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Studies on character association and path coefficient for quantitative traits to yield and its attributes in garlic

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Abstract

Association between characters and path analysis in seventeen genotypes/lines of garlic (*Allium sativum* L.) was studied at the Vegetable Research Farm, BUAT, Banda during 2019 and 2020. The pooled data of correlation studies, revealed that gross yield plot^{-1} had positive and significant correlation with equatorial bulb diameter, weight of 20 bulbs and weight of 50 cloves at genotypic and phenotypic level respectively. This showed that improving these features could improve the crop's physiological capacity to mobilise and translocate photosynthates to economically valuable organs (the bulb), perhaps increasing bulb yield as seen in the study. Yield was significantly and negatively correlated with bulb shape index, number of cloves bulb^{-1}, and thrips plant^{-1} at genotypic level. The genotypic path coefficient analysis showed that equatorial bulb diameter and plant height had the highest positive direct effect on bulb yield. Weight of 20 bulbs and collar thickness had negative direct effect on bulb yield. Positive direct effect of equatorial bulb diameter and plant height indicated good scope for improvement in bulb yield by selecting genotypes having bigger bulb along with increased plant height.

Keywords: Garlic, direct effect, correlation, path analysis, clove, bulb

Introduction

Garlic (*Allium sativum* L.) is the second most frequently cultivated *Allium* crop in India, behind onion. It belongs to the Alliaceae family and has chromosome 2n = 2x = 16. Garlic is an annual bulb-producing herbaceous crop. The edible underground stem is a composite bulb that is made up of many smaller bulbs known as cloves. The blades of the leaves are firm and slender. Garlic is an obligatory apomitic crop, which means it reproduces vegetatively. Despite the fact that certain types have flowers, these blossoms do not yield seeds. Some types develop bulbils, which are vegetative bulbs on the top of the plant. In some circumstances,

they are also employed for propagation. It is consumed as green or mostly as a spice and is also processed into pickles, flakes, granules and curry powder etc. Crude protein, crude oil, crude energy, crude fibre, ash, dimethyl sulphite (DMS), essential oil and minerals such as K, P, Mg, Na, Ca, Fe, and others were found in fully ripe bulbs (Haciseferogullari *et al.,* 2005).

A sound plant breeding programme focused at increasing plant productivity must take into account not only yield but also the components of yield that have direct or indirect effects on yield. Knowledge of the nature and size of association with various component characters is a requirement for progress in the intended direction. Understanding the link between distinct plant traits is critical for increasing the bulb output potential of garlic varieties. Furthermore, understanding the direct contribution of individual component features to yield would be quite valuable in developing a selection strategy. As a result, the goal of this study was to determine the genotypic and phenotypic association among agronomic characters, as well as to carry out path analysis to determine the direct and indirect effects of characters on garlic yield.

Materials and methods

The field experiments for present investigation was conducted at the Vegetable Research Station of Banda University of Agriculture and Technology, Banda during Rabi season of 2019 and 2020. The material comprised of seventeen genotypes/lines of garlic grown in randomized block design with 3 replications in each year. Cloves with uniform size were selected and planted in first fortnight of October in beds of 3.0 m × 1.5 m with a spacing of 15.0 cm × 7.5 cm. To ensure a healthy crop, the recommended cultural procedures were carried out. Observations were recorded on 10 randomly selected plants in each replication for the characters *viz.,* plant height (cm), number of leaves plant^{-1}, collar thickness, equatorial bulb diameter (cm), polar bulb diameter (cm), bulb shape index, weight of 20 bulbs (kg), weight of 50 cloves (g), number of cloves bulb^{-1}, thrips plant^{-1}, stemphylium blight intensity (%), days to harvest, TSS (%) and gross yield (kg plot^{-1}). Falconer's methods (1981) were used to analyse the combined data from both years to determine correlation and path coefficient analysis. The path analysis was used to calculate the direct and indirect contributions of various traits to yield, as described by Wright (1921) and elaborated by Dewey and Lu (1959).

Results and discussion

Character association by correlation and path coefficient analysis

The relationship between garlic yield and 13 other essential characteristics was determined.

