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Correlation and path analysis studies in garlic (*Allium sativum* L.)

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Abstract

Thirty genotypes of garlic were grown during the *Rabi* season of 2001-2002 to study the correlation and path analysis for some important yield and its contributing characters. Equatorial bulb diameter, leaf breadth, number of leaves per plant, average clove weight, days to maturity, clove length and clove diameter showed significant positive association with bulb yield per plant. Path coefficient analysis revealed that leaf breadth had the maximum direct effect on bulb weight per plant followed by average clove weight, cloves per bulb, plant height, clove length and dry matter content. These traits also had maximum indirect contributions through each other which ultimately resulted in increased bulb weight. From the present investigation it can be concluded that these traits can be exploited for making effective selection for further improvement in garlic aimed at increased bulb yield.

Introduction

Garlic (*Allium sativum* L.) from *Allium* group, ranking second to onion in production and consumption, is an important spice and condiment. Most of the cultivated varieties of garlic are indigenous clonal stocks though; some high yielding exotic genotypes have been introduced recently. A very little information is available on association studies of different characters with yield which is a prerequisite for execution of effective breeding programme. This is on account of lack of systematic studies to improve this crop. The improvement in garlic is not possible through hybridization due to false reproductive parts thus clonal selection is the only alternative to improve this crop. Keeping in view the above facts, the present studies were undertaken to determine the relationship between various characters and their direct and indirect contributions to the bulb yield.

Material and Methods

The present investigation involving thirty genotypes of garlic was carried out at the Experimental Farm of Department of Vegetable Science and Floriculture, CSK HP Krishi Vishvavidyalaya, Palampur during *Rabi* season of 2001-2002. The experiment was laid out in randomized block design with three replications. Each clone was planted in 5 rows of one meter by dibbling at inter and intra row spacing of 20 and 10 cm, respectively. The observations were recorded on ten randomly taken competitive plants for number of characters *viz.*, plant height (cm), number of leaves per plant, leaf length (cm), leaf breadth (cm), polar bulb diameter (cm), equatorial bulb diameter (cm), number of cloves per plant, average clove weight (g), clove length (cm), clove diameter (cm), number of bulbils per plant, average weight of bulbils per plant (g), days to maturity, TSS (%), dry matter (%) and bulb weight per plant (g). The genotypic and phenotypic correlations were worked out by following the standard statistical procedures of Al-Jibouri *et al.* (1958) while path coefficient analysis according to Dewey and Lu (1958).

Results and Discussion

The phenotypic and genotypic correlations (Table 1) in general, revealed that correlations at genotypic level were slightly higher than those at phenotypic levels. This indicates that inspite of strong inherent association between various characters studied, the environment may modify the full expression of the genotypes. Bulb weight which is the most important component showed positive and significant association with number of leaves per

Table 1. Estimates of phenotypic (P) and genotypic (G) correlation coefficients for different pair of horticultural traits in garlic

