39	53.80
Weight of clove (g)	2.30	1.01	1.23	18.96	16.49	75.62	0.35	29.54
Length of clove (cm)	3.48	1.26	2.34	15.47	12.42	64.48	0.56	20.55
Diameter of clove (cm)	2.01	0.88	1.38	23.85	19.61	67.60	0.47	33.22
Total soluble solids %	41.01	28.42	35.03	6.16	4.99	65.84	3.01	8.35

Table 3 elucidates that in general, the genotypic correlation coefficients were higher than the respective phenotypic correlations which might be from modifying effect of environment on the association of characters atgenotypic level. Selection of yield as such may not be effective since there may be number of genes for bulb yield and bulb yield may be resultant of interaction among its various components. The length of bulb, number of cloves per bulb and total soluble solids has positive and highly desirable association with bulb yield and selection of these traits would be effective for the yield improvement. Similar results have been reported by [17], [14, 15, 16] and [4].

The expression of a complex character such as bulb yield depends upon the interplay of a number of component attributes and the path coefficient analysis. Thus, a significant improvement in bulb yield can be expected through selection in the component traits with high positive direct effects.

Table 3: Phenotypic (P) correlation coefficients between twelve characters in garlic germplasm

Character	Number of Leaves per Plant	Leaf Length (cm)	Leaf Width (cm)	Diameter of Bulb (cm)	Neck Thickness of Bulb (cm)	Number Of Cloves per Bulb	Length of clove (cm)	Weight of Clove (g)	Diameter of Clove (cm)	T.S.S (%)	Bulb yield per plant (g)
Plant Height (cm)	0.4660**	0.6482**	0.2598**	0.4490**	0.2305*	0.2254*	0.3204**	-0.1018	-0.1293	0.2600*	0.0346
Number of Leaves per Plant		0.0637	0.2366*	0.3991**	0.0388	0.2759*	0.2182*	-0.0267	-0.0949	0.1882	0.1620

Length of leaf (cm)			-0.0495	0.1239	0.1259	-0.0467	0.3693**	-0.0545	0.0349	0.1601	-0.0364
Width of leaf (cm)				0.2859**	0.2348*	-0.0443	-0.0443	-0.0759	-0.0695	-0.0088	-0.1059
Diameter of Bulb (cm)					0.0448	0.2278*	0.0617	-0.0240	-0.0348	0.0093	-0.0599
Neck Thickness of bulb(cm)						-0.0211	-0.1033	0.0236	-0.0874	0.1372	-0.0805
Number 0f Cloves per Bulb							0.1401	0.0027	-0.1355	0.0940	0.4769**
Length of Clove (cm)								0.0378	-0.0171	0.1254	0.0597
Weight of Clove (g)									0.0628	-0.1171	-0.0179
Diameter of Clove (cm)										-0.1439	-0.1225
Total soluble solids (%)											-0.0415

***, ** Significant at 5% and 1% probability level, respectively**

The maximum positive direct effect towards the bulb yield per plant was expressed by number of cloves per bulb, weight of clove, total soluble solids, length of bulb, neck thickness of bulb, width of leaf and number of leaves per plant. Similar results have been reported by [22, 23, 4, 20].

Table-4: Direct and indirect effects of 12 characters on bulb yield per plant in garlic at phenotypic level

Bulb yield per plant (g)	0.0346	0.0225	-0.0364	-0.1059	-0.0599	-0.0805	0.4769	0.0559	-0.0179	-0.1222	-0.0415
T.S.S (%)	-0.0164	0.0310	0.0127	0.0003	-0.0011	-0.0063	0.0469	-0.0044	0.0038	0.0115	-0.1189
Diameter of clove(cm)	0.0081	-0.0156	0.0027	0.0030	0.0027	0.0040	-0.0676	0.0006	-0.0020	-0.0800	0.0171
Weight of clove (g)	0.0064	-0.0044	-0.0043	0.0032	0.0007	-0.0010	0.0013	0.0545	-0.033	-0.0050	0.0139
Length of clove(cm)	-0.0202	0.0360	0.0295	0.0019	-0.0022	0.0009	0.0699	-0.0358	0.0065	0.0013	-0.0149
Number of cloves per bulb	-0.0142	0.0455	-0.0037	0.0019	0.1137	0.0009	0.4991	-0.0050	0.0974	0.0108	-0.0111
Neck Thickness bulb (cm)	-0.0145	0.0064	0.0100	-0.0101	-0.0020	-0.0460	-0.0105	0.0037	-0.0007	0.0070	-0.0163
Diameter of bulb (cm)	-0.0283	0.0658	0.0099	-0.0123	-0.2070	-0.0092	-0.0471	-0.0127	0.0049	0.0072	-0.0019
Width of leaf (cm)	-0.0163	0.0390	-0.0039	-0.0432	-0.0592	-0.0108	-0.0221	0.0015	0.0025	0.0055	0.0010
Length of leaf (cm)	-0.0409	0.0105	0.0798	0.0021	-0.0256	-0.0058	-0.0233	-0.0132	0.0018	-0.0028	-0.0190
No. of leaves per plant	-0.0294	0.1650	0.0050	-0.0102	-0.0826	-0.0017	-0.0017	-0.0078	0.0008	0.0076	-0.0223
Plant height (cm)	-0.0630	0.0769	0.0517	-0.0112	-0.0929	-0.0106	0.1125	-0.0114	0.0033	0.0103	-0.0309
Characters	Plant height (cm)	No. of leaves per Plant	Length of leaf (cm)	Width of leaf (cm)	Diameter of bulb (cm)	Neck Thickness of bulb (cm)	No. of Cloves per bulb	Length of clove (g)	Weight of clove (cm)	Diameter of love (cm)	T.S.S (%)

Residual effect = 0.172

On the basis of the results obtained in present investigation, it may be concluded that there is highly significant differences among the genotypes for all the characters. The estimates of phenotypic co-efficient of variation (PCV) were higher than the genotypic co-efficient of variation (GCV) for all the characters. Both PCV and GCV were high for number of clove per, diameter of clove, weight of clove, neck thickness of bulb, width of leaf and length of clove in the genotypes. In general, genotypic correlation coefficient was higher than the corresponding phenotypic correlation coefficient suggesting, a strong inherent relationship in different pairs of the traits. The number of cloves have positive and desirable association with bulb yield and selection of these traits would be effective for yield improvement in garlic. On the basis of results shown in the present investigation it is concluded that The genotypes NDG- 33, NDG-32, NDG-26, NDG-9 and NDG- 34 produced highest bulb yield per plant which indicated that these genotypes may be considered in breeding programme.

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