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Character association studies in pea (*Pisum sativum* L.)

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Abstract
The character association study was carried out during Rabi 2021-22 in the College of Agriculture and Research Station Chhuikhadan, IGKV Raipur among yield and yield components. The green pod yield showed positive and significant correlation with germination percentage, plant height, number of nodes/plant, number of flowers/plant, number of flower clusters/plant, number of pods/cluster, seed diameter, fresh 100 seed weight, fresh pod weight/plant, days to 50% flowering, harvest index and shelling percentage at genotypic and phenotypic level, whereas green pod yield showed significant negative association with pod length and number of seeds/pod at genotypic and phenotypic level. In path coefficient analysis revealed that the characters germination percentage, number of nodes/plant, number of flowers/plant, number of flowers cluster/plant, number of pods/cluster, number of seeds/pod, fresh 100 seed weight (gm), fresh pod weight/plant (gm) and 50% flowering (days) exhibited maximum positive direct effect on fresh pods yield and negative direct effect was followed by plant height (cm), number of flowers/cluster, pod length (cm), number of pods/plant, seed diameter (mm), dry 100 seed weight (gm), 1st flowering (days), stover weight (gm), harvest index (%) and shelling percentage.

Keywords: Pea, correlation, character association, path coefficient

Introduction
Pea (*Pisum sativum* L) is an important leguminous vegetable crop grown for its tender pods. It is grown as a winter vegetable in the plains of Chhattisgarh. It is a great crop and has great commercial value due to its rich nutritional quality. Yield is a complex variable and depends on a large number of factors and their interaction to increase the yield. Hence, association studies provide information between any two characters. Correlation studies help in the evaluation of the relationship between yield and its traits. By path analysis, we can determine the traits that have the greatest impact on pea yield which allows the division into direct and indirect effects of the independent variable on the dependent variable while stating the relative importance of each factor. It is widely used to identify traits that have a significant impact on yield for potential used in evaluation. (Akkinolla and Owombo 2012) [1].

Materials and Methods
The experiment was conducted in a randomized block design (RBD) design with four replications during 2021-22 in Instructional Farm, College of Agriculture and Research Station Chhuikhadan, KCG, Chhattisgarh. All recommended agricultural practices were followed to grow a healthy crop. Path coefficient study described by Wright (1921) [12] and Dewey and Lu (1959) [4]. Correlation studies at genotypic and phenotypic level was suggested by Al-Jibourie *et al.* (1958) [2].

Table 1: Twelve genotypes collected from various places of Chhattisgarh state

Treatment	Pea genotypes	Place of collection
T_1	IGP – 1	Rajnandgoan
T_2	IGP – 2	Rajnandgoan
T_3	IGP – 3	Mahsamund
T_4	IGP – 4	Bilaspur
T_5	IGP – 5	Janjgir-Champa
T_6	IGP – 6	Jagdalpur
T_7	IGP – 7	Khairagarh
T_8	IGP – 8	Raipur
T_9	IGP – 9	Durg
T_{10}	IGP – 10	Dhamtari
T_{11}	IGP – 11	Chhuhikhadan
T_{12}	IGP – 12	Arkel (Check variety)

Results and Discussion

The present experiment revealed that the genotypic correlation coefficients were higher than phenotypic correlation coefficients for most of the traits (Table 2), suggesting, therefore, there is a strong genetic relationship between different attributes. Similar studies were also reported by Singh (2007) [10] and indicated less influence of environment and the main role of genetic factors in the expression of traits. Green pod yield showed positive and significant association with germination percentage, plant height, number of nodes/plant, number of flowers/plant, number of flower clusters/plant, number of pods/cluster, seed diameter, fresh 100 seed weight, fresh pod weight/plant, days to 50% flowering, harvest index and shelling percentage at genotypic and phenotypic level, whereas green pod yield showed significant negative association with pod length and number of seeds/pod at genotypic and phenotypic level. This indicates that these traits can be considered as criteria for selection of high yielding pea genotypes. Similar observation has been reported by Patel *et al.* (2006) [9].

Table 1 exhibited that the germination percentage was positively correlated with number of pods per cluster and number of pods per plant as reported by the findings of Basaiwala *et al.* (2013) [13]. On other hand, plant height was positively associated with stover weight, days to 50% flowering and fresh pod weight per plant at both levels (genotypic and phenotypic). Kumawat *et al.* (2018) [7] and Singh *et al.* (2019) [11] also made similar comments.

