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Research Article

Studies on the genetic variability, character association and path coefficient analysis in garlic (*Allium sativum* L.)

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Abstract

Studies on the genetic variability, character association and path coefficient analysis in Garlic was carried out at Horticultural Research Station, Tamil Nadu Agricultural University, Undagamandalam. The experiment was conducted with seventy two accessions laid out in Randomized Block Design (RBD) and replicated thrice. High GCV was observed for average bulb weight, number of cloves, 10 clove weight, plot yield, yield/ha and marketable yield. Low PCV was recorded for days to 50% neck fall and days to harvest. High heritability was recorded for the characters viz., leaf length, pseudostem diameter polar diameter, average bulb weight, the number of cloves, 10 clove weight, yield per plot, yield/ha and marketable yield. In the correlations study, the traits viz., plant height, the number of leaves, leaf length, pseudostem length, pseudostem diameter, equatorial diameter, polar diameter, average bulb weight, 10 clove weight were correlated with each other which will attribute to enhance the bulb yield. Similarly in path coefficients analysis, the characters viz., plant height, the number of leaves, leaf width, pseudostem length, pseudostem diameter, polar diameter, average bulb weight, the number of cloves, 10 clove weight showed a positive direct effect on yield. Therefore from the present investigation traits viz., pseudostem diameter, polar diameter, average bulb weight, the number of cloves, 10 clove weight and yield/ha emerged as important components for selection in garlic.

Keywords: Garlic, PCV, GCV, Correlation

INTRODUCTION

Garlic (*Allium sativum* L.) belonging to the family *Alliaceae* is one of the important remunerative bulbous spices of the *Allium* group next to the onion. Garlic has been cultivated throughout the world was originated from Central Asia. "*Allium*" is the largest and the most important representative genus of the *Alliaceae* family that comprises 700 species, widely distributed in North America, North Africa, Europe and Asia (Tsiaganis *et al.*, 2016). In India, to meet the local requirement of garlic, a selection of suitable varieties for growing under different agroclimatic conditions is necessary. As this crop is continuously propagated through vegetative methods, the variation in garlic occurs

only through random or induced mutations, somaclonal variation or genetic engineering. Limited work has been done on the genetic variability and association between different traits, which are pre requisites for executing a selection programme. The present investigation was carried out to evaluate the seventy two accessions of garlic for genetic variability, character association and path coefficient analysis for important characters.

MATERIALS AND METHODS

The experiment was conducted in Horticultural Research Station, Tamil Nadu Agricultural University, Udagamandalam. The experiment was conducted with

seventy two accessions laid out in a Randomized Block Design (RBD) and replicated thrice. The garlic bulbs were sown in the plot area of 1 m² at the spacing of 15 x 10 cm. Five plants were selected for recording biometrical observations viz., plant height (cm), the number of leaves, leaf length (cm), leaf width (cm), pseudostem length (cm), pseudostem diameter (cm), equatorial diameter (cm), polar diameter (mm), average bulb weight (g), the number of cloves, 10 clove weight, days to 50% neck fall, days to harvest, plot yield, total yield (q/ha) and marketable yield (q/ha). The analysis of variance was carried out based on the statistical methods suggested by Panse and Sukatme (1978). The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was calculated as per the formula proposed by Burton (1952). Heritability in the broad sense was estimated as per the formula suggested by Lush (1940) and expressed in per cent. The range of heritability was categorized as low (0-30 %), medium (31-60 %) and high (more than 60 %) as proposed by Johnson *et al.* (1955). The genetic advance was calculated as per the formula proposed by Johnson *et al.* (1955) and characters were classified into high (more than 20 %), medium (10 - 20 %) and low (less than 10 %) as per the procedure recommended by Johnson *et al.* (1955). The genotypic and phenotypic correlation coefficients were calculated by the formula suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

