Bot. Bull. Academia Sinica 23: 105-118 (1982)

VARIATION IN QUANTITATIVE CHARACTERS OF MUNG BEAN (*PHASEOLUS AUREUS* ROXB.) AFTER SEED IRRADIATION*

IRFAN A. KHAN**

Department of Botany, Osmania University, Hyderabad-500007 (A.P.), India

(Received April 7, 1982; Accepted May 27, 1982)

Abstract

Mutagenic effects of gamma radiation were studied on various quantitative characters in mung bean (*Phaseolus aureus* Roxb.). Micro-mutations were scored for number of fertile branches, number of pods, pod length, seeds per pod, 100 seeds weight and total plant yield in M1 to M3 generations. The shift of mean values after mutagenic treatment was not unidirectional in M1 whereas a shift was noticed in the positive direction for all characters compared with their respective controls in M2 and M3 generations. The induced genetic variance, values of heritability increased in all characters but the different traits responded differently to the mutagenic treatments. The maximum variability was generated in the M2 generation for plant yield, number of fertile branches, number of pods and 100 seeds weight indicate a possible preference of selection in M2 and for pod length and seeds per pod in M3. The nature and amount of genetic variability induced by gamma ray treatments can be exploited for the selection of characters contributing towards higher yield.

Introduction

Most of the workers in recent years have attempted to determine the effectiveness of ionizing radiations for the induction of mutations affecting quantitative characters. With the availability of new techniques for inducing mutations in crop plants, induced mutations are playing an important role in crop improvement (Khan, 1980). The importance of micro-mutations in evolution was first stressed by Baur as early as 1924, and subsequently by Stubbe and Von Wettstein (1941). There have been many studies on the induction of polygenic variability involving quantitative characters in various

* Part of the author's approved Ph. D. thesis submitted to the Osmania University, Hyderabad, India.

** Present Address: Nawab Shah Alam Khan Research Centre, Anwarul-Uloom College, Mallepally, Hyderabad, India.

Reprint request: 16-9-571, Old Malakpet, Hyderabad-500036, Andhra Pradesh, India.

crop plants by several workers (Gregory, 1955; Oka *et al.*, 1958; Rawlings *et al.*, 1958; Bateman, 1959; Kao *et al.*, 1960; Papa *et al.*, 1961; Williams and Hanway, 1961; Gaul, 1965; Scossiroli, 1968; Borojevic, 1969; Borojevic and Borojevic, 1972; Ramulu, 1974; Larik, 1978; Siddique *et al.*, 1979 and Larik, 1979). However, Mung bean, an important pulse crop of India, which is ideally suited for mutation breeding, the informations are very scanty in the field of mutation breeding with reference to quantitatively inherited characters. Due to its adaptability to adverse conditions, give it a paramount place in agriculture. In this report, the results are presented on the mutagenic effects of ionizing radiations (gamma rays) on various characters in inducing quantitative variability in M1 to M3 generations of mung bean (*Phaseolus aureus* Roxb.).

Materials and Methods

Dry seeds of uniform size of a commercial cultivar of mung bean, var. G-65 (released at Punjab Agricultural University, Ludhiana, Punjab, India) were irradiated with Co^{60} source. The material was exposed to doses ranging from 10 to 40 kR of gamma rays. Moisture content of seeds before treatment was 12.8 per cent.

M1 generation

The treated and control seeds were sown directly in the field in a randomized complete block design with three replications. Each plot had 3 rows of 14 seeds each with a spacing of 30 cms. between plants in the row and interrow distance was 60 cms. The data were recorded for the six quantitative characters;

1) Number of fertile branches,
2) Number of pods,
3) Pod length,
4) Seeds per pod,
5) 100 seeds weight (gms.),
6) Total plant yield.

(Data for the last two characters were recorded when the seeds were at 12 per cent of moisture content).

M2 generation

Seeds from each M1 treatment of replications I and III were bulked and used in a randomized complete block design to study the M2 generation. Whereas plants in the replication II were individually harvested and these seeds were used in plant progeny studies for all the treatments. These results have been reported elsewhere (Khan, 1979 & 1981). The bulked seed material was planted in a randomized complete block design with three replications of 100 seeds per plot to raise M2 generation. Each plot had 5 rows of 20 seeds each with the same spacing as kept in M1 generation. Data were recorded on all normal-looking plants for all the six quantitative characters.

M3 generation

For studying the quantitative variability in the M3 generation, equal seed samples from each treatment and control of M2 plants were sown in a randomized complete block design to study the same characters.