Character		No. of leaves/ plant	Leaf length (cm)	Leaf breadth (cm)	Polar bulb dia-meter (cm)	Equatorial bulb dia-meter (cm)	No. of cloves/ bulb	Average clove wt. (g)	Clove length (cm)	Clove diameter (cm)	No. of bulbils/ plant	Av.wt.of bulbils/ plant (g)	Days to maturity	TSS (%)	Dry matter (%)	Bulb weight (g)
Plant height (cm)	P	0.294	0.759*	0.263	0.304	0.222	0.097	-0.015	0.029	0.032	0.266	0.352	0.262	0.126	0.126	0.068
	G	0.324	0.799	0.258	0.346	0.118	0.064	-0.052	0.002	0.034	0.322	0.440	0.329	0.121	-0.020	-0.042
No. of leaves/ plant	P		0.386*	0.773*	0.188	0.652*	-0.174	0.570*	0.345	0.476*	-0.527*	-0.209	0.469*	-0.281	-0.448*	0.695*
	G		0.447	0.859	0.261	0.878	-0.251	0.661	0.421	0.560	-0.623	-0.249	0.552	-0.307	-0.633	0.804
Leaf length	P			0.551*	0.444*	0.412*	-0.175	0.263	0.340	0.325	0.031	0.297	0.597*	-0.125	-0.125	0.256
	G			0.598	0.471	0.300	-0.313	0.312	0.401	0.397	0.000	0.354	0.761	-0.139	-0.277	0.188
Leaf breadth	P				0.410*	0.753*	-0.463*	0.773*	0.610*	0.714*	-0.595*	-0.123	0.700*	-0.412*	-0.597*	0.796*
	G				0.436	0.875	-0.525	0.804	0.680	0.754	-0.641	-0.131	0.741	-0.486	-0.750	0.816
Polar bulb diameter	P					0.401*	-0.624*	0.463*	0.715*	0.633*	0.087	0.505*	0.271	0.060	-0.071	0.208
	G					0.273	-0.766	0.516	0.757	0.705	0.065	0.567	0.297	0.036	-0.012	0.166
Equatorial bulb dia.	P						-0.195	0.650*	0.535*	0.507*	-0.519*	-0.259	0.546*	-0.241	-0.493*	0.879*
	G						-0.344	0.786	0.605	0.611	-0.720	-0.341	0.671	-0.366	-0.737	0.985
No. of cloves/ bulb	P							-0.763*	-0.783*	-0.884*	0.240	-0.356	-0.258	0.058	0.135	-0.227
	G							-0.783	-0.881	-0.908	0.241	-0.370	-0.273	0.078	0.185	-0.280
Average clove weight	P								0.806*	0.915*	-0.584*	-0.076	0.516*	-0.287	-0.486*	0.739*
	G								0.867	0.928	-0.607	-0.078	0.539	-0.350	-0.634	0 764
Clove length	P									0.817*	-0.374*	0.131	0.453*	-0.165	-0.289	0.538*
	G									0.878	-0.431	0.139	0.494	-0.289	-0.366	0.561
Clove diameter	P										-0.378*	0.194	0.463*	-0.191	-0.370*	0.524*
	G										-0.397	0.196	0.479	-0.233	-0.469	0.551
No. of bulbils/ plant	P											0.710*	-0.369*	0.448*	0.577*	-0.717*
	G											0.716	-0.396	0.514	0.714	-0.783
Av. wt. of bulbils/ plant	P												-0.088	0.383*	0.476*-	0.450*
	G												-0.093	0.448	0.595	-0.477
Days to maturity	P													-0.341	-0.464*	0.543*
	G													-0.421	-0.599	0.569
TSS (%)	P														0.712*	-0.310
	G														0.834	-0.392
Dry matter (%)	P															-0.553*
	G															-0.744

* Significant at 5 per cent level

plant, leaf breadth, equatorial bulb diameter, average clove weight, clove length, clove diameter and days to maturity and negative correlation with number of bulbils per plant, average weight of bulbils per plant and dry matter. Similarly a positive correlation of plant height with leaf length; number of leaves per plant with leaf length, leaf breadth, equatorial bulb diameter average, clove weight, clove diameter and days to maturity; leaf length with leaf breadth, polar and equatorial bulb diameter and days to maturity; leaf breadth with polar and equatorial bulb diameter, average clove weight, clove length, clove diameter and days to maturity, polar bulb diameter with equatorial bulb diameter, average clove weight, clove length, clove diameter and average weight of bulbils per plant, equatorial bulb diameter with average clove weight, clove length, clove diameter and days to maturity, average clove weight with clove length, clove diameter and days to maturity; clove length with clove diameter and days to maturity; clove diameter with days to maturity; number and average weight of bulbils per plant with TSS and dry matter; number of bulbils with average weight of bulbils and TSS with dry matter was observed. A negative and significant association of number of cloves per bulb with leaf breadth, polar bulb diameter, average clove weight, clove length and clove diameter; number of bulbils per plant with number of leaves per plant, leaf breadth, equatorial bulb diameter, average clove weight, clove length, clove diameter, days to maturity and yield per hectare; TSS with leaf breadth and dry matter with number of leaves per plant, leaf breadth, equatorial bulb diameter, average clove weight, clove diameter and days to maturity was recorded.