Correlation analysis

Knowledge of the association among plant characteristics is useful while selecting traits for yield improvement. Interpretation of data on correlations showed that in general, the value of genotypic correlation was higher in magnitude than their corresponding phenotypes (Table 1) (Pooled data), as reported by Singh *et al.* (2013) and Agrawal & Tiwari (2009). This suggested the predominance of genotypic effects over environmental factor. Genotypic and phenotypic correlation of thirteen yield and yield attributing traits presented in Table 1 indicated that gross yield plot^{-1} had positive and significant correlation with equatorial bulb diameter (0.868, 0.681), weight of 20 bulbs (0.948, 0.660), weight of 50 cloves (0.846, 0.592), at genotypic and phenotypic level respectively and showed significant positive relation with plant height (0.603), polar bulb diameter (0.495) and TSS (0.472) at genotypic. These findings corroborated with the earlier findings of Singh *et al*. (2012), Singh *et al.* (2011), Chotaliya & Kulkarni (2017) for equatorial bulb diameter and Panse *et al.* (2013) for average weight of 10 cloves. Improving these features could

Table 1. Estimates of Genotypic (G) and Phenotypic (P) correlation coefficients among clove yield and its attributing traits in garlic (Pooled data) (2019-20)& indicates level of significance at 5% & 1% respectively

Traits		Plant Height (cm)	No. of leaves plant^{-1}	Collar thickness (cm)	Equatorial bulb diameter (cm)	Polar bulb diameter (cm)	Bulb shape index	Weight of 20 bulbs (kg)	Weight of 50 cloves (g)	Number of cloves bulb^{-1}	Thrips plant^{-1}	Stemphylium blight intensity (%)	Days to harvest	TSS (%)	Gross bulb yield (Kg plot^{-1})
Plant Height (cm)	G	1.000	0.897**	0.276	0.685**	0.397	-0.649**	0.811**	0.686**	-0.606**	-0.418	0.271	0.344	0.635**	0.603**
	P	1.000	0.288	0.060	0.352	0.186	-0.240	0.399	0.453	-0.244	-0.233	-0.036	-0.093	0.223	0.361
No. of leaves plant^{-1}	G		1.000	0.262	0.371	0.410	-0.109	0.465	0.705**	-0.702**	-0.313	0.515*	-0.388	0.468*	0.335
	P		1.000	0.037	0.173	0.157	-0.048	0.142	0.348	-0.319	-0.016	0.095	-0.007	0.106	0.200
Collar thickness (cm)	G			1.000	-0.045	0.083	0.148	-0.053	-0.266	-0.156	0.272	0.034	0.038	-0.290	-0.147
	P			1.000	-0.101	-0.034	0.080	0.021	-0.098	-0.136	0.077	-0.008	0.008	-0.304	-0.091
Equatorial bulb diameter (cm)	G				1.000	0.807**	-0.608**	0.963**	0.720**	-0.521*	-0.729**	-0.024	-0.074	0.378	0.868**
	P				1.000	0.561*	-0.599**	0.695**	0.505*	-0.319	-0.259	-0.048	-0.010	0.212	0.681**
Polar bulb diameter (cm)	G					1.000	-0.023	0.634**	0.454	-0.440	-0.331	0.066	-0.206	0.134	0.495*
	P					1.000	0.323	0.456	0.305	-0.249	-0.082	-0.079	-0.096	0.205	0.441
Bulb shape index	G						1.000	-0.782**	-0.637**	0.317	0.804**	0.159	-0.159	-0.483*	-0.800**
	P						1.000	-0.349	-0.290	0.126	0.229	0.006	-0.075	-0.050	-0.339
Weight of 20 bulbs (kg)	G							1.000	0.812**	-0.599**	-0.732**	0.131	-0.030	0.502*	0.948**
	P							1.000	0.516*	-0.383	-0.228	0.040	-0.015	0.202	0.660**
Weight of 50 cloves (g)	G								1.000	-0.515*	-0.699**	-0.030	-0.223	0.537*	0.846**
	P								1.000	-0.262	-0.323	-0.080	-0.166	0.289	0.592**
Number of cloves bulb^{-1}	G									1.000	-0.039	-0.110	0.448	-0.171	-0.504*
	P									1.000	0.060	-0.135	0.190	0.032	-0.332
Thrips plant^{-1}	G										1.000	-0.132	-0.106	-0.649**	-0.670**
	P										1.000	-0.078	0.001	-0.093	-0.228
Stemphylium blight intensity (%)	G											1.000	-0.242	0.236	0.061
	P											1.000	-0.137	0.092	-0.008
Days to harvest	G												1.000	0.186	-0.161
	P												1.000	0.004	-0.036
TSS (%)	G													1.000	0.472*
	P													1.000	0.242

