The Pharma Innovation Journal 2022; 11(9): 1264-1266

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 1264-1266

www.thepharmajournal.com
Received: 02-07-2022
Accepted: 13-08-2022

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Study on correlation and path Co-efficient in garlic (*Allium sativum*)

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Abstract
An experiment was conducted to assess correlation and path analysis in 16 genotypes of garlic grown in Randomized Block Design at RRS NHRDF, Salaru, Karnal during rabi season of 2016-17 and 2017-18. Observations were recorded for sixteen characters and observed for plant establishment, plant stand at maturity, % marketable bulb (on wt. basis), gross yield (kg/plot), marketable yield (kg/plot), marketable yield (qt/ha), Average weight of bulb (g), weight of 20 bulbs, bulb polar diameter (cm), bulb equatorial diameter (cm), T.S.S (%), Average no of cloves per bulb at genotypic levels. Gross yield (qt/ha) showed highly significant and positive correlation with plant establishment (3.621) at genotypic level and whereas significant and positive correlation with gross yield (kg/plot) (1.000) at phenotypic level. At genotypic level, path coefficient analysis revealed that marketable yield (kg/plot) (2.835) and at phenotypic level, path coefficient analysis revealed that gross yield (kg/plot) (0.907) had exerted positive direct effect on gross yield (q/ha) that selection for these traits would be effective for the improvement of bulb yield per plant.

Keywords: Correlation & path analysis, Garlic

Introduction
Garlic (*Allium sativum* L.) is important bulb crops grown and used as a spice or a condiment throughout India. It is also an important foreign exchange gaining crop for India. Garlic has higher nutritive value than other bulb crops. India exports fresh and chilled garlic, dried garlic, dehydrated garlic flakes, dehydrated garlic powder and garlic oil to Bahrain, Bangladesh, Germany, Japan. It is rich in protein, phosphorus, potassium, calcium, magnesium and carbohydrates. It helps in digestion of food, reduces cholesterol level in human blood and lowers blood sugar. The significance of this spice is increasing owing to its wide range of medicinal properties (Chanchan *et al*., 2013) [1]. Garlic is mostly strong flavoured due to presence of sulphur containing compounds that impart their distinctive small and pungency. Garlic grown is mainly in Gujarat, Madhya Pradesh, Orissa, Maharashtra, Uttar Pradesh, and Rajasthan. Since, production and productivity does not depend only on area and cultural practices but also on the genotypes of the crop and environmental conditions (Lawande *et al*., 2009) [4]. The present study was conducted to investigate genetic variability, heritability and correlation coefficients and path coefficient of 16 diverse genotypes collected from different sources.

The germplasm serves as most valuable natural reservoir and main source of genes pool having resistance to several biotic and abiotic resistance. Therefore, collection, conservation and evaluation of germplasm is indispensable for present as well as future crop improvement.

Material and Methods
The experiment was conducted at experimental farm, RRS NHRDF Karnal, Salaru. During two consecutive year 2016-17 and 2017-18 rabi season. Sixteen genotypes were grown in a randomized block design with three replications. The raised beds were prepared with drip irrigation system for the planting of garlic germplasm. The drip irrigation was made between all plots. Each genotype was planted in a plot of 2.25 × 1.2 m size by keeping 15 × 10 cm distance between two rows and two plants, respectively. Recommended cultural practices were followed for raising the crop. Observations were recorded on Plant stand at maturity (PSM), % Plant establishment (PPE), Maximum height of plant (cm) (PH), No. of leaves (NOL), Neck thickness (cm) (N), Bulb equatorial diameter (cm) (E), Bulb polar diameter (cm) (P), Weight of 20 bulbs (kg) (WOB), Average weight of bulb (g) (ABW), Average number of cloves per bulb (NOC), Marketable yield (kg/plot) (MY), Marketable yield (qt/ha) (MY), % Marketable

bulb (On Wt. basis) (MBW), Total soluble solids (%) (TSS), Gross yield (kg/plot) (GY), gross yield (qt/ha) (GY) measured by the method proposed by Singh *et al*. (2013) [6] and recorded on five randomly selected plants in each replication per accession on plot basis. The data was statistically analysed to estimate genotypic and phenotypic correlation coefficients and path analysis. In addition to this, it is requisite to know the types and nature of yield components and their inter relationship. The correlation coefficient analysis gives information of the relative importance of various contributing characters.

Result and Discussion

Correlation coefficient

In general, the genotypic correlation coefficients were higher than the respective phenotypic correlations (Table 1) which might be from modifying effect of environment on the association of characters at genotypic level.

