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RESEARCH ARTICLE

Character Association and Path Analysis in Indian Garlic (*Allium sativum* L.) Accessions using Agro-Morphological Traits

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ABSTARCT

Character association and path analysis in 25 genotypically diverse indigenous accessions of garlic (*Allium sativum* L.) were evaluated at Vegetable Farm, CSK HPKV Palampur, for 17 agro-morphological quantitative traits namely, plant height, leaves per plant, leaf length, leaf width at middle portion, pseudo stem length, pseudo stem diameter, bulb polar diameter, bulb equatorial diameter, cloves per bulb, clove weight, clove length, clove polar diameter, clove equatorial diameter, total soluble solids, bulbils per plant and bulb yield per plant. In general, the estimates of genotypic correlations, were higher than their respective phenotypic correlations for all the traits studied, indicating inherent relationship. Bulb yield per plant displayed significant positive correlation with bulb equatorial diameter, clove weight, clove equatorial diameter, pseudo stem diameter, clove polar diameter, bulb polar diameter, clove length, leaf length, leaf width at middle portion, plant height and leaves per plant indicated that selection based on these traits would be more effective. Path coefficients studies revealed that clove weight, bulb equatorial diameter, clove polar diameter, leaf length and clove equatorial diameter were the important traits for direct selection of bulb yield as these traits had high direct effects and significant positive correlation with bulb yield per plant. These traits can be considered as the best selection indices for increasing the bulb yield.

Keywords: *Garlic, correlation, path coefficient*

INTRODUCTION

Garlic (Allium sativum L.), an asexually propagated crop and member of family Amaryllidaceae is an important spice crop. It is the second most widely cultivated Allium after onion throughout the world. Garlic has been considered the 'Nectar of life' in Ayurveda as it is the richest source of Sulphur (S), reducing blood lipids cholesterol and *having* anti-cancerous and antiscorbutic effects. The chief constituents of oil are diallyl disulphide, diallyl trisulphide, allyl-propyl disulphide and a small quantity of diethyl disulphide and diallyl polysulphide. Diallyl disulphide is known to possess the true garlic odour. In India, it is mainly grown as short-day plant. However, long-day varieties need a photoperiod of more than 13 hrs. with 20-25 °C for bulbing. Hence temperate areas like Jammu and Kashmir, Himachal Pradesh and Uttarakhand are most suitable for long day garlic cultivars. Early sowing, longer photoperiod, and higher temperatures play key roles in quality garlic production (Atif *et al*. 2020). The major constraints in garlic production are the availability of improved varieties for commercial cultivation, processing and export. Consequently, farmers are restricted to using garlic landraces that are inferior in yield and prone to most diseases and insect attack. Because of lack of systematic study to improve this crop, very little information is available on correlation and path coefficient analysis of characters for bulb yield. This study was, therefore, conducted to

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assess the character association and path coefficient using morpho-agronomic traits among 25 garlic accessions.

MATERIALS AND METHODS

The study involving 25 garlic accessions collected within and outside the State was undertaken at Vegetable Farm, CSK HPKV, Palampur at an elevation of 1290 m above mean sea level with 320 6' N latitude and 760 3' E longitude. Agroclimatically, the location represents mid hill zone of H.P with high rainfall of 2500 mm annually, of which 80 % is received during June to September. The soil is acidic in nature with pH ranging from 5.0 to 5.6 and soil texture is silty clay loam. Mean temperature during the crop season varied from 13.5 to 25.8 0C while relative humidity varied from 52 to 84.3 %. The experiment was laid out in Randomized Complete Block Design (RBD) with three replications during Rabi, 2017-2018 with spacing of 20 x 10 cm. Each experimental plot consisted of 4 rows each of 0.6 m length, accommodating 6 plants per row. The standard agronomic practices and plant protection measures were followed to raise the healthy crop of garlic as per the "Package of Practices for Vegetable Crops" by CSKHPKV, Palampur. The observations were recorded on 10 randomly selected competitive plants from each entry per plot in each replication for 17 quantitative traits namely, plant height (PH), leaves per plant (LPP), leaf length (LL), leaf width at middle portion (LWMP), pseudo stem length (PSL), pseudo stem diameter (PSD), bulb polar diameter (BPD), bulb equatorial diameter (BED), cloves per bulb (CPB), clove weight (CW), clove length (CL), clove polar diameter (CPD), clove equatorial diameter (CED), total soluble solids (TSS), bulbils per plant (BPP) and bulb yield per plant (BYPP). Data were analysed using procedures of statistical software TNAUSTAT by Manivannan (2014).

