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Genetic variability, correlation and path coefficient analysis for yield and its attributing traits in pigeonpea (*Cajanus cajan*) grown under rainfed conditions of Manipur

JOGENDRA SINGH[1], R ABDUL FIYAZ[2], SUDHIR KUMAR[3], M A ANSARI[4] and SANJAY GUPTA[5]

ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal, Manipur 795 004

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ABSTRACT

The present investigation was conducted during the *kharif* season of 2007, 2008 and 2009 to obtain the knowledge of nature and magnitude of genetic parameters and its utilization in development of superior varieties of pigeonpea [*Cajanus cajan* (L.) Millsp.]. The genetic parameters studied namely, genotypic and phenotypic variability, genotypic and phenotypic coefficient of variation, heritability (h^2) and genetic advance. Besides, these parameters, correlation coefficient and path analysis were also studied for seed yield and its component traits in 21 diverse genotypes of short duration pigeonpea. The results indicated that the genotypes showed significant variability for all the traits studied. UPAS 120 yielded the highest seed yield/plant (39.21 g), followed by ICPL 88034 (35.66 g) and PA 134 (35.65 g). The high yield of UPAS 120 was attributed by high number of seeds/pod and pod length. Similarly, high yield of ICPL 88034 was contributed by primary branches/plant, pod length and 100-seed weight. The range of PCV was observed from 4.56 to18.59 % for the traits under study which provides a picture of the extent of phenotypic variability in the population. The PCV was noted moderate for the characters like seed yield/plant (18.59%), pods/plant (18.04%) and primary branches/plant (12.22%). Genotypic coefficient of variation ranged from 3.24% to 17.84%. Maximum GCV was observed for seed yield/plant (17.84%), followed by pods/plant (17.80%) and primary branches/plant (10.94%). Seed yield/plant was found to be significant positively associated with seeds/pod, pod length and plant height at genotypic level. The estimate of broad sense heritability was the highest for pods/plant (97%), followed by days to 50% flowering (94%), grain yield/plant (92%), days to maturity (90%), primary branches/plant (80%) and plant height (78%). The estimated genetic advance was recorded the moderate magnitude for pods/plant (36%) and grain yield/plant (35%). Seed yield/plant was found to be significant positively associated with seeds/pod, pod length and plant height at genotypic level. Seeds/pod exhibited the highest magnitude of direct effects on seed yield, followed by primary branches/plant and pod length. The component characters namely, pod length and seeds/pod showed positive and significant correlation (0.529 and 0.794) with seed yield/plant and also exhibited positive and strong direct effects (0.531 and 0.266) on seed yield/plant.

Key words: Correlation, Genetic variability, Heritability, Path analysis, Pigeonpea

Pigeonpea [*Cajanus cajan* (L.) Millsp.] known as red gram is the second most important pulse crop of India. It has been recognized as a good source of vegetarian protein particularly in the developing countries where majority of the population depends on the low priced vegetarian foods. In fact, this crop has diversified uses such as food, feed, fodder and fuel wood. It is also helpful to check the soil erosion and for maintaining the soil fertility. It is a hardy, widely adapted and drought tolerant crop. Each and every part of the plant is valuable for the farmers.

Globally, pigeonpea is cultivated in 4.86 million ha area with an annual production of 4.1 million tonnes. India is the leading producer of pigeonpea in the world accounting for 4.09 M ha area and 3.27 million tonnes of production (DAC 2011). Pigeonpea seeds have 19–25% protein and are consumed as green peas, whole grain or split peas (Ajay *et al*. 2011). The seed and pod husks make a quality feed, whereas dry branches and stems serve as domestic fuel. Fallen leaves from the plant provide vital nutrients to the soil and the plant also enriches soil through symbiotic nitrogen fixation (Varshney 2010). Productivity of pigeonpea worldwide in comparison to cereals is very low and stagnant

