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Character Association and Path Analysis in Heterotic Recombinant Inbred Lines in Garden Pea (*Pisum sativum* L.)

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ABSTRACT

Background: Garden pea is one of the principal vegetable crops cultivated in the temperate and sub- tropical areas of the world for its green pods. It is an important food legume worldwide after *Phaseolus vulgaris*. The knowledge about the interdependence of characters in a particular crop can effectively be employed to breed desirable cultivars and to challenge the consequences of the unprecedented biological, physical and chemical stresses of the future growing conditions. The regression and path analysis further has significance for the assured selection of the varieties with desirable traits and hence adaptation of species in different agro-climatic conditions; hence it is also one of the prerequisites for crop improvement programmes. Correlation and path analysis in garden pea explained that among all the yield contributing traits, number of pods per plant and pod weight have significant contribution in increasing the green pod yield per plant.

Methods: 14 heterotic recombinant inbred lines and 17 existing cultivars of garden pea, were put to experimentation for working out the association of the yield and yield contributing component characters under the open field conditions of Regional Horticultural Research and Training Station, Bajaura Kullu, Himachal Pradesh, India. This association was further elaborated through the coefficient of correlation and regression analysis and path coefficient analysis.

Result: The genotypic correlation coefficients were found higher than the phenotypic correlation coefficients for all the characters studied. The correlation coefficients revealed that green pod yield per plant had highly significant and positive association with pod weight and number of pods per plant. The path coefficient analysis also revealed that the maximum positive direct effect on green pod yield per plant was exerted by the number of pods per plant, pod weight and 100-seed weight. Through regression equation analysis it became clear that number of pods per plant, pod weight contributed significantly in increasing the green pod yield per plant. With a unit increase in these independent characters, the green pod yield per plant will increase by 2.34 and 33.45 per cent. It can thus be concluded that despite of the positive correlation of almost all the characters with green pod yield per plant, only number of pods per plant and pod weight are important and significant independent characters for increasing the green pod yield per plant.

Key words: Cefficient, Genetic correlation, *Pisum sativum*, Variance.

INTRODUCTION

Garden pea (*Pisum sativum* L.) an important crop of Leguminosae family, is commercially grown in *Rabi season* in the Northern plains of India for its immature succulent green pods, which are highly nutritive containing high percentage of digestible proteins (Burstin *et al*., 2011). Garden peas occupies an area of 540 thousand hectares with the production of 5422 thousand MT in India (NHB, 2018). However, due to the narrow genetic base of the crop and inclination of the farmers towards the specific characters, the variability of the germplasm has decreased. So, it is necessary to maintain and assess the available germplasm of pea for selecting high yielding genotypes which can be approved as such for commercial production or can be involved in the future breeding programmes for the improvement in yield and quality traits. Therefore, the association of characters with pod yield is an important factor for crop improvement programme for selecting high yielding genotypes. Like in other leguminous crops, pod yield in pea is a very complex character and depends upon many simply inherited component characters. Therefore, in order to improve pod yield, the association of yield contributing characters plays a vital role and this association of the characters can be known through correlation studies. Through these studies the breeding objectives can be easily achieved and it makes the association of the characters with yield clear. This association can further be quantified through regression analysis, which predicts the actual dependence of the dependent character. Similarly, the path coefficient analysis further provides the clarity of the relative importance of direct and indirect effects of each component

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character on yield. The correlation and regression analysis become more complex, when number of variables involved are large; hence, under these circumstances path coefficient analysis helps in partitioning of the correlation into direct and indirect effects. Therefore, garden pea having a very specific climatic requirement and being a very important crop for the hilly states like Himachal Pradesh needs to be fully interpreted on the basis of correlation regression and path coefficient analysis for identification of the desirable component characters for bringing out improvement in pod yield per plant.

MATERIALS AND METHODS

The plant genetic material

Fourteen (14) recombinants lines of the heterotic F_1's developed during 2005-06 alongwith seventeen (17) existing varieties/genotypes, including a check variety (PB-89), were assessed for correlation and path coefficients.

The field evaluation and data collection

The field experiment was carried out at Regional Horticultural Research and Training Station, Bajaura-Kullu, Himachal Pradesh, during *Rabi* seasons of 2018-19 and 2019-20. An experiment was conducted in randomized complete block design (RCBD) with 3 replications, at a spacing of 60cm x 7.5 cm, in a plot size of 2.5 m x 1.5 m consisting of 83 plants per plot. Observations were recorded on days to 50 per cent flowering, node number bearing first flower, days to marketable maturity, plant height, number of pods per plant, pod length (cm), pod weight (g), number of seeds per pod, shelling percentage, green pod yield per plant (g), seed yield per plant (g) and 100- seed weight (g). Data on green pod yield and 50 per cent flowering was recorded on plot basis and randomly selected 10 plants from each replication were used for recording plant height, number of pods per plant and pod length. The mean data for each character was analyzed as per Gomez and Gomez (1984), while the genotypic and phenotypic coefficients of correlation and regression analysis was done as per Al Jibouri *et al.* (1958). The genotypic and phenotypic correlation coefficients were partitioned into direct and indirect effects as per the methods of Dewey and Lu (1959).