In garlic, greater variability will have better chances of selection which enhances the breeding program. The

study of PCV, GCV, heritability, genetic advances helps in estimating the genes and environmental factors, which will be effective for better selection. The data revealed that greater PCV over GCV was recorded towards the major traits (**Table 1 and 2**). High GCV was observed for average bulb weight (12.16%), the number of cloves (14.83%), 10 clove weight (17.37%), plot yield (11.79%), yield/ha (16.31%) and marketable yield (16.67%) indicated the presence of high genetic variability for the above traits which will emphasise the yield improvement in garlic. The characters viz., the number of cloves, 10 clove weight, yield/ha, marketable yield observed the narrow difference between GCV and PCV. Similarly low PCV was recorded for days to 50% neck fall and days to harvest which are not having any significant impacts on the selection programme..

High heritability was recorded for the characters like leaf length (76.27%), pseudostem diameter (68.97%), polar diameter (62.28%), average bulb weight (69.75%), the number of cloves (72.98%), 10 clove weight (85.81%), yield per plot (73.81%), yield/ha (80.19%) and marketable yield (q/ha) (77.11%). The traits viz., average bulb weight, the number of cloves, 10 clove weight, yield/ha, marketable yield (q/ha) recorded the high genetic advance indicated the presence of inheritance which could influence the additive gene action. These traits will be effective for crop improvement in garlic. The present findings are in line with findings of Korla *et al.* (1981), Agrawal and Tiwari, (2004), Bhatt *et al.* (2017) and Aman Deep Ranga *et al.* (2021).

Table 1. ANOVA for quantitative traits

Source of Variation	Mean sum of squares		
	Replication	Genotypes	Error
DF	2	71	142
Plant height	47.87	83.95**	27.38
Number of leaves	0.35	0.91**	0.19
Leaf length	10.04	76.74**	7.21
Leaf width	0.09	0.13**	0.05
Pseudostem length	10.70	25.57**	6.13
Pseudostem diameter	0.08	0.34**	0.04
Equatorial diameter	11.89	29.21**	7.75
Polar diameter	9.69	39.59**	6.69
Average bulb weight	6.25	47.62**	6.01
Number of cloves	3.45	16.89**	1.86
10 clove weight	3.39	41.12**	2.15
Days to 50% neck fall	114.82	126.16**	64.12
Days to harvest	204.25	22.40**	115.09
Yield per plot	0.06	0.32**	0.34
Yield (q/ha)	51.77	649.05**	49.38
Marketable yield (q/ha)	65.75	550.41**	49.56

**Significant at 1% level

Table 2. Estimates of genetic parameters for yield contributing parameters of Garlic accessions

Characters	Mean	Genotypic variance	Phenotypic variance	GCV (%)	PCV (%)	Heritability (%)	Genetic advance as percent of mean
Plant height (cm)	65.87	18.85	46.23	6.59	10.32	40.78	8.67
Number of leaves	6.43	0.24	0.43	7.56	10.25	54.31	11.47
Leaf length (cm)	37.84	23.17	30.38	12.72	14.57	76.27	22.89
Leaf width (cm)	2.50	0.02	0.07	6.80	11.23	36.65	8.48
Pseudostem length (cm)	31.17	6.48	12.60	8.17	11.39	51.40	12.06
Pseudostem diameter (cm)	3.00	0.09	0.14	10.50	12.64	68.97	17.97
Equatorial diameter (mm)	35.00	7.15	14.90	7.64	11.03	48.00	10.91
Polar diameter (mm)	37.03	10.97	17.62	8.95	11.34	62.28	14.54
Average bulb weight (g)	30.61	13.86	19.88	12.16	14.56	69.75	20.93
Number of cloves	15.10	5.01	6.86	14.83	17.36	72.98	26.09
10 clove weight (g)	20.75	12.99	15.13	17.37	18.75	85.81	33.14
Days to 50% neck fall	99.91	20.68	84.81	4.55	9.22	24.38	4.63
Days to harvest	120.63	30.89	84.19	4.61	7.61	36.70	5.75
Yield per plot	2.63	0.09	0.13	11.79	13.72	73.81	20.86
Yield (q/ha)	86.69	199.89	249.27	16.31	18.21	80.19	30.09
Marketable yield (q/ha)	77.50	166.94	216.51	16.67	18.99	77.11	30.16