Data were collected on individual plants in M1, M2 and M3 generations and analysed quantitatively to assess the extent of induced variation. The within-plot variance in the control is assumed to be entirely of environmental origin. Hence, it is possible to estimate the induced genetic variance in each of the irradiated treatments by computing the difference between their respective within-plot variances and within-plot variances of control. This derived variance components "genetic variance" estimates the transmissible variation induced by radiation. This genetic variance was further used to determine the heritability of these characters in broad sense. The broad sense heritability (h^2) of a character was estimated according to the method followed earlier by Khan (1981).

$$\text{i. e. } h^2 = \frac{\sigma^2 g}{\sigma^2 t}$$

Where $\sigma^2 g$ = induced genetic variance and $\sigma^2 t$ = total phenotypic variance ($\sigma^2 t = \sigma^2 g + \sigma^2 e$) calculated from the radiated populations.

Results and Discussion

The data on the effects of various radiation doses of gamma rays on the mean values and variances of different quantitative characters of all normal-looking plants in the M1 generation are presented in Table 1. These results show that radiation doses increased the means and variances unidirectionally for the characters; number of pods, 100 seeds weight and total plant yield. However, the number of fertile branches increased at 15, 30 and 40 kR as compared to control. The mean pod length and seeds per pod reduced but the variability increased after every additional/increment of radiation dose except at 10 and 15 kR. The main reason for reduction in mean values and for the increase of variability in this generation, is due to the high sterility of the M1 seeds, induced by the direct effect of irradiation and also due to gene mutations.

As can be seen from the data presented in Tables 2–5, the range in the irradiated populations is greater as compared to the controls for all the

Table 1. *Estimates of mean values* ($\bar{X}$), *standard error of mean* ($S\bar{x}$) *and variances for six quantitative characters after gamma irradiation in M1 generation*

Doses (kR)	N	$\bar{X}\pm S\bar{x}$	Variance	N	$\bar{X}\pm S\bar{x}$	Variance
	Number of fertile branches			Number of pods		
0	71	3.77 0.23	1.14	71	23.95 2.05	92.14
10	69	3.63 0.15	0.81	69	24.97 1.56	92.92
15	75	3.85 0.15	0.73	75	28.70 1.81	108.70
20	69	3.75 0.23	1.69	69	30.34 3.15	317.29
25	66	3.56 0.13	0.83	66	26.06 1.24	94.02
30	61	4.53 0.21	1.98	61	40.44 1.89	161.14
35	60	3.67 0.17	0.87	60	30.07 2.10	131.79
40	56	4.06 0.20	1.22	56	39.52 3.32	341.60
	Pod length			Seeds per pod		
0	71	6.83 0.06	0.09	71	9.99 0.16	0.57
10	69	6.02 0.07	0.16	69	8.11 0.11	0.46
15	75	6.29 0.09	0.24	75	8.50 0.10	0.34
20	69	5.65 0.10	0.36	69	7.89 0.16	0.86
25	66	5.31 0.07	0.21	66	8.45 0.12	0.65
30	61	5.47 0.08	0.26	61	8.63 0.12	0.64
35	60	5.32 0.09	0.26	60	8.18 0.16	0.73
40	56	5.61 0.09	0.26	56	8.13 0.16	0.81
	100 seeds weight			Plant yield		
0	71	3.19 0.05	0.06	71	5.64 0.36	2.79
10	69	3.36 0.04	0.07	69	6.45 0.41	5.81
15	75	3.34 0.06	0.12	75	5.99 0.35	3.99
20	69	3.40 0.06	0.11	69	6.75 0.59	10.83
25	66	3.43 0.05	0.12	66	6.25 0.35	5.25
30	61	3.34 0.06	0.15	61	8.36 0.36	5.76
35	60	3.36 0.05	0.08	60	8.82 0.44	5.14
40	56	3.25 0.07	0.12	56	8.53 0.62	10.71

characters in the M2 and M3 generations. The increased range indicates considerable scope for selection. The range is increased in both positive and negative directions but the increased range in the positive direction is greater in all the characters. There have been increases in mean values for almost all the characters of the treated populations compared with their respective controls in M2 and M3 generations. Borojevic (1965) studied the effect of thermal-neutrons and gamma rays in *Triticumvulgare*, observed an increase in the M3 means, might have resulted from the purposeful elimination of all mutants which produce abnormal spike morphology and fertility [prior to M3 generation. Scossiroli *et al.* (1966) reported that the irradiation of wheat seeds caused a decrease in the mean of quantitative parameters in the M1 and M2 generations, whereas in M3, there was a decrease of this effect. They concluded that this change was a consequence of the elimination of undesirable genes and lethals after selfing and partly of a recovery from a transmitted radiation induced damage independent of chromosomal genes.