The multiple regression equation on pod yield per plant (Y), considering the characters *viz.*, days to 50 per cent flowering (X_1), node number bearing first flower (X_2), days to marketable maturity (X_3), plant height (X_4), number of pods per plant (X_5), pod length (X_6), pod weight (X_7), number of seeds per pod (X_8), shelling percentage (X_9), seed yield per plant (X_{10}) and 100- seed weight (X_{11}) was as under.

$$Y= -145.71- 0.03X_1 \pm 0.31 - 0.95X_2 \pm 0.65 + 0.46X_3 \pm 0.23 +0.08X_4 \pm 0.08 +1.63X_5 \pm 0.64 - 0.09X_6 \pm 2.84 + 32.85X_7 \pm 4.41 + 1.16X_8 \pm 3.15 + 0.08X_9 \pm 0.41 + 0.50X_{10} \pm 0.19 - 1.06X_{11} \pm 0.62$$

The partial regression coefficients when tested for their significance showed that only days to marketable maturity (b_3), number of pods per plant (b_5), pod weight (b_7) and seed yield per plant (b_{10}) were significant.

When only those independent characters were considered which were significant with pod yield per plant, the multiple regression equation was as follows.

$$Y= -125.55+ 0.23X_3 \pm 0.15 + 1.97X_5 \pm 0.44 + 31.98X_7 \pm 3.90+ 0.30X_{10} \pm 0.12$$

On further evaluation of the component characters for significance with the pod yield per plant, only number of pods per plant (b_5), pod weight (b_7) and seed yield per plant (b_{10}) showed significant contribution for green pod yield per plant (Y). So, the regression equation was as follows;

$$Y= -87.24+ 2.21X_5 \pm 0.41 + 30.03X_7 \pm 3.73 + 0.29X_{10} \pm 0.12$$

When the characters were again evaluated for the significance, only number of pods per plant (b_5), pod weight (b_7) was found significant for increasing the green pod yield per plant (Y). So, the final regression equation was as under.

$$Y= -96.96+ 2.34X_5 \pm 0.42 + 33.45X_7 \pm 3.55$$

RESULTS AND DISCUSSION

Correlation studies

To understand the association of various characters with green pod yield per plant, the genotypic and phenotypic correlations were calculated as shown in Table 1. The genotypic correlation coefficients were found higher than the phenotypic correlation coefficients for almost all the characters, thus indicating that the environment had little role in expression of genetic relationship of the characters under study. The genotypic and phenotypic correlation coefficients revealed that green pod yield per plant has highly significant and positive association with pod weight (0.983 and 0.958), followed by number of pods per plant (0.966 and 0.935), shelling percentage (0.865 and 0.826), seed yield per plant (0.803 and 0.802), 100- seed weight (0.793 and 0.765), number of seeds per pod (0.668 and 0.668), plant height (0.659 and 0.644), pod length (0.616 and 0.621), node number nearing first flower (0.273 and 0.204) and days to 50 per cent flowering (0.229), respectively. Kumar *et. al* (2015), Pandey *et al.* (2015), Katoch *et al.* (2016), Gautam *et al.* (2017), Thakur *et al.* (2017), Kumawat *et al.* (2018), Srivastava *et al.* (2018) and Singh *et al.* (2019) also reported significant and positive correlation of green pod yield with all these characters. Similarly, days to 50 per cent flowering showed positive and significant correlation with node number bearing first flower (0.759 and 0.736) (Sharma and Sharma, 2012 and Kumar *et al.,* 2015), days to marketable maturity (0.677 and 0.721) (Srivastava *et al.,* 2018), plant height (0.611 and 0.551) (Kumawat *et al.,* 2018) and Singh *et al.,* 2019), number of pods per plant (0.370 and 0.304) (Pandey *et al.,* 2015) and 100- seed weight (0.222), at both genotypic and phenotypic levels, respectively. Node number bearing first flower showed positive and significant correlation both at genotypic and phenotypic levels with days to marketable

Table 1: Genotypic and phenotypic correlation of different characters in Pea.

