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CHARACTER ASSOCIATION AND PATH CO-EFFICIENT ANALYSIS IN GARLIC (*Allium sativum* L.)

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ABSTRACT : Correlation co-efficient analysis in garlic (*Allium sativum* L.) revealed that total yield (rp=0.824), leaf length (rp=0.634), equatorial diameter of bulb (rp=0.559), leaf width (rp=0.544), plant height (rp=0.498) pseudostem diameter (rp=0.476), polar diameter of bulb (rp=0.460), average weight of bulb (rp=0.459) and days to maturity (rp=0.435) were positively and significantly associated with bulb yield plant^{-1}. Path analysis revealed that number of cloves bulb^{-1} (0.820) fallowed by pseudostem diameter (0.315), number of leaves plant^{-1} (0.163), leaf width (0.132), pseudostem length (0.091), equatorial diameter (0.050) and days to maturity (0.034) had the high positive direct effect on bulb yield per plant. It was also observed that the high negative direct effect was exerted by leaf length (–0.124) fallowed by plant height (–0.118), average weight of 10 cloves (–0.049) and polar diameter (–0.033). Hence, these characters should be given more weight age in selection programme of high yielding variety in garlic.

Keywords : *Garlic, correlation, path analysis, cloves, bulb yield.*

Garlic (*Allium sativum* L.) is one of the most important remunerative bulb spice and medicinal crop grown commercially. The fresh peeled garlic cloves contain 62.8% moisture, 29% carbohydrate, 6.3% protein, 1% mineral matter, 0.8% fiber, 0.1% fat, 1% total ash, 0.03% calcium, 0.31% phosphorus, 0.0001% iron, 0.4 mg/100 g nicotinic acid and 13 mg/100 g vitamin 'C'. The uninjured bulb contains a colorless, odorless water soluble amino acid Allin. The chief constituents of the oil are diallyl disulphide (60%), diallyl trisulphide (20%), allyl propyl disulphide (6%), a small quantity of a diethyl disulphide and probably diallylpoly sulphide. It is mostly a cross pollinated crops, despite many good attributes, the crop has remained unexploited owing to low productivity, photosensitivity and there is no single variety/cultivar which has occupied a large area in Madhya Pradesh. Only local types, traditional farmer collections and cultivars are being cultivated. The consumer preference also varies with respect to bulb size, shape, colour and aroma. The efforts of improving the crop by utilizing indigenous and exotic germplasm have been useful in breaking the yield barriers resulting in developing compact plant type with photo-insensitivity and high yield potential.

Direct selection for the yield is not much effective as quantitative characters are controlled by polygenes. Hence, knowledge about association of character which will directly or indirectly contribute to yield is crucial. Correlation coefficients explain the degree of association among the characters. However, it is difficult to explain a system of correlation when the indirect association between the characters increases. The method of path coefficient analysis helpful in partitioning correlation into direct and indirect effects and in the assessment of relative contributions of each component to the yield. Keeping in view of the above point the present investigation was taken up with the above objectives.

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MATERIALS AND METHODS

The experiment was conducted at the Vegetable Research Farm, Horticulture Complex, Department of Horticulture, JNKVV, Jabalpur (M.P.) during Rabi 2013-14 to the study the ''genetic association and path co-efficient analysis for bulb yield and its contributing traits of Garlic (*Allium sativum* L.) germplasm." The experiment was laid out in Randomized Block Design (RBD) with three replications and each replication consisted of thirty treatments. All the thirty genotypes of garlic (*Allium sativum* L.) collected from various region of Madhya Pradesh such as Mandsaur, Ratlam, Chhindwara, Betul, Neemach and Seoni were utilized for investigation. Randomly marked five plants from each plot were taken for recording observation on sixteen characters *viz.,* plant height (cm), number of leaves plant^{-1}, leaf length (cm), leaf width (cm),