[1]Senior scientist, Plant Breeding (e mail: jogendrasail@yahoo.co.in); [2]Scientst, Plant Breeding (e mail: genefiyaz@gmail.com), [3]Scientist, Plant Breeding (e mail: sudhiraaidu2006@gmail.com), [4]Scientist, Agronomy (e mail: merajiari@gmail.com); [5]Principal Scientist, Plant Breeding (e mail: sanju_in@rediffmail.com), Directorate of Soybean Research, Indore, Madhya Pradesh

due to several biotic and abiotic stresses. This low productivity is attributed to its low harvest index because of limited man made selections (Varshney *et al*. 2010, Ajay *et al*. 2011).

Manipur, a north eastern state of India covers a geographical area of 22 327 km^2 and is located in global geographical position between 93° 03' and 94° 78' E longitude and 23° 83' and 25° 68' N latitude. Its unique topography has an oval shaped central valley of 2 230 km^2 completely surrounded by rugged hills constituting 90% of the total geographical area. The altitude of the hills ranges from 2000 to 3000 m and that of the valley varies from 750 to 900 m above mean sea level. There are about 27 tribes of people having different cultural practices, taste, preference, food habits, etc in this state of India (Thongbam *et al*. 2010). In Manipur, pigeonpea is mainly grown in the backyard of a house in hilly areas and consumed as immature pods in the form of vegetable. Generally, perennial type of pigeonpea is cultivated by the farmers which take long time for maturity. It matures in the last week of March or first week of April and is affected by terminal drought. In order to improve the yield through breeding techniques, there is an urgent need to study the variability in this crop.

Determination of genetic diversity and information on gene interaction are of vital importance for improvement of the crop because they generate baseline data to guide selection of parental lines and design of breeding scheme. The assessment of genetic parameters like genotypic variability, phenotypic variability, genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance are useful for the effective selection and improvement of breeding population. The study of correlation and path analysis for yield and its attributing traits will be helpful in improving the grain yield. Thus, present investigation was undertaken to assess the magnitude of phenotypic and genotypic variability, phenotypic and genotypic coefficient of variation, heritability in broad sense, expected genetic advance, correlation coefficient and path analysis so that these informations may be utilized in development of superior genotypes of pigeonpea under rainfed conditions of Manipur.

MATERIALS AND METHODS

The experiments comprising 21 genetically diverse genotypes of pigeonpea were conducted in randomized complete block design with 3 replications during *kharif* season of 2007, 2008 and 2009 at Langol Farm of ICAR Research Complex for NEH Region, Manipur Centre, Imphal (Manipur). The climate of the state differs from place to place due to geographical distribution. Average annual rainfall during cropping season was recorded 1435 mm. Each genotype was sown in two rows plot of 3 meter length with 60 cm and 20 cm spacing between rows and plants respectively. All recommended agronomical practices were followed for raising the good crop.

Five plants were randomly selected for recording the data on 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) and seed yield/plant (g). The mean values over replications were subjected for analyzing the various parameters. The genotypic and phenotypic variance, genotypic and phenotypic coefficient of variation and heritability were estimated as suggested by Singh and Choudhary (1979), while genetic advance was computed as per the procedure of Johnson *et al*. (1955). The data were also analyzed for estimating the correlation coefficient (Al-Jibouri *et al*. 1958) and path analysis as per Dewey and Lu (1959) for grain yield and its component characters.

RESULTS AND DISCUSSION

Analysis of variance prepared by the pooled analysis of 3 years of data revealed high significant differences among genotypes for all the characters studied (Table 1). The interactions between genotype × environment were non-significant for all the traits, therefore, the data were pooled and discussed on the basis of mean of three years.