		Days to 50 per cent flowering	Node number bearing first flower	Days to marketable maturity	Plant height	Number of pods per plant	Pod length	Pod weight	Number of seeds per pod	Shelling percentage	Seed yield per plant	100- Seed weight
Node number bearing first flower	G	0.759*										
	P	0.736*										
Days to marketable maturity	G	0.677*	0.520*									
	P	0.721*	0.543*									
Plant height	G	0.611*	0.686*	0.263*								
	P	0.551*	0.555*	0.224*								
Number of pods per plant	G	0.370*	0.405*	0.094	0.794*							
	P	0.304*	0.282*	0.046	0.729*							
Pod length	G	0.143	0.347*	-0.006	0.392*	0.636*						
	P	0.117	0.260*	-0.026	0.380*	0.635*						
Pod weight	G	0.153	0.240*	-0.106	0.634*	0.935*	0.599*					
	P	0.125	0.157	-0.100	0.594*	0.915*	0.601*					
Number of seeds per pod	G	0.176	0.428*	-0.053	0.431*	0.686*	0.963*	0.649*				
	P	0.144	0.312*	-0.068	0.410*	0.684*	0.949*	0.643*				
Shelling percentage	G	0.081	0.112	-0.148	0.383*	0.821*	0.735*	0.844*	0.785*			
	P	0.057	0.035	-0.139	0.337*	0.817*	0.718*	0.834*	0.763*			
Seed yield per plant	G	0.122	0.322*	-0.084	0.513*	0.765*	0.644*	0.796*	0.759*	0.760*		
	P	0.106	0.246*	-0.082	0.497*	0.751*	0.648*	0.788*	0.751*	0.742*		
100- Seed weight	G	0.222*	0.393*	0.041	0.533*	0.741*	0.701*	0.779*	0.773*	0.729*	0.921*	
	P	0.169	0.250*	-0.003	0.474*	0.746*	0.688*	0.768*	0.754*	0.738*	0.887*	
Green pod yield per plant	G	0.229*	0.273*	0.002	0.659*	0.966*	0.616*	0.983*	0.668*	0.865*	0.803*	0.793*
	P	0.198	0.204*	-0.013	0.644*	0.935*	0.621*	0.958*	0.668*	0.826*	0.802*	0.765*

* Significant at 5% level of significance.

maturity (0.520 and 0.543) (Kumar *et al.,* 2015), plant height (0.686 and 0.555) (Thakur *et al.,* 2017 and Kumar *et al.,* 2015), number of pods per plant (0.405 and 0.283), pod length (0.347 and 0.260), pod weight (0.240), number of seeds per pod (0.428 and 0.312), seed yield per plant (0.322 and 0.246) and 100- seed weight (0.393 and 0.250). Days to marketable maturity showed positive and significant association with plant height (0.263 and 0.224) (Pal and Singh, 2012) and Kumawat *et al.,* 2018) at both genotypic and phenotypic levels. Positive and significant association with plant height at both genotypic and phenotypic levels were observed with the traits *viz.,* number of pods per plant (0.794 and 0.729) (Thakur *et al.,* 2017 and Kumawat *et al.,* 2018), pod weight (0.634 and 0.594), 100-seed weight (0.533 and 0.474), seed yield per plant (0.513 and 0.497) (Kumar *et al.,* 2014 and Singh *et al.,* 2011), number of seeds per pod (0.431 and 0.410) (Sharma and Sharma, 2012, Srivastava *et al.,* 2018 and Singh *et al.,* 2019) , pod length (0.392 and 0.380) (Thakur *et al.,* 2017) and shelling percentage (0.383 and 0.337) (Sharma and Sharma, 2012). Number of pods per plant showed positive and significant association at both genotypic and phenotypic levels were observed with the traits *viz.,* pod weight (0.935 and 0.915), shelling percentage (0.821 and 0.817), seed yield per plant (0.765 and 0.751), 100-seed weight (0.741 and 0.746), number of seeds per pod (0.686 and 0.684) (Kumar *et al.,* 2015) and pod length (0.636 and 0.635) (Kumar *et al.,* 2015 and Thakur *et al.,* 2017). Positive and significant association with plant height at both genotypic and phenotypic levels were observed with the traits *viz.,* number of seeds per pod (0.963 and 0.949) (Sharma and Sharma, 2012 and Singh *et al.,* 2019), shelling percentage (0.735 and 0.718) (Sharma and Sharma, 2012), 100-seed weight (0.701 and 0.688), seed yield per plant (0.644 and 0.648) (Singh *et al.,* 2011 and Kumar *et al.* (2014) and pod weight (0.599 and 0.601). Pod weight also showed positive and significant association at both genotypic and phenotypic levels with shelling percentage (0.844 and 0.834), seed yield per plant (0.796 and 0.788), 100-seed weight (0.779 and 0.768) and number of seeds per pod (0.649 and 0.643). Positive and significant association of number of seeds per pod at both genotypic and phenotypic levels were observed with the traits *viz.,* shelling percentage (0.785 and 0.763) (Kumar *et al,* 2015 and Gautam *et al.,* 2017), 100-seed weight (0.773 and 0.754) and seed yield per plant (0.759 and 0.751) (Kumar *et al.,* 2014). Positive and significant association of shelling percentage was observed with seed yield per plant (0.760 and 0.742) and 100-seed weight (0.729 and 0.738) at both genotypic and phenotypic levels. Seed yield per plant also showed positive and significant association with 100-seed weight (0.921 and 0.887) (Singh *et al.,* 2011 and Kumar *et al.,* 2014) at both genotypic and phenotypic levels.