pseudo stem length (cm), pseudo stem diameter (cm), polar diameter (cm), equatorial diameter (cm), number of cloves bulb^{-1}, average bulb weight (g), average weight of 10 cloves (g),marketable yield (q/ha), total yield (q/ha), number of days to maturity, storage analysis *viz.,* physiological weight loss at 15 day and 30 days after harvesting. The statistical analysis as correlation coefficients were calculated in all possible combinations taking all the characters into consideration at genotypic, phenotypic and environmental levels by using the formula as proposed by Miller *et al.* (7) and the phenotypic correlations were tested for their significance by using "t" test. Path coefficient analysis calculated by was under taken in parents and crosses. Wright (17) proposed the original technique; analysis was carried out by modified method devised by Dewey and Lu. (5).

RESULTS AND DISCUSSION

Correlation between yield components

In the present findings (Table 1) significant positive correlation of marketable yield was observed with total yield, leaf length, leaf width, equatorial diameter of bulb, plant height, pseudostem diameter, polar diameter of bulb, average weight of bulb and days to maturity. Thus the positive correlation showed the cumulative influence of various characters to improve the marketable yield per ha. These results are in close conformity with the findings of Biswas *et. al.* (4) and Singh *et al.* (12).

Polar diameter of bulb shown to have highly significant and positive correlation with equatorial diameter of bulb, total yield, average weight of bulb, marketable yield, Similarly, equatorial diameter of bulb showed positive and highly significant correlation with marketable yield, total yield, average weight of bulb, number of cloves per bulb, days to maturity and average weight of 10 cloves. Hence increasing polar and equatorial diameter of bulb improved the yield along with other related characters. Similar findings were also reported by Shridhar (10) and Singh *et al.* (13). Number of cloves per bulb showed positive correlation with average weight of bulb, days to maturity, marketable yield, total yield and average weight of 10 cloves .The findings are in close conformity with the results of Wani (16), Singh *et al.* (13) and Shrivastava *et al.* (11).

Average weight of 10 cloves showed negative association with physiological weight loss at 15 days after harvest, physiological weight loss at 30 days after harvest, total yield, marketable yield, average weight of bulb and days to maturity. However, the positive association was pseudostem length, polar diameter of bulb, equatorial diameter of bulb and number of cloves per bulb which might have compensated the negative correlation with above said characters. Although positive and negative association was not significant at both genotypic and phenotypic level. The findings are in close conformity with the results of Singh *et. al.* (13) and Agrawal and Tiwari (2). Average weight of bulb showed positive and significant associated with marketable yield and total yield.

Correlation between yield contributing characters

Plant height showed significant and positive correlation with leaf length, equatorial diameter of bulb, marketable yield, leaf width, total yield, polar diameter of bulb and average weight of bulb. The positive correlation showed that increase in plant height improved the photosynthetic area and resulted into increase in bulb size, bulb shape and ultimately yield. Highly significant and negative association was recorded for PWL at 15 days after harvesting and PWL at 30 days after harvesting. This negative correlation could be interpretated that less loss in physiological weight of bulb might be due to increase plant height. These results are in close conformity with the findings Narayan and Khan (8) and Shrivastava *et al.* (11). Number of leaves per plant had positive correlation with pseudostem length, leaf length, polar diameter of bulb, total yield, equatorial diameter of bulb and marketable yield. This showed increase number of leaves directly involved in improving yield and other characters. The results are in conformity with the findings of Wani *et. al.* (16) and Shrivastava *et al.* (11). Leaf length was found to be positively and highly significant correlated with equatorial diameter of bulb, total yield, marketable yield, polar diameter of bulb, leaf width, pseudostem diameter and average weight of bulb. The results confirmed the findings of Kohli and Prabal (6). Highly significant and negative association was recorded physiological weight loss at 15 and physiological weight loss at 30. Leaf width showed positive and highly significant association with equatorial diameter of bulb, marketable yield, polar diameter of bulb, total yield, pseudostem diameter, average weight of bulb and days to maturity. Similar findings were also reported by Kohli and Prabal (6) and Singh *et al.* (13). Significance and negative association was recorded for physiological weight loss at 15 days and physiological weight loss at 30 days.

