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Studies on genetic parameters, correlation and path coefficient analysis in *er*2 introgressed garden pea genotypes

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ABSTRACT

The present investigation was undertaken to estimate the genetic variability, correlation and path coefficient in seven *er*2 (powdery mildew resistant gene) introgressed lines along with four standard checks in garden pea for different horticultural traits. The analysis of variance showed large variability among all the genotypes studied. The magnitude of phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the traits. High heritability estimates coupled with high genetic gain were recorded for number of seeds per pod, number of primary branches per plant and pod yield per plant indicating that these traits are governed by additive genes and selection in early generation may be effective. Number of seeds per pod had significant and strong positive association with pod yield per plant both at genotypic and phenotypic levels and number of primary branches per plant at genotypic levels indicating that selection can be made on the basis of these characters for improving yield. Results of path analysis revealed that days to 50 per cent flowering, number of pods per plant and shelling percentage had maximum positive direct effect on pod yield per plant. Hence, these characters can be considered as the most important traits for selecting high yielding genotypes in pea improvement programme.

Key words: Correlation, Garden pea, Heritability, Path analysis, Variability.

INTRODUCTION

Pea (*Pisum sativum* L.) is an important vegetable crop grown in temperate and subtropical areas of the world for its tender and immature seeds. It is consumed as fresh vegetable in the growing season, while dried seeds are used as pulses during off-season (Gautam *et al*., 2017). Large proportion of peas is processed (canned, frozen or dehydrated). It is a rich source of protein, carbohydrates, vitamins (A and C), minerals like calcium and magnesium, dietary fibers and antioxidant compounds. Pea protein is limiting in sulfur containing amino acids (cysteine and methionine) but rich in lysine (Barcchiya *et al*., 2018).

It is a leading vegetable crop in the North-Western Himalayan region of the country comprising the states of Himachal Pradesh, Jammu & Kashmir and Uttarakhand. On account of diverse agro-climatic conditions in Himachal Pradesh, the crop is grown round the year in one or the other region, yielding remunerative prices to the growers (Katoch *et al*., 2016). Garden pea production is suffering on account of vulnerability to number of diseases, among them powdery mildew disease caused by *Erysiphe pisi* DC is one of the most important and widely prevalent disease all over the world. The age old varieties like 'Azad P-1', 'Lincoln' and 'Arkel' are still popular amongst the growers though they are highly susceptible to various diseases. Therefore, it is pertinent to develop high yielding variety (ies) having resistance to powdery mildew. Genetic variability and heritability are pre requisites for any crop improvement programme. Yield is a complex character which depend upon several other independent factors. In order to develop elite genotype(s), the knowledge of correlation component and path analysis is indispensable. Therefore, the present study was planned to find out the nature and magnitude of genetic variability, association among yield contributing traits and direct and indirect effect of each of the component traits towards pod yield of powdery mildew resistant garden pea lines which can be utilized in garden pea improvement programme.

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MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm of the Department of Vegetable Science and Floriculture, College of Agriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *rabi* 2015-16 and 2016-17 located in mid-hill zone of

Himachal Pradesh. The area is characterized by humid and temperate climate with an annual rainfall of 2,500 mm. The soil type is Alfisols typic Hapludalf clay having a pH of 5.7. The experimental material comprised of seven lines *viz.,* APL-55, APL-69, APL-80, APL-64, APL-84, Line 1-2 SPS5 and Line 1-2 SPS11 of garden pea along with four checks *viz*., Azad Pea-1, Lincoln, Palam Priya and Punjab-89. The lines APL-55, APL-69, APL-80, APL-64, APL-84, Line 1-2 SPS5 and Line 1-2 SPS11 have been developed through marker assisted backcross breeding followed by pedigree selection. Powdery mildew resistant gene *er*2 was sourced from pea genotype JI 2480. The experiment was laid out in randomized block design (RBD) with three replications. Each line along with checks were grown in six rows (2.15m each) per plot (2.70 × 2.30 m) in *rabi* 2015-16 and 2016-17 per replication. These lines were sown with inter and intra-row spacing of 45 cm × 5 cm respectively. The standard cultural practices as recommended in the Package of Practices for Vegetable Crops by CSK HPKV, were followed to raise the crop. Observations were recorded at appropriate stages of crop growth during both the seasons on characters *viz*., days to 50% flowering, days to first picking, pod length, number of seeds per pod, shelling percentage, number of pods per plant, total soluble solids, plant height, number of primary branches per plant and pod yield per plant. The correlation coefficients were calculated as per Al-Jibouri *et al*. (1958) by using analysis of variance and covariance matrix. Path coefficients of different traits towards pod yield per plant was obtained as per method given by Dewey and Lu (1959).

