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EARLY GENERATION TESTING IN PIGEONPEA (*CAJANUS CAJAN* [L.] MILLSP.)*

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Inter-generation relationship was studied in eight pigeonpea crosses involving parents of different maturities. Observations were recorded on grain yield, seed size, seeds/pod and days to flower on parents, their F1s and later generations extending up to F5 in three sets of experiments. The data on various characters indicated that irrespective of the maturity groups of the parents used in crosses, by and large, differences among generations were non-significant. This suggested that, on the basis of F1 performance, the low yielding crosses can be safely rejected. Crosses that are high yielding in the F1 should be tested in the F2 generation as well for confirming the cross performance and final selection, since the relationship between F2 performance and of later generations was more consistent.

Information on the potential of crosses at an early stage of a breeding programme helps in efficient utilization of resources. The performance of F1 hybrids is not always a good indicator of their potential in subsequent generations because of non-additive genetic effects which are expressed most in the F1 generation.

In the past, yield tests of early generation bulk populations have been used to evaluate the potential of crosses, but the results in various crops are not consistent. Harrington (1940), Sikka *et al.* (1959), Lupton (1961) in wheat; Harlan *et al.* (1940), Immer (1941), Smith & Lambert (1968) in barley, Leffel & Hanson (1961) in soybeans, concluded that the yield of early generation bulk could be used to identify potentially superior crosses. On the contrary, the results of Fowler & Heyne (1955) in wheat, Grafius *et al.* (1952) in barley, Atkins & Murphy (1949), in Oats, Kalton (1948) and Weiss *et al.* (1947) in soybeans did not find this approach useful in discriminating among crosses. Allard (1960), while reviewing the subject, concluded that, in early generations, selection for yield among crosses could be made but selection of lines within a cross was not possible.

With the advent of biometrical genetics, information on the general and specific combining ability of parents and crosses has been considered a good indicator of their potential and mating schemes such as diallel and line × tester crosses have been suggested (Whitehouse *et al.*, 1958). However, application of this technique is limited, because a large number of crosses are needed if a reasonably wide range of parents are to be examined (Lupton, 1961). With the indication that additive gene action for yield in most of the crop species predominates (Moll & Stuber, 1974), studies on the value of early generation testing have been revived (Coffelt & Hammons, 1974; Cooper, 1976; Hamblin & Evans, 1976; Cregan & Busch, 1977; Wynne, 1976; Bhullar *et al.*, 1977).

In pigeonpeas, information on the value of early generation testing is sparse. The present study was, therefore, undertaken to determine the relationship among different generations for seed yield, seeds per pod, seed size and days to flowering.

MATERIAL AND METHODS

Three experiments, conducted in different years, were included to study inter-generation relationship for yield and important yield components. In experiment I, three crosses, viz., No. 148 × ICP-6997, C-11 × ICP-6997 and ICP-3773 × ICP-6997, involving medium maturing parents differing in seed and pod size, were studied. Selfed-seed of the parents, their F1 and unselected F2 and F3 bulks from each cross, were evaluated in separate tests. Each of the three tests was planted in 5 × 5 m latin square design in vertisol at the ICRISAT Centre on 23 June 1975. Six rows, each five metre long, constituted plot. As seed for the F 1 was limited, only one row of each cross was raised in each replication, which was flanked by two and three filler

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rows of ICP-6997 on either side of the Fl row.

Experiment II consisted of early maturing parents, differing in seed and pod size, their F1's and F2 through F5 selfed bulk generations from two crosses UPAS-120 × Baigani and Pant A2 × Baigani. Seeds from each cross were planted in separate tests in alfisol at ICRISAT in RBD on 24 June 1978. Each plot, including Fl, consisted of six four-metre rows. Cross UPAS-120 × Baigani was tested using five replications, while the other cross had three replications.

In experiment III, unselected F2, F3 and F4 generations of three crosses, viz., HY-3C × Prabhat, UPAS-120 × ICP-7086 and ICP-1 × NP (WR)-15, involving parents of diverse maturity, seed and pod size were studied. The experiment was planted at ICRISAT on vertisol on 27 June 1978 in a split plot design, replicated four times, with crosses as main plots and generations sub-plots. Each plot consisted of six rows of four-metre length. Inter- and intra-rows spacing in experiments I and III was at 150 and 30 cm, respectively, while in the experiment II, they were 75 and 25 cm.

