



Title	CHARACTERIZATION OF INDUCED POLYGENIC VARIABILITY IN PIGEON PEA(CAJANUS CAJAN L. )
Author(s)	Rao, D.Manohar; Reddy, Tummala P.; KINOSHITA, T.
Citation	Journal of the Faculty of Agriculture, Hokkaido University, 63(4), 387-395
Issue Date	1988-10
Doc URL	<a href="http://hdl.handle.net/2115/13077">http://hdl.handle.net/2115/13077</a>
Type	bulletin (article)
File Information	63(4)_p387-395.pdf



[Instructions for use](#)

## CHARACTERIZATION OF INDUCED POLYGENIC VARIABILITY IN PIGEON PEA (*CAJANUS CAJAN* L.)

**D. Manohar RAO\***, **Tummala P. REDDY\***  
and **T. KINOSHITA**

Plant Breeding Institute, Faculty of Agriculture,  
Hokkaido University, Sapporo 060, Japan

Received June 8, 1988

### Introduction

Pigeon pea is a major grain legume of the semi-arid tropics and is included in the diets of a vast number of people in India. This crop, by virtue of its symbiotic nitrogen fixation and deep root system, is known to enrich soil fertility and the plants are also used as green manure<sup>6)</sup>. Even though pigeon pea is indigenous to India, due attention has not been paid to its improvement. This crop is beset with long duration, poor plant type, susceptibility to pests and frost, high flower drop and low yield potential<sup>1,10)</sup>. Enlargement of genetic variability for these traits is of the utmost importance. Limited work has been done on the induction of micromutations in pigeon pea<sup>7,8)</sup>. The present investigation was, therefore, initiated to assess the efficacy of independent and sequential treatments of four mutagens in the induction of genetic variability, and its evaluation in  $M_2$  and  $M_3$  generations.

### Materials and Methods

Sets of 150 dry and well developed seeds of pigeon pea, variety T-21, were exposed to 20 kR of gamma rays at a dose rate of 438 rads/minute. Similar lots of seeds were presoaked in distilled water for 8 hrs. and were treated with 100 ml fresh aqueous solutions of 0.05% dES, 0.1% EMS and 0.02% HZ for 3, 4 and 5 hrs., respectively, at a room temperature of  $26 \pm 2^\circ\text{C}$ . Identical sets of seeds were also used in sequential treatments of 20 kR gamma rays with 0.05% dES, 0.1% EMS and 0.02% HZ. The seeds were first exposed to gamma rays and were presoaked for 8 hrs. prior to treatment with different chemical mutagens. Another set of presoaked seeds were

---

\* Department of Genetics, Osmania University, Hyderabad-500 007, A. P., India.

first treated with 0.05% dES and 0.1% EMS for 3 and 4 hrs., respectively, and were treated with 0.02% HZ for 3 hrs. The seeds were then washed under tap water for 30 minutes and kept overnight in distilled water. The treated seeds along with the respective controls were sown in the field to raise  $M_1$  generation.

From each treatment 30 plant progenies were raised in  $M_2$  in a completely randomised design (CRD) with a spacing of  $30 \times 45$  cm. Data on five quantitative characters; viz., days to maturity, plant height, number of pod-bearing branches, number of pods per plant and seed yield per plant, were recorded on five random normal plants in each progeny.

From each  $M_2$  progeny, seeds of 5 plants were bulked and 30  $M_3$  progenies were raised in each treatment in a CRD. The data were recorded on the same five attributes.

### Results

The range and means along with standard error are depicted in Fig. 1. The estimates of different genetic parameters of the five characters in the  $M_2$  and  $M_3$  generations are given in Tables 1-5.