Table 3. Genotypic and Phenotypic correlation for yield contributing parameters of Garlic accessions

Traits	Correlation	Plant height	Number of leaves	Leaf length	Leaf width	Pseudostem length	Pseudo stem diameter	Equatorial diameter	Polar diameter)
Plant height	Genotypic	1	-0.387	0.183	-0.533	-0.283	-0.086	-0.067	-0.060
	Phenotypic	1	0.333**	0.471**	0.401**	0.400**	0.377**	0.522**	0.439**
Number of leaves	Genotypic		1	-0.099	-0.372	-0.268	-0.067	-0.015	-0.006
	Phenotypic		1	0.255*	0.365**	0.326**	0.328**	0.476**	0.408**
Leaf length	Genotypic			1	-0.459	0.023	0.023	0.274*	0.261*
	Phenotypic			1	0.137	0.340**	0.281*	0.511**	0.473**
Leaf width	Genotypic				1	-0.501	-0.103	-0.646	-0.493
	Phenotypic				1	0.326**	0.381**	0.297*	0.247*
Pseudostem length	Genotypic					1	0.191	-0.099	0.034
	Phenotypic					1	0.493**	0.447**	0.442**
Pseudo stem diameter	Genotypic						1	0.040	0.085
	Phenotypic						1	0.418**	0.393**
Equatorial diameter	Genotypic							1	0.879**
	Phenotypic							1	0.923**
Polar diameter	Genotypic								1
	Phenotypic								1
Average bulb weight	Genotypic								
	Phenotypic								
Number of cloves	Genotypic								
	Phenotypic								
10 clove weight	Genotypic								
	Phenotypic								
Days to 50% neck fall	Genotypic								
	Phenotypic								
Days to harvest	Genotypic								
	Phenotypic								
Yield per plot	Genotypic								
	Phenotypic								
Yield/ha (q/ha)	Genotypic								
	Phenotypic								

* = 0.05 level of significance; ** = 0.01 level of significance

Table 3. Continued

Traits	Correlation	Average bulb weight	Number of cloves	10 clove weight	Days to 50% neck fall	Days to harvest	Yield per plot	Yield/ha	Marketable yield (q/ha)
Plant height	Genotypic	0.253*	-0.261	0.071	-1.110	-0.652	0.013	0.192	0.143
	Phenotypic	0.554**	0.249*	0.326**	0.301**	0.643**	0.396**	0.446**	0.443**
Number of leaves	Genotypic	-0.099	-0.195	0.017	-0.335	-0.447	0.125	0.095	0.067
	Phenotypic	0.307**	0.223*	0.261*	0.455**	0.587**	0.420	0.357	0.361**
Leaf length	Genotypic	0.500**	-0.315	0.249*	-0.959	-0.216	-0.130	0.276*	0.203*
	Phenotypic	0.625**	0.006	0.379**	-0.016	0.442**	0.145	0.428**	0.383**
Leaf width	Genotypic	-0.501	0.138	-0.387	-0.544	-0.734	0.100	-0.193	-0.114
	Phenotypic	0.176	0.477**	0.074	0.513**	0.655**	0.452**	0.243*	0.314**
Pseudostem length	Genotypic	0.058	0.044**	-0.026	-0.877	-0.396	0.111	0.285*	0.189
	Phenotypic	0.414**	0.384**	0.238*	0.285*	0.638**	0.418**	0.485**	0.445**
Pseudo stem diameter	Genotypic	0.110	-0.023	-0.028	-0.434	-0.193	0.363**	0.382**	0.297**
	Phenotypic	0.375**	0.262*	0.184	0.279*	0.542**	0.542**	0.524**	0.476**
Equatorial diameter	Genotypic	0.570**	-0.540	0.625**	-0.812	-0.510	0.035	0.512**	0.531**
	Phenotypic	0.724	0.046	0.669**	0.332**	0.625**	0.385**	0.635**	0.664**
Polar diameter	Genotypic	0.577**	-0.429	0.601**	-0.560	-0.332	0.076	0.525**	0.572**
	Phenotypic	0.716**	0.022	0.668**	0.302**	0.555**	0.362**	0.640**	0.687**
Average bulb weight	Genotypic	1	-0.249*	0.487**	-0.752	-0.236	0.135	0.527**	0.519**
	Phenotypic	1	0.102	0.580**	0.158	0.519**	0.373**	0.634**	0.640**
Number of cloves	Genotypic		1	-0.739**	-0.259	-0.264	0.039	-0.172	-0.236
	Phenotypic		1	-0.400	0.334**	0.463**	0.286*	0.091	0.063
10 clove weight	Genotypic			1	-0.257	-0.143	0.174	0.472**	0.540**
	Phenotypic			1	0.193	0.351**	0.328**	0.555**	0.616**
Days to 50% neck fall	Genotypic				1	-1.090	-0.220	-0.393	-0.272
	Phenotypic				1	0.676**	0.331**	0.200*	0.285*
Days to harvest	Genotypic					1	-0.090	-0.008	-0.056
	Phenotypic					1	0.543**	0.508**	0.521**
Yield per plot	Genotypic						1	0.472**	0.350**
	Phenotypic							0.585**	0.503**
Yield/ha (q/ha)	Genotypic							1	0.933**
	Phenotypic							1	0.946**