Pseudostem length shown to have positive correlation with number of cloves per bulb, average weight of 10 cloves, average weight of bulb and

physiological weight loss at 15 days.Negative association was recorded total yield, marketable yield, pseudostem diameter, days to maturity and equatorial diameter of bulb. The result might be due to increased

Table 1: Genotypic and phenotypic correlation coefficients among 30 genotype for yield and its contributing traits in garlic.

Characters		PH (cm)	No.L.	L.L. (cm)	L.W. (cm)	P.L. (cm)	P.D. (cm)	P.D.B. (cm)	E.D.B. (cm)	N.C.B.	A.W.C. (g)	D.M.	P.W.L. 15 D	P.W.L. 30 D.	A.W.B. (cm)	M.Y. (q/ha)	T.Y. (q/ha)
P.H. (cm)	G	1.000	0.651	0.924	0.613	0.210	0.604	0.904	0.834	0.435	-0.112	0.634	0.651	0.585	0.559	0.781	0.690
	P	1.000	0.306	0.604**	0.477**	0.207	0.230	0.421*	0.516**	0.161	-0.075	0.255	-0.526**	-0.450*	0.380*	0.498**	0.448*
No.L	G		1.000	0.253	0.042	0.310	0.057	0.567	0.222	-0.067	-0.050	0.148	-0.189	-0.137	0.051	0.099	0.216
	P		1.000	0.219	-0.001	0.251	0.000	0.210	0.100	0.012	-0.050	0.039	-0.058	-0.048	0.048	0.090	0.179
L.L. (cm)	G			1.000	0.715	0.074	0.610	0.794	0.917	0.398	-0.127	0.281	-0.823	-0.718	0.463	0.647	0.663
	P			1.000	0.539**	0.080	0.476**	0.548**	0.678**	0.291	-0.101	0.187	-0.498**	-0.454*	0.460*	0.634**	0.647**
L.W. (cm)	G				1.000	-0.432	0.799	0.961	0.994	0.265	-0.188	0.486	-0.505	-0.457	0.451	0.702	0.663
	P				1.000	-0.234	0.427*	0.520**	0.568**	0.158	-0.156	0.349	-0.406*	-0.347	0.356	0.544**	0.510**
P.L. (cm)	G					1.000	-0.125	0.014	-0.123	0.104	0.171	-0.004	0.054	0.084	0.081	-0.228	-0.284
	P					1.000	-0.171	-0.004	-0.016	0.189	0.153	-0.064	0.023	-0.007	0.080	-0.195	-0.255
P.D. (cm)	G						1.000	0.906	0.990	0.537	-0.030	0.541	-0.570	-0.518	0.751	0.593	0.768
	P						1.000	0.522**	0.525**	0.336	-0.047	0.335	-0.375*	-0.338	0.591**	0.476**	0.602**
P.D.B. (cm)	G							1.000	0.955	0.434	0.033	0.461	-0.099	-0.089	0.685	0.670	0.687
	P							1.000	0.816**	0.247	0.013	0.200	-0.236	-0.192	0.484**	0.460*	0.486**
E.D.B. (cm)	G								1.000	0.481	0.001	0.457	-0.767	-0.607	0.684	0.790	0.731
	P								1.000	0.336	0.015	0.263	-0.479**	-0.418*	0.518**	0.559**	0.526**
No.C.B.	G									1.000	0.018	0.535	-0.241	-0.186	0.949	0.280	0.221
	P									1.000	0.008	0.251	-0.212	-0.205	0.686**	0.207	0.165
A.W. 10 C. (g)	G										1.000	-0.002	-0.206	-0.226	-0.033	-0.067	-0.068
	P										1.000	-0.041	-0.138	-0.117	-0.043	-0.058	-0.065
D.M.	G											1.000	0.357	-0.325	0.629	0.621	0.469
	P											1.000	-0.138	-0.143	0.444*	0.435*	0.323
P.W.L.15 D. (%)	G												1.000	0.998	-0.496	-0.626	-0.770
	P												1.000	0.973**	-0.328	-0.474**	-0.446*
P.W.L. 30.D. (%)	G													1.000	-0.416	-0.595	-0.775
	P													1.000	-0.305	-0.428*	-0.410*
A.W.B. (g)	G														1.000	0.468	0.419
	P														1.000	0.459*	0.413*
M.Y. (q/ha)	G															1.000	0.829
	P															1.000	0.824**
T.Y.	G																1.000
	P																1.000