*Days to maturity:* In  $M_2$  the range was bi-directional for 20 kR+EMS, whereas for 20 kR, dES, EMS, 20 kR+dES, dES+HZ and EMS+HZ is shifted towards the negative direction. In  $M_3$ , the range was bi-directional for HZ, 20 kR+dES, 20 kR+HZ and EMS+HZ. However, for 20 kR and 20 kR+EMS it was in the positive direction. In  $M_3$ , the range was bi-directional for HZ, 20 kR+dES, 20 kR+HZ and EMS+HZ. However, for 20 kR, 20 kR+EMS it was in the positive direction, while for dES, EMS and dES+HZ it was in the negative direction. The mean values did not alter significantly in either of the generations. It was observed that genotypic variance and other genetic parameters were increased in both generations. In different mutagenic treatments, except for 20 kR, dES and EMS+HZ, the estimates for various genetic parameters were high in  $M_2$  as compared to  $M_3$  generation (Table 1).

*Plant height:* The range was bi-directional in  $M_2$  for EMS, HZ, 20 kR+HZ, dES+HZ and EMS+HZ, while it tended towards the positive side for 20 kR and 20 kR+EMS. For dES and 20 kR+dES the range showed a negative shift. In  $M_3$  the range was bi-directional in nature for all the treatments. Significant decreases in mean values were observed for 20 kR+dES in  $M_2$  and for dES and dES+HZ in  $M_3$  generation. All the treatments except dES+HZ showed higher genotypic variance ( $\sigma^2_g$ ), genotypic coefficient of variation (GCV), heritability ( $h^2$ ) and genetic advance (GA) in  $M_3$  generation

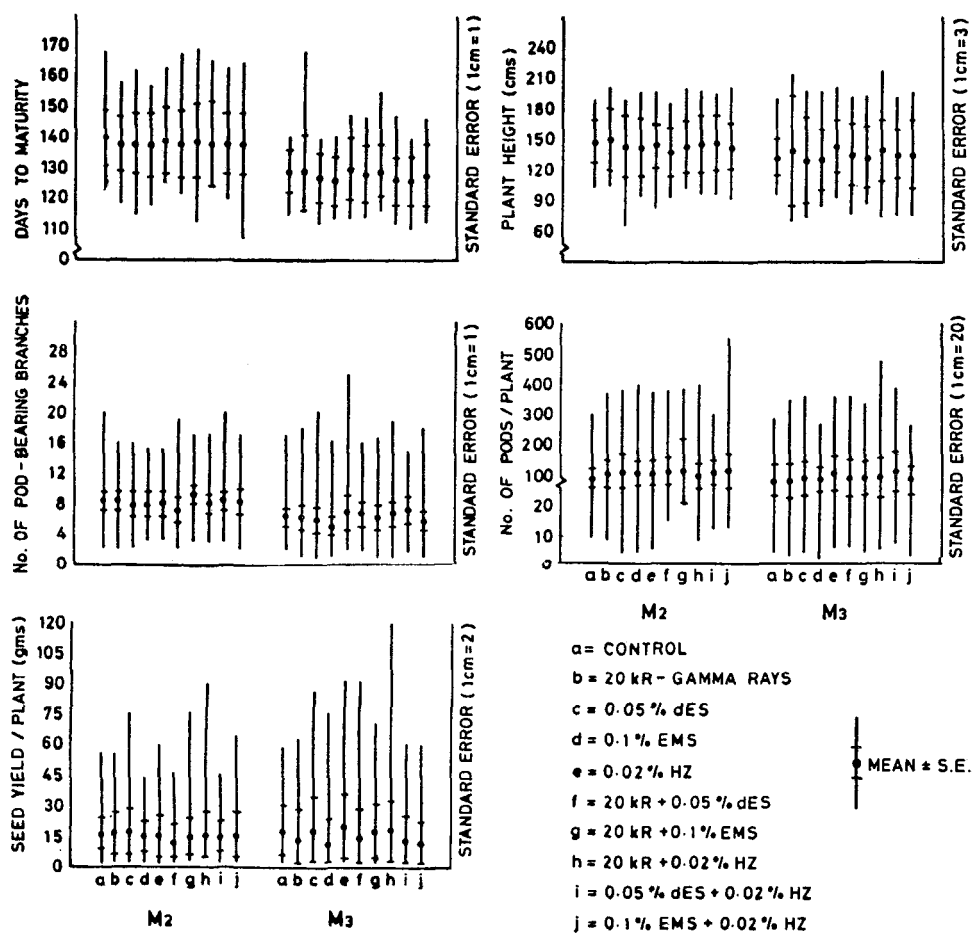


Fig. 1. Range and means of five quantitative characters in T-21 in M<sub>2</sub> and M<sub>3</sub> generations.

when compared to M<sub>2</sub> (Table 2).