* = 0.05 level of significance; ** = 0.01 level of significance

In the present study, genotypic and phenotypic correlation coefficients and path-coefficient analysis were carried out in garlic accession for 16 quantitative characters are presented in **Table 3**. The genotypic correlation coefficient was higher than the phenotypic correlation coefficient. Among the traits, the marketable yield in genotypic correlation was found to be positively and significantly correlated with plant height (0.143), the number of leaves (0.067), leaf length (0.203), pseudostem length (0.189), pseudostem diameter (0.297), equatorial diameter (0.531), polar diameter (0.572), average bulb weight (0.519), 10 clove weight (0.540), yield per plot (0.35) and yield per ha (0.933). This is in consonance with the results of Singh *et al.* (2011). Marketable yield was negatively correlated with leaf width (-0.114), the number of cloves (-0.236), days to 50 % neck fall (-0.272) and days to harvest (-0.056). It may be concluded from the correlations studies that, plant height, the number of leaves, leaf length, pseudostem length, pseudostem diameter, equatorial diameter, polar diameter, average bulb weight, 10 clove weight are

correlated with each other and helpful in increasing the bulb yield as reported earlier by Tsega *et al.* (2010) and Shivakumar *et al.* (2020).

The results of path co-efficient analysis are presented in **Table 4**. Path co-efficient is a powerful tool that enables partitioning of the given relationship in its further components. *i.e.*, it enables partitioning of the total correlation coefficient into direct and indirect effects. The plant height (0.008), the number of leaves (0.011), leaf width (0.102), pseudostem diameter (0.001), polar diameter (0.116), average bulb weight (0.059), the number of cloves (0.010), 10 clove weight (0.138) and days to 50% neck fall (0.044) were found to have positive effect with yield. A negative effect was noticed in leaf length (-0.075), pseudostem length (-0.013), equatorial diameter (-0.087), days to harvest (-0.079) and yield per plot (-0.157). This is in conformity with reports of Sathish Kumar *et al.* (2015). The direct effect was the highest (0.954) for yield per hectare followed by 10 clove

