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Research Note

Variability and transgressive segregation for yield and yield contributing traits in pigeonpea crosses

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Abstract
In the present study F_2 and F_3 generations were evaluated for yield and yield contributing traits to understand genetic variability and to identify transgressive segregants in three pigeonpea crosses. High variance, high heritability and high genetic advance were recorded for secondary branches per plant, number of pods per plant and seed yield in F_2 and F_3 generations. There was decrease in variability from F_2 to F_3 generation for some traits. High heritability and high genetic advances indicates that traits are under the control of additive gene action and selection will be effective. Among the three crosses transgressive segregants were high in the cross TTB 7 × ICPL87119 indicating the superiority of this cross over the others.

Key words
Pigeonpea, variation, heritability, genetic advance, segregating generation

Pigeonpea (*Cajanus cajan* L. Millsp) is an important leguminous short lived perennial shrub cultivated as annual crop in semi-arid tropical and subtropical regions of the world. Productivity of pulses worldwide in comparison to cereals is very low. This low productivity is attributed to its low harvest index and limited man made selections (Ganapathy *et al.*, 2012). Progress in breeding programme depends on amount of variability created during hybridization. Success of any plant breeding programme will depend on variability existing in the populations. Hence study of genetic variability, heritability and genetic advance becomes important for effective selection and utilization of genotypes in breeding programme. Genotypic coefficient of variation (GCV), which indicates the relative magnitude of genetic diversity present in the material, will help to study the genetic variability present for different characters.
The heritability in broad sense was proposed as the ratio of genotypic variance to total variance. Heritability in narrow sense was proposed as the ratio of additive variance to total variance (Lush, 1949). According to Johnson *et al.* (1955) genetic advance is more useful in predicting the actual value of selection than heritability, although later value indicates the relative effectiveness of selection based on phenotypic expression of the character. According to Allard (Allard, 1970), heritability of yield is less and that of yield components is more. Keeping this in view present study was carried out to understand variation, heritability and genetic advance in early generations of pigeonpea.

The study was conducted at All India Co-ordinated Research Project (AICRP) on Pigeonpea, University of Agricultural Sciences (UAS), Bengaluru, India during kharif season of 2009. Materials used for this study consisted of F_2 and F_3 generations from three crosses of pigeonpea namely BRG-1×ICP-8863, TTB-7×ICP-8863 and TTB-7×ICPL87119. F_2 and F_3 generations were raised by selfing under insect proof nylon net. All the recommended cultural practices were followed for raising the crop. At maturity, observations were recorded on primary branches (PB), secondary branches (SB), plant height (PH), pods per plant (PP), seeds per pod (SPP), 100 seed weight (100SW), pod yield per plant (PY), seed yield per plant (SY) and shelling per cent (SH). Genetic variability parameters *viz.* phenotypic coefficient of variance (PCV), genotypic coefficient of variance (GCV) (Burton and Devane, 1953), Heritability in broad sense (h^2) (Lush, 1949) Genetic advance (GA) and genetic advance as per cent mean (GAM) (Johnson *et al.*, 1955) were estimated. PCV and GCV (Robinson *et al.*, 1949) and GA and GAM (Johnson *et al.*, 1955) were classified into low (0-10%), moderate (10.1-20%) and high (>20%). Heritability in broad sense was classified into low (0-30%), Moderate (30.1-60%) and High (>60%) (Robinson *et al.*, 1949).