The mean performance of twenty one genotypes for nine characters has been depicted in Table 2. A perusal study on mean performance revealed that the genotype UPAS 120 yielded the highest seed yield/plant (39.21 g), followed by ICPL 88034 (35.66 g) and PA 134 (35.65 g). The high yield of the genotype UPAS 120 was attributed by high number of seeds/pod and pod length. Similarly, high yield of ICPL 88034 was contributed by primary branches/plant, pod length and 100-seed weight. GT 101 showed good performance due to more plant height and number of seeds/pod. Least days to 50% flowering as well as days to maturity were recorded in the genotype H 94–6 (77 days), followed by ICPL 85010 (79 days). ICPL 99004 exhibited the maximum number of primary branches/plant, followed by ICPL 88034 and ICPL 85010. However, highest number of pods/plant was registered in CORG 2001-05, followed by Pusa 2003-01 and GT 101. The genotypes ICPL 98015, GT 101 and ICPL 87 expressed high

Table 1 ANOVA for significance of seed yield and its component characters in pigeonpea

Source of variation	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches/plant	Pods/ plant	Seeds/ pod	Pod length (cm)	100-seed weight (g)	Grain yield/ plant (g)
Replications	3.87	14.57	171.40*	0.76	2.36	0.11	0.01	1.01*	3.62
Genotypes	74.95**	124.02**	442.10**	5.20**	1534.2**	0.31**	0.13**	2.00**	81.54**
Error	1.69	4.53	38.83	0.39	13.98	0.11	0.05	0.33	2.27

Table 2 Mean performance for various characters of pigeonpea genotypes

Genotype	Days to 50% flowering	Days to maturity	Primary branches/plant	Plant height (cm)	Pods/ plant	Pod length (cm)	Seeds/ pod	100-seed weight(g)	Seed yield/ plant (g)
Pusa 2003-1	82	142	12.09	216.36	175.67	4.46	4.10	08.21	30.80
CORG 2001-05	84	140	12.29	225.92	179.67	5.11	4.42	09.50	29.72
TT 302	85	138	12.01	216.80	127.67	4.65	4.11	09.13	22.97
Phule T 1037	81	144	11.62	208.60	89.00	5.14	4.36	09.35	25.85
H97 24	89	153	12.92	230.49	126.00	5.13	4.41	09.32	30.00
WRGE 28	87	146	10.16	218.62	131.00	4.88	4.33	08.50	26.16
Phule T 80208-1	84	149	09.42	213.39	119.67	4.96	4.46	08.46	32.38
Pusa 992	82	142	10.33	224.44	114.67	4.58	4.22	08.77	29.15
H 82-1	85	145	10.97	231.09	116.67	5.07	4.37	09.94	22.66
Pant A 286	81	144	10.49	200.80	126.67	5.03	4.33	10.24	29.79
H 94-6	77	133	08.50	177.39	126.33	5.04	4.26	10.61	17.89
WRGE 31	80	148	10.67	222.33	107.00	5.00	4.40	10.51	26.42
AL 1491	88	152	12.33	229.90	125.33	5.26	4.19	09.74	30.85
ICPL 87	88	136	11.20	218.50	128.67	5.13	4.49	09.04	26.31
GT 101	81	144	11.80	229.64	157.33	5.24	4.56	09.18	34.09
PA 134	95	156	12.02	221.26	122.67	5.04	4.30	09.36	35.65
ICPL 98015	83	145	12.82	215.72	131.67	5.39	4.97	09.57	29.27
ICPL 88034	84	144	13.90	221.22	120.67	5.36	4.46	11.25	35.66
ICPL 99004	93	150	13.94	218.31	119.67	4.88	4.29	10.30	20.44
ICPL 85010	79	137	12.98	213.74	84.00	4.88	4.19	10.65	29.44
UPAS 120	93	142	11.50	228.82	126.00	5.29	4.53	08.78	39.21
Mean	85	146	11.57	218.25	126.46	5.04	4.22	09.54	28.81
Range	77-95	133-156	8.50-13.94	177.39-231.09	84.00-179.67	4.86-5.39	4.10-4.97	8.21-11.25	17.89-39.21
SE	1.06	1.74	0.51	5.09	3.05	0.19	0.27	0.47	1.23
CV (%)	2.35	1.47	4.47	2.86	2.96	4.57	3.17	5.84	33.08

number of seeds/pod. This variability among genotypes can be used for exploiting these traits directly or through recombination breeding.