* &** indicates level of significance at 5% & 1% respectively

improve the crop's physiological capacity to mobilise and translocate photosynthates to economically valuable organs (the bulb), perhaps increasing bulb yield as seen in the study. Yield was significantly and negatively correlated with bulb shape index (-0.800), number of cloves bulb^{-1} (-0.504), thrips plant^{-1} (-0.670) at genotypic level. The findings of Kumari (2021) and Agrawal & Tiwari (2009) also stated that yield was significantly and negatively correlated with number of cloves bulb^{-1}.

Plant height had significant and positive association with number of leaves plant^{-1} (0.897), equatorial bulb diameter (0.685), weight of 20 bulbs (0.811), weight of 50 cloves (0.686) and TSS (0.635) at genotypic level and had significant negative association with bulb shape index (- 0.649), number of cloves bulb^{-1} (-0.606) and thrips plant^{-1} (-0.418). The findings of Singh *et al.* (2013) for number of leaves plant^{-1}, Panse *et al.* (2013) for equatorial bulb diameter and average weight of 10 cloves are in close harmony with the present findings. Number of leaves plant^{-1} had significant positive association with weight of 50 cloves (0.705), stemphylium blight intensity (0.515) and TSS (0.468) at genotypic level and significant negative association with number of cloves bulb^{-1} (-0.702). Equatorial bulb diameter had significant and positive association with polar bulb diameter (0.807, 0.561), weight of 20 bulbs (0.963, 0.695), weight of 50 cloves (0.720, 0.505) and significant negative association with bulb shape index (-0.608, -0.599) at genotypic and phenotypic level respectively. Similar result was reported by Panse *et al.* (2013) for average weight of 10 cloves. Polar bulb diameter had significant and positive association with weight of 50 cloves (0.634) at genotypic level. The significant and positive association of polar bulb diameter with average weight of cloves was also reported by Panse *et al.* (2013). Weight of 20 bulbs had significant and positive association with weight of 50 cloves (0.812, 0.516).

Path Coefficient Analysis

The path coefficient analysis was used to estimate direct and indirect influences of characteristics on bulb yield plot^{-1} after collecting information from the correlation analysis results. The genotypic and phenotypic path coefficient analysis is presented in Tables 2 and 3 respectively. The size and direction of the mutual association of component characters may vary, and the simple correlation coefficient may not reflect the true link between yield and yield attributes. As a result, path coefficient analysis is required, which allows for a careful investigation of individual direct and indirect effects of characters as well as the measurement of their relative intensity in defining the end objective the yield.

The genotypic path coefficient analysis (Table 2) showed that equatorial bulb diameter (0.054) had highest positive direct effect on bulb yield followed by plant height (0.0159) whereas, weight of 20 bulbs (-0.090) and collar thickness (-0.0121) had negative direct effect on bulb yield. The phenotypic path coefficient analysis (Table 3) showed that days to harvest (0.013) had highest positive direct effect on bulb yield followed by weight of 50 cloves (0.011). These findings are in close association with earlier findings of Singh *et. al.* (2013) for equatorial bulb diameter and Panse *et al.* (2013) for plant height. Highly positive indirect effect on gross yield (kg plot^{-1}) exerted by bulb shape index (0.0706), thrips plant^{-1} (0.066) and number of cloves (0.0541) via weight of 20 bulbs; weight of 20 bulbs (0.052), polar bulb diameter (0.044), weight of 50 cloves (0.039), plant height (0.037), TSS (0.020) and number of leaves plant^{-1} via equatorial bulb diameter was observed.

In path analysis, the residual effect determines how well the component (independent) factors explain the variability of the dependent variable, bulb produced plot^{-1}. The effect of residual factors (0.009 and 0.037) on gross bulb yield was normal at the genotypic and phenotypic levels, implying that certain minor yield

Table 2. Genotypic path coefficients showing direct (diagonal) and indirect effects of different characters on gross yield (kg plot^{-1}) in garlic (Pooled data) (2019-20)

