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Studies on character association and path analysis in garden pea (*Pisum sativum* L. sub sp. *hortense* Asch.)

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Abstract
Forty four genotypes of garden pea including checks were evaluated to estimate correlation and path coefficient for seventeen yield contributing traits and identification of superior recombinants for their utilization in crop improvement programme during *Rabi*, 2016-17, at Main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, in Randomized Block Design with three replication. The most important trait pod yield per plant had exhibited highly significant positive phenotypic correlation with number of pods per plant (0.794) followed by number of nodes per plant (0.253), primary branches per plant (0.231), pod circumference (0.190), shelling percentage (0.184), and number of seeds per pod (0.166). Higher magnitude of positive direct effect on pod yield per plant was exerted by plant height (1.2567) followed by number of pod per plant (0.6431), days to 50% flowering (0.2599), number of seeds per 100g pod (0.1655), node to first flower appears (0.1249), T.S.S. (0.1055), primary branches per plant (0.0940) pod length (0.0439) and 100-seed weight (0.0360). Direct contribution of these traits indicates the scope of improvements through selection for number of pods per plant and number of seeds per pod in the available germplasms.

Keywords: Garden pea (*Pisum sativum* L. sub sp. *hortense* Asch.), correlation and path analysis

Introduction
Garden pea (*Pisum sativum* L. sub sp. *hortense* Asch.) belongs to Leguminosae family and sub family Fabaceae having diploid chromosome number 2n=2x=14. It is one of the most popular vegetable crop grown as cool season crop in all over the world. The crop is grown for its green pods and dried seeds. It is harvested at tender immature stage and consumed fresh or preserved through canning or freezing. It has a prime place among all the vegetables because of its high amount of health benefiting phytonutrients such as carbohydrates, vitamin A, B and C, minerals like calcium, phosphorus, magnesium with no cholesterol and is known for its superior quality protein like lysine content, which is limiting in cereals (Monti, 1983) [8]. Moreover, pea contributes to yield of the succeeding crop in rotation by improving nitrogen status of the soil due to presence of root nodules (Sattar *et al.* 1998) [5].

Garden pea is an annual, herbaceous plant with tap root system. It is highly self-pollinated due to hermaphrodite flower, homogamy *i.e.* maturation of stigma and anthers at the same time. Most of the early cultivars the first flower produce from 5 to 11 nodes and the late cultivars start flowering at about 13 to 15 nodes. Early cultivars are often single flowered or bear some single and some double flowers while, late cultivars are usually double/triple flowered.

Breeding efforts have contributed substantially to improve yield potential, regional adaptation through resistance or tolerance to abiotic and biotic stresses, plant type and grain characteristics. The path coefficient analysis provides the partitioning of correlation coefficients into direct and indirect effect giving the relative impotence of each causes factors. The understanding of association of characters is of prime impotence in developing an efficient breeding programme.

Correlation studies provide an opportunity to study the magnitude and direction of association of one character with another, while path coefficient analysis gives the direct and indirect contribution of independent variables on dependent variable (Rathi and Dhaka, 2007) [9].

Therefore, present investigation was carried out to assess the magnitude and direction of association, direct and indirect effects between yield and its component traits in 44 different genotypes for 17 characters of garden pea under Ayodhya conditions.

Materials and Methods

The experimental material for the present investigation was comprised of 44 genotypes including 4 checks were replicated thrice in Randomized Complete Block Design. The experiment was carried out at Main Experiment Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya, during *Rabi* season of 2016-17. The whole investigation was conducted under the scientific management practices. During study, observations for 50% flowering, plant height, number of nodes per plant, intermodal length, node to first flower appearance, node to first pod appearance, primary branches per plant, pod circumference, pod length, number of seeds per pod, number of pods per plant, shelling per cent, 100-seed weight, number of seeds per 100g pod, number of pods per 100g, total soluble solid (T.S.S.) and pod yield per plant were recorded on five randomly selected plants from each treatment.

The recorded data from experiment for seventeen characters in garden pea was subjected to the following statistical analysis such as correlation coefficient (Searle, 1961) [6] and path coefficient analysis (Dewey and Lu, 1959) [3].

Results and Discussion

The correlation among seventeen characters were worked out at phenotypic and genotypic levels had been presented in Table-1, indicated a strong genetic association between the traits and the phenotypic expression which was suppressed due to environmental influence. In other words, the performance of all the genotypes with respect to characters studied were statistically different. The result indicating the better chance of selection in the available garden pea genotypes.

In this respect, the correlation coefficient provides symmetrical measurement of degree of association between two variables or characters help us in understanding the nature and magnitude of association among yield and yield components.

The most important trait pod yield per plant had exhibited highly significant and positive phenotypic correlation with number of pods per plant (0.794) followed by number of nodes per plant (0.253). Whereas, primary branches per plant (0.231), pod circumference (0.190), shelling percentage (0.184) and number of seeds per pod (0.166) exhibited moderate to low significant positive phenotypic correlation which prove well with earlier reports by Singh *et al*. (2005) [7].