The ranges for components of variability are as under:

	GCV and PCV	Heritability	Genetic advance
High (%)	>14	>60	>25
Moderate (%)	10-14	40-60	10-25
Low(%)	<10	<40	<10

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the genotypes for all the characters indicating high degree of variability in the material studied therefore, it offers ample opportunity for improvement in yield and associated traits in garden pea (Table 1).

Wide range was observed for days to 50% flowering (87.3-95.5 days) and days to first picking (124.0-134.6 days), which determine the earliness of a particular genotype. Significant differences were observed with respect to pod length (7.95-10.20 cm), number of seeds per pod (6.25-9.25), shelling percentage (40.92%-53.24%), number of pods per plant (13.17-19.17), plant height (63.72-74.13 cm), number of primary branches per plant (1.14-2.17) and pod yield per plant (69.17-105.75 g). Wide variations with respect to different characters have been reported by Gautam *et al*. (2017), Khan *et al*. (2017), Ali *et al*. (2018) and Barcchiya *et al*. (2018).

Magnitude of phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the traits studied suggesting that the environment played an important role in the expression of these traits (Table 2). Phenotypic coefficient of variation (PCV) ranged from 2.99% for days to first picking to 26.87% for number of primary branches per plant. Whereas, genotypic coefficient of variation (GCV) ranged from 2.79 for days to first picking to 21.68% for number of primary branches per plant. High phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were observed for number of primary branches per plant, pod yield per plant and number of seeds per pod, indicating sufficient scope for improvement in these characters.

The estimates of heritability (broad sense) varied from 40.47%-93.91% for different traits studied. It was found high for the traits *viz.,* days to 50 per cent flowering (93.91), number of seeds per pod (90.59), days to first picking (87.16), pod yield per plant (81.90), number of primary branches per plant (65.12) and number of pods per plant (60.80), whereas, moderate for shelling percentage (57.81), total soluble solids (55.25), pod length (47.77) and plant height (40.47). Values of genetic gain ranged from 4.47-36.04 for the traits under study.

High heritability coupled with high genetic advance was observed for number of seeds per pod, number of primary branches per plant and pod yield per plant indicating that these traits are being governed by additive gene effects and selection in early generation may be effective. Ali *et al*. (2018) reported high heritability coupled with high genetic gain for number of primary branches per plant and pod yield per plant, Sharma and Bora (2013) and Barcchiya *et al*., (2018) for pod yield per plant and Gudadinni *et al*. (2017) for number of seeds per pod and pod yield per plant.

High heritability coupled with moderate genetic advance was recorded for number of pods per plant indicating the presence of both additive and non-additive gene effects. Sharma *et al*. (2011) also reported high heritability coupled with moderate genetic advance for number of pods per plant. Moderate heritability along with moderate genetic gain was observed for pod length. Moderate to high heritability with low genetic gain were recorded for days to 50 per cent flowering, days to first picking, shelling percentage (57.81), total soluble solids (55.25) and plant height (40.47) and delineated the presence of non-additive gene action. Therefore, hybridization should be followed to improve the trait.

Correlation studies revealed the relationship between various characters and determine the component characters on which selection can be relied for crop improvement (Table 3). Number of seeds per pod (0.868, 0.796) had significant and strong positive association with pod yield per plant both at genotypic and phenotypic levels. These findings corroborated with those of Jeberson *et al*. (2016), Pal and Singh (2012) and Ram *et al*. (2010) for number of seeds per pod. Number of primary branches per plant

Table 1: Analysis of variance for various horticultural traits in pea.

Source	Mean sum of squares			
Character	Replications	Genotypes	Errors	Total
df	2	10	20	32
Days to 50 per cent flowering	1.14	30.84*	0.65	32.64
Days to first picking	0.55	41.71*	1.95	44.21
Pod length (cm)	1.62	4.48*	1.20	7.29
Number of seeds per pod	0.53	3.73*	0.13	4.39
Shelling percentage	12.53	35.56*	6.96	55.05
Number of pods per plant	8.98	12.52*	2.22	23.71
Total soluble solids (°Brix)	0.01	0.94*	0.20	1.15
Plant height (cm)	70.40	41.12*	13.53	125.06
Number of primary branches per plant	0.03	0.39*	0.06	0.48
Pod yield per plant (g)	393.39	495.46*	34.01	922.86

*Significant at the 5% level of significance.

Table 2: Estimates of parameters of variability for pod yield and other horticultural traits in pea.