Maximum and minimum values for F_2 and F_3 generations are presented in Table 1. SB, PP, PY and SY exhibited high PCV and GCV in three crosses in both F_2 and F_3 generation. High PCV and GCV for these traits indicate the presence of substantial variability and scope for improving these characters (Bhadru, 2011; Visakho *et al.*, 2013). PH, 100SW and SHP in general had moderate to low GCV and PCV in both the generations of three crosses and is in agreement with earlier reports of Ganapathy (2009). SPP had moderate to low PCV and GCV in F_2 generation whereas in F_3, all the crosses had low PCV and GCV estimates. DFF had low PCV and GCV values in three crosses of both generations. For all the characters variability has reduced from F_2 to F_3 generation. This is possibly due to selfing of pigeonpea under honey bee proof net to avoid cross pollination and genotypes attained homozygous condition (Kurer et al. 2010). Low PCV and GCV estimates indicate lack of opportunity for selection for these traits which is in agreement with studies of earlier workers (Ganapathy, 2009; Vanisree *et al.*, 2013).

Heritability estimates along with genetic gain would be more useful than the heritability alone in selecting the best individuals (Johnson *et al.*, 1955). Therefore, it is essential to consider the predicted genetic advance along with heritability estimates as a tool in the selection programme for better efficiency. High heritability accompanied with high genetic advance indicates that most likely the heritability is due to additive gene effects and selection may be effective. High heritability accompanied with low genetic advance indicates non-additive gene action and selection for such traits may not be rewarding. Low heritability accompanied with high genetic advance reveals that the character is governed by additive gene effects. Selection may be effective in such cases. Low heritability accompanied with low genetic advance indicates that the character is highly influenced by environmental effects and selection would be ineffective (Nadarajan and Gunasekaran, 2005).

High heritability along with high GA was recorded for, PP and SY in both the generations of three crosses corroborating with earlier reports (Venkateswarlu, 2001; Aher *et al.*, 1998). PB in F_2 generation had moderate heritability and high GA in TTB-7×ICP-8863 and BRG-1×ICP-8863 crosses. In F_3 generation, crosses BRG-1×ICP-8863 and TTB-7×ICPL87119 exhibited high heritability and high GA whereas, TTB-7×ICP-8863 cross had moderate estimates. These results are similar to findings made by Aher *et al*. (1998). Heritability of PB has improved from F_2 to F_3 while genetic advance was high in both generations.

PH and 100SW had high heritability and high genetic advance in F_2 generation of two crosses namely BRG-1×ICP-8863 and TTB-7×ICP-8863 while TTB-7×ICPL87119 cross had low GA. In F_3 generation, GA varied from high to low between three crosses for PH and moderate to high for 100SW. As the average PH of a cross increased, GA has reduced. BRG-1×ICP-8863 cross was shortest of the three crosses but had high GA whereas TTB-7×ICPL87119 was tallest with low GA (Table 1). High heritability and GA for PH (Pansuriya *et al.*, 1998) and 100SW (Ahmad Neyaz and Bajpai, 2002) have been reported by earlier workers

High Heritability with moderate GA was observed for SHP in two crosses except TTB-7×ICP-8863. In F_3 heritability was high with moderate genetic advance in two crosses, while TTB-7×ICP-8863 had moderate heritability with low genetic advance. This indicates that in TTB-7×ICP-8863 SHP is governed by non-additive gene action whereas in other two crosses it is governed by additive gene action. High heritability with low genetic advance was reported by Satish Kumar *et al*. (2006) and Ganapathy (2009).

Transgressive segregants identified for PP and SY in F_2 and F_3 generations are presented in Table 2 and 3 respectively. In F_2 generation of a cross BRG-1×ICP-8863 24 transgressive segregants were observed with SY ranging from 43.2 to 221.0 and PP ranged from 123 to 494. In cross TTB-7×ICP-8863 31 transgressive segregants were observed with SY and PP ranging from 53.8 to 147.1 and 155 to 499 respectively. Whereas, in cross TTB-7×ICP-87119 37 transgressive segregants were observed with SY and PP ranging from 50.89 to 115 and 140 to 590 respectively. In F3 generation of a cross BRG-1×ICP-8863 26 transgressive segregants were observed with SY ranging from 43.7 to 68.7 and PP ranged from 103.9 to 192.7. In cross TTB-7×ICP-8863 20 transgressive segregants were observed with SY and PP ranging from 49.3 to 74.5 and 142.3 to 225.5 respectively. Whereas, in cross TTB-7×ICP-87119 45 transgressive segregants were observed with SY and PP ranging from 52 to 118.4 and 147.3 to 348.1 respectively. Cross TTB-7×ICPL87119 recorded more number of transgressive segregants compared to other two crosses which could be due the use of diverse parents for hybridization.

