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ASSOCIATION STUDIES IN F₂ SEGREGATING POPULATION OF PIGEON PEA (*CAJANUS CAJAN* L. MILL SP.)

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ABSTRACT

This study investigated the combining ability and gene action for yield and its attributing traits in Pigeonpea (*Cajanus cajan* (L.) Mill. sp.) across four different crosses viz.: GRG-152 x Chhattisgarh Arhar-1, GRG-152 x Rajeevlochan, Rajeevlochan x Chhattisgarh Arhar-1 and Rajeevlochan x GRG-152. The research aimed to assess genetic variability, heritability, genetic advance, association patterns in F₂ populations, inheritance of non-metric traits, magnitude of heterosis and inbreeding depression and the nature of gene action. Correlation analysis indicated significant positive associations between yield per plant and traits like number of branches per plant and number of pods per plant, while days to maturity and days to 50% flowering showed significant negative correlations with yield. Path analysis further elucidated the direct and indirect effects, with number of branches per plant and number of pods per plant consistently exhibiting strong positive direct effects on yield.

Keywords : Pigeon pea, *Cajanus cajan* (L.) Mill sp., Association studies, segregating population, Path analysis, Correlation analysis.

Introduction

Pigeon pea accounts for 40% of pulse production in our country and improvement in its yield and potential would play an important role in food security. It is cultivated by millions of farmers in semi-arid and tropical countries of Asia, Africa etc. (Varshney *et al.*, 2010). India ranked first in area and production in the world with 73% and 67% of world's acreage and production respectively. India leads production at 77%, followed by Malawi (11%), Myanmar (8%), Kenya, and Tanzania (2% each). According to the FAO's report (2023). The area, production and productivity of pigeon pea in India is 4.13 million ha, 3.41 million tons and 827 kg/ha respectively. This pulse crop occupies an important position in Chhattisgarh as well. It covers an area of about 34.87 lakh hectares with a production of 20.75 lakh tons and productivity of 595 kg/ ha. (PC report 2024-25, AICRP on Pigeonpea). This crop has gained popularity over the last few decades because of its ability to perform well in adverse environmental conditions with minimal inputs.

As a protein-rich legume, Pigeonpea plays a crucial role in combating malnutrition in developing countries, being a key source of plant-based protein, essential amino acids and minerals (Singh, 2017). However, its productivity remains low compared to cereals, necessitating genetic improvement through breeding.

Genetic variability, heritability and genetic advance are essential for effective selection and yield improvement (Rao and Rao, 2020). Heterosis exploitation in F₁ hybrids, gene action analysis using Hayman's model, and inbreeding depression studies help in determining the appropriate breeding strategy (Pandey *et al.*, 2015). Tools like the scaling test and statistical measures such as skewness and kurtosis aid in understanding gene interactions and trait inheritance.

Despite its economic significance, Pigeonpea breeding is limited due to its long life cycle and susceptibility to stresses. Quantitative Trait Loci (QTL) mapping has emerged as an effective approach for identifying genomic regions associated with complex traits like yield and stress resistance, aiding in the

development of improved cultivars (Saxena *et al.*, 2017).

Materials and Methods

The present investigation was carried out at the experimental field of the College of Agriculture, Raipur (IGKV). This experiment was conducted during the *Kharif* season 2020-21 & 2021-22. Geographically, the experimental site is situated between 21° North latitude and 81.6° East longitude at an altitude of 298.16 meters above mean sea level. This region falls under agro-climatic zone Zone 7 – Eastern Plateau and Hills Region which comprises the Chotanagpur plateau, Rajmahal Hills, Chhattisgarh plains and Dandakaranya of pigeonpea. The region enjoys 26°C-34°C of temperature in July, 10° C - 27° C in January and 80 cm-150 cm of annual rainfall.

Three parental genotypes—GRG-152, Rajeevlochan, and Chhattisgarh Arhar-1—were used to generate 12 crosses, including F₁, F₂, F₃, BC₁, and BC₂ generations. Observations were recorded on various agronomic traits including maturity duration, flowering time, plant height (in cm), branches per plant, pods per plant and 100-seed weight (g) and seed yield (g). Additionally, non-metric traits such as seed color, pod pubescence, and flower morphology were evaluated as per PPVFRA guidelines.

The data obtained were subjected to statistical analysis on op stat software for correlation and path coefficient analyses to determine interrelationships among traits and their direct and indirect contributions to yield.