Number of flowers per plant exhibited positive association with the number of flowers per cluster and number of flower clusters per plant at genotypic and phenotypic levels. A similar finding was previously reported by Yenda *et al.* (2018) [14]. Number of flower clusters per plant showed positive association with fresh pod weight per plant and fresh pod yield at genotypic and phenotypic levels. On the other hand, the number of pods per cluster significantly positively correlated with fresh pod weight per plant, fresh pod yield and stover weight at both levels (genotypic and phenotypic). A similar result was also reported by Lal *et al.* (2011) [8].

Pod length exhibited positive association with number of seeds per pod, shelling percentage and harvest index at both genotypic and phenotypic level. Whereas number of pods per plant exhibited positive association with stover weight and harvest index at genotypic and phenotypic level respectively. Similar findings were also observed by Kumawat *et al.* (2018) [7]. Seed diameter had a positive association with fresh 100 seed weight, dry 100 seed weight, harvest index, fresh pod weight per plant, fresh pod yield, stover weight and days to 50% flowering. Similar studies were also made by Singh *et al.* (2019) [11].

Days to 1st flowering showed a positive association with days to 50% flowering and stover weight under study, while days to 50% flowering expressed a positive association with stover weight and harvest index. Further stover weight was positively associated with fresh pod yield and harvest index under study, whereas harvest index expressed positive association with shelling percentage and fresh pod yield at both genotypic and phenotypic levels. Shelling percentage also observed positive association with fresh pod yield at both the levels (genotypic and phenotypic). Similar findings were also obtained by Singh *et al.* (2019) [11] and Gautam *et al.* (2017) [5].

The results of the present study with respect to direct and indirect effects on fresh pod yield are presented in Table 3. Path analysis provides better insight into the cause of the association. This allows correlation coefficients to be divided into direct and indirect effects of traits that contribute to the dependent variable. The Path analysis revealed that the highest positive direct effect contributing to fresh pod yield was noted due to fresh pod weight per plant, fresh 100 seed weight number of flowers per plant, number of pods per cluster and number of seeds per pod. This shows that if other factors are held constant, increases in these traits individually will be reflected in increased pod yield, indicating that these are the main contributors to green pod yield/plant. Whereas dry 100 seed weight, number of flowers per cluster and number of pods per plant showed negative direct effect on yield per plant.

The maximum positive direct effect of germination percentage (0.00006) was noted for fresh pod yield, number of pods per cluster, pod length and number of pods per plant and days to 1st flowering. Similar result was also reported by Bjjalwan *et al.* (2018) [3] and Gupta *et al.* (2017) [6]. On otherhand, number of flowers per plant (0.00129) exhibited maximum positive direct effect for fresh pod yield and higher positive indirect effect contributing to fresh pod yield was observed due to number of flowers per cluster followed by number of flower cluster per plant and number of pods per plant.

Number of flower clusters per plant and number of pods per cluster showed positive direct effect for fresh pod yield, whereas number of pods per plant had negative direct effect on fresh pod yield and maximum positive indirect effect was observed via fresh 100 seed weight, dry 100 seed weight and number of seeds per pod. Similar findings were also reported earlier by Bijalwan *et al.* (2018) [3]. Number of seeds per plant had shown positive direct effect on fresh pod yield and higher maximum positive indirect effect was observed via pod length followed by shelling percentage and harvest index under study. Similar finding was earlier reported by Kumawat *et al.* (2018) [7] and Gupta *et al.* (2017) [6].

Fresh 100 seed weight of pods expressed a positive direct effect on fresh pod yield and maximum positive indirect effect was reported by dry 100 seed weight followed by seed diameter and number of nodes per plant. On other hand, dry 100 seed weight of pods exhibited a negative direct effect on fresh pod yield. Stover weight, harvest index and shelling percentage recorded a negative direct effect on the fresh pod yield. Similar results were also reported by Singh *et al.* (2019) [11] and Patel *et al.* (2006) [9].