In each plot, 15 to 24 competitive plants were marked randomly and observations were recorded on yield per plant, seeds per pod, 100-seed weight and days to first flower. For recording mean seeds per pod, 20 well-filled, healthy pods were collected from each selected plant. Analysis of variance was carried out for each test and Duncan's multiple range test was applied to test the differences among generations.

RESULTS AND DISCUSSION

In experiment I, significant differences were obser among the treatments (parents and generations) for the characters, except days to flower in the cross IC 3773 × ICP-6997 (Table 1). In cross UPAS-120 Baigani of experiment II, treatment differen were significant only for seed size. In the thi experiment, differences among the crosses were hig significant for all the characters studied, wh differences among the generations were significa only for days to flower (Table 1).

In experiments I and II, a comparison of the hybrids with their respective mid-parent values, most of the cases, indicated a predominance additive gene action for seeds per pod (Table 4) a seed size (Table 5). However, differences between and mid-parent values were noticed for yield in cro No 148 × ICP-6997 and ICP-3773×ICP-6997 and days to flower in crosses C-11 × ICP-6997 and No × ICP-6997. Previous genetic studies have shown heritability and a preponderance of additive g action with some degree of partial dominance, days to flower, seeds per pod, seed size, and yi (Sharma & Green 1975; Dahiya & Brar, 1977; Sa *et al.*, 1981). With a high degree of additive g action, parental performance should be a usef criterion when selecting these for use in poten crosses. Quinones (1969) and Hamblin & Evans (19 working with dry beans, concluded that an accu assessment of parental yields at recommended c

Table 1. *Mean sum of squares for various characters in experiments I, II and III*

Experiment	Test/ Source of variation	Yield/plant	Days to flower	Seeds/ pod	Seed Size
I	*Test*				
	a) No. 148 × ICP-6997	893.31*	77.14*	0.24**	5.28**
	b) C-11 × ICP-6997	1381.59**	303.40**	0.40**	5.66**
	c) ICP-3773×ICP-6997	1372.31**	2.04	0.24**	27.02**
II	a) Pant A2 × Baigani	12.20	7.71**	0.13**	4.79**
	b) UPAS-120 × Baigani	11.00	7.90	0.02	3.15**
III	*Source of variation*				
	Replication	18.88	0.70	0.01	0.33
	Crosses	3212.63**	480.49**	0.40**	3.34**
	Error (a)	132.98	8.67	0.02	0.08
	Generations	15.90	33.58*	0.01	0.05
	Crosses × Generations	91.28	7.87	0.03	0.12
	Error (b)	45.01	7.61	0.01	0.09

* Significant at 5% and 1% respectively.

Table 2. *Mean yield q/plant of parents and different generations in various crosses*

Parents/ Generation	Experiment I			Experiment II		Experiment III		
	No. 148 × ICP-6997	C-11 × ICP-6997	ICP-3773 × ICP-6997	UPAS-120 × Baigani	Pant A2 × Baigani	HY-3C × Prabhat	UPAS-120 × ICP-7086	ICP-1 × NP(WR)-15
P_1	119.7	118.1	117.3	25.9	28.9	–	–	–
P_2	98.3	69.8	88.1	26.3	28.3	–	–	–
F_1	133.2^{a}	90.4^{a}	134.2^{a}	29.4^{a}	32.6^{a}	–	–	–
F_2	127.7^{a}	92.3^{a}	113.5^{b}	30.2^{a}	31.2^{a}	35.6^{a}	65.5^{a}	71.8^{a}
F_3	123.2^{a}	95.2^{a}	116.2^{b}	28 9^{a}	27.7^{a}	36.0^{a}	57.6^{a}	72.5^{a}
F_4	–	–	–	26.7^{a}	28.7^{a}	43.5^{a}	59.7^{a}	66.1^{a}
F_5	–	–	–	30.4^{a}	30.6^{a}	–	–	–
LSD 5%	19.07	19.88	12.54	NS	NS	For comparing		NS
CV%	11.59	15.62	8.00	19.49	14.63	generations within across		20.4