This comprehensive approach combining traditional and advanced biometric tools enables effective identification of promising parental lines and crosses, offering valuable insights into the genetic mechanisms controlling yield and its related traits. The findings are expected to contribute to the development of high-yielding, stress-tolerant Pigeonpea varieties suited for rainfed conditions.

Results and Discussion

The present study revealed that genotypic correlations were generally higher than phenotypic correlations, suggesting that the observed associations among traits were primarily governed by genetic factors with limited environmental influence. Yield per

plant exhibited a strong positive association with number of pods per plant, number of branches per plant, plant height (cm), and hundred-seed weight (g), indicating that these traits are critical contributors to yield improvement in Pigeonpea. Path coefficient analysis further clarified these associations by partitioning correlations into direct and indirect effects. The number of pods per plant exerted the highest positive direct effect on seed yield, followed by hundred-seed weight (g) and number of branches per plant, while traits such as plant height (cm) and days to flowering influenced yield (g) indirectly through their effects on yield-contributing traits. A low residual effect confirmed that the traits under study accounted for a major portion of variation in yield, highlighting the robustness of the selected model.

These findings align with earlier reports in Pigeonpea, where several researchers emphasized number of pods per plant, seed weight (g), and branching traits as reliable indicators for selection. Saroj *et al.* (2013) observed high positive direct effects of pods per plant and 100-seed weight (g) on grain yield, suggesting their utility in breeding programs. Similarly, Jayalakshmi (2018) and Singh *et al.* (2013) reported strong correlations of seed yield (g) with number of pods per plant, primary and secondary branches, with direct effects predominantly from pods per plant and branching traits. Shukla *et al.* (2025) confirmed these trends, identifying secondary branches, number pods per plant, and seed weight (g) as key determinants of yield, while plant height (cm) showed a negative direct effect, indicating the need for balanced plant architecture. Recent studies by Dharana *et al.* (2025) also emphasized the significance of biological yield, harvest index, pods per plant, and seed weight, reinforcing the conclusion that seed yield is a complex trait controlled by multiple yield components that are mostly interdependent. Collectively, these studies confirm that selection strategies focusing on traits with strong direct effects particularly number of pods per plant, seed weight (g), and branching can significantly enhance yield potential in Pigeonpea breeding programs. Present outcome was also observed in study conducted Sahu *et al.*, (2025), Mishra *et al.*, (2025).

Table 1: Correlation analysis for yield and its attributing traits of cross 1 (GRG152 X CG Arhar I).

Trait		Days to 50% flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Hundred seed weight (g)	Yield per plant (g)
Days to maturity	G	0.411**	-0.148*	-0.434**	-0.122*	-0.029	-0.393**
	P	0.41**	-0.143*	-0.432**	-0.116*	-0.032	-0.391**
Days to 50% flowering	G	1.000	-0.083	-0.278**	-0.032	0.084	-0.384**
	P	1.000	-0.08	-0.277**	-0.028	0.082	-0.383**
Plant height (cm)	G		1.000	0.477**	0.425**	0.104	0.137*
	P		1.000	0.47**	0.418**	0.109	0.133*
Number of branches per plant	G			1.000	0.464**	0.037	0.426**
	P			1.000	0.451**	0.049	0.426**
Number of pods per plant	G				1.000	0.028	0.219**
	P				1.000	0.034	0.215**
Hundred seed weight (g)	G					1.000	0.052
	P					1.000	0.055

Table 2: Correlation analysis for yield and its attributing traits of cross 2 (GRG152 X Rajeevlochan)

Trait		Days to 50% flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Hundred seed weight (g)	Yield per plant (g)
Days to maturity	G	0.997**	0.925**	-0.383**	-0.1	0.555**	-0.671**
	P	0.461**	0.295**	-0.238**	-0.058	0.122*	-0.44**
Days to 50% flowering	G	1.000	0.566**	-0.487**	-0.373**	0.478**	-0.625**
	P	1.000	0.232**	-0.228**	-0.096	0.08	-0.415**
Plant height (cm)	G		1.000	-0.414**	-0.326**	0.078	-0.816**
	P		1.000	-0.044	0.038	0.028	-0.277**
Number of branches per plant	G			1.000	0.841**	0.367**	0.847**
	P			1.000	0.563**	0.089	0.531**
Number of pods per plant	G				1.000	1.000	0.749**
	P				1.000	0.197**	0.408**
Hundred seed weight (g)	G					1.000	0.246**
	P					1.000	0.065

Table 3: Correlation analysis for yield and its attributing traits of cross 3 (Rajeevlochan X CG Arhar I).