Estimates of genetic parameters, viz. genotypic and phenotypic variability, genotypic and phenotypic coefficient of variation, heritability and genetic advance as percent of mean are presented in Table 3. A considerable range of variation was observed for all the characters under study. Generally, phenotypic coefficient of variation revealed relatively high values in comparison to corresponding genotypic coefficients of variation for all the characters, indicating the effects of environment in expression of traits. The range of PCV was observed from 4.56 to 18.59 % for the traits under study which provides a picture of the extent of phenotypic variability in the population. The PCV was noted moderate for the characters like seed yield/plant (18.59%),

Table 3 Estimates of genetic parameters for yield and its components in 21 pigeonpea genotypes

Character	Variance		Coefficient of variation		Broad sense heritability (%)	Genetic advance	Genetic advance as mean (%)
	Genotypic	Phenotypic	Genotypic	Phenotypic			
Days to 50% flowering	24.42	26.11	5.79	5.99	93.53	9.85	11.55
Days to maturity	39.83	44.36	4.32	4.56	89.77	12.32	8.44
Primary branches/plant	1.82	2.09	10.94	12.21	80.22	2.34	20.19
Plant height (cm)	134.42	173.25	5.31	6.03	77.58	21.04	9.64
Pods/plant	506.74	520.71	17.8	18.04	97.31	45.75	36.17
Pod length (cm)	0.03	0.08	3.24	5.59	33.52	0.19	3.86
Seeds/pod	0.067	0.18	6.11	9.99	37.5	0.33	7.71
100-seed weight (g)	0.56	0.89	7.83	9.86	63.09	1.22	12.81
Seed yield/plant (g)	26.43	28.69	17.84	18.59	92.08	10.16	35.27

pods/plant (18.04%) and primary branches/plant (12.22%). Rest of the characters showed low values of PCV. Genotypic coefficient of variation, which expresses a picture of the extent of genetic variability in the population, ranged from 3.24% to 17.84%. The maximum GCV was observed for seed yield/plant (17.84%), followed by pods/plant (17.80%) and primary branches/plant (10.94%). These findings are in agreement with Takalkar *et al*. (1998). Thus, these traits further provided an opportunity for genetic improvement. Although, remaining traits revealed low values of GCV. A perusal study on phenotypic and genotypic coefficient of variation indicated that seed yield/plant, number of pods/ plant and primary branches/plant were found to be important characters. Low estimates of GCV and PCV were recorded for days to 50% flowering, days to maturity, plant height, pod length, seeds/pod and 100-seed weight. It is in conformity with the findings of Patel and Acharya (2011) and Vange and Moses (2009). GCV alone is not sufficient to measure the heritable portion of a genotype. Genetic coefficient of variation along with heritability estimates would provide clear picture on the efficiency of the selection (Burton 1952). The estimate of broad sense heritability was the highest for pods/plant (97%), followed by days to 50% flowering (94%), grain yield/plant (92%), days to maturity (90%), primary branches/plant (80%) and plant height (78%). Similar results were reported by Takalkar *et al.* (1998). In the present investigation, pods/plant, days to 50% flowering and seed yield/plant showed high magnitude of heritability in broad sense, suggesting that the highly heritable characters were least affected by environmental variation and selection for these characters based on phenotypic performance may be more effective for pigeonpea improvement. These results are in conformity with the findings of Dahat *et al*. (1997), Takalkar *et al*. (1998) and Patel and Acharya (2011). The estimated genetic advance was recorded the moderate magnitude for pods/plant (36%) and grain yield/plant (35%). Contrary to our findings, Patel and Acharya (2011) reported the high magnitude of genetic advance for these characters.

