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Character association and path coefficient studies in garlic (*Allium sativum* L.)

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ABSTRACT

The investigation on “Character association and Path coefficient studies in Garlic (*Allium sativum* L.)” was conducted on 26 genotypes of garlic to know the interrelationship among yield and its components, their direct and indirect effects on bulb yield of various garlic genotypes. The present investigation was undertaken during the Rabi, 2024-25 season at AICRP, Mahatma Phule Krishi Vidyapeeth, Rahuri. The experiment was laid out in a Randomized Block Design with three replications and observations were recorded on thirteen quantitative traits, including plant height, days to 50 per cent neckfall, days to maturity, number of leaves per plant, length of bulb, diameter of bulb, neck thickness, length of clove, diameter of clove, number of cloves per bulb, bulb weight, yield per plot. The estimates of genotypic correlations, in general were slightly higher than phenotypic correlation, indicating little masking or modifying effects of environment on the expression of character. The yield per plot exhibited positive and significant correlation with plant height, length of bulb, diameter of bulb, length of clove, diameter of clove, bulb weight, number of cloves per bulb. Among the different traits under path analysis study bulb weight exhibited maximum direct effect on yield per plot, length of clove, while days to 50 per cent neckfall followed by days to maturity, neck thickness had negative direct effects on yield per plot.

Keywords: Garlic, *Allium sativum* L., Correlation, Path analysis, Yield etc.

Introduction

Garlic (*Allium sativum* L.) is an important bulb crop belonging to the family Alliaceae and is widely cultivated for its use as a spice, condiment, flavouring agent and medicinal crop. It is nutritionally rich and contains carbohydrates, proteins, minerals and other bioactive compounds, which contribute to its considerable nutritional and therapeutic value. India is the second-largest producer of garlic after China, with Madhya Pradesh being the major producing state followed by Rajasthan, Gujarat and Uttar Pradesh which are important garlic-producing states, while Nashik, Pune, Thane, Marathwada and Vidarbha are prominent production regions in Maharashtra. The crop also has considerable export potential and contributes to agricultural income and foreign exchange earnings. Garlic is predominantly propagated clonally because of its sexual sterility, and therefore clonal selection remains an important approach for its improvement. Despite its asexual mode of propagation, substantial phenotypic variability exists among garlic genotypes for bulb size, colour, growth habit and other agronomic traits. Evaluation of genetic and phenotypic variability is therefore essential for identifying superior genotypes and formulating effective breeding strategies. Since yield is a complex quantitative character influenced by several contributing traits, understanding the association among yield and its component characters is important for effective selection. Correlation analysis helps to determine the degree and direction of association among characters, whereas path coefficient analysis further partitions these associations into direct and indirect effects. (Dewey and Lu, 1959) [2]. Thus, the combined assessment of genetic variability, correlation and path relationships provides useful information for identifying promising garlic genotypes and improving yield and other desirable traits.

Material and methods

The investigation was conducted using 26 genotypes which were obtained from the All India Co-ordinated Research Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. The experiment was evaluated in a Randomized Block Design (RBD) with three replications. The experimental materials of studies comprised of 26 garlic (*Allium sativum* L.) genotypes. The experiment was laid out in Randomized Block Design (RBD), with plot size of (3.0 × 2.0) m², spacing 15 × 10 cm having three replications. The observations were recorded on five randomly selected plants from each treatment in each replication for twelve characters viz., plant height, days to 50 per cent neckfall, days to maturity, number of leaves per plant, length of bulb, diameter of bulb, neck thickness, length of clove, diameter of clove, number of cloves per bulb, bulb weight, yield per plot. The data collected on individual characters were subjected to the method of analysis of vari

ance commonly applicable to the randomized block design (Panse and Sukhatme, 1967). The correlations between different characters at genotypic (g) and phenotypic (p) levels were worked out between characters as suggested by Searle S. R. (1961). To establish a cause and effect relationship, the genotypic correlation were partitioned into direct and indirect effects by path analysis as suggested by Dewey and Lu (1985).

Results and discussion

Correlation

Correlation analysis helps to understand the interrelationship among characters and improves the efficiency of selection. In the present study, genotypic correlations were generally slightly higher than phenotypic correlations, indicating limited environmental influence on character expression. Correlation analysis at genotypic and phenotypic levels revealed a similar overall trend among the characters, although the magnitude of associations varied between the two levels. At the genotypic level, yield per plot showed significant positive associations with plant height, number of leaves per plant, bulb length, bulb diameter, clove length, clove diameter, bulb weight and number of cloves per bulb, while significant negative associations were observed with days to 50 per cent neckfall, days to maturity and neck thickness. Bulb length, bulb diameter, clove length, clove diameter, bulb weight and number of cloves per bulb also exhibited positive associations with yield and several other yield-contributing characters. In contrast, days to 50 per cent neckfall and days to maturity were generally negatively associated with important yield attributes. These associations indicate the importance of bulb and clove characters in relation to yield performance and their potential usefulness in selection.