*Number of pod-bearing branches:* The range did not alter significantly in M<sub>2</sub>, whereas in M<sub>3</sub> it was bi-directional for 20 kR, dES, 20 kR+HZ and EMS+HZ, while it was in the positive direction for HZ and towards negative side in EMS and 20 kR+EMS. Significant differences in the mean values were not observed in any of the treatments in either of the generations. After mutagenic treatments, the various genetic parameters increased for all the treatments. Estimates of various genetic parameters for this trait, disclosed increased values in M<sub>3</sub> generation when compared to M<sub>2</sub> (Table 3).

TABLE 1 Estimates of different genetic parameters for days to maturity in T-21 in  $M_2$  and  $M_3$  generations

Treatment	$\sigma^2g$		GCV		$h^2$		GA	
	$M_2$	$M_3$	$M_2$	$M_3$	$M_2$	$M_3$	$M_2$	$M_3$
Control	—	—	—	—	—	—	—	—
20 kR	2.34	39.08	0.28	3.03	9.12	33.25	1.04	7.84
0.05% dES	6.94	7.10	0.70	0.82	9.19	15.77	1.64	2.19
0.1% EMS	17.04	5.31	1.44	0.66	23.15	13.40	4.09	1.74
0.02% HZ	18.93	16.15	1.55	1.52	31.94	21.25	5.06	3.95
20 kR+0.05% dES	18.95	11.60	1.58	1.21	25.92	16.02	4.56	2.91
20 kR+0.1% EMS	15.15	3.11	1.28	0.37	10.87	6.44	2.72	0.93
20 kR+0.02% HZ	38.21	4.34	2.66	0.55	46.60	8.41	8.69	1.26
0.05% dES+0.02% HZ	10.71	3.60	1.00	0.47	22.13	13.24	3.20	1.43
0.1% EMS+0.02% HZ	7.84	12.30	0.77	1.26	16.41	12.62	2.36	2.75

TABLE 2. Estimates of different genetic parameters for plant height in T-21 in  $M_2$  and  $M_3$  generations

Treatment	$\sigma^2g$		GCV		$h^2$		GA	
	$M_2$	$M_3$	$M_2$	$M_3$	$M_2$	$M_3$	$M_2$	$M_3$
Control	—	—	—	—	—	—	—	—
20 kR	105.22	323.04	2.51	8.32	24.75	34.12	10.56	22.99
0.05% dES	143.66	230.08	3.71	7.17	13.74	25.19	10.12	16.82
0.1% EMS	31.12	108.77	1.02	3.94	9.92	8.64	3.62	7.47
0.02% HZ	4.66	60.39	0.23	1.92	4.66	9.65	1.12	5.26
20 kR+0.05% dES	17.50	136.73	1.10	4.61	1.02	13.46	1.17	9.87
20 kR+0.1% EMS	18.02	142.12	0.74	4.17	9.15	19.08	2.72	11.39
20 kR+0.02% HZ	64.28	167.20	1.83	5.18	12.02	17.82	5.85	12.27
0.05% dES+0.02% HZ	41.88	33.64	1.22	1.74	1.13	7.55	2.46	0.28
0.1% EMS+0.02% HZ	25.60	193.71	1.10	6.06	1.75	20.66	1.74	14.13

TABLE 3. Estimates of different genetic parameters for number of pod-bearing branches in T-21 in  $M_2$  and  $M_3$  generations