RESULTS AND DISCUSSION

Genotypic correlation provides a measure of genetic association between traits and is more reliable than phenotypic correlation, and these, along with observed correlations, help to identify the traits to be considered in breeding programs. Data in Table 1 revealed that genotypic correlations were higher than their respective phenotypic correlations for all the traits, which might be due to the modifying effect of the environment on the association of traits indicating inherent relationship.

Bulb yield per plant had a positive and significant correlation with bulb equatorial diameter, clove weight, clove equatorial diameter, pseudo stem diameter, clove polar diameter, bulb polar diameter, clove length, leaf length, leaf width at middle portion, plant height, and leaves per plant. This indicated that these attributes were more in terms of influencing the bulb yield in garlic and therefore, were important determinants for bringing improvement in bulb yield. Findings of Khar *et al*. (2015); Bhatt *et al*. (2017) and Kumar *et al*. (2017) followed close proximity with our results.

The path coefficient divides correlations into direct and indirect effects to determine the degree of relationship between the dependent trait and its component factors. Data in Table 2 based on path coefficients studies revealed that clove weight, bulb equatorial diameter, clove polar diameter, leaf length and clove equatorial diameter were the important bulb yield determinants as these displayed high direct effects and significant positive correlation with bulb yield per plant (Fig. 1). Results of earlier researchers Pervin *et al*. (2014), Bhatt *et al*. (2017) and Kumar *et al*. (2017) were in close proximity with the results obtained.

CONCLUSION

Findings revealed that traits with significant positive correlation and direct effects with bulb yield can be considered best for selection, utilization and variety development efforts of garlic accessions. It can be concluded that traits like clove weight, bulb equatorial diameter, clove polar diameter, leaf length and clove equatorial diameter were the important bulb yield determinants. These traits could serve as good selection criteria to improve bulb yield in garlic through breeding/selection as garlic accession reflected sufficient genetic variability.

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Conflicts of interest

The authors declare that there is no conflict of interest.

Table 1. Estimates of Phenotypic (P) and genotypic (G) coefficients of correlation among different characters in garlic

Character		LPP	LL (cm)	LWMP (cm)	PSL (cm)	PSD (cm)	BPD (mm)	BED (mm)	CPB	CW (g)	CL (cm)	CPD (mm)	CED (mm)	TSS	BPP	BYPP
PH	P	0.32*	0.64*	0.35*	0.45*	0.43*	0.65*	0.69*	0.15	0.31*	0.30*	0.35*	0.42*	-0.21	-0.30*	0.558*
	G	0.50*	0.67*	0.35*	0.47*	0.46*	0.69*	0.71*	0.15	0.34*	0.34*	0.37*	0.44*	-0.29*	-0.30*	0.589*
LPP	P		0.43*	0.32*	0.02	0.34*	0.47*	0.51*	-0.06	0.37*	0.36*	0.40*	0.32*	-0.34*	-0.35*	0.542*
	G		0.73*	0.51*	0.01	0.57*	0.72*	0.82*	-0.19	0.72*	0.56*	0.65*	0.56*	-0.45*	-0.55*	0.926*
LL (cm)	P			0.55*	0.34*	0.35*	0.54*	0.62*	-0.19	0.42*	0.46*	0.45*	0.38*	-0.30*	-0.16	0.572*
	G			0.59*	0.36*	0.37*	0.60*	0.64*	-0.03	0.47*	0.48*	0.45*	0.40*	-0.33*	-0.17	0.607*
LWMP (cm)	P				0.12	0.70*	0.49*	0.51*	-0.26	0.61*	0.56*	0.58*	0.58*	-0.44*	-0.38*	0.570*
	G				0.12	0.76*	0.50*	0.56*	-0.35*	0.70*	0.65*	0.62*	0.61*	-0.59*	-0.40*	0.585*
PSL (cm)	P					0.03	0.23	0.17	0.29	-0.19	-0.12	0.14	-0.02	0.37*	0.11	-0.026
	G					0.05	0.24*	0.17	0.30*	-0.18	-0.11	0.14	-0.02	0.48*	0.12	0.01
PSD (cm)	P						0.60*	0.73*	-0.26	0.68*	0.56*	0.60*	0.73*	-0.42*	-0.32*	0.650*
	G						0.67*	0.80*	-0.32*	0.79*	0.65*	0.66*	0.81*	-0.58*	-0.36*	0.755*
BPD (mm)	P							0.74*	-0.15	0.53*	0.57*	0.60*	0.60*	-0.20	-0.42*	0.612*
	G							0.80*	-0.16	0.62*	0.65*	0.65*	0.65*	-0.30*	-0.45*	0.657*
BED (mm)	P								-0.13	0.70*	0.66*	0.59*	0.66*	-0.44*	-0.34*	0.848*
	G								-0.16	0.73*	0.70*	0.60*	0.70*	-0.53*	-0.34*	0.902*
CPB	P									-0.64*	-0.36*	-0.13	-0.40*	0.17	0.00	-0.054
	G									-0.66*	-0.40*	-0.17	-0.47*	0.21	0.00	-0.133
CW (g)	P										0.72*	0.60*	0.81*	-0.43*	-0.27	0.735*
	G										0.80*	0.66*	0.89*	-0.56*	-0.29*	0.790*
CL (cm)	P											0.72*	0.63*	-0.46*	-0.44*	0.606*
	G											0.77*	0.66*	-0.55*	-0.46*	0.663*
CPD (mm)	P												0.66*	-0.19	-0.47*	0.622*
	G												0.69*	-0.26*	-0.48*	0.664*
CED (mm)	P													-0.21	-0.22	0.693*
	G													-0.28*	-0.22	0.741*
TSS	P														0.36*	-0.403*
	G														0.41*	-0.555*
BPP	P															-0.399*
	G															-0.401*

