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Assessment of genetic variability, correlation and path coefficient for yield and yield contributing traits in field pea (*Pisum sativum* L. var. arvense)

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Abstract
A field experiment was carried out with ninety genotypes along with four check varieties during *Rabi* 2016-17 in Augmented Block Design, a wide range of variability for different characters had been observed by comparing the means of various genotypes using least significant differences and revealed that existence of very high degree of variability for all the characters except pod length (cm). The following four most promising genotypes exhibited high mean performance for seed yield/plant were PANT P 266, EC 507770, PANT P 195 and IPFD 13-4. Seed yield per plant exhibited highly significant and positive correlation with plant height, (0.3641), primary branches per plant (0.4189), seeds per pod (0.3034) and pod length (0.370). The magnitude of phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the characters, higher estimates of (GCV) was recorded for number of pod length (22.84 %) followed by number of pod per plant (20.96 %). The highest positive and direct effect on seed yield per plant was exerted by biological yield (0.7133) followed by harvest index (0.5588), pods per plant (0.0210). However, negative and direct effect on seed yield per plant was exerted by plant height (-0.0060) and number of seeds per pod (-0.0057).

Keywords: Field pea, GCV, variability, correlation, direct and indirect effect

Introduction
India has largest cultivated area of pulses in the world, but average productivity is very low, and the production is not sufficient to meet the per capita requirement. Pulses shortfall may increase to 6.8 mt by 2020-21 and the anticipated increase in per capita consumption of pulses from 9 kg/year in 2007-08 to 10.9 kg by 2020-21 (Joshi, 2009) [6]. To alleviate protein-energy malnutrition, a minimum of 50 g pulses/capita should be available in addition to other sources of proteins such as cereals, milk, meat and eggs (Mehta *et al.*, 2005) [8]. The recommendation of per capita availability of pulse is 65 g/day/capita by Indian Council of Medical Research in 2008 (Reddy, 2009) [9], whereas FAO/WHO recommendation of minimum requirement of 80 g/day/person.

Among various grain legumes grown, field pea (*Pisum sativum* L. var. arvense), is one of the most important pulse crop of India, grown in winter season and belonging to tribe- Vicieae, order- fabales, family– leguminosae (fabaceae), sub-family- papilionaceae, genus– *Pisum* and species– *sativum* with chromosome number 2n = 14. Pea has versatile uses as food, feed and fodder. Pea (*Pisum sativum* L.) besides pulse, residues are nutritious feed for livestock and milch cattle and thus, offer an added advantage to the poor farmer families.

Green pea and the immature pods of pea are typified by high level of active lipotropic antisclerotic substances-choline and inositol. Choline deficiency may lead to the development and growth of malignant tumor.

In India the annual production of pulses is around 22.40 mt from an area of 23.587 m ha with productivity level of 1053 kg/ha (Anonymous 2016) [1]. Field pea contributed around 0.76 mt production from an area of 0.67 m ha with productivity level of 886kg/ha. Utter Pradesh ranked 1st in the productivity (1263 kg/ha) followed by Madhya Pradesh (Anonymous 2016) [1]. The relatively low crop yield may be attributed to non availability of improved cultivars, poor crop husbandry and exposure to a number of biotic and abiotic stresses in field pea growing regions.

Narrow genetic base in cultivated germplasm has further hampered the effective utilization of conventional breeding as well as development and utilization of genomic tools, resulting in development of poor yielding genotypes.

The major field pea producing state are M.P, U.P, Jharkhand, Rajasthan, Assam, Bihar, Chhattisgarh, Maharastra with production of 362.9, 314.00, 40.40, 30.90, 27.70, 18.20, 10.30, 9.60 thousand tonns respectively in 2014-15 (Anonymous 2016) [1].

The success of any crop breeding programme depends on the nature and amount of variability existing with germplasm collections. The genetic reconstruction of plant is required for developing high yielding varieties by incorporating and improving the characters. Yield improvement through genetic means usually comes from exploitation of new germplasm or traits. Germplasm serves as the most valuable natural reservoir in providing needed attributes for engineering successful varieties. Therefore, collection, evaluation and conservation of germplasm are essential for present as well as future crop improvement.