Traits	General Mean ± S.E.(d)	Range	Coefficient of variation		Heritability	Genetic	Genetic
			PCV(%)	GCV(%)	h^2bs (%)	advance	gain (%)
Days to 50 per cent flowering	92.02±0.66	87.34-95.50	3.56	3.45	93.91	6.33	6.88
Days to first picking	130.49±1.14	124.00-134.67	2.99	2.79	87.16	7.00	5.37
Pod length (cm)	8.95±0.89	7.95-10.20	16.91	11.69	47.77	1.49	16.64
Number of seeds per pod	7.47±0.29	6.25-9.25	15.42	14.67	90.59	2.15	28.77
Shelling percentage	49.52±2.15	40.92-53.24	8.20	6.24	57.81	4.84	9.77
Number of pods per plant	15.22±1.22	13.17-19.17	15.62	12.18	60.80	2.98	19.56
Total soluble solids (°Brix)	17.02±0.37	16.08-17.34	3.93	2.92	55.25	0.76	4.47
Plant height (cm)	68.83±3.00	63.72-74.13	6.93	4.41	40.47	3.97	5.77
Number of primary branches per plant	1.53±0.20	1.14-2.17	26.87	21.68	65.12	0.55	36.04
Pod yield per plant (g)	79.89±4.76	69.17-105.75	17.16	15.53	81.90	23.12	28.94

(0.464) showed significant and positive correlation with pod yield per plant at genotypic level suggesting that direct selection for this trait should be practiced to develop high yielding genotypes. Similar observations were also reported by Pal and Singh (2012), Gautam *et al*. (2017) and Khan *et al*. (2017). Days to first picking (-0.641, -0.526) exhibited significant negative correlation with pod yield per plant both at genotypic and phenotypic levels. Significant negative correlation for days to first picking towards pod yield per plant was reported by Katoch *et al*. (2016). Days to 50 per cent flowering showed significant and positive correlation with days to first picking at genotypic and phenotypic levels and at genotypic level with plant height. Shelling percentage was positively associated with number of pods per pod and total soluble solids at genotypic levels.

Path coefficient analysis measures the direct and indirect contribution of various independent characters on a dependent character. The results of path analysis revealed that days to 50 per cent flowering (0.493) had maximum positive direct effect on pod yield per plant followed by number of seeds per pod (0.394), number of pods per plant (0.260), shelling percentage (0.113), plant height (0.052) and total soluble solids (0.035) at the phenotypic level and days to 50 per cent flowering (1.460) followed by number of pods per plant (0.258), shelling percentage (0.135) and number of primary branches per plant (0.009) at genotypic level (Table 4). Similar findings have already been reported for number of pods per plant by Gautam *et al*. (2017), Sharma *et al*., (2009), Kumar *et al*. (2014) and Bijalwan *et al*. (2018). Sharma *et al*., (2011) also reported positive direct effect of shelling percentage on pod yield per plant. Similar results had also been reported by Kumar *et al*. (2014) for days to 50 per cent flowering. Days to first picking (-1.883, -0.594) and pod length (-0.231, -0.282) exhibited negative direct effect on pod yield per plant both at genotypic and phenotypic levels. While, number of seeds per pod (-0.530), total soluble solids (-0.113) and plant height (-0.056) exhibited negative direct effects on pod yield per plant at genotypic level and number of primary branches per plant (-0.089) at the phenotypic level. Low and negative direct effects of total soluble solids and number of primary branches per plant on pod yield per plant was compensated by high indirect effect *via* by days to first picking. Low residual effects (0.02926 and 0.19104) at genotypic and phenotypic levels indicating the sufficiency of the characters studied towards pod yield per plant.

Table 3: Estimates of phenotypic (P) and genotypic (G) correlation coefficients between pod yield per plant and other horticultural traits in pea.

Traits		Days to first picking	Pod length (cm)	Number of seeds per pod	Shelling per centage	Number of pods per plant	Total soluble solids (°Brix)	Plant height (cm)	Number of primary branches per plant	Pod yield per plant (g)
Days to 50 per cent flowering	P	0.641**	0.039	0.087	-0.183	-0.104	-0.121	0.286	0.087	0.090
	G	0.651**	0.116	0.103	-0.177	-0.132	-0.166	0.546**	0.130	0.085
Days to first picking	P		0.025	-0.579**	-0.056	-0.069	-0.270	0.187	-0.129	-0.526**
	G		0.189	-0.660**	0.000	-0.086	-0.312	0.469**	-0.180	-0.641**
Pod length (cm)	P			-0.136	0.242	0.001	-0.129	0.148	-0.106	-0.291
	G			-0.044	0.170	0.133	-0.326	0.187	-0.259	-0.313
Number of seeds per pod	P				-0.257	0.156	0.146	-0.166	0.349*	0.796**
	G				-0.315	0.189	0.317	-0.354*	0.482**	0.868**
Shelling percentage	P					0.142	0.232	0.302	0.258	-0.075
	G					0.481**	0.616**	0.078	0.125	0.054
Number of pods per plant	P						0.161	-0.072	0.226	0.309
	G						0.015	-0.103	0.477**	0.168
Total soluble solids (°Brix)	P							-0.213	0.208	0.269
	G							-0.169	0.393*	0.239
Plant height (cm)	P								-0.230	0.002
	G								-0.496**	0.001
Number of primary branches per plant	P									0.280
	G									0.464**

*Significant at the 5 % level, **Significant at the 1% level.