Table 4. Path co-efficient analysis among traits in Garlic accessions

Traits	Plant height	Number of leaves	Leaf length	Leaf width	Pseudostem length	Pseudo stem diameter	Equatorial diameter	Polar diameter)
Plant height	0.008	-0.004	-0.014	-0.054	0.004	0.009	0.006	-0.007
Number of leaves	-0.003	0.011	0.007	-0.038	0.003	0.007	0.001	-0.001
Leaf length	0.001	-0.001	-0.075	-0.047	0.000	0.002	-0.024	0.030
Leaf width	-0.004	-0.004	0.034	0.102	0.006	0.001	0.056	-0.057
Pseudostem length	-0.002	-0.003	-0.002	-0.051	-0.013	0.002	0.009	0.004
Pseudostem diameter	-0.001	-0.001	-0.002	-0.011	-0.002	0.001	-0.003	0.010
Equatorial diameter	-0.001	0.000	-0.020	-0.066	0.001	0.004	-0.087	0.102
Polar diameter	0.000	0.000	-0.020	-0.050	0.000	0.009	-0.077	0.116
Average bulb weight	0.002	-0.001	-0.037	-0.051	-0.001	0.001	-0.050	0.067
Number of cloves	-0.002	-0.002	0.024	0.014	-0.001	0.002	0.047	-0.050
10 clove weight	0.001	0.000	-0.019	-0.040	0.000	0.003	-0.055	0.070
Days to 50% neck fall	-0.009	-0.004	0.072	-0.056	0.011	0.006	0.071	-0.065
Days to harvest	-0.005	-0.005	0.016	-0.075	0.005	0.002	0.045	-0.039
Yield per plot	0.000	0.001	0.010	0.010	-0.001	0.009	-0.003	0.009
Yield (q/ha)	0.001	0.001	-0.021	-0.020	-0.004	0.004	-0.045	0.061

Table 4. Continued

Traits	Average bulb weight	Number of cloves	10 clove weight	Days to 50% neck fall	Days to harvest	Yield per plot	Yield/ ha	Marketable yield (q/ha)
Plant height	0.015	-0.003	0.010	-0.049	0.052	-0.002	0.183	0.008
Number of leaves	-0.006	-0.002	0.002	-0.015	0.036	-0.020	0.091	0.011
Leaf length	0.030	-0.003	0.034	-0.042	0.017	0.020	0.263	-0.075
Leaf width	-0.030	0.001	-0.053	-0.024	0.058	-0.016	-0.184	0.102
Pseudostem length	0.003	0.000	-0.004	-0.039	0.031	-0.017	0.272	-0.013
Pseudostem diameter	0.006	0.000	-0.004	-0.019	0.015	-0.057	0.364	0.001
Equatorial diameter	0.034	-0.006	0.086	-0.036	0.041	-0.006	0.489	-0.087
Polar diameter	0.034	-0.005	0.083	-0.025	0.026	-0.012	0.501	0.116
Average bulb weight	0.059	-0.003	0.067	-0.033	0.019	-0.021	0.502	0.059
Number of cloves	-0.015	0.010	-0.102	-0.011	0.021	-0.006	-0.164	0.010
10 clove weight	0.029	-0.008	0.138	-0.011	0.011	-0.027	0.451	0.138
Days to 50% neck fall	-0.044	-0.003	-0.035	0.044	0.086	0.035	-0.375	0.044
Days to harvest	-0.014	-0.003	-0.020	-0.048	0.079	0.014	-0.008	-0.079
Yield per plot	0.008	0.000	0.024	-0.010	0.007	-0.157	0.450	-0.157
Yield (q/ha)	0.031	-0.002	0.065	-0.017	0.001	-0.074	0.954	0.954

Residual Effect = 0.2765

weight (0.138) and polar diameter (0.116). Average bulb weight had the highest indirect effect on yield per hectare (0.502). The findings of the present investigation are corroborated with the findings of Hosamani *et al.* (2010) and Dhall and Brar (2013).

In the present study on genetic variability, character association and path coefficient analysis indicated that the characters, pseudostem diameter, polar diameter average bulb weight, number of cloves, 10 clove weight and yield per ha emerged as an important component trait for selection in garlic.

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