*Significant at 5% level of significance

PH- Plant height, LPP- Leaves per plant, LL-Leaf length, LWMP- Leaf width at middle portion, PSL- Pseudo stem length, PSD- Pseudo stem diameter, BPP- Bulb polar diameter, BED- Bulb equatorial diameter, CPB- Cloves per bulb, CW- Clove weight, CL- Clove length, CPD- Clove polar diameter, CEC- Clove equatorial diameter, TSS- Total soluble solids, BPP- Bulbils per plant, BYPP- Bulb yield per plant

Table 2. Estimates of direct and indirect effects of different characters on bulb yield of garlic

Character		PH	LPP	LL (cm)	LWMP (cm)	PSL (cm)	PSD (cm)	BPD (mm)	BED (mm)	CPB	CW (g)	CL (cm)	CPD (mm)	CED (mm)	TSS (^{0}B)	BPP	BYPP
PH	P	-0.023	0.038	0.014	0.050	-0.055	-0.063	-0.084	0.377	0.074	0.240	-0.043	0.004	0.033	-0.024	0.020	0.558*
	G	-0.109	0.019	0.057	-0.036	0.020	-0.061	-0.180	0.467	0.064	0.326	-0.102	0.046	0.017	0.012	0.049	0.589
LPP	P	-0.007	0.118	0.009	0.046	-0.002	-0.050	-0.060	0.283	-0.030	0.272	-0.050	0.004	0.026	-0.041	0.024	0.542*
	G	-0.054	0.038	0.063	-0.052	0.001	-0.075	-0.188	0.538	-0.079	0.689	-0.165	0.082	0.021	0.018	0.089	0.926
LL	P	-0.015	0.051	0.021	0.079	-0.042	-0.051	-0.071	0.340	-0.010	0.323	-0.064	0.005	0.030	-0.035	0.011	0.572*
	G	-0.073	0.028	0.086	-0.060	0.015	-0.049	-0.156	0.417	-0.013	0.441	-0.141	0.057	0.015	0.013	0.027	0.607
LWMP	P	-0.008	0.038	0.012	0.144	-0.015	-0.103	-0.063	0.283	-0.130	0.465	-0.079	0.006	0.046	-0.052	0.026	0.570*
	G	-0.038	0.019	0.050	-0.103	0.005	-0.100	-0.131	0.364	-0.145	0.664	-0.191	0.079	0.023	0.024	0.065	0.585
PSL	P	-0.010	0.002	0.007	0.018	-0.122	-0.005	-0.030	0.091	0.144	-0.139	-0.017	0.002	-0.002	0.043	-0.008	-0.026
	G	-0.051	0.001	0.031	-0.013	0.042	-0.006	-0.064	0.110	0.128	-0.179	0.033	0.018	-0.001	-0.020	-0.019	0.01
PSD	P	-0.010	0.040	0.007	0.101	-0.004	-0.146	-0.079	0.402	-0.129	0.510	-0.079	0.007	0.058	-0.050	0.022	0.650*
	G	-0.050	0.022	0.032	-0.078	0.002	-0.132	-0.181	0.521	-0.134	0.749	-0.191	0.083	0.030	0.023	0.059	0.755