Traits	Plant height (cm)	No. of leaves plant^{-1}	Collar thick-ness (cm)	Equatorial bulb diame-ter (cm)	Polar bulb diameter (cm)	Bulb shape index	Weight of 20 bulbs (kg)	Weight of 50 cloves (g)	Number of cloves bulb^{-1}	Thrips plant^{-1}	Stemphyli-um blight intensity (%)	Days to harvest	TSS (%)	Gross bulb yield (Kg plot^{-1})
Plant height (cm)	0.0159	-0.0004	-0.0033	0.0370	-0.0034	-0.0057	-0.0732	-0.0091	0.0036	0.0020	-0.0025	0.0023	-0.0002	0.603**
No. of leaves plant-1	0.0143	-0.0004	-0.0032	0.0200	-0.0035	-0.0010	-0.0420	-0.0093	0.0041	0.0015	-0.0047	-0.0026	-0.0001	0.335
Collar thickness (cm)	0.0044	-0.0001	-0.0121	-0.0024	-0.0007	0.0013	0.0048	0.0035	0.0009	-0.0013	-0.0003	0.0003	0.0001	-0.147
Equatorial bulb diameter (cm)	0.0109	-0.0001	0.0005	0.0540	-0.0069	-0.0053	-0.0869	-0.0095	0.0031	0.0034	0.0002	-0.0005	-0.0001	0.868**
Polar bulb diameter (cm)	0.0063	-0.0002	-0.0010	0.0436	-0.0086	-0.0002	-0.0572	-0.0060	0.0026	0.0016	-0.0006	-0.0014	0.0000	0.495*
Bulb shape index	-0.0103	0.0000	-0.0018	-0.0328	0.0002	0.0088	0.0706	0.0084	-0.0019	-0.0038	-0.0015	-0.0011	0.0001	-0.800**
Weight of 20 bulbs (kg)	0.0129	-0.0002	0.0006	0.0520	-0.0055	-0.0069	-0.0903	-0.0107	0.0035	0.0034	-0.0012	-0.0002	-0.0001	0.948**
Weight of 50 cloves (g)	0.0109	-0.0003	0.0032	0.0389	-0.0039	-0.0056	-0.0733	-0.0132	0.0030	0.0033	0.0003	-0.0015	-0.0002	0.846**
Number of cloves bulb^{-1}	-0.0097	0.0003	0.0019	-0.0281	0.0038	0.0028	0.0541	0.0068	-0.0059	0.0002	0.0010	0.0030	0.0000	-0.504*
Thrips plant^{-1}	-0.0067	0.0001	-0.0033	-0.0393	0.0028	0.0071	0.0661	0.0092	0.0002	-0.0047	0.0012	-0.0007	0.0002	-0.670**
Stemphylium blight intensity (%)	0.0043	-0.0002	-0.0004	-0.0013	-0.0006	0.0014	-0.0118	0.0004	0.0006	0.0006	-0.0092	-0.0016	-0.0001	0.061
Days to harvest	0.0055	0.0002	-0.0005	-0.0040	0.0018	-0.0014	0.0027	0.0030	-0.0026	0.0005	0.0022	0.0067	-0.0001	-0.161
TSS (%)	0.0101	-0.0002	0.0035	0.0204	-0.0012	-0.0042	-0.0454	-0.0071	0.0010	0.0031	-0.0022	0.0013	-0.0003	0.472*

* &** indicates level of significance at 5% & 1% respectively

Table 3. Phenotypic path coefficients showing direct (diagonal) and indirect effects of different characters on gross yield (kg plot^{-1}) in garlic (Pooled data) (2019-20)