The correlation study alone would be incomplete without path analysis which measures the relative magnitude of direct and indirect effects of components contribution to yield. Path analysis at genotypic level (Table 2) revealed that leaf breadth had the maximum direct positive effect on bulb weight followed by average clove weight, number of cloves per bulb, plant height, clove length and dry matter content. The indirect contribution of these traits via each other indicated that if other factors are held constant, an increase in these traits will be reflected in an increased bulb weight. Equatorial bulb diameter, days to maturity and clove length had positive direct effects of low magnitude on bulb weight. However, their indirect effects via leaf breadth and average clove weight were positive and high. Negative direct effects were shown by leaf length, number of leaves per plant and clove diameter, nevertheless their respective association with bulb weight was positive and significant except leaf length but their indirect effects via leaf breadth and average clove weight were the major contributing factors. Polar bulb diameter exhibited positive direct effect of very low magnitude and considerable indirect effect via leaf breadth and average clove weight but it proved counter productive by negative indirect contribution via number of cloves per bulb and leaf length. Plant height had positive direct and indirect effects via leaf breadth, though it did not show significant positive correlation with bulb weight because of its negative indirect effects via leaf length and leaves per plant. The direct effect of dry matter content on bulb weight was positive through its association with bulb weight was negative. The contribution of residual factor accounting for all the characters (0.0042) was negligible. These results are in agreement with the findings of Srivastava *et al.* (1993), Selvaraj *et al.* (1997), Shaha and Kale (1999), Shridhar, (2002) and Naruka and Dhaka (2004). From the present study, it was inferred that among causal variables studied, the major contribution on bulb weight was provided by leaf breadth and average clove weight followed by equatorial bulb diameter, number of leaves per plant, clove length and clove diameter. Hence these traits are important for making effective selections for garlic improvement.

Table 2.Estimates of direct and indirect effects of different horticultural traits on bulb weight at phenotypic (P) and genotypic (G) levels