Pod yield per plant and yield contributing attributes are interrelated among themselves. This creates hindrance in drawing a clear picture of association between characters. The mutual relationship expressed as correlation coefficient between the traits is either positive or negative but complex in nature and sometimes fails to give a meaningful interpretation. In such situation a biometrical tool, path coefficient analysis is used to measure the different ways of contribution of independent traits on the dependent one (yield). Path coefficient analysis breaks the correlation coefficient into the measures of direct and indirect effect and point out the precise causes of association. The results of path coefficient are presented in Table-2. Similar results were also reported by Chaudhary *et al.* (2003) [2].

The path coefficient analysis at genotypic level, the highest positive direct effect on pod yield per plant was exerted by plant height (1.2567), number of pods per plant (0.6431), days to 50% flowering and number of seeds per 100g pod (0.1655), node to first flower appears (0.1249), T.S.S. (0.1055), primary branches per plant (0.0940) pod length (0.0439) and 100-seed weight (0.0360).

The substantial negative direct effect was exhibited by internodal length (-1.2153) followed by number of pods per 100g (-0.8836), number of nodes per plant (-0.7493), number of seeds per pod (-0.2928), node to first pod appears (-0.2822) and shelling per cent (-0.0315). While, number of pods per plant (0.3828), number of seeds per pod (0.3809) and shelling per cent (0.3087) exerted substantial positive indirect effect via number of pods per 100g and internodal length (1.1041), node to first pod appears (0.7564), days to 50% flowering (0.7165), node to first flower appears (0.7021), number of pods per 100g (0.4628) also exerted substantial positive indirect effect via plant height on pod yield per plant. Node to first pod appears (0.2357), node to first flower appears (0.2273) plant height (0.14820) and intermodal length (0.1369) were showed highly indirect positive effect via days to 50% flowering on pod yield per plant. Similar findings were also given by Chaudhary *et al.* (2003) [2], Singh *et al.* (2005) [7], Katoch *et al.* (2016) [4] and Bashir *et al.* (2017) [1].

Thus, in the light of above findings it may be concluded that improvement of characters such as number of seeds per pod, number of pods per plant, number of seeds per 100g would help in improving the pod yield. Therefore, these traits should be considered in fixing selection criteria to improve the pod yield per plant in garden pea.

Table 1: Estimates of phenotypic correlation coefficients among seventeen characters in garden pea

Characters	Plant height	Number of Nodes per plant	Internodal Length	Node to first flower appears	Node to first pod appears	Primary branches per plant	Pod circumference	Pod length	Number of seeds Per pod	Number of pods per plant	Shelling	100-seed weight	Number of seeds per 100 g pod	Number of pods per 100 g	T.S.S. (^{0}Brix)	Pod yield per plant
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Days to 50% flowering	0.5374**	0.1318	0.4986**	0.7994**	0.8067**	0.0093	-0.1281	0.3322**	0.1851*	-0.3455**	-0.3943**	0.2908**	0.5588**	0.3977**	0.1400	-0.4536**
Plant height (cm)		0.3247**	0.8597**	0.5129**	0.5337**	0.0260	0.0685	0.2121*	-0.0071	-0.1713*	-0.2013*	0.1889*	0.3321**	0.3442**	0.2784**	-0.3138**
Number of Nodes per plant			-0.2000*	0.1936*	0.1809*	0.5026**	0.2572**	-0.0352	-0.1745*	0.3237**	-0.0927	-0.0102	-0.2118*	-0.0809	-0.0857	0.2537**
Internodal length (cm)				0.4351**	0.4632**	-0.2301**	-0.0636	0.2425**	0.0826	-0.3505**	-0.1777*	0.2078*	0.4701**	0.4173**	0.3554**	-0.4690**
Node to first flower appears					0.9292**	0.0159	-0.1347	0.3140**	-0.0147	-0.2805**	-0.2133*	0.3649**	0.3496**	0.3826**	0.1082	-0.3971**
Node to first pod appears						0.0064	-0.0868	0.2968**	-0.0042	-0.2546**	-0.1888**	0.3475**	0.3586**	0.3702**	0.1343	-0.3764**
Primary branches per plant							0.0305	-0.0746	-0.1224	0.3191**	-0.0916	0.1221	-0.1059	0.0287	0.0972	0.2318**
Pod circumference (cm)								-0.3692**	-0.1699	0.1755*	-0.1091	-0.3502**	-0.2531**	-0.1281	-0.1265	0.1906*
Pod length (cm)									0.1920*	-0.1497	-0.0405	0.0740	0.5021**	0.3418**	0.0258	-0.2897**
Number of seeds per pod										-0.0491	-0.1140	-0.0404	0.4644**	-0.3804**	0.0017	0.1665
Number of pods per plant											0.1065	-0.2392**	-0.4023**	-0.3557**	-0.1833*	0.7948**
Shelling per cent												-0.1116	-0.4064**	-0.2985**	-0.1445	0.1840*
100-seed weight (g)													0.2306**	0.2644**	0.3682**	-0.3087**
Number of seeds per 100 g pod														0.5750**	0.2448**	-0.5523**
Number of pods per 100 g															0.3094**	-0.7242**
T.S.S. (^{0}Brix)																-0.2554**