At the phenotypic level, yield per plot exhibited significant positive associations with plant height, number of leaves per plant, bulb length, bulb diameter, clove length, clove diameter, bulb weight and number of cloves per bulb, whereas significant negative associations were recorded with days to 50 per cent neckfall, days to maturity and neck thickness. Plant height was positively associated with bulb length, bulb weight and yield, while bulb diameter showed significant positive relationships with bulb weight, number of cloves per bulb and yield. Neck thickness exhibited significant negative associations with bulb weight, number of cloves per bulb and yield. Similar positive associations of yield with bulb and clove-related traits have been reported in garlic by Singh *et al.* (2012) [3], Sharma *et al.* (2016) [4], Ranjitha *et al.* (2018) [5] and Tiwari *et al.* (2020) [6].

Path analysis

Correlation coefficient appears to be inadequate measure in selection as it does not provide sufficient information to decide the breeding procedure to be adopted or making simultaneous selection for crop

improvement. Therefore, the path coefficient analysis as proposed by Dewey *et al.* (1959) [2] was adopted to estimate the direct and indirect contributions. Path coefficient analysis revealed considerable variation in the magnitude and direction of direct effects of different characters on total bulb yield per plot. Bulb weight exhibited the highest positive direct effect (0.5340), followed by number of cloves per bulb (0.0853). Length of bulb (0.0843), no. of leaves per plant (0.0637), length of clove (0.0506) recorded relatively low positive direct effects. In contrast, days to 50 per cent neckfall (-0.1453), days to maturity (-0.1560), neck thickness (-0.0609), number of leaves per plant (-0.0637) and plant height (-0.0543) showed negative direct effects on yield. Bulb weight also exhibited a highly significant positive genotypic correlation with yield (0.9842), supported by positive indirect effects through number of cloves per bulb, diameter of clove, plant height, diameter of bulb and number of leaves per plant. However, its negative indirect effects through plant height, days to maturity, days to 50 per cent neckfall and neck thickness indicated the contrasting contribution of these traits to yield association. Among the remaining characters, plant height, bulb length, bulb diameter, clove length, clove diameter and number of cloves per bulb showed significant positive genotypic associations with yield and generally possessed positive direct effects, indicating their favourable contribution to yield. Days to 50 per cent neckfall, days to maturity and neck thickness, plant height exhibited negative genotypic associations as well as negative direct effects on yield, although their indirect effects through other traits varied in magnitude and direction. Number of cloves per bulb showed a significant positive correlation (0.5151) and positive direct effect (0.0853) on yield, further supporting its importance in selection. The importance of bulb weight and other bulb and clove characters as direct or indirect contributors to garlic yield has also been reported by Singh *et al.* (2012) [3], Singh *et al.* (2017) [7], Sharma *et al.* (2016) [4], Ranjitha *et al.* (2018) [5], Tiwari *et al.* (2020) [6] and Esho (2023) [8].

Conclusion

The present investigation revealed substantial genetic variability among the twenty six garlic genotypes, as indicated by significant differences for all characters. The estimates of genotypic correlation coefficients were generally higher than phenotypic correlations, suggesting stronger inherent genetic associations among the traits, with environmental factors influencing their phenotypic expression. The consistent positive relationship of major bulb and clove traits with yield suggests that these characters may be effectively considered as selection criteria for improving yield in garlic. The path analysis indicated that bulb weight was the most important contributor to yield, making favourable direct contributions. Therefore, greater emphasis on bulb weight along with other positively contributing bulb and clove traits, may be useful for identifying superior garlic genotypes with higher yield potential.

Table 1. Analysis of variance for twelve different characters in Garlic.

Sr. No.	Name of Characters	Mean sum of squares		
		Replication	Treatment	Error
1	Plant height (cm)	3.07	38.36**	0.98
2	Days to 50 percent Neckfall	10.42	67.98**	2.38
3	Number of leaves per plant	0.13	0.42**	0.14
4	Days to maturity	3.23	76.74**	3.87
5	Length of bulb (cm)	0.16	0.21**	0.04
6	Diameter of bulb (cm)	0.06	0.23**	0.05
7	Neck thickness (cm)	0.01	0.09**	0.02
8	Length of clove (cm)	0.02	0.01**	0.004
9	Diameter of clove (cm)	0.01	0.03**	0.03
10	Number of cloves per bulb	0.73	97.63**	1.16
11	Bulb weight (g)	0.59	9.25**	0.85
12	Yield (kg/plot)	0.09	1.37**	0.13

** indicate significant at 1 per cent level, respectively

Table 2. Estimates of Phenotypic (P) and Genotypic (G) correlations of different characters in garlic.