***Significant at 5% level = (0.361) ** Significant at 1% level = (0.463)**

P.H. = Plant height, NOL. = No. of Leaves/plant, L.L. = Leaf length (cm), L.W. = Leaf width (cm), P.L. =Pseudostem length cm, P.D. = Pseudostem diameter (cm), P.D.B. = Polar diameter of bulb (cm), E.D.B. = Equatorial diameter of bulb (cm), No.C.B = Number of cloves / bulb A.W.C. = Average weight of 10 cloves (g), D.M. = Days to maturity, P.W.L.15 DAH. = Physiological weight loss at 15 days after harvesting, P.W.L.30 DAH. = Physiological weight loss at 30 days after harvesting, A.W.B. =Average weight of bulb (g), M.Y. (q/ha) =

Table 2: Path coefficients showing direct and indirect effects of different characters on bulb yield per plant (g) in garlic.

Characters		Plant height (cm)	Number of leaves plant^{-1}	Leaf length (cm)	Leaf width (cm)	Pseudo stem length (cm)	Pseudo stem diameter(cm)	Polar diameter (cm)	Equatorial diameter (cm)	Number of cloves Bulb^{-1}	Average weight of 10 cloves	Days to maturity (days)	"r" value bulb yield plant^{-1} (g)
Plant height (cm)	G	-0.118	0.106	-0.115	0.081	0.019	0.190	-0.030	0.042	0.357	0.005	0.022	0.559
	P	0.168	-0.019	0.020	-0.032	0.002	0.062	0.081	-0.030	0.080	0.002	0.047	0.380
No. of leaves plant^{-1}	G	-0.077	0.163	-0.031	0.006	0.028	0.018	-0.019	0.011	-0.055	0.002	0.005	0.051
	P	0.051	-0.063	0.007	0.001	0.003	0.001	0.040	-0.006	0.006	0.001	0.007	0.048
Leaf length(cm)	G	-0.109	0.041	-0.124	0.094	0.007	0.192	-0.026	0.046	0.326	0.006	0.010	0.463
	P	0.102	-0.014	0.033	-0.036	0.001	0.128	0.105	-0.039	0.144	0.003	0.034	0.460
Leaf width(cm)	G	-0.072	0.007	-0.089	0.132	-0.039	0.252	-0.032	0.050	0.217	0.009	0.017	0.451
	P	0.080	0.001	0.018	-0.068	-0.003	0.115	0.100	-0.033	0.078	0.004	0.064	0.356
Pseudostem length(cm)	G	-0.025	0.050	-0.009	-0.057	0.091	-0.039	-0.005	-0.006	0.085	-0.008	-0.001	0.081
	P	0.035	-0.016	0.003	0.016	0.011	-0.046	-0.001	0.001	0.094	-0.004	-0.012	0.080
Pseudostem diameter (cm)	G	-0.071	0.009	-0.076	0.105	-0.011	0.315	-0.030	0.050	0.440	0.001	0.018	0.751
	P	0.039	0.001	0.016	-0.029	-0.002	0.269	0.100	-0.031	0.166	0.001	0.061	0.591
Polar diameter (cm)	G	-0.106	0.092	-0.098	0.126	0.001	0.285	-0.033	0.048	0.356	-0.002	0.016	0.685
	P	0.071	-0.013	0.018	-0.035	0.001	0.140	0.192	-0.048	0.122	0.001	0.037	0.484
Equatorial Diameter (cm)	G	-0.098	0.036	-0.114	0.131	-0.011	0.312	-0.032	0.050	0.394	0.000	0.016	0.684
	P	0.087	-0.006	0.022	-0.038	0.001	0.141	0.157	-0.058	0.166	0.001	0.048	0.518
Number of cloves bulb^{-1}	G	-0.051	-0.011	-0.049	0.035	0.009	0.169	-0.014	0.024	0.820	-0.001	0.018	0.949
	P	0.027	-0.001	0.010	-0.011	0.002	0.090	0.048	-0.020	0.495	0.001	0.046	0.686
Average weight of 10 cloves	G	0.013	-0.008	0.016	-0.025	0.015	-0.009	-0.001	0.001	0.015	-0.049	0.001	-0.033
	P	-0.013	0.003	-0.003	0.011	0.002	-0.013	0.003	-0.001	0.004	-0.028	-0.008	-0.043
Days to maturity	G	-0.075	0.024	-0.035	0.064	0.004	0.170	-0.015	0.023	0.439	0.001	0.034	0.629
	P	0.043	-0.002	0.006	-0.024	-0.001	0.090	0.038	-0.015	0.124	0.001	0.183	0.444