In general, genotypic correlations had higher magnitude than corresponding phenotypic correlations for all the characters under study (Table 4). This indicated that there was inherent association among the characters. Seed yield/ plant was found to be significant positively associated with seeds/pod, pod length and plant height at genotypic level, indicating that these attributes are predominant and may contribute considerably towards higher seed yield of pigeonpea. Similar findings were also reported by Patel and Acharya (2011). However, 100-seed weight showed negative correlation with seed yield/plant. Among yield components, days to 50% flowering registered positive and significant association with days to maturity at both genotypic and phenotypic levels. Similarly, primary branches/plant revealed positive and significant correlations with plant height at both levels. Days to maturity had positive association with pod length and pod length was positive associated with seeds/ pod at genotypic level. However, 100-seed weight was negatively associated for most of the characters except primary branches/plant and pod length at genotypic and phenotypic level.

The phenotypic correlation coefficients for nine metric

Table 4 Genotypic and phenotypic correlations among different characters in pigeonpea

Character		Days to maturity	Primary branches/ plant	Plant height (cm)	Pods/ plant	Pod length (cm)	Seeds/ pod	100-seed weight (g)	Seed yield/ plant (g)
Days to 50% flowering	r_g	0.671**	0.518*	0.524*	0.026	0.298	0.243	-0.152	0.391
	r_p	0.611**	0.417	0.425	0.024	0.219	0.151	-0.074	0.35
Days to maturity	r_g		0.395	0.4768	-0.077	0.557**	0.148	-0.04	0.339
	r_p		0.324	0.369	-0.079	0.337	0.129	0.039	0.306
Primary branches/plant	r_g			0.535*	0.032	0.414	0.03	0.319	0.305
	r_p			0.432*	0.044	0.203	-0.005	0.182	0.258
Plant height (cm)	r_g				0.176	0.409	0.324	-0.295	0.509*
	r_p				0.046	0.369	0.638**	-0.254	0.432
Pods/plant	r_g					0.145	0.324	-0.426	0.188
	r_p					0.062	0.176	-0.347	0.165
Pod length (cm)	r_g						0.737**	0.37	0.5283*
	r_p						0.293	0.179	0.325
Seeds/pod	r_g							-0.346	0.794**
	r_p							-0.113	0.491
100-seed weight (g)	r_g								-0.24
	r_p								-0.22

*,** Significant at P=0.01 and 0.05, respectively., r_g, r_p : genotypic and phenotypic correlation coefficients, respectively.

traits revealed that all characters were positively associated with seed yield/plant except 100-seed weight. These findings are in conformity with Chandirakala and Subbaraman (2010). Primary branches/plant exhibited positive and significant phenotypic correlation with plant height. In the same pattern, phenotypic correlation was observed between plant height and seeds/pod. Similar findings were also reported by Kingshlin and Subbaraman (1999).

Seed yield is a complex character and it also exhibits low heritability. On the other hands, seed yield is affected by interactive effects of various traits. Moreover, ancillary characters are being less influenced by environmental fluctuations than the seed yield, thus selection will be more effective based on these traits than seed yield per se. Hence, path coefficient analysis was carried out to estimate the direct and indirect effects of various component traits for recommending a reliable selection criterion. In the present investigation, pod length (0.531) exhibited the highest magnitude of direct effects on seed yield, followed by seeds/pod (0.266) and primary branches/plant (0.243) in Table 5 and Fig 1. These characters are considered the principal components of seed yield and may be helpful in increasing the seed yield of pigeonpea. These results were in agreement with Thanki and Sawargaonkar (2010). Days to 50% flowering had positive correlation with seed yield/plant (r_g = 0.388). Its direct effect was also positive but had low magnitude (0.073). This character also showed positive indirect effects via primary branches/plant (0.126), plant height (0.049), pod length (0.158), seeds/pod (0.064) and 100-seed weight (0.075). In contrary, Thanki and Sawargaonkar (2010) obtained the direct and indirect effects with days to 50% flowering. Negative direct effect was found in days to maturity (–0.225), whereas it had positive association (r_g = 0.338). Positive and moderate to low path values of indirect effects were noticed for all the characters via days to maturity.