Table 2: Estimates of direct and indirect effects of different characters on gross pod yield per yield plant.

	Days to 50 per cent flowering	Node number bearing first flower	Days to marketable maturity	Plant height	Number of pods per plant	Pod length	Pod weight	Number of seeds per pod	Shelling percentage	Seed yield per plant	100- Seed weight	Correlation coefficient
Days to 50 per cent flowering	**-0.019**	0.033	-0.002	-0.147	0.298	0.005	0.056	-0.028	0.000	-0.007	0.041	0.229
Node number bearing first flower	-0.014	**0.043**	-0.001	-0.165	0.326	0.011	0.088	-0.068	-0.001	-0.019	0.073	0.273
Days to marketable maturity	-0.013	0.022	**-0.003**	-0.063	0.076	0.000	-0.039	0.008	0.001	0.005	0.008	0.002
Plant height	-0.012	0.030	-0.001	**-0.241**	0.640	0.012	0.232	-0.068	-0.002	-0.031	0.099	0.659
Number of pods per plant	-0.007	0.017	0.000	-0.191	**0.806**	0.020	0.342	-0.108	-0.004	-0.046	0.138	0.966
Pod length	-0.003	0.015	0.000	-0.094	0.512	**0.032**	0.219	-0.152	-0.004	-0.039	0.130	0.616
Pod weight	-0.003	0.010	0.000	-0.153	0.753	0.019	**0.366**	-0.103	-0.005	-0.048	0.145	0.983
Number of seeds per pod	-0.003	0.018	0.000	-0.104	0.553	0.031	0.237	**-0.158**	-0.004	-0.046	0.144	0.668
Shelling percentage	-0.002	0.005	0.000	-0.092	0.661	0.023	0.309	-0.124	**-0.005**	-0.046	0.136	0.865
Seed yield per plant	-0.002	0.014	0.000	-0.123	0.616	0.020	0.291	-0.120	-0.004	**-0.060**	0.171	0.803
100- Seed weight	-0.004	0.017	0.000	-0.128	0.597	0.022	0.285	-0.122	-0.004	-0.055	**0.186**	0.793

Residual effect is 0.00509

Path coefficient analysis

In this analysis, green pod yield per plant was taken as the dependent variable and other traits were taken as the independent factors. The path coefficient analysis splits the correlation coefficient in such a manner that the sum of direct and indirect effects equals the genotypic correlation. The results of path analysis are shown in Table 2. The results revealed that the maximum positive direct effect on green pod yield per plant was exerted by the number of pods per plant (0.806) followed by pod weight (0.366), 100-seed weight (0.186), node number bearing first flower (0.043) and pod length (0.032). The correlation coefficients for these traits were also found to be positive and significant on green pod yield per plant. The other traits like plant height (-0.241), number of seeds per pod (-0.158), seed yield per plant (-0.060), days to 50 per cent flowering (-0.019), shelling percentage (-0.005) and days to marketable maturity (-0.003) exerted a negative direct effect on green pod yield per plant but showed a positive and significant correlation with yield. The maximum positive indirect effect on green pod yield per plant was exerted by pod weight through number of pods per plant while the maximum negative indirect effect on green pod yield per plant was exerted by number of pods per plant through plant height. The residual effect (0.0051) on green pod yield per plant was very less. Similar results were obtained by Katoch *et al.* (2016), Gupta *et al.* (2018), Kumawat *et al.* (2018). Thus, based on the above results/ findings, it may be concluded that improvement of characters such as number of pods per plant, pod weight, 100-seed weight would help in improving the pod yield. Therefore, these traits should be considered for selection criteria for improving the green pod yield per plant in garden pea.

Regression analysis

The interrelationship of all the characters and green pod yield per plant and amongst each other were perplexing to find the actual characters contributing towards the green pod yield per plant, thus, the partial regression coefficients were worked out to predict the actual contribution of independent characters on yield.

The results showed that with the increase in the independent characters *i.e.,* number of pods per plant and pod weight, the green pod yield per plant will also increase by 2.34 and 33.45 percent, respectively.

CONCLUSION

It can thus be concluded that pod yield per plant had positive correlation with almost all the characters studied at both genotypic and phenotypic levels however the regression and analysis indicated that only number of pods per plant and pod weight are important independent characters for increasing the green pod yield per plant. Path coefficient analysis further indicated that these two characters were directly related to the increase in the yield of pea crops through pod yield per plant.

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