Residual effect, Genotypic = -0.0010, Phenotypic = 0.303

length of pseudostem which affected the pseudostem diameter and had relatively weaker plant strength resulted into low yield. The result in corroboration to the finding of Shrivastava *et al.* (11). Pseudostem diameter shown to have highly significant and positive correlation with total yield, average weight of bulb, equatorial diameter of bulb, polar diameter of bulb, marketable yield , number of cloves per bulb and days to maturity. The association was negative and significant physiological weight loss at 15 days and physiological weight loss at 30 days. The findings are in close conformity with the results of Shrivastava *et al.* (11). Days to maturity showed positively associated with all the characters except pseudostem length, Physiological weight loss at 15 days after harvest showed positive and highly significant correlation with physiological weight loss at 30 days after harvest and negative and significant correlation with marketable yield, total yield, average weight of bulb. The findings are in close conformity with the results of Singh *et al.* (13).

Path co-efficient analysis

The genotypic and phenotypic path coefficient analysis is presented in (Table 2). At genotypic level, high positive direct effect was noted for number of cloves bulb^{-1} (0.820) fallowed by pseudostem diameter (0.315), number of leaves plant^{-1} (0.163), leaf width (0.132), pseudostem length (0.091), equatorial diameter (0.050), days to maturity (0.034). It