This indicated that these attributes were more influencing the bulb yield in garlic and therefore, were important for bringing improvement in bulb yield. Such positive interrelationships between bulb yield and plant height, number of leaves per plant, bulb polar diameter and bulb weight was noted by Singh *et al*. (2013) [6], Sharma *et al*. (2016) [7], Prajapati *et al*. (2016) [5].

Gross yield (qt/ha) showed highly significant and positive correlation with plant establishment (3.621), plant stand at maturity (3.546), % marketable bulb (on wt. basis) (1.009), gross yield (kg/plot) (1.00), marketable yield (kg/plot) (1.000), marketable yield (qt/ha) (1.000), Average weight of bulb (g) (0.973), weight of 20 bulbs (0.905), bulb polar diameter (cm) (0.460), bulb equatorial diameter (cm) (0.840), T.S.S (%) (0.491), Average no of cloves per bulb (0.381) at genotypic levels,

whereas significant and positive correlation with gross yield (kg/plot) (1.000), marketable yield (kg/plot) (0.999), marketable yield (qt/ha) (0.999), average weight of bulb (g) (0.944), weight of 20 bulbs (kg) (0.780), bulb equatorial diameter (cm) (0.533), plant stand at maturity (0.486), % plant establishment (0.486), bulb polar diameter (cm) (0.455), T.S.S (%) (0.354), Average no of cloves per bulb (0.383) with gross yield (qt/ha) at phenotypic level.

Table 1: Genotypic & phenotypic Correlations Matrix for different characters on bulb yield per plant at Phenotypic & Genotypic level in Garlic

		PSM	PPE	PH	NOL	N	E	P	WOB	ABW	NOC	GY (plot/kg)	MY (plot/kg)	MY (q/ha)	MBW	T.S.S (%)	GY (q/ha)
PSM	G	1															
	P	1															
PPE	G	1.000**	1														
	P	1.000**	1														
PH	G	-0.136NS	-0.138NS	1													
	P	-0.156NS	-0.155NS	1													
NOL	G	-0.635**	-0.649**	-0.086NS	1												
	P	-0.117NS	-0.116NS	-0.078NS	1												
N	G	-3.556**	-3.630**	0.101NS	0.381*	1											
	P	-0.231NS	-0.231NS	0.012NS	0.308NS	1											
E	G	0.727**	0.741**	-0.201NS	0.074NS	0.476**	1										
	P	0.401*	0.401*	-0.391*	0.114NS	0.288NS	1										
P	G	0.238NS	0.242NS	0.215NS	0.632**	0.375*	0.169NS	1									
	P	-0.013NS	-0.013NS	-0.057NS	0.650**	0.378*	0.268NS	1									
WOB	G	2.132**	2.179**	0.107NS	0.350*	0.449**	0.856**	0.520**	1								
	P	0.324NS	0.324NS	-0.055NS	0.459**	0.420*	0.738**	0.621**	1								
ABW	G	3.153**	3.221**	-0.055NS	0.257NS	0.348NS	0.874**	0.394*	0.949**	1							
	P	0.377*	0.377*	-0.078NS	0.346NS	0.289NS	0.663**	0.486**	0.874**	1							
NOC	G	3.530**	3.608**	-0.170NS	-0.488**	-0.034NS	0.438*	-0.378*	0.315NS	0.417*	1						
	P	0.382*	0.382*	-0.095NS	-0.302NS	-0.003NS	0.325NS	-0.217NS	0.341NS	0.429*	1						
GY (plot/kg)	G	3.547**	3.622**	-0.086NS	0.277NS	0.224NS	0.840**	0.460**	0.905**	0.973**	0.380*	1					
	P	0.486**	0.486**	-0.027NS	0.310NS	0.142NS	0.552**	0.455**	0.780**	0.944**	0.383*	1					
MY (plot/kg)	G	3.508**	3.582**	-0.086NS	0.281NS	0.223NS	0.841**	0.467**	0.906**	0.975**	0.381*	1.000**	1				
	P	0.482**	0.482**	-0.028NS	0.313NS	0.151NS	0.558**	0.464**	0.787**	0.946**	0.386*	0.999**	1				
MY (q/ha)	G	3.508**	3.582**	-0.085NS	0.281NS	0.223NS	0.840**	0.467**	0.906**	0.975**	0.381*	1.000**	1.000**	1			
	P	0.482**	0.482**	-0.028NS	0.313NS	0.151NS	0.558**	0.464**	0.787**	0.946**	0.386*	0.999**	1.000**	1			
MBW	G	-0.972**	-0.984**	-0.107NS	0.818**	-0.184NS	0.943**	1.520**	1.053**	1.138**	0.552**	1.009**	1.010**	1.010**	1		
	P	-0.080NS	-0.080NS	-0.023NS	0.068NS	0.251NS	0.166NS	0.268NS	0.215NS	0.095NS	0.118NS	0.029NS	0.064NS	0.063NS	1		
T.S.S (%)	G	3.768**	3.849**	0.156NS	-0.234NS	-0.864**	-0.537**	-0.794**	-0.608**	0.178NS	0.106NS	0.491**	0.473**	0.473**	-2.083**	1	
	P	0.160NS	0.160NS	-0.085NS	0.207NS	-0.253NS	-0.030NS	0.098NS	0.135NS	0.276NS	0.172NS	0.354*	0.355*	0.355*	0.040NS	1	
GY (q/ha)	G	3.546**	3.621**	-0.086NS	0.277NS	0.224NS	0.840**	0.460**	0.905**	0.973**	0.381*	1.000**	1.000**	1.000**	1.009**	0.491**	1
	P	0.486**	0.486**	-0.027NS	0.310NS	0.142NS	0.553**	0.455**	0.780**	0.944**	0.383*	1.000**	0.999**	0.999**	0.029NS	0.354*	1