Trait		Days to 50% flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Hundred seed weight (g)	Yield per plant (g)
Days to maturity	G	0.495**	-0.032	-0.338**	-0.219**	0.11*	-0.487**
	P	0.5**	-0.025	-0.338**	-0.212**	0.103	-0.488**
Days to 50% flowering	G	1.000	0.068	-0.274**	-0.158**	0.055	-0.458**
	P	1.000	0.063	-0.274**	-0.168**	0.063	-0.459**
Plant height (cm)	G		1.000	0.084	0.13*	-0.024	-0.008
	P		1.000	0.084	0.116*	-0.008	-0.008
Number of branches per plant	G			1.000	0.496**	0.13*	0.476**
	P			1.000	0.501**	0.131*	0.476**
Number of pods per plant	G				1.000	0.291**	0.619**
	P				1.000	0.319**	0.627**
Hundred seed weight (g)	G					1.000	0.25**
	P					1.000	0.251**

Table 4: Correlation analysis for yield and its attributing traits of cross4 (Rajeevlochan X GRG152).

Trait		Days to 50% flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Hundred seed weight (g)	Yield per plant (g)
Days to maturity	G	0.218**	0.017	-0.267**	-0.079	0.005	-0.406**
	P	0.221**	0.017	-0.276**	-0.08	0.005	-0.406**
Days to 50% flowering	G	1.000	-0.15**	-0.282**	-0.188**	-0.084	-0.221**
	P	1.000	-0.105*	-0.261**	-0.176**	-0.094	-0.217**
Plant height (cm)	G		1.000	0.446**	0.306**	0.102*	0.142**
	P		1.000	0.387**	0.289**	0.152**	0.135**
Number of branches per plant	G			1.000	0.645**	0.133**	0.507**
	P			1.000	0.641**	0.155**	0.512**
Number of pods per plant	G				1.000	0.094	0.466**
	P				1.000	0.103*	0.464**
Hundred seed weight (g)	G					1.000	0.044
	P					1.000	0.048

Table 5: Path coefficient for yield and its attributing traits of cross 1 (GRG152 X CG Arhar I).

Trait		Days to maturity	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Hundred seed weight (g)	Yield per plant (g)
Days to maturity	G	-0.1696	-0.0698	0.0251	0.0737	0.0207	0.0049	-0.393**
	P	-0.1685	-0.0691	0.0241	0.0728	0.0195	0.0054	-0.391**
Days to 50% flowering	G	-0.1015	-0.2467	0.0205	0.0685	0.0080	-0.0207	-0.384**
	P	-0.1010	-0.2462	0.0197	0.0682	0.0069	-0.0202	-0.383**
Plant height (cm)	G	0.0133	0.0074	-0.0897	-0.0428	-0.0381	-0.0093	0.137*
	P	0.0129	0.0072	-0.0901	-0.0424	-0.0377	-0.0098	0.133*
Number of branches per plant	G	-0.1214	-0.0777	0.1334	0.2795	0.1296	0.0103	0.426**
	P	-0.1213	-0.0777	0.1320	0.2806	0.1264	0.0137	0.426**
Number of pods per plant	G	-0.0118	-0.0031	0.0412	0.0449	0.0969	0.0027	0.219**
	P	-0.0113	-0.0027	0.0407	0.0439	0.0973	0.0034	0.215**
Hundred seed weight (g)	G	-0.0019	0.0054	0.0067	0.0024	0.0018	0.0641	0.052
	P	-0.0020	0.0051	0.0068	0.0030	0.0021	0.0623	0.055

Residual effect-0.3032, ** significance at 1% level, * significance at 5% level

Table 6 : Path coefficient for yield and its attributing traits of cross 2 (GRG152 X Rajeevlochan).