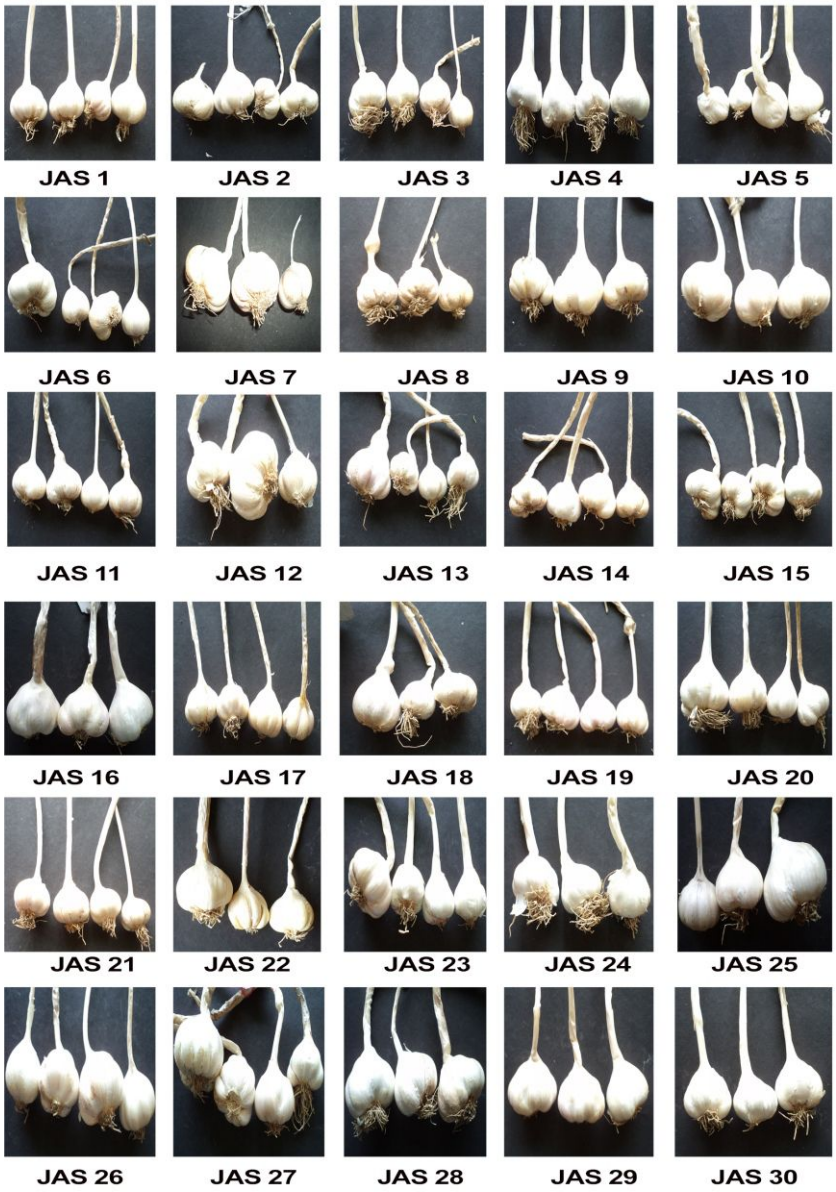

Plate 1 : Different genotypes of garlic (*Allium sativum* L.)

was also observed that the high negative direct effect was exerted by leaf length (-0.124) fallowed by plant height (-0.118), average weightof 10 cloves (-0.049) and polar diameter (-0.033). Similar results were reported by previous works Agarwal and Tiwari (1), Singh *et al.* (14), Barad *et al.* (3), Patil *et al.* (9) and Singh *et al.* (15). The indirect effect of most of the traits had medium to high positive and negative indirect effect were noted for most of character under study.

The residual effect (G = – 0.0010, P = 0.3035) on bulb yield plant^{-1} was negligible which suggest that most of yield component was included in the present study. The highest positive direct effect was noted for number of cloves bulb^{-1} fallowed by pseudostem diameter, number of leaves plant^{-1}, leaf width, pseudostem length, equatorial diameter and days to maturity which also had significant positive correlation with total yield, leaf length, leaf width, equatorial diameter of bulb, plant height, pseudostem diameter, polar diameter of bulb, average weight of bulb and days to maturity. Hence these traits are to be considered in selection for increasing bulb yield per plant in garlic.

CONCLUSION

It could be concluded that bulb yield per plant in garlic was positively and significantly correlated with total yield, leaf length, leaf width, equatorial diameter of bulb, plant height, pseudostem diameter, polar diameter of bulb, average weight of bulb and days to maturity. In path coefficient analysis the highest positive direct effect was noted in number of cloves bulb^{-1} fallowed by pseudostem diameter, number of leaves plant^{-1}, leaf width, pseudostem length, equatorial diameter and days to maturity. So, these traits have direct effect on cloves yield. Hence these traits can be used as selection indices in cloves to bring about the improvement in garlic yield.

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