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Table 1. Estimates of genetic parameters for yield and its attributing characters in segregating generations of pigeonpea

Cross	Min		Max		PCV (%)		GCV (%)		h^2 (broad sense)		GAM	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
DFF – days to 50% flowering												
BRG-1×ICP-8863	87.0	81.5	113.0	103.0	8.4	6.5	8.3	5.4	98.1	71.2	16.9	9.5
TTB-7×ICP-8863	83.0	85.0	115.0	103.0	8.0	5.9	7.9	4.7	97.4	62.0	16.0	7.6
TTB-7×ICPL87119	100.0	103.0	121.0	109.0	5.5	1.1	5.0	0.4	84.2	12.5	4.6	0.3
PB – primary branches												
BRG-1×ICP-8863	4.0	5.3	20.0	18.4	43.5	24.4	30.0	21.2	47.5	75.4	42.6	37.8
TTB-7×ICP-8863	4.0	10.5	29.0	23.3	33.6	15.8	19.4	12.2	31.4	58.9	27.7	19.2
TTB-7×ICPL87119	2.0	6.0	38.0	24.1	38.9	19.3	32.2	15.2	68.4	61.9	26.6	24.7
SB – Secondary branches												
BRG 1 x ICP 8863	0.0	0.0	18.0	23.1	97.8	93.7	56.0	88.8	32.8	89.8	66.1	173.3
TTB 7 x ICP 8863	1.0	0.2	38.0	26.4	100.4	70.1	23.0	66.9	7.8	91.0	16.1	131.4
TTB 7 x ICPL 87119	1.0	6.0	37.0	35.0	65.1	31.3	31.3	28.7	23.1	83.9	15.0	54.2
PP – pods per plant												
BRG-1×ICP-8863	10.0	39.4	308.0	192.7	75.2	34.3	74.4	33.9	98.1	98.0	153.8	69.2
TTB-7×ICP-8863	20.0	51.5	499.0	227.7	72.0	30.5	71.4	30.0	98.4	96.8	145.9	60.8
TTB-7×ICPL87119	12.0	28.5	590.0	348.3	65.1	35.7	62.5	35.2	92.0	97.3	59.9	71.6
SPP – seeds per pod												
BRG-1×ICP-8863	3.0	3.2	4.8	5.0	15.3	8.2	8.2	6.0	28.6	54.3	9.0	9.2
TTB-7×ICP-8863	2.8	3.4	4.6	4.2	9.3	6.4	8.5	3.3	85.0	26.3	16.4	3.5
TTB-7×ICPL87119	2.8	3.4	5.0	4.6	11.0	7.5	10.4	3.9	89.4	27.3	9.8	4.2
100SW – 100 seed weight (g)												
BRG-1×ICP-8863	7.1	10.0	16.9	15.4	40.6	8.9	40.4	6.7	98.8	56.8	82.6	10.4
TTB-7×ICP-8863	6.9	7.9	14.2	12.9	13.2	10.5	13.1	7.7	98.7	52.9	26.8	11.5
TTB-7×ICPL87119	4.5	3.1	14.6	11.3	15.3	11.5	14.0	8.6	84.0	55.6	12.8	13.2
PH – plant height (cm)												
BRG-1×ICP-8863	90.0	78.6	168.0	166.2	14.9	10.8	14.3	10.3	92.1	91.5	28.3	20.3
TTB-7×ICP-8863	85.0	127.2	200.0	187.9	14.6	7.9	13.5	7.5	86.1	89.7	25.9	14.7
TTB-7×ICPL87119	103.0	143.0	180.0	192.6	12.5	7.4	10.9	5.5	76.1	54.3	9.5	8.3
PY – pod yield (g/plant)												
BRG-1×ICP-8863	6.0	16.1	174.0	68.7	82.8	32.9	81.7	32.1	97.3	95.1	166.0	64.5
TTB-7×ICP-8863	7.0	20.4	215.0	110.3	73.0	34.7	66.9	33.8	94.5	94.9	142.1	67.9
TTB-7×ICPL87119	6.0	15.0	223.0	168.0	63.5	36.8	61.1	36.1	92.8	96.4	58.9	73.1
SY – seed yield (g/plant)												
BRG-1×ICP-8863	3.9	19.5	112.0	108.6	80.2	35.3	79.1	34.7	97.3	96.6	160.7	70.2
TTB-7×ICP-8863	4.9	14.1	147.1	75.5	75.4	34.8	68.7	33.6	96.1	93.2	149.3	66.8
TTB-7×ICPL87119	4.5	8.2	115.0	118.4	60.3	35.7	55.5	34.6	84.9	94.0	51.1	69.1
SH – shelling per cent												
BRG-1×ICP-8863	43.7	34.8	94.2	82.8	12.3	12.2	10.7	11.2	75.5	83.6	19.1	21.0
TTB-7×ICP-8863	37.2	55.0	90.5	84.0	33.5	10.0	13.0	6.9	99.7	48.4	68.8	9.9
TTB-7×ICPL87119	34.9	45.0	87.6	81.0	13.8	12.3	13.8	10.3	100.0	70.2	13.8	17.7