Treatment	$\sigma^2g$		GCV		$h^2$		GA	
	$M_2$	$M_3$	$M_2$	$M_3$	$M_2$	$M_3$	$M_2$	$M_3$
Control	—	—	—	—	—	—	—	—
20 kR	0.62	2.49	3.78	13.63	11.10	24.58	0.55	1.63
0.05% dES	2.06	2.36	10.89	13.87	27.07	28.34	1.54	1.69
0.1% EMS	1.69	1.56	9.13	13.53	21.48	29.70	1.24	1.40
0.02% HZ	1.80	5.10	9.15	18.58	23.32	42.93	1.34	3.08
20 kR+0.05% dES	1.56	2.16	9.86	10.33	19.00	28.74	1.12	1.63
20 kR+0.1% EMS	1.01	2.36	4.95	13.43	11.66	27.15	0.71	1.66
20 kR+0.02% HZ	1.08	3.39	6.62	15.11	16.95	27.66	0.89	2.03
0.00% dES+0.02% HZ	0.87	3.45	4.75	12.34	9.24	40.23	0.58	2.43
0.1% EMS+0.02% HZ	1.45	4.88	7.69	23.91	15.87	39.67	0.99	2.90

TABLE 4. Estimates of different genetic parameters for number of pods per plant in T-21 in  $M_2$  and  $M_3$  generations

Treatment	$\sigma^2g$		GCV		$h^2$		GA	
	$M_2$	$M_3$	$M_2$	$M_3$	$M_2$	$M_3$	$M_2$	$M_3$
Control	—	—	—	—	—	—	—	—
20 kR	938.10	579.89	8.32	10.19	16.75	10.45	26.24	16.16
0.05% dES	1791.89	1685.03	14.44	17.93	23.06	22.33	43.26	40.99
0.1% EMS	1354.31	37.96	11.32	3.84	22.09	18.80	36.30	12.07
0.02% HZ	611.99	1315.44	3.43	1.14	9.73	5.53	16.37	22.79
20 kR+0.05% dES	348.04	1397.14	1.55	7.98	2.47	10.90	7.32	28.21
20 kR+0.1% EMS	880.79	1052.43	4.74	2.73	18.23	12.52	26.31	24.67
20 kR+0.02% HZ	726.25	1707.93	6.13	6.01	14.23	15.04	21.19	35.64
0.05% dES+0.02% HZ	146.34	2276.84	3.42	2.76	1.18	16.09	3.24	43.79
0.1% EMS+0.02% HZ	1090.73	107.09	8.37	5.10	6.76	9.67	20.92	7.96

TABLE 5. Estimates of different genetic parameters for seed yield per plant in T-21 in  $M_2$  and  $M_3$  generations

Treatment	$\sigma^2g$		GCV		$h^2$		GA	
	$M_2$	$M_3$	$M_2$	$M_3$	$M_2$	$M_3$	$M_2$	$M_3$
Control	—	—	—	—	—	—	—	—
20 kR	22.94	37.97	12.56	25.84	9.85	24.84	3.29	6.33
0.05% dES	13.83	62.27	27.58	20.54	0.73	10.99	1.21	6.08
0.1% EMS	1.56	22.34	1.94	23.08	0.61	13.90	0.11	3.63
0.02% HZ	12.42	43.88	8.55	5.07	4.23	7.74	1.67	4.35
20 kR+0.05% dES	5.90	27.54	7.19	17.35	3.99	10.72	1.03	3.61
20 kR+0.1% EMS	4.06	24.07	5.48	9.61	3.65	6.62	0.79	2.77
20 kR+0.02% HZ	16.73	9.97	13.17	5.32	13.67	15.91	3.12	1.81
0.05% dES+0.02% HZ	1.94	4.52	1.34	13.72	4.21	4.78	0.20	0.99
0.1% EMS+0.02% HZ	16.32	15.89	8.05	24.12	2.82	21.36	1.86	3.99

*Number of pods/plant*: In  $M_2$ , a bi-directional shift in range was observed for 20 kR, dES, EMS, HZ and 20 kR+HZ, while in the rest of the treatments a positive shift was noticed. In  $M_3$ , a bi-directional shift was noticed only for 20 kR, while for dES, HZ, 20 kR+dES, 20 kR+EMS, 20 kR+HZ and dES+HZ the range was towards the positive direction. However, for EMS and EMS+HZ the range was towards the negative direction. Significant alterations in the mean values were not observed in either of the generations. HZ and most of the sequential treatments revealed higher values for  $\sigma^2g$  and GA in  $M_3$  than in  $M_2$  generation. Whereas other independent treatments and EMS+HZ showed increased values in  $M_2$  compared to  $M_3$  for genetic parameters (Table 4).