Character		PH	D50N	DM	NL	LB	DB	NT	LC	DC	BW	NC	YP
PH	G	1.000	0.1830	0.1295	0.3802*	0.3413*	-0.1812	-0.3202*	0.1947	0.0303	0.4112*	-0.0531	0.4110**
	P	1.000	0.1678	0.1226	0.1497	0.2387*	-0.1024	-0.2946*	0.0178	0.0388	0.3547**	0.0535	0.3545**
D50N	G		1.000	0.8180**	0.1949	0.5753**	-0.0046	0.5135**	0.6508**	-0.7287*	-0.4286*	-0.4847*	-0.4280**
	P		1.000	0.8054**	-0.1105	0.4588**	-0.0314	0.4625**	0.2106	-0.3895*	-0.3528*	-0.4512**	-0.3525**
DM	G			1.000	-0.2495*	0.6647**	0.0141	0.4882*	0.6918**	-0.7356**	-0.4669*	-0.4579*	-0.4665**
	P			1.000	-0.1209	0.4534**	0.0228	0.4103**	0.2345*	-0.3776*	-0.3663*	-0.4255**	-0.3660**
NL	G				1.000	-0.4391*	-0.3639*	-0.2642*	-0.5868**	-0.1055	0.1642	0.0514	0.2634*
	P				1.000	-0.1504	-0.2827*	-0.1509	-0.3132*	-0.0970	0.1675	0.0409	0.2680*
LB	G					1.000	0.3567*	0.2482*	0.2655*	0.2852*	0.0599	0.3088*	0.2865*
	P					1.000	0.1894	0.1617	0.0727	-0.2630*	0.0033	-0.2287*	0.2833*
DB	G						1.000	0.3568*	0.2484*	0.2653*	0.2854*	-0.0595	0.3040**
	P						1.000	0.1434	0.0943	0.0270	0.2696*	0.3710*	0.2699*
NT	G							1.000	0.3611*	-0.4752*	0.4163*	-0.3546*	-0.4167**
	P							1.000	0.0944	-0.1917	-0.3498*	-0.3247*	-0.3499**
LC	G								1.000	0.0470	0.4973*	0.5577**	0.2950**
	P								1.000	-0.0622	0.0746	-0.1868	0.2750*
DC	G									1.000	0.0472	0.4973**	0.3146*
	P									1.000	0.1247	0.1690	0.2247*
BW	G										1.000	0.5152**	0.9842**
	P										1.000	0.4468*	0.9640**
NC	G											1.000	0.5151**
	P											1.000	0.4469**
YP	G												1.000
	P												1.000

PH = Plant height; D50N = Days to 50% neckfall; DM = Days to maturity; NL = Number of leaves per plant; LB = Length of bulb; DB = Diameter of bulb; NT = Neck thickness; LC = Length of clove; DC = Diameter of clove; BW = Bulb weight; NC = Number of cloves per bulb; YP = Yield per plot.
*and ** - Significant at 5% and 1% level of significance, respectively.

(continued on next page)

Table 3. Direct (diagonal) and indirect effects for yield and yield components in garlic.

Genotypes	Plant height (cm)	Days to 50 % neck-fall	Days to Maturity	No. of leaves/plant	Length of bulb (cm)	Diameter of bulb (cm)	Neck Thickness (cm)	Length of clove (cm)	Diameter of clove (cm)	Bulb weight (g)	No. of cloves per bulb	Genotypic correlation Yield/plot
Plant height (cm)	-0.0543	-0.0099	-0.0070	-0.0206	-0.0185	0.0098	0.0174	0.0106	-0.0016	-0.0223	0.0029	0.4110**
Days to 50 % neckfall	-0.0266	-0.1453	-0.1479	0.0283	-0.0836	0.0007	-0.0746	-0.0945	0.1059	0.0623	0.0704	-0.4280**
Days to maturity	0.0202	0.1588	-0.1560	-0.0389	0.1037	0.0022	0.0762	0.1079	-0.1147	-0.0728	-0.0714	-0.4665**
Number of leaves per plant	0.0242	-0.0124	-0.0159	0.0637	-0.0279	-0.0232	-0.0168	-0.0374	-0.0067	0.0105	0.0033	0.2634**
Length of bulb (cm)	0.0288	0.0485	0.0561	-0.0370	0.0845	0.0301	0.0209	0.0224	-0.0241	-0.0051	-0.0260	0.2865**
Diameter of bulb (cm)	0.0204	0.0005	-0.0016	0.0411	-0.0402	-0.1128	-0.0233	-0.0025	-0.0317	-0.0434	-0.0598	0.3040**
Neck thickness (cm)	-0.0195	0.0313	0.0297	-0.0161	0.0151	0.0126	-0.0609	0.0220	-0.0290	-0.0254	-0.0216	-0.4167**
Length of clove (cm)	-0.0099	0.0329	0.0350	-0.0297	0.0134	0.0011	0.0183	0.0506	0.0024	-0.0252	-0.0282	0.2950**
Diameter of clove (cm)	0.0015	-0.0353	-0.0357	-0.0051	-0.0138	0.0136	-0.0230	0.0023	0.0485	0.0207	0.013	0.3146**
Bulb weight (g)	0.4330	-0.4515	-0.4918	0.1729	-0.0631	0.4056	-0.4389	-0.5238	0.4492	0.5340	0.5427	0.9842**
Number of cloves per bulb	-0.0043	-0.0389	-0.0368	0.0041	-0.0248	0.0425	-0.0285	-0.0448	0.0227	0.0414	0.0853	0.5151**

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