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Table 2. Transgressive segregants for pod per plant and seed yield per plant in F_2 generations among three crosses in pigeonpea

	BRG-1 x ICP-8863			TTB-7 x ICP-8863			TTB-7 x ICPL-87119		
Sl	Plt. No No	PP	SY	Plt. No	PP	SY	Plt. No	PP	SY
Parents									
1	BRG-1	86.975	42.96	TTB-7	141.75	47.41	TTB-7	141.75	47.41
2	ICP-8863	102.25	29.7	ICP-8863	102.25	29.7	ICPL-87119	79.75	26.8
Transgressive segregants									
1	48	158.0	43.2	51	155.0	53.8	34	184.0	50.9
2	21	119.0	44.6	64	180.0	60.4	25	256.0	51.1
3	17	146.0	47.8	89	171.0	60.9	73	230.0	51.9
4	5	220.0	50.2	33	161.0	63.5	86	220.0	52.1
5	37	137.0	51.0	81	184.0	64.8	9	200.0	52.1
6	46	140.0	51.2	31	196.0	64.8	80	208.0	55.1
7	34	188.0	51.7	24	167.0	66.8	63	210.0	56.7
8	30	138.0	53.9	40	235.0	68.3	15	235.0	57.7
9	29	123.0	55.1	53	215.0	69.5	6	285.0	58.2
10	8	159.0	60.9	35	187.0	72.7	10	140.0	60.2
11	47	217.0	63.9	72	258.0	73.1	54	214.0	61.9
12	32	230.0	64.7	13	227.0	74.0	27	285.0	62.1
13	31	185.0	69.6	90	218.0	75.9	81	206.0	62.8
14	15	176.0	71.7	49	228.0	76.3	8	200.0	63.7
15	27	182.0	76.7	29	240.0	83.2	38	260.0	64.0
16	49	212.0	79.0	88	250.0	85.3	26	273.0	64.4
17	39	195.0	80.0	21	175.0	87.1	36	238.0	67.1
18	7	228.0	83.1	25	265.0	87.8	37	233.0	67.1
19	13	246.0	94.2	16	190.0	90.4	17	320.0	67.2
20	51	257.0	97.9	18	333.0	91.9	74	292.0	69.6
21	9	225.0	104.6	32	378.0	92.7	33	375.0	72.2
22	22	308.0	112.0	34	260.0	94.0	30	318.0	74.0
23	3	301.0	135.0	37	257.0	95.5	24	256.0	74.6
24	50	494.0	221.0	15	303.0	99.3	18	336.0	77.8
25				44	315.0	103.7	7	300.0	77.8
26				52	271.0	112.3	62	205.0	80.3
27				41	317.0	113.2	39	267.0	81.7
28				8	454.0	129.0	16	310.0	82.0
29				22	376.0	138.4	32	363.0	85.3
30				43	499.0	140.0	72	230.0	85.4
31				42	315.0	147.1	14	267.0	85.5
32							75	335.0	90.1
33							19	328.0	93.8
34							55	222.0	98.4
35							31	330.0	98.9
36							20	428.0	100.4
37							21	590.0	115.0