*Seed yield/plant*: For dES and HZ treatments in  $M_2$  the range was bi-directional in nature, while for 20 kR, 20 kR+EMS, 20 kR+HZ and EMS+HZ the range shifted towards positive direction; whereas for EMS, 20 kR+dES and dES+HZ the shift in range was towards the negative side. However in  $M_3$ , a positive shift in the range was observed. No significant alterations were observed for the mean values in both the generations. For various treatments, except 20 kR+HZ, the genetic parameters showed increased values in  $M_3$  generation when compared to  $M_2$  (Table 5).

### Discussion

The practical utility of induced mutations for improvement of polygenic characters is well recognised, since most of the economic traits in crop species are quantitatively inherited. It is well established that ionising radiations and chemical mutagens are effective in inducing micromutations in various crops<sup>2,3,4,10,12</sup>.

Increases in range, means and estimates of different genetic parameters, viz.,  $\sigma^2g$ , GCV,  $h^2$  and GA, for five attributes provide ample evidence that mutagenic treatments could create additional genetic variability in polygenic systems.

The range in the mutagenised populations was greater when compared to controls for all the characters in  $M_2$  and  $M_3$  generations, indicating enhanced scope for selection. The mean values for all the characters in  $M_2$  and  $M_3$  did not alter significantly despite the increased variance observed for these characters, suggesting the incidence of plus and minus mutations with equal frequency<sup>9</sup>.

Maximum values for  $\sigma^2g$ , GCV,  $h^2$  and GA were observed for days to maturity in  $M_2$  when compared to  $M_3$  indicating a fewer number of genes controlling this character. Hence effective selection could be practised for this trait in  $M_2$  itself. On the other hand, increased values for genetic parameters were observed for plant height, number of pod-bearing branches and seed yield per plant in  $M_3$  generation than in  $M_2$  suggesting that these attributes are governed by a relatively greater number of genes. Therefore efficient selection may be practised for these traits in  $M_3$  and/or later generations. Such differences observed in  $M_2$  and  $M_3$  generations are conceivably due to variation in the number of genes governing these characters. Effective use of induced variability through selection would be possible if the generation in which maximum variability is likely to be released is identified. From the present investigation, it is evident that selection of desirable mutant progenies could be made in  $M_2$  for earliness. Whereas, selections may be practised for plant height, increased pod-bearing branches and seed yield per plant in the  $M_3$  generation. For number of pods per plant the independent mutagenic treatments could generate higher levels of genetic variability in  $M_2$ , while sequential treatments showed greater genetic variability in  $M_3$ . Hence, for this trait, selection may be practised in  $M_2$  after independent treatments and in  $M_3$  after sequential treatments.

The data further indicate that, in general, maximum variance in  $M_2$  was caused by 0.05% dES and 20 kR+0.02% HZ, while in  $M_3$ , 20 kR induced



maximum variance. Thus, the extent of induced variation seems to depend on the mutagen used as well as its mode of administration. Increased variability might also arise from enhanced crossovers near the centromere<sup>6,19</sup>.

The estimates of  $h^2$  and GA were of higher magnitude for all the characters in both the generations. This may be mainly due to an increase in the genetic component; from the crop improvement stand point, this implies higher response to selection.

Independent mutagenic treatments, in general, when compared to sequential treatments, generated higher levels of  $\sigma^2g$ , resulting in higher GCV,  $h^2$  and GA, probably because of more severe diplontic and haplontic selections operating after sequential treatments.