BPD	P	-0.015	0.055	0.012	0.070	-0.029	-0.089	-0.129	0.409	-0.058	0.405	-0.079	0.007	0.048	-0.024	0.029	0.612*
	G	-0.075	0.028	0.051	-0.052	0.010	-0.092	-0.260	0.523	-0.068	0.593	-0.194	0.083	0.024	0.013	0.073	0.657
BED	P	-0.016	0.061	0.013	0.074	-0.020	-0.107	-0.096	0.547	-0.068	0.525	-0.093	0.006	0.052	-0.053	0.023	0.848*
	G	-0.078	0.032	0.055	-0.057	0.007	-0.106	-0.209	0.651	-0.066	0.700	-0.208	0.077	0.026	0.022	0.056	0.902
CPB	P	-0.003	-0.007	0.000	-0.037	-0.035	0.038	0.015	-0.074	0.501	-0.488	0.050	-0.001	-0.033	0.020	0.000	-0.054
	G	-0.017	-0.007	-0.003	0.036	0.013	0.043	0.042	-0.103	0.418	-0.627	0.121	-0.021	-0.018	-0.009	-0.001	-0.133
CW (g)	P	-0.007	0.043	0.009	0.089	0.023	-0.099	-0.070	0.381	-0.325	0.753	-0.101	0.007	0.064	-0.051	0.019	0.735*
	G	-0.037	0.028	0.040	-0.072	-0.008	-0.104	-0.162	0.478	-0.275	0.952	-0.235	0.083	0.033	0.023	0.046	0.790
CL	P	-0.007	0.042	0.010	0.081	0.015	-0.082	-0.073	0.361	-0.177	0.543	-0.140	0.008	0.050	-0.055	0.030	0.606*
	G	-0.038	0.021	0.041	-0.066	-0.005	-0.086	-0.170	0.458	-0.170	0.755	-0.296	0.098	0.025	0.022	0.074	0.663
CPD	P	-0.008	0.048	0.010	0.083	-0.017	-0.088	-0.078	0.320	-0.067	0.450	-0.102	0.011	0.051	-0.023	0.032	0.622*
	G	-0.040	0.025	0.039	-0.064	0.006	-0.087	-0.171	0.394	-0.071	0.621	-0.229	0.126	0.026	0.011	0.078	0.664
CED	P	-0.010	0.039	0.008	0.083	0.003	-0.107	-0.078	0.360	-0.204	0.612	-0.089	0.007	0.079	-0.025	0.015	0.693*
	G	-0.048	0.021	0.034	-0.063	-0.001	-0.108	-0.170	0.458	-0.196	0.839	-0.196	0.087	0.037	0.011	0.036	0.741
TSS	P	0.005	-0.041	-0.006	-0.063	-0.045	0.061	0.026	-0.242	0.085	-0.324	0.065	-0.002	-0.017	0.119	-0.024	-0.403*
	G	0.031	-0.017	-0.028	0.060	0.020	0.076	0.080	-0.346	0.088	-0.530	0.163	-0.033	-0.011	-0.041	-0.067	-0.555
BPP	P	-0.007	-0.041	-0.004	-0.055	-0.014	0.048	0.055	-0.187	0.001	-0.208	0.062	-0.005	-0.018	0.042	-0.068	-0.399*
	G	0.033	-0.021	-0.015	0.041	0.005	0.048	0.118	-0.226	0.002	-0.275	0.136	-0.061	-0.008	-0.017	-0.161	-0.401

Residual effects (P) = 0.086; (G) = 0.022 *Significant at 5% level of significance