Positive association was noticed for primary branches/plant (0.304) with seed yield/plant and it also revealed positive direct effect (0.243). This character indirectly contributed to the seed yield/plant via positive path values of days to 50% flowering (0.038), plant height (0.095), pod length (0.219) and seeds/pod (0.008). Plant height showed significant and positive correlation (0.589) with seed yield/plant. Its direct effect was also registered positive with low path values (0.051). This character indirectly contributed mainly via primary branches/plant (0.130), pod length (0.13), seeds/pod (0.115) and 100-seed weight (0.147) towards seed yield. Thus, plant height may be considered useful either directly or indirectly for the seed yield/plant. Dahiya and Singh (1994) have also found that, days to 50% flowering, plant height and pods/plant exhibited considerable direct and indirect influence on seed yield of pigeonpea. Pods/plant revealed positive association (0.188) with seed yield/plant. However, it had negative direct effect (–0.231) on seed yield/plant. This character indirectly influenced to the seed yield/plant via days to 50% flowering (0.002), days to maturity (0.017), primary branches/plant (0.008), plant height (0.017), pod length (0.077), seeds/pod (0.086) and 100-seed weight (0.212). Similar findings were obtained by Chandirakala and Subbaraman (2010) in full-sibs of pigeonpea. Hence, pods/plant can play an important role in increasing the seed yield/plant.

The component characters namely, pod length and seeds/pod are very important characters for seed yield because they showed positive and significant correlation (0.529 and 0.794) with seed yield/plant respectively. Both characters also had positive and strong direct effect (0.531 and 0.266) on seed yield/plant. These characters have also been indirectly contributed to the seed yield/plant via days to 50% flowering, plant height, primary branches/plant. Kingshlin and Subbaraman (1999) also reported that pod length and seeds/pod were important yield components in pigeonpea. Similarly, 100-seed weight indirectly contributed via days to maturity (0.009), primary branches/plant (0.078), pods/plant (0.098) and pod length (0.197). The residual effect was found to be 0.594 in path analysis. This indicated that other attributing

Table 5 Path coefficient analysis showing direct and indirect effects of eight casual variables on seed yield/plant

Character	Days to 50% flowering	Days to maturity	Primary branches/ plant	Plant height (cm)	Pods/ plant	Pod length (cm)	Seeds/ pod	100-seed weight (g)	Correlation with grain yield/plant (g)
Days to 50% flowering	**0.073**	–0.151	0.126	0.049	–0.006	0.158	0.064	0.075	0.388
Days to maturity	0.049	**–0.225**	0.096	0.045	0.018	0.296	0.039	0.02	0.338
Primary branches/plant	0.038	–0.089	**0.243**	0.095	–0.007	0.219	0.008	–0.159	0.304
Plant height (cm)	0.038	–0.107	0.13	**0.051**	0.041	0.13	0.115	0.147	0.589*
Pods per plant	0.002	0.017	0.008	0.017	**–0.231**	0.077	0.086	0.212	0.188
Pod length (cm)	0.022	–0.125	0.101	0.021	–0.033	**0.531**	0.196	–0.184	0.529*
Seeds per pod	0.018	–0.033	0.007	0.047	–0.075	0.392	**0.266**	0.172	0.794**
100-seed weight (g)	–0.011	0.009	0.078	–0.028	0.098	0.197	–0.092	**–0.498**	–0.247