*Significant at 5% probability level.

**Significant at 1% probability level.

Table 2: Direct and indirect effect for different characters on bulb yield per plant at Phenotypic & Genotypic level in Garlic

		PSM	PPE	PH	NOL	N	E	P	WOB	ABW	NOC	GY (plot/kg)	MY (plot/kg)	MY (q/ha)	MBW	T.S.S (%)
PSM	G	**0.286**	-0.2802	0.00011	0.00072	0.00636	-0.00072	-0.00037	0.00454	-0.01781	0.00022	-3.62992	9.94422	-2.77849	0.01253	-0.00146
	P	**0.212**	-0.2117	-0.00001	-0.00003	-0.00002	0.00007	0	-0.00009	-0.00006	0.00005	0.44101	0.05629	-0.01144	0.00024	-0.00001
PPE	G	0.28609	**-0.28**	0.00011	0.00073	0.00649	-0.00073	-0.00038	0.00464	-0.01819	0.00022	-3.70692	10.15531	-2.83747	0.01267	-0.00149
	P	0.212	**-0.212**	-0.00001	-0.00003	-0.00002	0.00007	0	-0.00009	-0.00006	0.00005	0.44096	0.05628	-0.01144	0.00024	-0.00001
PH	G	-0.0388	0.03873	**-0.001**	0.0001	-0.00018	0.0002	-0.00034	0.00023	0.00031	-0.00001	0.08799	-0.24253	0.06771	0.00138	-0.00006
	P	-0.033	0.03291	**0**	-0.00002	0	-0.00007	0.00001	0.00002	0.00001	-0.00001	-0.02436	-0.00321	0.00065	0.00007	0.00001
NOL	G	-0.1815	0.18174	0.00007	**-0.001**	-0.00068	-0.00007	-0.001	0.00074	-0.00145	-0.00003	-0.28385	0.79795	-0.22294	-0.01054	0.00009
	P	-0.0247	0.02465	0	**0**	0.00002	0.00002	-0.00013	-0.00013	-0.00005	-0.00004	0.28151	0.03652	-0.00742	-0.0002	-0.00002
N	G	-1.017	1.0168	-0.00008	-0.00043	**-0.002**	-0.00047	-0.00059	0.00096	-0.00197	0	-0.22936	0.63158	-0.17634	0.00237	0.00033
	P	-0.049	0.04884	0	0.00007	**0**	0.00005	-0.00007	-0.00012	-0.00004	0	0.12904	0.01768	-0.00359	-0.00075	0.00002
E	G	0.20783	-0.2077	0.00016	-0.00008	-0.00085	**-0.001**	-0.00027	0.00182	-0.00494	0.00003	-0.85989	2.38266	-0.66563	-0.01215	0.00021
	P	0.08507	-0.085	-0.00002	0.00003	0.00002	**0**	-0.00005	-0.00021	-0.0001	0.00004	0.50125	0.06509	-0.01322	-0.0005	0
P	G	0.06794	-0.0677	-0.00017	-0.00072	-0.00067	-0.00017	**-0.002**	0.00111	-0.00223	-0.00002	-0.47058	1.32369	-0.36986	-0.01958	0.00031
	P	-0.0027	0.00266	0	0.00015	0.00003	0.00005	**0**	-0.00018	-0.00007	-0.00003	0.41253	0.05412	-0.01099	-0.00081	-0.00001
WOB	G	0.60981	-0.6103	-0.00008	-0.0004	-0.0008	-0.00084	-0.00082	**0.002**	-0.00536	0.00002	-0.92625	2.56899	-0.71774	-0.01357	0.00024
	P	0.06872	-0.0687	0	0.0001	0.00003	0.00014	-0.00012	**0**	-0.00013	0.00004	0.70771	0.09181	-0.01865	-0.00065	-0.00001
ABW	G	0.90174	-0.9022	0.00004	-0.00029	-0.00062	-0.00086	-0.00062	0.00202	**-0.006**	0.00003	-0.99618	2.7627	-0.77195	-0.01466	-0.00007
	P	0.07995	-0.0799	0	0.00008	0.00002	0.00012	-0.00009	-0.00025	**0**	0.00005	0.85628	0.11037	-0.02242	-0.00028	-0.00002
NOC	G	1.00979	-1.0109	0.00013	0.00055	0.00006	-0.00043	0.0006	0.00067	-0.00236	**0**	-0.3894	1.08099	-0.30203	-0.00711	-0.00004
	P	0.08094	-0.0809	0	-0.00007	0	0.00006	0.00004	-0.0001	-0.00006	**0**	0.34735	0.04505	-0.00915	-0.00035	-0.00001
GY (plot/kg)	G	1.01446	-1.0147	0.00007	-0.00031	-0.0004	-0.00083	-0.00073	0.00193	-0.0055	0.00002	**-1.023**	2.83476	-0.79213	-0.013	-0.00019
	P	0.10305	-0.1029	0	0.00007	0.00001	0.0001	-0.00009	-0.00022	-0.00014	0.00005	**0.907**	0.11663	-0.0237	-0.00009	-0.00003
MY (plot/kg)	G	1.00334	-1.0036	0.00007	-0.00032	-0.0004	-0.00083	-0.00074	0.00193	-0.00551	0.00002	-1.02343	**2.835**	-0.79214	-0.01302	-0.00018
	P	0.10225	-0.1021	0	0.00007	0.00001	0.0001	-0.00009	-0.00022	-0.00014	0.00005	0.90671	**0.117**	-0.02371	-0.00019	-0.00003
MY (q/ha)	G	1.00324	-1.0035	0.00007	-0.00032	-0.0004	-0.00083	-0.00074	0.00193	-0.00551	0.00002	-1.02343	2.83478	**-0.792**	-0.01302	-0.00018
	P	0.10229	-0.1021	0	0.00007	0.00001	0.0001	-0.00009	-0.00022	-0.00014	0.00005	0.90672	0.1167	**-0.024**	-0.00019	-0.00003
MBW	G	-0.2781	0.27556	0.00008	-0.00092	0.00033	-0.00093	-0.0024	0.00224	-0.00643	0.00003	-1.0329	2.86438	-0.80024	**-0.013**	0.00081
	P	-0.017	0.01692	0	0.00002	0.00002	0.00003	-0.00005	-0.00006	-0.00001	0.00001	0.02663	0.00743	-0.0015	**-0.003**	0
T.S.S (%)	G	1.07782	-1.0782	-0.00012	0.00026	0.00155	0.00053	0.00125	-0.0013	-0.00101	0.00001	-0.50252	1.3412	-0.37489	0.02684	**0**
	P	0.03391	-0.0338	0	0.00005	-0.00002	-0.00001	-0.00002	-0.00004	-0.00004	0.00002	0.32099	0.04137	-0.00841	-0.00012	**0**