Table 2: Correlation coefficients among various pod yield traits in pea

		PH	NPP	FPP	FPC	FCPP	PPC	PL	PPP	SPP	SD	FHSW	DHSW	FPWPP	DFF	DFFL	SW	HI	SP	FPY
GP	P	0.202	-0.091	0.147	0.024	0.236	0.211	0.118	0.273	-0.122	-0.228	-0.276	-0.258	0.143	0.051	0.196	0.209	-0.125	-0.107	0.143
	G	0.332*	-0.220	0.250	0.149	0.352*	0.772**	0.051	0.541**	-0.109	-0.542**	-0.367*	-0.342*	0.193	0.027	0.251	0.263	-0.227	0.049	0.193
PH	P		0.481**	0.404**	0.172	0.448**	0.194	-0.582**	0.452**	-0.523**	0.177	0.299*	0.364*	0.700**	0.468**	0.648**	0.771**	0.196	-0.296*	0.700**
	G		0.643**	0.457**	0.223	0.561**	0.309*	-0.643**	0.542**	-0.543**	0.259	0.317*	0.385**	0.726**	0.612**	0.861**	0.863**	0.242	-0.382**	0.726**
NPP	P			0.094	0.101	-0.002	0.027	-0.572**	0.055	-0.553**	0.407**	0.681**	0.706**	0.520**	0.320*	0.399**	0.562**	0.286*	-0.168	0.520**
	G			0.207	0.202	0.084	0.038	-0.735**	0.126	-0.672**	0.591**	0.808**	0.839**	0.659**	0.563**	0.623**	0.709**	0.427**	-0.247	0.659**
FPP	P				0.848**	0.812**	0.705**	-0.205	0.875**	-0.225	-0.227	-0.088	-0.071	0.650**	0.092	0.242	0.514**	0.159	0.117	0.650**
	G				0.944**	0.909**	0.897**	-0.260	0.904**	-0.276	-0.457**	-0.101	-0.080	0.778**	0.307*	0.576**	0.685**	0.219	-0.086	0.778**
FPC	P					0.387**	0.710**	-0.224	0.582**	-0.306*	-0.322*	-0.103	-0.098	0.438**	0.105	0.167	0.425**	-0.072	-0.042	0.437**
	G					0.726**	0.726**	-0.341*	0.713**	-0.419**	-0.571**	-0.150	-0.142	0.599**	0.441**	0.541**	0.619**	-0.011	-0.262	0.599**
FCPP	P						0.507**	-0.044	0.913**	0.015	-0.080	-0.081	-0.061	0.630**	-0.012	0.180	0.372**	0.381**	0.325*	0.630**
	G						0.980**	-0.015	0.997**	0.025	-0.307*	-0.084	-0.058	0.823**	0.002	0.437**	0.568**	0.463**	0.227	0.823**
PPC	P							0.025	0.806**	0.015	-0.276	-0.173	-0.163	0.455**	-0.077	0.049	0.325*	0.136	0.364*	0.455**
	G							0.087	0.984**	-0.017	-0.699**	-0.319*	-0.299*	0.726**	0.177	0.499**	0.577**	0.367*	0.168	0.726**
PL	P								-0.061NS	0.830**	-0.189	-0.424**	-0.466**	-0.392**	-0.613**	-0.609**	-0.681**	0.004	0.547**	-0.392**
	G								-0.031	0.927**	-0.279	-0.452**	-0.499**	-0.435**	-0.911**	-0.866**	-0.789**	0.059	0.794**	-0.435**
PPP	P									-0.023	-0.157	-0.109	-0.086	0.661**	-0.001	0.191	0.452**	0.312*	0.362*	0.661**
	G									-0.039	-0.427**	-0.142	-0.112	0.824**	0.123	0.525**	0.631**	0.438**	0.160	0.824**
SPP	P										-0.179	-0.453**	-0.485**	-0.386**	-0.587**	-0.627**	-0.625**	0.196	0.623**	-0.386**
	G										-0.222	-0.471**	-0.503**	-0.407**	-0.801**	-0.793**	-0.707**	0.250	0.725**	-0.407**
SD	P											0.670**	0.668**	0.214	0.043	0.044	0.005	0.310*	0.100	0.214
	G											0.888**	0.887**	0.235	-0.089	-0.005	0.017	0.404**	0.028	0.235
FHSW	P												0.997**	0.376**	0.083	0.191	0.192	0.403**	0.135	0.376**
	G												0.997**	0.395**	0.095	0.243	0.221	0.494**	0.108	0.395**
DHSW	P													0.408**	0.129	0.245	0.249	0.407**	0.097	0.408**
	G													0.427**	0.162	0.315*	0.283	0.500**	0.064	0.427**
FPWPP	P														0.260	0.479**	0.728**	0.466**	0.012	0.912**
	G														0.337*	0.636**	0.826**	0.563**	0.016	0.980**
DFF	P															0.840**	0.592**	-0.100	-0.571**	0.260
	G															0.922**	0.862**	-0.162	-0.888**	0.337*
DFFL	P																0.735**	0.063	-0.481**	0.479**
	G																0.949**	0.045	-0.593**	0.636**
SW	P																	0.156	-0.424**	0.728**
	G																	0.230	-0.517**	0.826**
HI	P																		0.502**	0.466**
	G																		0.681**	0.563**
SP	P																			0.012
	G																			0.016