Materials and Methods

The experiment was conducted to evaluate 90 genotype lines including four checks *viz*. Rachana, HFP-4, HFP-8909 and HUDP-15 under irrigated normal soil condition in Augmented Block Design. The experiment was laid out during Rabi 2016-17 at Genetics and Plant Breeding Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.). The seeds of different genotypes were available with Pulses Section of the University and institute. The experimental plot will be divided into six blocks of equal size. Each block was 19 plots in which four plots will be randomly allotted to the four checks while remaining 15 plots of a block will be used for accommodating the un-replicated test genotypes. Each plot was consist of a single row of 4 m length, following inter and intra row spacing 30 cm and 10 cm respectively. Observations were recorded on randomly selected five competitive plants from each genotypes for nine characters, viz., Plant height (cm), number of primary branches per plant, number of pods per plant, pod length (cm), number of seeds per pod, 100-seed weight, biological yield per plant, harvest index and seed yield per plant (g), while two characters viz., days to 50 per cent flowering, days to maturity were recorded on the plot basis.The analysis of variance for different characters in Augmented Block Design was done according to Federer (1956) [5]. The simple correlations between different characters at genotypic (g) and phenotypic (p) levels were estimated as below according to Searle (1961) [10]. Path coefficient analysis was carried out according to Dewey and Lu (1959) [4].

Result and Discussion

The results obtained from the experiment have been discussed in the light of relevant literature available in pea here under. An analysis of variance for Augmented Block Design accommodating ninety germplasm lines and four checks in twelve blocks was carried out for each of the eleven characters in field pea. The mean squares due to blocks, checks, and error for all the characters are presented in Table-1. During the course of study it was found that variation due to blocks was highly-significant for all the characters studied. The variation due to block was highly significant because in some blocks high fertility was present and in some block there is lack of fertility as well as it was due to improper irrigation condition. The variation due to checks was highly significant for majority of the traits except pod length. Mehta *et al*. (2005) [8] and Georgieva *et al*. (2016) also noted that the genotypes differed significantly for all the traits except the Pod length (cm).

The estimates of genotypic and phenotypic coefficient of variation for 11 characters are presented in Table 2. The magnitude of phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the characters. Higher estimates (25.30 %) of PCV were recorded for pod length followed by pod/plant (21.02 %). While higher estimates of (GCV) was recorded for number of pod length (22.84 %) followed by number of pod per plant (20.96 %).The characters which exhibited moderate estimates (between 4.99 to 21.02 %) of PCV and GCV were 100 seed weight, number of pods per plant, biological yield per plant, harvest index, pod length. Bashir *et al.* (2017) [3] and Meena *et al.* (2017) [7] also reported that relative magnitude of phenotypic coefficients of variation was higher than genotypic coefficients of variation for all the characters under study indicating environmental influence on the traits.

The Estimate of simple correlation coefficient among the eleven characters of field pea genotypes is presented in Table 3. Seed yield per plant exhibited highly significant and positive correlation with plant height (0.3641), primary branches per plant (0.4189), seeds per pod (0.3034), pod length (0.370), biological yield per plant (0.7881) and harvest index (0.6807); positive association with 100 seed weight (0.1897) and remaining characters showed negative non significant. Harvest index per plant exhibited highly significant and positive correlation with seed yield per plant (0.6807) followed by number of pod per plant (0.4744), number of primary branches per plant (0.3225), seeds/ pod (0.3115); positive association with pod length (0.2333). However, seed yield per plant had negative and non significant correlation with days to 50% flowering (-0.0956) and days to maturity (-0.0753). Biological yield per plant showed highly significant and positive association with seed yield per plant (0.7881) followed by plant hight (0.3697) and pod per plant (0.05225); positive association with number of primary branches per plant (0.2922), pod length (0.2486),100 seed weight (0.1735), number of seed per pod (0.1655). However, Biological yield showed negative and highly significant association with day to maturity (-0.1885) followed by day to 50 % flowering (-0.0936). 100-seed weigh positive association with seeds per pod (0.2124), pod length (0.1961), plant height (0.0547), while non-significantly and negatively correlated with days to maturity (-0.1613), pods/plant (-0.1018), number of primary branches per plant (-0.1437), days to 50% flowering (-0.1210) Pod length showed positive and highly significant association with seeds per pod (0.3977); positive association with plant height (0.1099), pods/plant (0.0326), and days to 50% flowering (0.094) whereas negative and highly significant correlation with number of primary branches per plant (-0.2794) while negative and significant correlation with days to maturity (-0.0004). Number of seeds per pod showed highly significant and negative correlation with pods per plant (-0.1158) followed by days to maturity (-0.0088) and number of primary branches per plant (-0.2161). However, number of seeds per pod showed non-significant and positive correlation with plant height (0.1215). Number of pods per plant showed highly significant and positive correlation with number of primary branches per plant (0.7535) and plant height (0.3471). However, days to maturity (-0.1466) showed negative and non significant correlation. Number of primary

branches per plant exhibited significant and positive correlation with plant height (0.1692). However, number of primary branches per plant showed negative and non-significant correlation with days to 50% flowering (-0.397) and days to maturity (-0.0854). Plant height exhibited non-significant and positive correlation with days to 50 per cent flowering (0.0687) and days to maturity (0.0196). Days to maturity were positively and highly significantly associated with days to 50 per flowering (0.8688). (Tofiq *et al.* (2015) [13]. In addition Basaiwala *et al.* (2013) [2] also found that seed yield per plant was positively and significantly correlated with seeds per pod and harvest index. One another report in field pea also indicated that length and width of pod and 100- seed weight were associated positively and significantly with grain yield per plant (Singh *et al.* (2008) [12].