Table 4: Estimates of direct and indirect effects of different horticultural traits on pod yield at phenotypic (P) and genotypic (G) levels in pea.

Traits		Days to 50 per cent flowering	Days to first picking	Pod length (cm)	Number of seeds per pod	Shelling percentage	Number of pods per plant	Total soluble solids (°Brix)	Plant height (cm)	Number of primary branches per plant	Pod yield per plant (g)
Days to 50 per cent flowering	P	**0.493**	-0.380	-0.011	0.034	-0.021	-0.027	-0.004	0.015	-0.008	0.090
	G	**1.460**	-1.225	-0.027	-0.055	-0.024	-0.034	0.019	-0.031	0.001	0.085
Days to first picking	P	0.316	**-0.594**	-0.007	-0.228	-0.006	-0.018	-0.010	0.010	0.012	-0.526**
	G	0.950	**-1.883**	-0.044	0.350	0.000	-0.022	0.035	-0.026	-0.002	-0.641**
Pod length (cm)	P	0.019	-0.015	**-0.282**	-0.054	0.027	0.000	-0.005	0.008	0.009	-0.291
	G	0.170	-0.356	**-0.231**	0.023	0.023	0.034	0.037	-0.011	-0.002	-0.313
Number of seeds per pod	P	0.043	0.344	0.038	**0.394**	-0.029	0.041	0.005	-0.009	-0.031	0.796**
	G	0.150	1.242	0.010	**-0.530**	-0.042	0.049	-0.036	0.020	0.004	0.868**
Shelling percentage	P	-0.090	0.034	-0.068	-0.101	**0.113**	0.037	0.008	0.016	-0.023	-0.075
	G	-0.259	-0.001	-0.039	0.167	**0.135**	0.124	-0.069	-0.004	0.001	0.054
Number of pods per plant	P	-0.051	0.041	0.000	0.061	0.016	**0.260**	0.006	-0.004	-0.020	0.309
	G	-0.193	0.161	-0.031	-0.100	0.065	**0.258**	-0.002	0.006	0.004	0.168
Total soluble solids (°Brix)	P	-0.059	0.160	0.036	0.058	0.026	0.042	**0.035**	-0.011	-0.019	0.269
	G	-0.243	0.587	0.075	-0.168	0.083	0.004	**-0.113**	0.010	0.004	0.239
Plant height (cm)	P	0.141	-0.111	-0.042	-0.066	0.034	-0.019	-0.008	**0.052**	0.021	0.002
	G	0.797	-0.883	-0.043	0.188	0.011	-0.026	0.019	**-0.056**	-0.004	0.001
Number of primary branches per plant	P	0.043	0.076	0.030	0.137	0.029	0.059	0.007	-0.012	**-0.089**	0.280
	G	0.189	0.338	0.060	-0.256	0.017	0.123	-0.044	0.028	**0.009**	0.464**

Residual effects (P) = 0.19104; (G) = 0.02926. Bold values indicates direct effects , *Significant at the 5% level, ** Significant at the 1% level.

APL-55, APL-69, APL-80 and Line 1-2SPS5 exhibited resistant reaction against powdery mildew as these lines harbour gene *er*2. The commercial checks, Azad Pea-1, Lincoln, Punjab-89 and Palam Priya along with APL-84 were susceptible to powdery mildew, while APL-64 and Line 1-2SPS11 exhibited moderately resistance reaction. The maximum and significantly higher pod yield was recorded in Line 1-2SPS5 and Line 1-2SPS11.

CONCLUSION

From the above discussion, it can be concluded that three traits *viz*., number of seeds per pod, number of primary branches per plant and pod yield per plant were controlled by additive genes and selection could be effective for the improvement of these traits. From the correlation and path coefficient studies it is clear that for the genetic improvement of garden pea, emphasis should be given on traits like number of seeds per pod, number of primary branches per plant, days to 50 per cent flowering, number of pods per plant and shelling percentage, while selecting high yielding genotypes. Line1-2-SPS5 can be commercially utilized as it was high yielding and exhibited resistance reaction to powdery mildew disease. This line should be evaluated at multi locations in the state for further release and utilization in improvement of garden pea.

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