Character		Plant height (cm)	No. of leaves/ plant	Leaf length (cm)	Leaf breadth (cm)	Polar bulb diameter (cm)	Equatorial bulb diameter (cm)	No. of cloves/ bulb	Average clove wt. (g)	Clove length (cm)	Clove diameter (cm)	No. of bulbils/ plant	Av.wt. of bulbils/ plant (g)	Days to maturity	TSS (%)	Dry matter (%)	Correlation coefficient with bulb Wt.
Plant height	P	**0.001**	-0.017	-0.094	0.114	-0.005	0.073	0.041	-0.009	0.005	-0.005	-0.022	-0.027	-0.005	0.008	0.011	0.068
	G	**0.291**	-0.114	-0.471	0.272	0.017	0.014	0.038	-0.04	0.00	-0.007	-0.005	-0.101	0.048	0.021	-0.004	-0.042
No. of	P	0.00	**-0.056**	-0.048	0.336	-0.003	0.214	-0.073	0.358	0.054	-0.082	0.044	0.016	-0.009	-0.018	-0.038	0.695*
leaves/ pl.	G	0.094	**-0.351**	-0.264	0.905	0.013	0.102	-0.147	0.508	0.094	-0.109	0.01	0.057	0.08	-0.052	-0.136	0.804
Leaf length	P	0.001	-0.022	**-0.124**	0.24	-0.007	0.135	-0.073	0.165	0.053	-0.056	-0.003	-0.023	-0.011	-0.008	-0.011	0.256
	G	0.233	-0.157	**-0.59**	0.63	0.023	0.035	-0.183	0.24	0.09	-0.078	0.00	-0.081	0.11	-0.024	-0.06	0.188
Leaf breadth	P	0.00	-0.044	-0.069	**0.435**	-0.007	0.247	-0.194	0.485	0.095	-0.122	0.05	0.009	-0.013	-0.027	-0.051	0.796*
	G	0.075	-0.301	-0.352	**1.054**	0.021	0.101	-0.308	0.618	0.152	-0.147	0.01	0.03	0.107	-0.083	-0.161	0.816
Polar bulb	P	0.00	-0.011	-0.055	0.178	**-0.016**	0.132	-0.261	0.291	0.111	-0.108	-0.007	-0.039	-0.005	0.004	-0.006	0.208
diameter	G	0.101	-0.092	-0.278	0.459	**0.049**	0.032	-0.449	0.396	0.169	-0.138	-0.001	-0.131	0.043	0.006	-0.002	0.166
Equatorial	P	0.00	-0.037	-0.051	0.328	-0.007	**0.328**	-0.082	0.408	0.083	-0.087	0.043	0.02	-0.01	-0.016	-0.042	0.879*
bulb dia.	G	0.034	-0.308	-0.177	0.922	0.013	**0.116**	-0.202	0.604	0.135	-0.119	0.011	0.078	0.097	-0.062	-0.158	0.985
No. of	P	0.00	0.01	0.022	-0.201	0.01	-0.064	**0.419**	-0.479	-0.122	0.151	-0.02	0.027	0.005	0.004	0.012	-0.227
cloves./ bulb	G	0.019	0.088	0.185	-0.554	-0.038	-0.04	**0.586**	-0.602	-0.197	0.177	-0.004	0.085	-0.04	0.013	0.04	-0.28
Average	P	0.00	-0.032	-0.033	0.336	-0.008	0.213	-0.32	**0.628**	0.126	-0.157	0.049	0.006	-0.009	-0.019	-0.042	0.739*
clove wt.	G	-0.015	-0.232	-0.184	0.848	0.025	0.091	-0.459	**0.768**	0.194	-0.182	0.009	0.018	0.078	-0.059	-0.136	0.764
Clove length	P	0.00	-0.019	-0.042	0.266	-0.012	0.176	-0.328	0.506	**0.156**	-0.14	0.031	-0.01	-0.008	-0.011	-0.025	0.538*
	G	0.00	-0.147	-0.236	0.716	0.037	0.07	-0.516	0.666	**0.224**	-0.172	0.007	-0.032	0.072	-0.049	-0.079	0.561
Clove	P	0.00	-0.027	-0.04	0.311	-0.01	0.167	-0.37	0.574	0.127	**-0.171**	0.031	-0.015	-0.008	-0.013	-0.032	0.524*
diameter	G	0.00	-0.196	-0.234	0.794	0.035	0.071	-0.532	0.713	0.196	**-0.196**	0.006	-0.045	0.069	-0.04	-0.101	0.551
No. of	P	0.00	0.03	-0.004	-0.259	-0.001	-0.17	0.100	-0.367	-0.058	0.065	**-0.083**	-0.055	0.007	0.029	0.049	-0.717*
bulbils/ pl.	G	0.094	0.219	0.00	-0.675	0.003	-0.083	**0.141**	-0.466	-0.096	0.078	**-0.015**	-0.165	-0.057	0.087	0.153	-0.783
Av. wt. of	P	0.00	0.012	-0.037	-0.054	-0.008	-0.085	-0.149	-0.048	0.02	-0.033	-0.059	**-0.077**	0.002	0.025	0.041	0.450*
bulbils/ pl.	G	0.128	0.087	-0.209	-0.138	0.028	-0.039	-0.217	-0.06	0.031	-0.038	-0.011	**-0.23**	-0.013	0.076	0.128	-0.477
Days to	P	0.00	-0.026	-0.074	0.305	-0.004	0.179	-0.108	0.324	0.071	-0.079	0.031	0.007	**-0.018**	-0.022	-0.04	0.543*
maturity	G	0.096	-0.194	-0.449	0.781	0.015	0.078	-0.16	0.414	0.11	-0.094	0.006	0.021	**0.145**	-0.072	-0.129	0.569
TSS (%)	P	0.00	0.016	0.016	-0.179	-0.001	-0.079	0.024	-0.18	-0.026	0.033	-0.037	-0.029	0.006	**0.066**	0.061	-0.31
	G	0.035	0.108	0.082	-0.512	0.002	-0.042	0.046	-0.269	-0.064	0.046	-0.008	-0.103	-0.061	**0.17**	0.179	-0.392
Dry matter	P	0.00	0.025	0.016	-0.26	0.001	-0.162	0.057	-0.305	-0.045	0.063	-0.048	-0.037	0.008	0.047	**0.086**	-0.553*
(%)	G	-0.006	0.222	0.163	-0.791	-0.001	-0.085	0.109	-0.487	-0.082	0.092	-0.011	-0.137	-0.087	0.142	**0.215**	-0.744

Residual effect: P = 0.05999; G= 0.0042

* Significant at 5 per cent level, Bold values indicate direct effect.

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