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Association studies among yield attributes in erect and semi-spreading pigeonpea (cajanus cajan l)

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ABSTRACT

The correlation and path coefficient analysis among seed yield and its components in pigeonpea were worked out in 25 erect and 25 semi spreading genotypes separately during 2007-08. Results of the correlation coefficient analysis revealed that seed yield plant^{-1} was positively correlated with seeds plant^{-1} in erect group whereas, pod clusters plant^{-1}, pods plant^{-1} and 100 seed weight in semi-spreading group. Path coefficient analysis of various characters towards seed yield indicated that the maximum positive direct effect on seed yield was exhibited by seeds plant^{-1} in erect group and days to 50% flowering in semi-spreading group. Whereas, path coefficients for 100 seed weight revealed the maximum positive direct effect due to days to 50% flowering in erect group and days to flower initiation in semi-spreading group.

Introduction

Pigeonpea is an important component of human diet in developing countries like India where it supplements cereal-based foods by improving its nutritional status. Pigeonpea is the fourth most important pulse crop in the world where in, India alone accounts for 85 per cent of the world supply (Fattepurkar *et al.*, 2004). It is commonly known as '*Arhar*' or '*Tur*', generally used in preparing *dal*, which is fairly rich in protein and minerals and eaten by majority of Indian population. Pulses accounts for about one-fifth of total crop area under food grain production. Pulses play a vital role in Indian agriculture and are the major source of dietary protein. It can grow under low fertility and harsh conditions due to its ability to use atmospheric nitrogen through biological nitrogen fixation up to 40 kg N ha^{-1} (Nene, 1987), which is useful in maintaining soil health through increasing nitrogen availability and microbial activities. In India, Gujarat, Andhra Pradesh, Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka and Bihar are the major pigeonpea growing states. Historical evidences revealed that this crop is being grown in Chhattisgarh since long back especially in areas like Surguja, Rajnandgaon, Raipur, Durg, Bastar, Bilaspur, Dantewada and Kabeerdham. In Chhattisgarh, presently it is being cultivated in an area of about 163.63 thousand hectare with an annual production of 68.23 thousand tones and productivity 417 kg/ha during 2006-07 (Anonymous, 2007). However, major abiotic constraints in growing pigeonpea in Chhattisgarh are water logging and drought at later stage whereas, Phytopthora stem blight and pod borers among biotic constraints are important (Sharma *et al*., 2008). Two kinds of growth habit *viz* erect and semi-spreading usually found in cultivated pigeonpea. These have certain advantages in one hand and certain limitations on other hand. Erect type can fit well in inter cropping, mixed cropping system and for cultivation on rice bunds whereas, semi-spreading types are good for sole cropping. Therefore, separate breeding strategy required to develop high yielding varieties for erect and semi-spreading pigeonpea. The measurement of phenotypic, genotypic and environmental correlations between yield and other characters has basic and foremost endeavors to find out guidelines for plant selection. The magnitude and direction of correlation offers an idea for future improvement in concerned traits. In situations where more variables are included in correlation studies, the indirect association becomes complex and the path analysis is proved to be useful tool in finding out the direct and indirect causes of association.

Materials and Methods

The experimental materials for the present study consisted of 25 erect and 25 semi-spreading genotypes of pigeonpea. Separate experiments for erect and semi-spreading types were conducted in Randomized Complete Block Design (RBD) with two replications during *Kharif*, 2007 -08. The every genotype was sown in single row of 4.0 m length with 60 cm x 20 cm inter and intra row spacing. Sowing was done on July 12, 2007. Recommended dose of fertilizer *i.e.* NPK 20:50:20 kg ha^{-1} was applied in the rows before sowing. Observations were recorded as per the standard descriptors. Recommended package of practices were adopted to raise a normal crop.

The data obtained for the traits were statistically analyzed as per the procedure suggested by Miller *et al.* (1958) for estimation of Correlation coefficient and Wright (1921) for estimation of genotypic path coefficients.

Results and Discussion

Yield *per se* is a complex character governed under polygenic control and influence by various environmental effects too. Further, the yield component may not necessarily be independent in nature. Hence, direct selection for yield may not be very effective. The selection practiced for one character may simultaneously bring change in the other traits. Thus, to bring change in any characters especially in seed yield proper understanding of interrelationship among yield and yield attributing characters is must. This may help in selection of traits with high expression and association with yield without affecting other traits if association is positive, it considerably will accelerate the rate of desirable genes, while correlation in

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negative direct, will retard the genetic progress except for the traits like earliness.