*Significant at 5% level of probability, **Significant at 1% level of probability

Table 2: Direct and indirect effects of seventeen characters on pod yield per plant (g) at genotypic level in garden pea

Characters	Days to 50% flowering	Plant height	Number of nodes per plant	Internodal length	Node to first flower appears	Node to first Pod appears	Primary branches per plant	Pod circumference	Pod length	Number of seeds per pod	Number of pods per plant	Shelling	100-seed weight	Number of seeds per 100 g pod	Number of pods per 100 g	T. S. S. (^{0}Brix)	Correlation with Pod yield per plant
Days to 50% flowering	0.2599	0.7165	-0.1235	-0.6403	0.1092	-0.2559	0.0010	-0.0161	0.0183	-0.0563	-0.2813	0.0147	0.0106	0.1020	-0.4069	0.0161	-0.5317
Plant height (cm)	0.1482	1.2567	-0.2551	-1.0678	0.0698	-0.1698	0.0032	0.0066	0.0107	0.0040	-0.1235	0.0077	0.0070	0.0572	-0.3254	0.0297	-0.3408
Number of nodes per plant	0.0428	0.4278	-0.7493	0.1794	0.0304	-0.0638	0.0556	0.0331	-0.0030	0.0589	0.2664	0.0039	0.0001	-0.0457	0.1098	-0.0107	0.3356
Internodal length (cm)	0.1369	1.1041	0.1106	-1.2153	0.0589	-0.1485	-0.0237	-0.0093	0.0133	-0.0242	-0.2648	0.0067	0.0075	0.0859	-0.4155	0.0392	-0.5382
Node to first flower appears	0.2273	0.7021	-0.1823	-0.5734	0.1249	-0.2849	0.0011	-0.0211	0.0160	0.0047	-0.1990	0.0072	0.0144	0.0628	-0.3654	0.0127	-0.4529
Node to first pod appears	0.2357	0.7564	-0.1695	-0.6395	0.1261	-0.2822	0.0017	-0.0139	0.0160	0.0011	-0.2205	0.0089	0.0141	0.0685	-0.3983	0.0170	-0.4782
Primary branches per plant	0.0028	0.0425	-0.4435	0.3058	0.0015	-0.0052	0.0940	0.0034	-0.0024	0.0399	0.2651	0.0043	0.0039	-0.0216	-0.0172	0.0109	0.2843
Pod circumference (cm)	-0.0407	0.0808	-0.2413	0.1099	-0.0256	0.0381	0.0032	0.1029	-0.0201	0.0562	0.1378	0.0035	-0.0148	-0.0473	0.1265	-0.0162	0.2527
Pod length (cm)	0.1087	0.3074	0.0512	-0.3672	0.0455	-0.1029	-0.0051	-0.0472	0.0439	-0.0681	-0.0969	0.0012	0.0036	0.0911	-0.3115	0.0036	-0.3427
Number of seeds per pod	0.0500	-0.0172	0.1508	-0.1006	-0.0020	0.0011	-0.0128	-0.0197	0.0102	-0.2928	-0.0380	0.0044	-0.0017	0.0818	0.3809	-0.0001	0.1943
Number of pods per plant	-0.1137	-0.2414	-0.3104	0.5004	-0.0386	0.0968	0.0388	0.0220	-0.0066	0.0173	0.6431	-0.0040	-0.0111	-0.0794	0.3828	-0.0212	0.8748
Shelling per cent	-0.1215	-0.3064	0.0917	0.2586	-0.0285	0.0799	-0.0128	-0.0113	-0.0017	0.0405	0.0809	-0.0315	-0.0050	-0.0807	0.3087	-0.0192	0.2417
100-seed weight (g)	0.0768	0.2459	-0.0024	-0.2538	0.0499	-0.1106	0.0102	-0.0424	0.0044	0.0140	-0.1976	0.0043	0.0360	0.0416	-0.2664	0.0415	-0.3486
Number of seed per 100 g pod	0.1602	0.4344	0.2071	-0.6311	0.0474	-0.1169	-0.0123	-0.0294	0.0241	-0.1448	-0.3087	0.0154	0.0090	0.1655	-0.4769	0.0278	-0.6291
Number of pods per 100 g	0.1197	0.4628	0.0931	-0.5715	0.0516	-0.1272	0.0018	-0.0147	0.0155	0.1262	-0.2786	0.0110	0.0108	0.0893	-0.8836	0.0363	-0.8573
T. S. S. (^{0}Brix)	0.0398	0.3543	0.0763	-0.4518	0.0150	-0.0455	0.0097	-0.0158	0.0015	0.0002	-0.1292	0.0057	0.0141	0.0435	-0.3045	0.1055	-0.2812

R Square = 1.0616, Residual Effect = 0.0616

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