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Table 3. Transgressive segregants for pod per plant (PP) and seed yield per plant (P) in F_3 generations among three crosses in pigeonpea

	BRG-1 x ICP-8863			TTB-7 x ICP-8863			TTB-7 x ICPL-87119		
Sl NO	Plt No	PP	SY	Plt. No	PP	SY	Plt. No	PP	SY
				Parents					
1	BRG-1	86.9	42.9	TTB-7	141.8	47.41	TTB-7	141.8	47.41
2	ICP-8863	102.3	29.7	ICP-8863	102.3	29.7	ICPL-87119	79.8	26.8
				Transgressive segregants					
1	24	113.0	43.7	85	156.6	49.3	8	199.5	52.0
2	30	139.5	45.1	13	159.8	49.9	5	210.0	52.0
3	41	127.1	46.2	90	155.0	50.0	1	168.7	52.6
4	72	163.0	48.7	74	162.9	50.3	77	185.6	53.7
5	60	133.1	49.0	61	176.5	51.9	18	205.9	54.1
6	21	134.9	49.7	69	168.7	52.7	88	155.4	54.1
7	47	106.0	51.2	28	200.2	53.3	32	186.0	54.3
8	31	132.0	51.3	41	170.7	54.0	21	178.6	54.6
9	46	131.1	52.7	67	179.8	54.8	14	172.2	55.1
10	52	103.9	53.2	64	142.3	55.0	31	194.8	55.1
11	50	133.6	54.1	36	176.8	55.2	58	190.0	56.3
12	82	151.5	54.2	24	163.6	55.8	86	185.7	56.4
13	11	124.8	54.6	51	179.4	58.8	78	220.9	58.6
14	87	133.1	54.9	23	224.6	60.8	71	202.2	59.0
15	71	124.5	57.8	53	192.3	62.5	33	228.7	60.9
16	53	156.9	57.8	63	154.9	67.8	3	147.3	61.2
17	81	157.8	57.9	30	188.0	68.0	41	229.8	61.4
18	54	139.0	58.6	76	198.8	73.9	75	172.2	61.7
19	33	106.4	58.7	38	225.5	73.9	64	232.0	61.8
20	12	152.2	59.1	1	214.6	74.5	80	236.6	62.6
21	42	141.8	59.7				17	215.4	62.8
22	55	140.3	61.4				28	217.9	63.5
23	77	182.7	63.3				49	178.4	65.3
24	20	166.5	64.8				60	228.9	66.0
25	34	192.7	66.8				10	267.1	66.0
26	3	168.7	68.7				37	252.9	66.0
27							79	235.5	68.4
28							68	230.3	68.8
29							47	239.3	68.9
30							29	211.8	70.3
31							2	241.3	71.8
32							24	206.2	72.1
33							63	255.8	72.4
34							72	266.8	72.7
35							65	263.8	73.3
36							51	282.1	73.7
37							66	286.2	76.2
38							40	348.3	76.7
39							48	264.2	77.5
40							69	270.2	80.1
41							38	263.3	81.7
42							67	283.8	84.9
43							4	294.9	88.6
44							73	306.0	94.2
45							44	334.3	118.4