Correlation analysis

Correlation analysis clearly revealed that the phenotypic and genotypic correlations in general are similar in direction but the magnitude of genotypic correlations was higher than the phenotypic correlations. The low phenotypic correlation could result due to masking influence and modifying effect of the environment on the association of characters. Pandey and Gritton (1975) have pointed out that no suitable test of significance of genetic correlation is available. Therefore, their primary utility is in strengthening interpretations based on phenotypic correlation and in better predicting correlated responses to selection. Hence, important findings based on phenotypic correlation are discussed here. The correlation coefficients are the index of association between two variables, these have been worked out in all possible combinations at phenotypic (P), genotypic (G) and environmental (E) levels for erect (Table 4.5) and semi-spreading (Table 1, 2) groups separately.

i. In erect group

Results of genotypic, phenotypic and environmental correlation coefficients in erect group revealed that the highest significant positive correlation of seed yield plant^{-1} was observed with seeds plant^{-1} (r=0.625).

Seeds plant^{-1} exhibited significance positive correlation with pods plant^{-1} (r=0.721) and pod clusters plant^{-1} (r=0.714) whereas, the pod clusters plant^{-1} exhibited significant and positive correlation with pods plant^{-1} (r=0.810). Days to maturity was found to be positively correlated with days to 50% flowering (r=0.831) and days to flower initiation (r=0.759). Similarly, the character days to 50% flowering showed significant positive correlation with days to flower initiation (r=0.858). An overall observation of correlation coefficient analysis revealed that seeds plant^{-1} showed positive correlation with seed yield plant^{-1}. Hence, direct selection for this trait may lead to the development of high yielding erect pigeonpea genotypes.

ii. In semi-spreading group

Results of genotypic, phenotypic and environmental correlation coefficients in semi-spreading group revealed that the highest positive correlation of seed yield plant^{-1} was observed with seeds plant^{-1} (r =0.730) followed by pods plant^{-1} (r=0.664), 100 seed weight (r=0.573) and pod clusters plant^{-1} (r=0.547). Whereas, seeds plant^{-1} showed significant positive correlation with pods plant^{-1} (r=0.648) and pod clusters plant^{-1} (r=0.519). Pod clusters plant^{-1} was significantly and positively correlated with pods plant^{-1} (r=0.760). Days to maturity exhibited significant positive correlation with days to 50% flowering (r=0.847) and days to flower initiation (r=0.836). Similarly, the character days to 50% flowering exhibited significant positive correlation with days to flower initiation (r=0.989). An overall observation of correlation coefficient analysis in semi-spreading pigeonpea group revealed that seeds plant^{-1}, pods plant^{-1}, 100 seed weight and pod clusters plant^{-1} exhibited the positive correlation with seed yield plant^{-1}. Hence, selection for these traits may lead to the development of high yielding semi-spreading pigeonpea genotypes.

The experimental findings on correlation coefficient analysis are in general agreement with the results reported earlier by Brar (1993), Jahagirdar *et al* (1994) Sarma *et al*. 1994), Gowda *et al*. (1996), Pansuriya *et al*. (1998), Srinivas *et al*. (1999), Kingshlin and Subbaraman (1999), Sinha and Singh (2005), Firoz *et al.* (2006) and Baskaran and Muthiah (2007).

Path coefficient analysis

Correlation indicates the types of relationship exists among the characters but does not provide information on extent of relationship established when one of the characters appear to be dependent over a number of other characters. Path coefficient analysis can explain the extent of relative contribution. In the present investigation, path coefficient analysis was carried out by taking seed yield plant^{-1} and 100 seed weight as dependent variables and rest of the quantitative traits as independent variables. Hence, experimental findings of path coefficient analysis for above two traits are discussed here separately for both the erect and semi-spreading group in the light of available literature.

i. In erect group

Genotypic correlation coefficients of various yield attributing characters for seed yield and 100 seed weight were further partitioned into direct and indirect effects and are given in Table 3 and Table 4 respectively.

The highest positive direct effect contributing to seed yield plant^{-1} was observed due to seeds plant^{-1} (10.627) followed by the days to maturity (7.945) and 100 seed weight (0.906). As the trait seeds plant^{-1} exhibited the positive correlation with seed yield plant^{-1}. Hence, direct selection for the traits seeds plant^{-1} could be effective in developing high yielding genotype of erect nature.