PH- Plant height, LPP- Leaves per plant, LL-Leaf length, LWMP- Leaf width at middle portion, PSL- Pseudo stem length, PSD- Pseudo stem diameter, BPP- Bulb polar diameter, BED- Bulb equatorial diameter, CPB- Cloves per bulb, CW- Clove weight, CL- Clove length, CPD- Clove polar diameter, CEC- Clove equatorial diameter, TSS- Total soluble solids, BPP- Bulbils per plant, BYPP- Bulb yield per plant

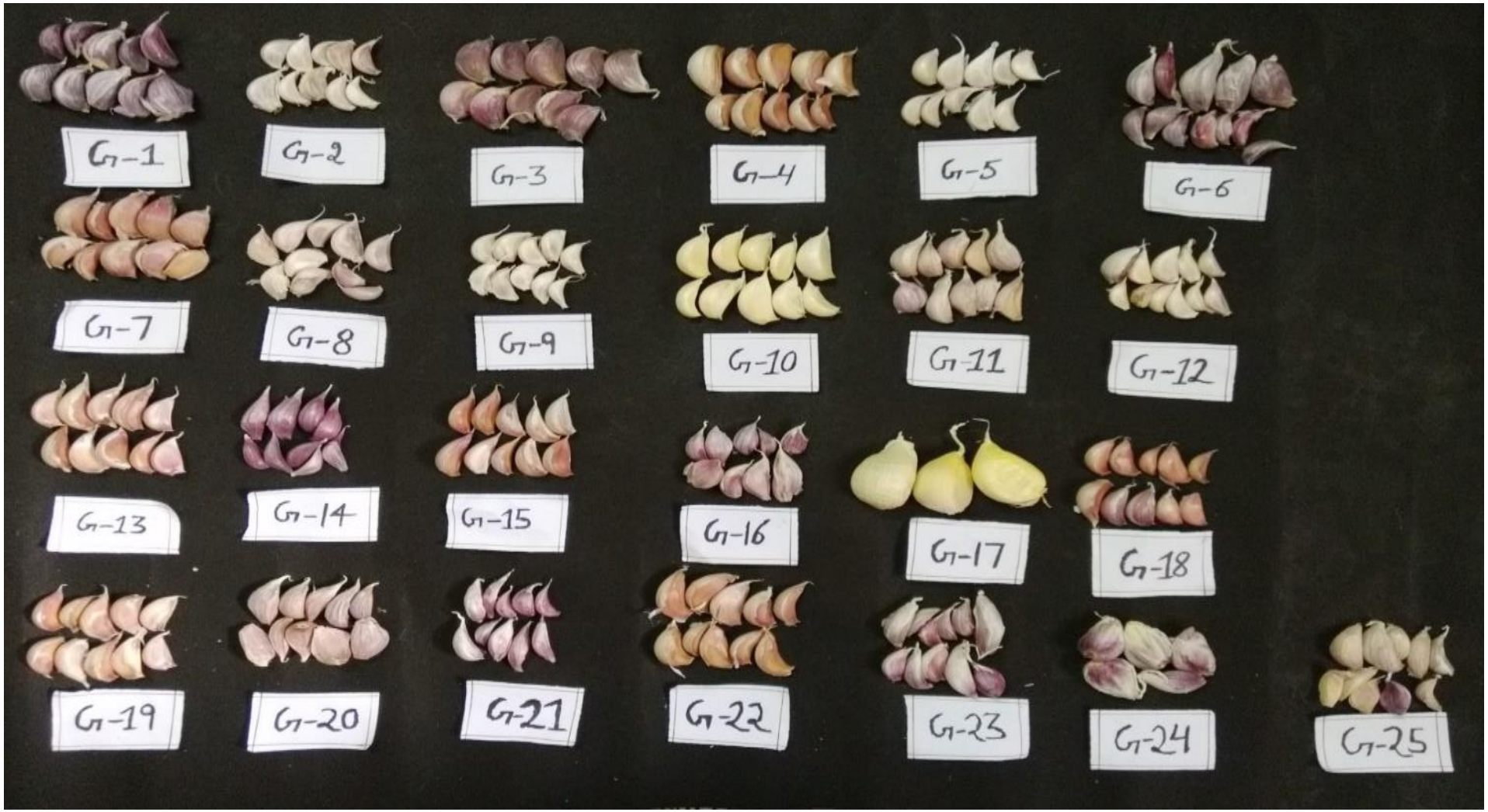

Fig. 1. Variation for clove size, shape and color in garlic

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