An overview of the results indicates that additional genetic variability could be generated for seed yield and yield components. Hence, genetic improvements may be achieved through judicious selection in the mutagenised populations of pigeon pea.

### Summary

The present paper deals with the varietal improvement of the important characters related with the yield potential of pigeon pea, (*Cajanus cayan* L.) by means of mutagenesis.

Dried seeds of the variety, T-21 were irradiated with 20 kR of gamma rays at a dose rate of 438 rads/minute following to various kinds of pre-treatments with aqueous solutions of the chemical mutagens such as dES, EMS and HZ.

Obtained data indicated that increases in range, means and estimates of different genetic parameters, viz.,  $\sigma^2g$ , GCV,  $h^2$  and GA, for five characters provide ample evidence that mutagenic treatments could create additional genetic variability in polygenic systems. From the present investigation, it is also evident that selection of desirable mutant progenies could be made in  $M_2$  for earliness. Whereas, selections may be practised for plant height, increased pod-bearing branches and seed yield per plant in the  $M_3$  generation. The data further indicated that, in general maximum variance in  $M_2$  was caused by 0.05% dES and 20 kR+0.02% HZ, while in  $M_3$ , 20 kR induced maximum variance. Thus the extent of induced variation seems to depend on the mutagens as well as their application modes. It is expected that independent mutagenic treatments, in general, when compared to sequential treatments, generated higher levels of  $\sigma^2g$ , resulting in higher GCV,  $h^2$  and GA. Hence, genetic improvements may be achieved through rational selection in the mutagenized populations.

### Acknowledgements

The authors are grateful to Prof. G. M. REDDY of Department of Genetics, Osmania University, Hyderabad (India), for his kind help and constant encouragement.

### Literature Cited

1. BYTH, D. E. 1980: Critique and synthesis-Breeding. *Proc. Intl. Workshop on pigeon peas*. 1: 487-495.
2. FREY, K. J. 1965: Mutation breeding for quantitative attributes. *Rad. Bot.* (Suppl.) 5: 465-475.
3. GAUL, H. and K. AASTVEIT 1966: Induced variability of culm length in different genotypes of hexaploid wheat following X-irradiation and EMS-treatment. *Contemporary Agriculture*. 11-12: 263-276.
4. GREGORY, W. C. 1955: X-ray breeding of peanut (*Arachis hypogaea* L.) *Agron. J.* 47(9): 396-399.
5. KACHROO, P. and M. ARIF 1970: Red gram. *Pulse crops of India*: 14-53.
6. LAWRENCE, C. W. 1961: The effect of irradiation of different stages in microsporogenesis on chiasma frequency. *Heredity* 16: 83-89.
7. Manohar RAO, D. and T. P. REDDY 1986: Induced polygenic variability in *Cajanus cajan* L. *Perspectives in Cytology and Genetics*. 5: 303-309.
8. Mohammed SHERIFF, N. and R. VEERASWAMY 1977: Genotypic and phenotypic variability of mutants in red gram (*Cajanus cajan* (L.) Millsp.). *Madras Agric. J.* 64(1): 45-47.
9. OKA, H. I., J. HAYASHI and I. SHIOGIRI 1958: Induced mutations of polygenes for quantitative characters in rice. *J. Heredity* 49: 11-14.
10. RAWLINGS, J. O., D. G. HANWAY and C. O. GARDNER 1958: Variation in quantitative characters of soybeans after seed irradiation. *Agron. J.* 50: 524-528.
11. SINGH, U. and R. JAMBUNATHAN 1980: A survey of the methods of milling and consumer acceptance of pigeon peas in India. In: *Proc. Intl. Workshop on pigeon peas, ICRISAT*. 2: 419-425.
12. SWAMINATHAN, M. S. 1963: Induced mutations in relation to phylogenetic analysis in *Triticum*. *J. Ind. Bot. Soc.* 42 A: 276-282.
13. WHITTINGHILL, M. 1951: Some effects of gamma rays on recombination and crossing over in *Drosophila melanogaster*. *Genetics* 36: 352-355.