Table 3. *Mean days to flower of parents and different generations in various crosses*

ts Generation	Experiment I			Experiment II		Experiment III		
	No. 148 × ICP-6997	C-II × ICP-6997	ICP-3773 × ICP-6997	UPAS-120 × Baigani	Pant A2 × Baigani	HY-3C × Prabhat	UPAS-120 × ICP-6997	ICP-1 × NP(WR)-15
P_1	97.8	123.6	109.0	75.5	74.8			
P_2	107.6	111.8	108.4	75.4	75.3			
F_1	98.6^{a}	103.6^{d}	109.4^{d}	73.5^{a}	74.9^{a}			
F_2	100.0^{a}	107.0^{ab}	108.2^{d}	78.3^{a}	77.9^{b}	119.0^{ab}	126.4^{d}	133.3^{a}
F_3	99.8^{a}	107.4^{b}	107.8^{d}	76.9^{a}	77.1^{b}	122.1^{bc}	130.8^{d}	134.3^{a}
F_4	–	–	–	75.2^{a}	74 8^{d}	124.1^{bc}	128.1^{d}	135.2^{a}
F_5	–	–	–	77.6^{d}	75.1^{d}	–	–	–
LSD 5%	2.85	6.02	NS	NS	1.75	For comparing		4.09
CV%	1.75	3.98	2.39	2.26	1.77	generations within a cross		2.30

Table 4. *Mean seeds/pod of parents and different generations in various crosses*

Parents/ Generation	Experiment I			Experiment II		Experiment III		
	No. 148 × ICP-6997	C-11 × ICP-6997	ICP-3733 × ICP-6997	UPAS-120 × Baigani	Pant A2 × Baigani	HY-3C × Prabhat	UPAS-120 × ICP-6997	ICP-1 × NP(WR)-15
P_1	3.9	3.6	3.7	3.9	3.9	–	–	–
P_2	4.4	4.3	4.4	4.0	4.4	–	–	–
F_1	4.5^{a}	4.2^{a}	4.1^{a}	4.1^{a}	4.2^{a}	–	–	–
F_2	4.2^{b}	4.0^{a}	4.1^{a}	4.1^{a}	4.1^{b}	3.8^{a}	3.4^{a}	3.5^{a}
F_3	4.1^{b}	4.0^{a}	4.1^{a}	4.1^{a}	4.1^{b}	3.7^{a}	3.4^{a}	3.5^{a}
F_4	–	–	–	4.1^{a}	4.1^{b}	3.7^{a}	3.5^{a}	3.4^{a}
F_5	–	–	–	4.0^{a}	4.3^{a}	–	–	–
LSD 5%	0.21	0.26	0.26	NS	0.15	For comparing		NS
CV%	3.70	4.80	5.00	2 15	2.83	generations within a cross		3.54

density is useful in choosing parents for crosses which are likely to have a good potential yield. However, parental performance alone may not be adequate to reflect the cross potential since genetic diversity of the parent is important. The genetic diversity of parents is best indicated by the cross performance in the F1 or F2 generation, because of inter- and intra-allelic interactions.

In only one cross (ICP-3773 × ICP-6997), the mean yield of the F1 was different from subsequent generations. In the remaining seven crosses, no differences were observed in the yield of various generations (Table 2). Minor differences in days to flower, seed size and pod size were observed among the various generations of some of the crosses. These differences could be attributed to the diversity of the

Table 5. *Mean seed size (g/100 seeds) of parents and different generations in various crosses*