*5% level of significance, **1% level of significance

GP= Germination percentage SD= Seed diameter (mm) PH= Plant height (cm) SPP = No. of seeds / pod FPP= No of flower / plant

NPP= No. of nodes/ plant FHSW= Fresh 100 seed weight (gm) PPC= No. of pod /cluster DHSW= Dry 100 seed weight (gm FPC = No of flower/ cluster

PPP = No. of pod /plant FPWPP = Fresh pod weight / plant (gm) FCPP= No of flower cluster per plant DFF=Days to 1st flowering FPWPP = Fresh pod yield (qt./ ha)

PL= Pod length (cm) SW = Stover weight (gm) DFFL= Days to 50% flowering

HI =Harvest index (%) SP= Shelling percentage

Table 3: Path coefficient analysis on various pod yield traits in pea

	GP	PH	NPP	FPP	FPC	FCPP	PPC	PL	PPP	SPP	SD	FHSW	DHSW	FPWPP	DFF	DFFL	SW	HI	SP	GCCFPY
GP	0.00006	-0.00002	-0.00007	0.00032	-0.00014	0.00002	0.00049	-0.00002	-0.00051	-0.00005	0.00003	-0.00054	0.00046	0.19297	0.00002	0.00004	-0.0001	0.00004	-0.00001	0.193
PH	0.00002	-0.00006	0.00021	0.00059	-0.00022	0.00003	0.0002	0.00023	-0.00051	-0.00026	-0.00002	0.00046	-0.00051	0.72624	-0.00004	0.00015	-0.00033	-0.00005	0.00009	0.726**
NPP	-0.00001	-0.00004	0.00032	0.00027	-0.0002	0.00003	0.00002	0.00026	-0.00012	-0.00032	-0.00003	0.00118	-0.00112	0.65863	-0.00004	0.00011	-0.00027	-0.00008	0.00006	0.659**
FPP	0.00002	-0.00003	0.00007	0.00129	-0.00091	0.00004	0.00057	0.00009	-0.00085	-0.00013	0.00003	-0.00015	0.00011	0.7778	-0.00002	0.0001	-0.00026	-0.00004	0.00002	0.778**
FPC	0.00001	-0.00001	0.00007	0.00122	-0.00097	0.00004	0.00046	0.00012	-0.00067	-0.0002	0.00003	-0.00022	0.00019	0.59936	-0.00003	0.0001	-0.00024	0.00003	0.00006	0.599**
FCPP	0.00002	-0.00003	0.00003	0.00117	-0.0007	0.00005	0.00062	0.00001	-0.00093	0.00001	0.00002	-0.00012	0.00008	0.82323	0.00003	0.00008	-0.00022	-0.00009	-0.00005	0.823**
PPC	0.00005	-0.00002	0.00001	0.00115	-0.0007	0.00004	0.00063	-0.00003	-0.00092	-0.00001	0.00004	-0.00047	0.0004	0.72611	-0.00001	0.00009	-0.00022	-0.00007	-0.00004	0.726**
PL	0.00004	0.00004	-0.00024	-0.00033	0.00033	0.00003	0.00006	-0.00035	0.00003	0.00044	0.00002	-0.00066	0.00067	-0.43493	0.00006	-0.00015	0.0003	-0.00001	-0.00019	-0.435**
PPP	0.00003	-0.00003	0.00004	0.00116	-0.00069	0.00004	0.00062	0.00001	-0.00094	-0.00002	0.00003	-0.00021	0.00015	0.82431	-0.00001	0.00009	-0.00024	-0.00008	-0.00004	0.824**
SPP	-0.00001	0.00003	-0.00022	-0.00036	0.00041	0.00003	-0.00001	-0.00033	0.00004	0.00048	0.00001	-0.00069	0.00067	-0.40724	0.00006	-0.00014	0.00027	-0.00005	-0.00017	-0.407**
SD	-0.00003	-0.00001	0.00019	-0.00059	0.00055	-0.00001	-0.00044	0.0001	0.0004	-0.00011	-0.00006	0.00129	-0.00118	0.23518	0.00001	0.00003	-0.00001	-0.00008	-0.00001	0.235
FHSW	-0.00002	-0.00002	0.00026	-0.00013	0.00015	0.00003	-0.0002	0.00016	0.00013	-0.00022	-0.00005	0.00146	-0.00133	0.39463	-0.00001	0.00004	-0.00008	-0.00009	-0.00003	0.395**
DHSW	-0.00002	-0.00002	0.00027	-0.0001	0.00014	0.00003	-0.00019	0.00018	0.00011	-0.00024	-0.00005	0.00145	-0.00134	0.42663	-0.00001	0.00006	-0.00011	-0.00009	-0.00002	0.427**
FPWPP	0.00001	-0.00004	0.00021	0.0001	-0.00058	0.00004	0.00046	0.00015	-0.00077	-0.00019	-0.00001	0.00058	-0.00057	1.00006	-0.00002	0.00011	-0.00032	-0.00011	0.00003	0.980**
DFF	0.00003	-0.00003	0.00018	0.00039	-0.00043	0.00003	0.00011	0.00032	-0.00012	-0.00038	0.00001	0.00014	-0.00022	0.33715	-0.00007	0.00016	-0.00033	0.00003	0.00021	0.337*
DFFL	0.00002	-0.00005	0.0002	0.00074	-0.00052	0.00002	0.00032	0.0003	-0.00049	-0.00038	0.00003	0.00035	-0.00042	0.63622	-0.00007	0.00018	-0.00036	-0.00001	0.00014	0.636**
SW	0.00002	-0.00005	0.00023	0.00088	-0.0006	0.00003	0.00037	0.00028	-0.00059	-0.00034	0.00003	0.00032	-0.00038	0.82628	-0.00006	0.00017	-0.00038	-0.00004	0.00012	0.826**
HI	-0.00001	-0.00001	0.00014	0.00028	0.00001	0.00002	0.00023	-0.00002	-0.00041	0.00012	-0.00002	0.00072	-0.00067	0.56325	0.00001	0.00001	-0.00009	-0.00019	-0.00016	0.563**
SP	0.00002	0.00002	-0.00008	-0.00011	0.00025	0.00001	0.00011	-0.00028	-0.00015	0.00035	0.00001	0.00016	-0.00009	0.01569	0.00006	-0.0001	0.0002	-0.00013	-0.00024	0.016