Path-coefficient analysis is a tool to partition the observed correlation into direct and indirect effects of seed yield components, which provide very clear picture of character association for formulating efficient selection strategy (Table 4). The highest positive and direct effect on seed yield per plant was exerted by biological yield (0.7133) followed by harvest index (0.5588), pods per plant (0.0210) whereas very low positive and direct effect on seed yield per plant was exerted by primary branches per plant (0.0012) and pod length (0.0065). However, negative and direct effect on seed yield per plant was exerted by plant height (-0.0060) and number of seeds per pod (-0.0057). Highly positive and indirect effect on seed yield per plant was exerted by biological yield per plant via number of pod per plant (0.3761), plant height (0.2751), number of primary branches per plant (0.2134), pod length (0.1898), 100- seed weight (0.1293) and number of seed per pod (0.1226); harvest index via number of pod per plant (0.2905), number of primary branches per plant (0.1996), number of seeds per pod (0.1837) and pod length(0.1670). However, negative indirect effect on seed yield per plant was exerted by harvest index via day to maturity (-0.0325) and day to 50% flowering (-0.0483); biological yield via day to maturity (-0.0748) and day to 50% flowering (-0.1565); 100-seed weight via number of primary branches per plant (-0.0014),day to maturity (-0.0012) and day to 50% flowering (-0.0019); pod length via days to 50% flowering (-0.0002), days to maturity (-0.0004) and number of primary branches per plant(-0.0020), number of seeds per pod via plant height (-0.0007), number of pods per plant via day to maturity(-0.0001), primary branches per plant via day to maturity (-0.0003), plant height via day to maturity (-0.0003) and days to maturity via day to 50% flowering (-0.0076). Tofiq *et al.* (2015) [13] also reported biological weight per plant and harvest index exhibited maximum positive direct effect in weight of seeds per plant recording (0.630 and 0.456) respectively. Singh *et al.* (2014) [11] also reported that biological yield per plant, harvest index and plant height had positive and direct effect on grain yield per plant. Similarly days to 50% flowering and pod length had positive and direct effect on grain yield per plant. Bashir *et al.* (2017) [3] also reported that 100–seed weight and number of seed per pod had maximum direct effect on grain yield per plant.

All over analysis indicated that high amount of variability was present in the genotypes under study which provides a better opportunity to select desirable genotypes for further utilization in breeding programme. Correlation and path analysis indicated that harvest index, biological yield per plant, number of seeds per pod, pod length and 100-seed weight, had true relationship with seed yield and they are the major yield contributing traits.

Table 1: Analysis of variance of augmented block design for 11 characters in field pea genotypes

S.V.	D.F.	Days of 50% flowering	Days to maturity	Plant height (c)	Number of Pods/ plant	Pod length (cm)	Number of Primary branches/ plant	Number of Seeds/ Pod	100-Seed weight (g)	Biological yield/ plant (g)	Seed yield (g)	Harvest index (%)
Block (ignoring Treatments)	5	42.58**	15.02	481.78**	3.189**	18.207**	0.224**	0.962**	7.637**	4.343**	2.238**	37.89**
Checks	3	41.38**	24.78*	7631.9**	4.463**	0.051	0.230**	0.128**	2.113**	2.0553**	0.441**	35.10**
ERROR	15	4.48	4.78	4.83	0.0167	0.158	0.001	0.0045	0.118	0.0820	0.009	0.848

*,** Significant at 5% and 1% probability level respectively

Table 2: Range, mean, coefficient of variation and least significant differences for 11 character of field pea

Characters	Range (Min-Max)	Mean Value	Coefficient of variation (%)			Range of parameters			
			GCV (%)	PCV (%)	Coefficient of variation (%)	LSD_1 5%	LSD_2 5%	LSD_3 5%	LSD_4 5%
Days to 50% flowering	70.292-88.792	79.746	4.99	5.66	5.892	2.604	6.378	7.130	5.446
Days to maturity	122.583-142.583	133.067	2.99	3.41	3.715	2.691	6.591	7.369	5.628
Plant height (cm)	39.550-137.68	87.370	17.40	17.58	20.219	2.70	6.62	7.40	5.65
Number of primary branches plant^{-1}	1.292-3.11	2.091	20.78	20.83	22.511	0.039	0.096	0.108	0.082
Number of pods plant^{-1}	4.181-12.88	7.688	20.96	21.02	22.835	0.159	0.389	0.435	0.333
Number of seeds pod^{-1}	2.049-5.16	3.527	13.37	13.51	14.439	0.083	0.203	0.227	0.174
Pod length (cm)	2.626-4.88	3.650	22.84	25.30	11.796	0.489	1.198	1.339	1.023
100-seed weight (g)	16.620-28.50	19.230	7.62	7.83	8.445	0.423	1.037	1.159	0.886
Biological yield plant^{-1}(g)	3.405-6.77	4.923	11.434	11.646	17.154	0.352	0.863	0.965	0.737
Harvest index (%)	8.494-15.43	12.953	9.53	9.83	12.609	1.134	2.777	3.104	2.371
Seed yield/plant(g)	28.702-46.63	37.960	15.96	16.08	10.445	0.118	0.288	0.322	0.246