Traits	Plant height (cm)	No. of leaves plant^{-1}	Collar thick-ness (cm)	Equatorial bulb diameter (cm)	Polar bulb diameter (cm)	Bulb shape index	Weight of 20 bulbs (kg)	Weight of 50 cloves (g)	Number of cloves bulb^{-1}	Thrips plant^{-1}	Stemphylium blight intensi-ty (%)	Days to har-vest	TSS (%)	Gross bulb yield (Kg plot^{-1})
Plant height (cm)	-0.0011	-0.0018	-0.0005	-0.0004	0.0011	-0.0004	-0.0055	0.0049	0.0008	0.0018	-0.0001	-0.0012	-0.0017	0.361
No. of leaves plant-1	-0.0003	-0.0061	-0.0003	-0.0002	0.0009	-0.0001	-0.0020	0.0038	0.0010	0.0001	0.0004	-0.0001	-0.0008	0.200
Collar thickness (cm)	-0.0001	-0.0002	-0.0080	0.0001	-0.0002	0.0001	-0.0003	-0.0011	0.0004	-0.0006	0.0000	0.0001	0.0023	-0.091
Equatorial bulb diameter (cm)	-0.0004	-0.0011	0.0008	-0.0011	0.0032	-0.0010	-0.0096	0.0054	0.0010	0.0020	-0.0002	-0.0001	-0.0016	0.681**
Polar bulb diameter (cm)	-0.0002	-0.0010	0.0003	-0.0006	0.0057	0.0005	-0.0063	0.0033	0.0008	0.0006	-0.0003	-0.0012	-0.0015	0.441
Bulb shape index	0.0003	0.0003	-0.0006	0.0007	0.0018	0.0017	0.0048	-0.0031	-0.0004	-0.0018	0.0000	-0.0010	0.0004	-0.339
Weight of 20 bulbs (kg)	-0.0004	-0.0009	-0.0002	-0.0008	0.0026	-0.0006	-0.0138	0.0056	0.0012	0.0018	0.0002	-0.0002	-0.0015	0.660**
Weight of 50 cloves (g)	-0.0005	-0.0021	0.0008	-0.0006	0.0017	-0.0005	-0.0071	0.0108	0.0008	0.0025	-0.0003	-0.0021	-0.0021	0.592**
Number of cloves bulb^{-1}	0.0003	0.0020	0.0011	0.0004	-0.0014	0.0002	0.0053	-0.0028	-0.0031	-0.0005	-0.0005	0.0025	-0.0002	-0.332
Thrips plant^{-1}	0.0003	0.0001	-0.0006	0.0003	-0.0005	0.0004	0.0031	-0.0035	-0.0002	-0.0078	-0.0003	0.0000	0.0007	-0.228
Stemphylium blight inten-sity (%)	0.0000	-0.0006	0.0001	0.0001	-0.0005	0.0000	-0.0005	-0.0009	0.0004	0.0006	0.0038	-0.0018	-0.0007	-0.008
Days to harvest	0.0001	0.0000	-0.0001	0.0000	-0.0005	-0.0001	0.0002	-0.0018	-0.0006	0.0000	-0.0005	0.0129	0.0000	-0.036
TSS (%)	-0.0002	-0.0007	0.0024	-0.0002	0.0012	-0.0001	-0.0028	0.0031	-0.0001	0.0007	0.0003	0.0001	-0.0074	0.242

* &** indicates level of significance at 5% & 1% respectively

components are left out of the programme. To calculate, equatorial bulb diameter and plant height could be used as selection parameters for yield improvement in garlic.

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References

Agarwal A & Tiwari R S 2009 Character association and path analysis in garlic (*Allium sativum* L.). Veg. Sci. 36: 69–73.

Chotaliya P & Kulkarni G U 2017 Character association and path analysis for quantitative traitsin garlic (*Allium sativum* L.). Int. J. Curr. Microbiol. App. Sci. 6(8): 175–184.

Dewey D R & Lu K H 1959 A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 51(9): 515–518.

Falconer D S 1981 Introduction to quantitative genetics. Longmann, 340 pp.

Hacıseferoğulları H, Özcan M, Demir F & Çalışır S 2005 Some nutritional and technological properties of garlic (*Allium sativum* L.). J. Food. Eng. 68(4): 463–469.

Kumari S 2021 Study on genetic parameters in garlic (*Allium sativum* L.) for yield and quality traits. Elec. J. Plant Breed. 12(2): 477–484.

Panse R, Jain P K, Gupta A & Sasode D S 2013 Morphological variability and character association in diverse collection of garlic germplasm. African J. Agri. Res. 8: 2861–2869.

Singh S R, Ahmed N A, Lal S, Amin A, Amin M, Ganie S A & Jan N 2013 Character association and path analysis in garlic (*Allium sativum* L) for yield and its attributes. SAARC J Agri. 11(1): 45–52.

Singh R K, Dubey B K, Singh S K & Bhonde S R 2012 Character association and path coefficient analysis in garlic. Prog. Hort. 44(1): 148–152

Singh R K, Dubey B K, Bhonde S R & Gupta R P 2011 Correlation and path coefficient studies in garlic (*A. sativum* L). J. Spices Arom. Crop. 20(2)**:** 81–85.

Wright S 1921 Correlation and causation. J. Agric. Res. 20:557–587.