Trait		Days to maturity	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Hundred seed weight (g)	Yield per plant (g)
Days to maturity	G	-0.2939	-0.2929	-0.2720	0.1126	0.0293	-0.1632	-0.671**
	P	-0.2253	-0.1038	-0.0665	0.0536	0.0130	-0.0274	-0.44**
Days to 50% flowering	G	0.2204	0.2211	0.1252	-0.1076	-0.0825	0.1058	-0.625**
	P	-0.0861	-0.1867	-0.0434	0.0426	0.0178	-0.0149	-0.415**
Plant height (cm)	G	-0.3760	-0.2300	-0.4063	0.1684	0.1325	-0.0315	-0.816**
	P	-0.0479	-0.0377	-0.1622	0.0072	-0.0062	-0.0045	-0.277**
Number of branches per plant	G	-0.1765	-0.2242	-0.1909	0.4607	0.5035	0.1689	0.847**
	P	-0.0742	-0.0712	-0.0138	0.3120	0.1756	0.0279	0.531**
Number of pods per plant	G	-0.0209	-0.0781	-0.0682	0.2287	0.2092	0.2091	0.749**
	P	-0.0114	-0.0190	0.0076	0.1119	0.1987	0.0391	0.408**
Hundred seed weight (g)	G	-0.0239	-0.0206	-0.0033	-0.0158	-0.0430	-0.0430	0.246**
	P	0.0055	0.0036	0.0013	0.0040	0.0089	0.0452	0.065

Residual effect-0.1732, ** significance at 1% level, * significance at 5% level

Table 7: Path coefficient for yield and its attributing traits of cross 3 (Rajeevlochan X CG Arhar 1).

Trait		Days to maturity	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Hundred seed weight (g)	Yield per plant (g)
Days to maturity	G	-0.1696	-0.0698	0.0251	0.0737	0.0207	0.0049	-0.393**
	P	-0.1685	-0.0691	0.0241	0.0728	0.0195	0.0054	-0.391**
Days to 50% flowering	G	-0.1015	-0.2467	0.0205	0.0685	0.0080	-0.0207	-0.384**
	P	-0.1010	-0.2462	0.0197	0.0682	0.0069	-0.0202	-0.383**
Plant height (cm)	G	0.0133	0.0074	-0.0897	-0.0428	-0.0381	-0.0093	0.137*
	P	0.0129	0.0072	-0.0901	-0.0424	-0.0377	-0.0098	0.133*
Number of branches per plant	G	-0.1214	-0.0777	0.1334	0.2795	0.1296	0.0103	0.426**
	P	-0.1213	-0.0777	0.1320	0.2806	0.1264	0.0137	0.426**
Number of pods per plant	G	-0.0118	-0.0031	0.0412	0.0449	0.0969	0.0027	0.219**
	P	-0.0113	-0.0027	0.0407	0.0439	0.0973	0.0034	0.215**
Hundred seed weight (g)	G	-0.0019	0.0054	0.0067	0.0024	0.0018	0.0641	0.052
	P	-0.0020	0.0051	0.0068	0.0030	0.0021	0.0623	0.055

Residual effect-0.2414 ** significance at 1% level, * significance at 5% level

Table 8: Path coefficient for yield and its attributing traits of cross 4 (Rajeevlochan X GRG152).

Trait		Days to maturity	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Hundred seed weight (g)	Yield per plant (g)
Days to maturity	G	-0.3044	-0.0665	-0.0051	0.0812	0.0239	-0.0015	-0.406**
	P	-0.3036	-0.0670	-0.0052	0.0838	0.0242	-0.0015	-0.406**
Days to 50% flowering	G	-0.0083	-0.0381	0.0057	0.0108	0.0071	0.0032	-0.221**
	P	-0.0088	-0.0398	0.0042	0.0104	0.0070	0.0037	-0.217**
Plant height (cm)	G	-0.0010	0.0092	-0.0609	-0.0272	-0.0186	-0.0062	0.142**
	P	-0.0007	0.0044	-0.0416	-0.0161	-0.0120	-0.0063	0.135**
Number of branches per plant	G	-0.0690	-0.0731	0.1156	0.2588	0.1669	0.0344	0.507**
	P	-0.0704	-0.0666	0.0986	0.2548	0.1633	0.0396	0.512**
Number of pods per plant	G	-0.0226	-0.0540	0.0882	0.1856	0.2879	0.0272	0.466**
	P	-0.0225	-0.0499	0.0819	0.1816	0.2833	0.0292	0.464**
Hundred seed weight (g)	G	-0.0001	0.0011	-0.0013	-0.0017	-0.0012	-0.0128	0.044
	P	-0.0001	0.0016	-0.0026	-0.0026	-0.0017	-0.0168	0.048

Residual effect-0.2785 ** significance at 1% level, * significance at 5% level.

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