Residual are 0.00000

Path coefficient analysis

At genotypic level, path coefficient analysis revealed that marketable yield (kg/plot) (2.835), plant stand at maturity (0.286), weight of 20 bulb (kg) (0.002) had exerted positive direct effect on gross yield (qt/ha). Gross yield (kg/plot) (-1.023), marketable yield (qt/ha) (-0.792), % plant establishment (-0.280), % marketable bulb (on wt. basis) (-0.013), Average weight of bulb (g) (-0.006), bulb polar diameter (cm) (-0.002), Neck thickness (cm) (-0.002), No. of leaves (-0.001), Maximum height of plant (cm) (-0.001), bulb equatorial diameter (cm) (-0.001) exhibited negative direct effect on gross yield (qt/ha).

At phenotypic level, path coefficient analysis revealed that gross yield (kg/plot) (0.907), plant stand at maturity (0.212), marketable yield (kg/plot) (0.117) had exerted positive direct effect on gross yield (qt/ha). % plant establishment (-0.212), Marketable yield (qt/ha) (-0.024), % Marketable bulb (on wt. basis) (-0.003) exhibited negative direct effect on gross yield (qt/ha). Dubey *et al*. (2010) [2] also reported similar correlation between bulb yield with bulb weight and bulb size. Direct effect of clove weight and number of leaves per plant on bulb yield was noted by Kumar *et al*. (2015) [3].

Conclusion

On the basis of above studies, it can be concluded that due weightage should be given to bulb yield, bulb weight and average number of cloves per bulb while imposing selection for genetic improvement of bulb yield in garlic.

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