The highest positive direct effect contributing to 100 seed weight was observed due to days to 50% flowering (5.906) followed by pod clusters plant^{-1} (4.532), plant height (3.692), pods plant^{-1} (2.615), days to flower initiation (2.205) and seed yield plant^{-1} (1.004).

ii. In semi-spreading group

Genotypic correlation coefficients of various yield attributing characters for seed yield and 100 seed weight were further partitioned into direct and indirect effects and are given in Table 5 and 6 respectively.

The data presented in table for semi-spreading group revealed that days to 50% flowering had the highest positive direct effect (1.048) on seed yield followed by seeds plant^{-1} (0.694), days to maturity (0.486), 100 seed weight (0.445), branches plant^{-1} (0.180) and pods plant^{-1} (0.167). Although, character pod clusters plant^{-1} exhibited the positive correlation with seed yield plant^{-1} but its direct effect on seed yield plant^{-1} was negative which is mainly due to nullifying effects via seeds plant^{-1}, 100 seed weight and days to 50% flowering. Hence, direct selection for seeds plant^{-1}, pods plant^{-1} and 100 seed weight could be effective in developing high yielding semi-spreading pigeonpea genotypes.

The highest positive direct effect on 100 seed weight was noted due to days to flower initiation (3.654) followed by seed yield plant^{-1} (0.588), pods plant^{-1} (0.265) and days to maturity (0.103). These findings are general agreement with the findings reported earlier by Patel and Patel (1988), Holkar *et al.* (1991), Brar (1993), Jahagirdar *et al* (1994), Sarma *et al.* (1994), Gowda *et al.* (1996), Paul and Upadhyay (1996), Musuna and Nadhy (1998), Kingshlin and Subbarman (1999), Sinha and Singh (2005) and Baskaran and Muthiah (2007).

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Table 1. Genotypic (G), Phenotypic (P) and Environmental (E) correlation coefficients for seed yield and its components in erect group of pigeonpea

S. No.	Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Pods plant^{-1}	Pod clusters plant^{-1}	Seeds plant^{-1}	Seed yield plant^{-1} (g)	100 seed weight (g)
1	Days to flower initiation	P	0.858**	0.759**	0.243	-0.195	-0.271	-0.082	-0.113	0.169
		G	0.946	0.955	0.516	-0.245	-0.465	-0.140	-0.162	0.356
		E	0.718	0.262	-0.151	-0.130	-0.042	-0.020	-0.022	-0.026
2	Days to 50% flowering	P		0.831**	0.384	-0.092	-0.182	-0.006	-0.138	0.176
		G		0.926	0.681	-0.148	0.216	0.095	-0.071	0.279
		E		0.248	-0.340	0.021	-0.158	-0.218	-0.383	0.034
3	Days to maturity	P			0.332	-0.035	-0.114	-0.062	-0.172	0.095
		G			0.526	-0.046	-0.218	-0.042	-0.232	0.286
		E			-0.148	-0.015	-0.015	-0.132	0.025	-0.278
4	Plant height (cm)	P				0.237	0.215	0.441	0.344	-0.037
		G				0.430	0.479	0.758	0.462	-0.142
		E				0.010	-0.070	0.134	0.156	0.063
5	Pods plant^{-1}	P					0.810**	0.721**	0.454	-0.321
		G					0.873	0.808	0.768	-1.008
		E					0.750	0.648	-0.001	0.279
6	Pod clusters plant^{-1}	P						0.714**	0.312	-0.308
		G						0.873	0.512	-1.015
		E						0.582	0.052	0.262
7	Seeds plant^{-1}	P							0.625*	-0.336
		G							0.753	-0.797
		E							0.507	0.004
8	Seed yield plant^{-1} (g)	P								-0.099
		G								-0.107
		E								-0.097

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

Table 2. Genotypic (G), Phenotypic (P) and Environmental (E) correlation coefficients for seed yield and its components in semi-spreading group of pigeonpea