Residual value: 0.00036 Diagonal and bold underline figures shows direct effect on fresh pod yield.
GP= Germination percentage SD= Seed diameter (mm) PH= Plant height (cm) SPP = No. of seeds / pod FPP= No of flower / plant
NPP= No. of nodes/ plant FHSW= Fresh 100 seed weight (gm) PPC= No. of pod /cluster DHSW= Dry 100 seed weight (gm FPC = No of flower/ cluster
PPP = No. of pod /plant FPWPP = Fresh pod weight / plant (gm) FCPP= No of flower cluster per plant DFF=Days to 1st flowering FPWPP = Fresh pod yield (qt./ ha)
PL= Pod length (cm) SW = Stover weight (gm) DFFL= Days to 50% flowering
HI =Harvest index (%) SP= Shelling percentage

Conclusion

Green pod yield showed positive and significant assocaition with germination percentage, plant height, number of nodes/plant, number of flowers/plant, number of flower clusters/plant, number of pods/cluster, seed diameter, fresh 100 seed weight, fresh pod weight/plant, days to 50% flowering, harvest index and shelling percentage at both genotypic and phenotypic level, whereas green pod yield showed significant negative association with pod length and number of seeds/pod at genotypic and phenotypic level. Association analysis revealed that selection criteria based on these traits may provide better results for improving pod yield and quality in pea.

The path coefficient study revealed that positive direct effect on fresh pod yield, germination percentage, number of nodes/plant, number of flowers/plant, number of flower clusters/plant, number of pods/cluster, number of seeds/pod, fresh 100 seed weight, fresh pod weight/plant and days to 50% flowering. However, a negative direct effect on fresh pod yield was observed by plant height, number of flowers/cluster, pod length, number of pods/plant, seed diameter, dry 100 seed weight, days to 1st flowering, stover weight, harvest index and shelling percentage. The path analysis study indicated that the direct selection of these attributes could be used as selection criteria for improvement.

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