Figures in bold letters indicate the direct effects, Residual effect = 0.594

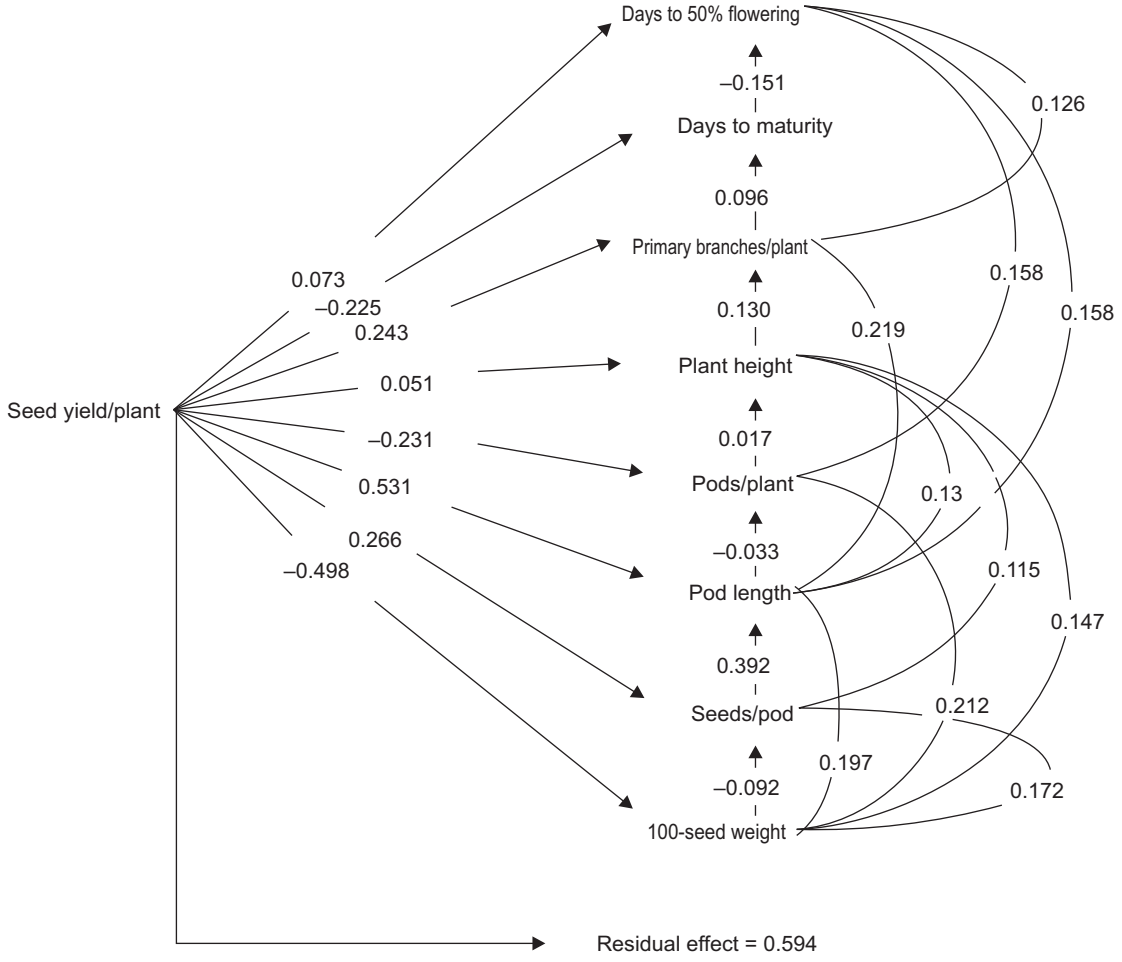

Fig 1 Path coefficient diagram showing direct and indirect effects of attributing traits on seed yield of pigeon pea

characters were also important and may play a critical role in pigeonpea improvement.

It is concluded from the present study that genotype UPAS 120 revealed the highest seed yield/plant, which was attributed by high number of seeds/pod and pod length.

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