S. No.	Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Pod clusters plant^{-1}	Pods cluster^{-1}	Seeds plant^{-1}	Seed yield plant^{-1} (g)	100 seed weight (g)
1	Days to flower initiation	P	0.989**	0.836**	0.411	0.079	0.044	0.221	-0.223	0.120	-0.108	-0.261
		G	0.993	0.847	0.475	0.130	0.114	0.289	-0.303	0.157	-0.139	-0.346
		E	0.791	0.280	-0.296	-0.184	-0.366	-0.064	-0.082	0.111	-0.195	-0.096
2	Days to 50% flowering	P		0.847**	0.402	0.056	0.021	0.173	-0.215	0.085	-0.138	-0.305
		G		0.858	0.457	0.124	0.083	0.262	-0.293	0.142	-0.589	-0.413
		E		0.368	-0.094	-0.303	-0.294	-0.310	-0.066	-0.126	-0.159	-0.047
3	Days to maturity	P			0.313	0.168	0.140	0.247	-0.086	0.037	-0.031	-0.224
		G			0.349	0.222	0.217	0.354	-0.082	0.079	-0.014	-0.305
		E			0.004	0.084	-0.051	-0.314	-0.269	-0.178	-0.194	-0.020
4	Plant height (cm)	P				-0.111	0.106	0.142	-0.160	-0.033	-0.239	-0.342
		G				-0.290	0.055	0.137	-0.153	-0.047	-0.417	-0.459
		E				0.274	0.231	0.168	-0.204	-0.008	0.021	-0.124
5	Branches plant^{-1}	P					0.329	0.427	0.170	0.230	0.295	0.187
		G					0.425	0.640	0.302	0.345	0.460	0.232
		E					0.236	0.143	0.025	0.109	0.148	0.135
6	Pods plant^{-1}	P						0.760**	0.164	0.648*	0.664**	0.443
		G						1.127	0.360	0.875	0.900	0.730
		E						0.351	-0.021	0.439	0.479	0.157
7	Pod clusters plant^{-1}	P							0.006	0.519*	0.547*	0.405
		G							0.229	0.692	0.817	0.637
		E							-0.285	0.308	0.276	0.087
8	Pods cluster^{-1}	P								0.256	0.248	0.079
		G								0.384	0.318	0.041
		E								0.124	0.188	0.121
9	Seeds plant^{-1}	P									0.730**	0.280
		G									0.944	0.679
		E									0.551	-0.155
10	Seed yield plant^{-1} (g)	P										0.573*
		G										0.923
		E										0.254

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

Table 3. Genotypic path coefficients of various characters for seed yield plant $^{-1}$ in erect group of pigeonpea

Characters	Days to flower initiation	Days to 50% flowering	Days to maturity	Plant height (cm)	Pods plant^{-1}	Pod clusters plant^{-1}	Seeds plant^{-1}	100 seed weight (g)	Genotype 'r' with seed yield plant^{-1}
Days to flower initiation	-1.867	-5.504	7.585	-1.835	0.637	1.988	-1.489	0.322	-0.162
Days to 50% flowering	-1.767	-5.816	7.360	-2.421	0.384	0.925	1.010	0.253	-0.071
Days to maturity	-1.782	-5.388	7.945	-1.872	0.121	0.931	-0.445	0.259	-0.232
Plant height (cm)	-0.963	-3.958	4.180	-3.557	-1.116	-2.048	8.053	-0.129	0.462
Pods plant^{-1}	0.458	0.860	-0.369	-1.530	-2.595	-3.732	8.589	-0.914	0.768
Pod clusters plant^{-1}	0.868	1.258	-1.729	-1.703	-2.265	-4.277	9.279	-0.920	0.512
Seeds plant^{-1}	0.262	-0.553	-0.333	-2.696	-2.098	-3.734	10.627	-0.722	0.755
100 seed weight (g)	-0.664	-1.622	2.273	0.507	2.616	4.341	-8.464	0.906	-0.107

Diagonal values indicate direct effects Residual effect=0.0430

Table 4. Genotypic path coefficients of various characters for 100 seed weight in erect group of pigeonpea

Characters	Days to flower initiation	Days to 50% flowering	Days to maturity	Plant height (cm)	Pods plant^{-1}	Pod clusters plant^{-1}	Seed plant^{-1}	Seed yield plant^{-1} (g)	Genotype 'r' with 100 seed weight
Days to flower initiation	2.205	5.589	-7.976	1.905	-0.642	-2.107	1.545	-0.162	0.356
Days to 50% flowering	2.087	5.906	-7.740	2.513	-0.387	-0.981	-1.048	-0.071	0.279
Days to maturity	2.105	5.471	-8.354	1.943	-0.121	-0.986	0.462	-0.233	0.286
Plant height (cm)	1.137	4.019	-4.396	3.692	1.124	2.170	-8.354	0.465	-0.142
Pods plant^{-1}	-0.541	-0.873	0.388	1.588	2.615	3.955	-8.911	0.772	-1.008
Pod clusters plant^{-1}	-1.025	-1.278	1.818	1.768	2.282	4.532	-9.626	0.514	-1.015
Seeds plant^{-1}	-0.309	0.561	0.350	2.798	2.114	3.957	-11.024	0.757	-0.797
Seed yield plant^{-1} (g)	-0.357	-0.420	1.937	1.708	2.009	2.318	-8.306	1.004	-0.107