Parents/ Generation	Experiment I			Experiment II		Experiment III		
	No. 148 × ICP-6997	C-II × ICP-6997	ICP-3773 × ICP-6997	UPAS-120 × Baigani	Pant A2 × Baigani	HY-3C × Prabhat	UPAS-120 × ICP-6997	ICP-I × NP (WR)
P_1	9.6	11.2	8.8	6.4	8.3	–	–	–
P_2	12.4	12.8	12.0	9.9	11.3	–	–	–
F_1	10.7^{a}	10.1^{a}	10.0^{a}	8.4^{a}	8.9^{a}	–	–	–
F_2	10.3^{a}	10.6^{b}	9.9^{a}	8.3^{a}	9.2^{a}	8.5^{a}	9.3^{a}	8.7^{a}
F_3	10.6^{a}	10.5^{ab}	9.8^{a}	8.3^{a}	8.9^{a}	8.1^{a}	9.3^{a}	8.9^{a}
F_4	–	–	–	8.3^{a}	8.8^{a}	8.2^{a}	9.5^{a}	8.9^{a}
F_5	–			7.6^{b}	10.0^{b}	–	–	–
LSD 5%	0.62	0.47	2.31	0.57	0.63	For comparing generations within a cross		NS
CV%	4.20	3.11	1.66	3.92	5.17			3.23

parents and probably small sample size for such crosses. In cross plant A-2×Baigani, the mean days to flower in different generations differed significantly and did not follow any distinct pattern of relationship from generation to generation. This variation was probably due to differential water-logging in the early growth stages. Water-logging delays flowering and one of the parents involved in this (Baigani) is known to be susceptible to water-logging.

The inter-fillial generation relationship for different characters studied (Tables 2-5) indicated that, irrespective of the maturity groups of the parents used in crosses, by and large, differences among generations were nonsignificant. This corroborates the conclusion of Moll & Stuber (1974), that a major proportion of genetic variance is additive in nature and further suggests that preliminary selection can be made among Fl's for identifying potentially good crosses for advancement in the breeding programme. However, because of the occasional case of heterosis and the difficulty of obtaining an adequate seed supply, for Fl yield testing, F2 testing should be considered for further selection. Multilocation yield testing of F2 or F3 bulks and rejection of low yielding crosses has been suggested for chickpea (Byth *et al.*, 1979), wheat (Cregan & Busch, 1977; Bhullar *et al.*, 1977; Knott & Kumar, 1975) and dry beans (Hamblin & Evans, 1976). Hamblin & Evans (1976) emphasized that apart from mean yield, cross variance should also be considered in selecting crosses for advancement. However, Green *et al.* (1981) in pigeonpeas, and Hamblin (1977) in beans (*Phaseolus vulgaris*) showed that variance of individual plant yields in some of the parents was similar to those of the F2s. Hamblin (1977) explained these results on the basis of "genotype-density competitive ability interactions" and suggested that the confounding effects of competition on cross variance could be avoided by growing the genotype at a low density to prov[illegible] non-competitive environment. However, in a cro[illegible] pigeonpea where plant structure and stature provi[illegible] considerable plasticity for adjusting its growth much wider spacing than most other crop plants, it unlikely that the noncompetitive conditions, such [illegible] wide spacing, would be practical proposition f[illegible] reducing inter-plant competition. Therefore, pigeonpea, variance in F2 generation has li[illegible] relevance as a selection criterion and one has to mai[illegible] depend on bulk yield performance.

The close relationship observed in the present tri[illegible] among different generations of a number of cros[illegible] which involved diverse parents indicated that, f[illegible] practical purposes, low yielding crosses can be safe[illegible] rejected in a pigeonpea breeding programme on the [illegible] of their Fl performance. In general, the lsevel [illegible] performance of the crosses which give low yield in [illegible] Fl is not likely to improve substantially in la[illegible] generations, except in certain very wide crosses. T[illegible] probability of recovering high yielding segregai[illegible] from a low yielding cross is low. Crosses that are hi[illegible] yielding in the Fl should be tested again in the [illegible] generation for further selection, since the [illegible] performance is consistently related to the cr[illegible] performance in succeeding generations (Table 2-5). [illegible] addition, sufficient seed supply in the F2 perm[illegible] multilocation testing and evaluation of F2 bulks f[illegible] adaptation. Also, multilocation tests help in reduc[illegible] the bias caused by genotype and environme[illegible] interaction in selecting crosses based on [illegible] sing[illegible] location performance.

The above stated conclusions, though based on limited number of crosses of pigeonpea, are [illegible] conformity with the results obtained in most se[illegible] pollinated crops and are, therefore, likely to hav[illegible] general application in the crop.

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