LSD_1 = difference between two check means.
GCV = genotypic coefficient of variance
LSD_2 = difference between adjusted yield of two genotype in the same block.
PCV = phenotypic coefficient of variance
LSD_3 = difference between adjusted mean of two genotypes in the different block.
LSD_4 = difference between adjusted yield of genotype and check mean

Table 3: Simple correlation coefficients between different characters in field pea germplasm

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches /plant	Number of Pods / Plant	Number of seeds / pod	Pod length (cm)	100-seed Weight	Seed yield/ plant (g)	Biological yield/ plant	Harvest index (%)
Days to 50% flowering	1.0000	0.868**	0.0687	-0.0397	-0.0313	-0.0834	0.0494	-0.1613	-0.1272	-0.0936	-0.0956
Days to maturity		1.0000	0.0196	-0.0854	-0.0889	-0.0088	-0.0004	-0.1210	-0.1853	-0.1885	-0.0753
Plant height(cm)			1.0000	0.1692	0.3471**	0.1215	0.1099	0.0547	0.3641	0.3697**	0.1561
Branches / plant				1.0000	0.7535**	-0.2163	-0.2794	-0.1437	0.4189**	0.2922*	0.3225**
Pods / plant					1.0000	-0.1158	0.0326	-0.1018	0.6828**	0.5225*	0.4744**
Seeds / pod						1.0000	0.3977**	0.2124	0.3034**	0.1655	0.3115**
Pod length(cm)							1.0000	0.1961	0.3270**	0.2486*	0.2333*
100-Seed weight (g)								1.0000	0.1897	0.1735	0.0895
Seed Yield/plant (g)									1.0000	0.7881**	0.6807**
Biological yield/ plant(g)										1.0000	0.0906
Harvest index (%)											1.0000

***, ****Significant at 5% & 1% probability level Respectively.

Table 4: Direct and indirect effects of different characters on seed yield per plant in Field pea germplasm

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches / Plant	Number of Pods / plant	Number of seeds/ pod	Pod length (cm)	100-seed weight (g)	Biological yield / plant(g)	Harvest index (%)	Seed yield / plant(g)
Days to 50% flowering	0.0088	-0.0076	-0.0006	0.0000	-0.0006	0.0005	-0.0002	-0.0019	-0.0748	-0.0483	-0.1248
Days to maturity	0.0076	-0.0088	-0.0003	-0.0001	-0.0019	0.0000	-0.0004	-0.0012	-0.1565	-0.0325	-0.1941
Plant height (cm)	0.0009	-0.0004	-0.0060	0.0002	0.0074	-0.0007	0.0006	0.0008	0.2751	0.0918	0.3699
Number of primary Branches /plant	-0.0003	0.0008	-0.0010	0.0012	0.0159	0.0013	-0.0020	-0.0021	0.2134	0.1986	0.4258
Number of Pods/plant	-0.0002	0.0008	-0.0021	0.0009	0.0210	0.0007	0.0003	-0.0014	0.3761	0.2905	0.6866
Number of Seeds/pod	-0.0007	0.0000	-0.0007	-0.0003	-0.0025	-0.0057	0.0027	0.0032	0.1226	0.1837	0.3022
Pod length(cm)	-0.0003	0.0006	-0.0005	-0.0004	0.0010	-0.0024	0.0065	0.0036	0.1898	0.1670	0.3649
100 seed weight (g)	-0.0012	0.0007	-0.0004	-0.0002	-0.0021	-0.0013	0.0017	0.0139	0.1293	0.0562	0.1966
Biological yield/ plant (g)	-0.0009	0.0019	-0.0023	0.0004	0.0111	-0.0010	0.0017	0.0025	0.7133	0.0755	0.8021
Harvest Index (%)	-0.0007	0.0005	-0.0009	0.0004	0.0104	-0.0018	0.0018	0.0013	0.0914	0.5888	0.6912

R square = 0.9958, Residual factor = 0.0647, Bold figures indicate the dire

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