Diagonal values indicate direct effects Residual effect= 0.0477

Table 5. Genotypic path coefficients of various characters for seed yield plant $^{-1}$ in semi-spreading group of pigeonpea

Characters	Days to flower initiation	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Pod clusters plant^{-1}	Pods cluster^{-1}	Seeds plant^{-1}	100 seed weight (g)	Genotype 'r' with seed yield plant^{-1}
Days to flower initiation	-1.561	1.041	0.411	-0.020	0.023	0.019	-0.058	0.050	0.109	-0.154	-0.139
Days to 50% flowering	-1.551	1.048	0.417	-0.019	0.022	0.014	-0.053	0.049	0.099	-0.184	-0.159
Days to maturity	-1.322	0.899	0.486	-0.015	0.040	0.036	-0.071	0.014	0.055	-0.136	-0.014
Plant height (cm)	-0.741	0.479	0.170	-0.043	-0.052	0.009	-0.028	0.026	-0.033	-0.205	-0.417
Branches plant^{-1}	-0.203	0.130	0.108	0.012	0.180	0.071	-0.129	-0.050	0.239	0.103	0.460
Pods plant^{-1}	-0.178	0.087	0.105	-0.002	0.076	0.167	-0.227	-0.060	0.607	0.325	0.900
Pod clusters plant^{-1}	-0.451	0.275	0.172	-0.006	0.115	0.188	-0.202	-0.038	0.480	0.283	0.817
Pods cluster^{-1}	0.473	-0.307	-0.040	0.007	0.054	0.060	-0.046	-0.167	0.266	0.018	0.318
Seeds plant^{-1}	-0.245	0.149	0.038	0.002	0.062	0.146	-0.140	-0.064	0.694	0.302	0.944
100 seed weight (g)	0.540	-0.432	-0.148	0.020	0.042	0.122	-0.128	-0.007	0.471	0.445	0.923

Diagonal values indicate direct effects
Residual effect = -0.1434

Table 6. Genotypic path coefficients of various characters for 100 seed weight in semi-spreading group of pigeonpea

Characters	Days to flower initiation	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Pod clusters plant^{-1}	Pods cluster^{-1}	Seeds plant^{-1}	Seed yield plant^{-1} (g)	Genotype 'r' with 100 seed weight
Days to flower initiation	3.654	-4.008	0.087	-0.109	-0.015	0.030	-0.012	0.098	0.010	-0.082	-0.346
Days to 50% flowering	3.630	-4.034	0.088	-0.105	-0.014	0.022	-0.011	0.095	0.009	-0.093	-0.413
Days to maturity	3.094	-3.462	0.103	-0.080	-0.026	0.057	-0.015	0.027	0.005	-0.008	-0.305
Plant height (cm)	1.735	-1.843	0.036	-0.230	0.033	0.014	-0.006	0.050	-0.003	-0.245	-0.459
Branches plant^{-1}	0.475	-0.499	0.023	0.067	-0.115	0.112	-0.026	-0.098	0.023	0.271	0.232
Pods plant^{-1}	0.416	-0.334	0.022	-0.013	-0.049	0.264	-0.047	-0.117	0.058	0.529	0.730
Pod clusters plant^{-1}	1.056	-1.058	0.036	-0.032	-0.074	0.297	-0.041	-0.074	0.046	0.480	0.637
Pods cluster^{-1}	-1.107	1.183	-0.008	0.035	-0.035	0.095	-0.009	-0.325	0.025	0.187	0.041
Seeds plant^{-1}	0.574	-0.573	0.008	0.011	-0.040	0.231	-0.029	-0.125	0.066	0.555	0.679
Seed yield plant^{-1} (g)	-0.509	0.641	-0.001	0.096	-0.053	0.237	-0.034	-0.103	0.062	0.588	0.923

Diagonal values indicate direct effects
Residual effect=-0.189