Table 2. *Estimates of mean values* ($\bar{X}$), *standard error of mean* ($S\bar{x}$), *within-plot variance* (δ^2p), *genetic variance* (δ^2g) *and heritability* (h^2) *for three quantitative characters after gamma irradiation in M2 generation*

Doses (kR)	N	Range	$\bar{X} \pm S\bar{x}$	δ^2p	δ^2g	h^2
			Number of fertile branches			
0	223	3-8	4.68 0.0900	0.5509	—	—
10	209	3-10	4.96 0.1628	0.0571	0.51	0.48
15	203	1-11	5.18 0.1300	1.5733	1.02	0.65
20	211	2-10	5.56 0.1700	2.4459*	1.90	0.77
25	214	1-10	4.73 0.1180	2.1509*	1.60	0.74
30	195	2-9	5.41 0.1544	2.0790*	1.53	0.74
35	182	2-10	5.43 0.1894	3.4829**	2.93	0.84
40	171	1-10	4.89 0.1536	2.0471*	1.50	0.73
			Number of pods			
0	223	13-52	27.62 0.6908	49.0188	—	—
10	209	7-72	28.05 1.0777	168.8989*	199.88	0.71
15	203	6-77	36.77 1.3000	153.3339*	104.31	0.68
20	211	4-75	31.94 1.3800	156.4926*	107.47	0.69
25	214	4-72	26.69 0.8629	115.2217	66.20	0.57
30	195	4-65	31.86 1.2711	137.0597	88.04	0.64
35	182	8-73	31.78 1.3257	161.0531*	112.03	0.70
40	171	5-56	26.91 1.0780	101.2875	52.26	0.52
			Pod length			
0	223	5.27-7.48	6.27 0.0293	0.3529	—	—
10	209	5.46-8.21	6.73 0.0521	0.4247	0.07	0.17
15	203	5.13-8.47	6.78 0.0600	0.4219	0.07	0.16
20	211	5.49-8.40	6.93 0.0582	0.3721	0.02	0.05
25	214	4.31-8.29	6.59 0.0497	0.3795	0.03	0.07
30	195	4.30-8.37	6.48 0.0873	0.7785	0.43	0.55
35	182	4.95-7.79	6.43 0.0544	0.7229	0.37	0.51
40	171	4.25-8.66	6.70 0.0657	0.4170	0.06	0.15

* Significant at 5 per cent.
** Significant at 1 per cent.

Table 3. *Estimates of mean values* ($\bar{X}$), *standard error of mean* ($S\bar{x}$), *within-plot variance* ($\delta^2 p$), *genetic variance* ($\delta^2 g$) *and heritability* (h^2) *for three quantitative characters after gamma irradiation in M2 generation*

Doses (kR)	N	Range	$\bar{X} \pm S\bar{x}$	$\delta^2 p$	$\delta^2 g$	h^2
			Seeds per pod			
0	223	8.60-12.60	10.64 0.0635	0.1508	—	—
10	209	7.70-13.70	11.48 0.0706	0.7992**	0.65	0.81
15	203	9.70-13.80	11.64 0.0900	0.6593*	0.51	0.77
20	211	7.10-13.70	11.89 0.0932	1.0361**	0.86	0.85
25	214	5.30-13.10	11.29 0.0751	0.8366**	0.69	0.82
30	195	5.80-12.90	11.49 0.0971	0.9258**	0.78	0.84
35	182	6.80-13.66	11.47 0.1144	1.2673**	1.12	0.88
40	171	6.20-13.10	11.44 0.1111	1.1567**	1.01	0.87
			100 seeds weight			
0	223	1.93- 3.30	2.43 0.0240	0.0144	—	—
10	209	1.80- 3.20	2.61 0.0111	0.0385	0.02	0.63
15	203	2.00- 3.40	2.67 0.0300	0.0928**	0.08	0.84
20	211	1.90- 3.70	2.64 0.0100	0.0356	0.02	0.59
25	214	2.00- 3.60	2.64 0.0200	0.0740**	0.06	0.80
30	195	2.00- 3.70	2.64 0.0240	0.0573*	0.04	0.75
35	182	2.00- 3.50	2.73 0.0226	0.0480*	0.03	0.70
40	171	2.00- 3.50	2.70 0.0275	0.0583*	0.04	0.75
			Plant yield			
0	223	3.40-12.10	6.28 0.1588	1.9263	—	—
10	209	2.90-16.30	7.66 0.2558	9.6220**	7.70	0.80
15	203	3.30-18.00	9.66 0.3100	8.1087**	6.18	0.76
20	211	2.10-20.70	9.04 0.3400	12.4098**	10.48	0.84
25	214	2.40-17.90	7.70 0.2209	6.7404*	4.81	0.71
30	195	2.20-23.80	8.19 0.3291	8.5390**	6.61	0.77
35	182	2.20-18.80	8.41 0.3157	9.3363**	7.41	0.79
40	171	2.60-15.20	7.67 0.2742	6.0176*	4.09	0.68

* Significant at 5 per cent.
** Significant at 1 per cent.

Ramulu (1974) exercised selections for normal-looking plants in M2 and for grain yield in the M3, the increase in the mean values of the treated population in the M3 and M4 in comparison with the control mean, might be due to the elimination of aberrant plants, and also due to genetic nature of the changes induced after mutagenic treatment. In the present study, selection was exercised for normal-looking plants starting from M1 generation. The increase in the mean values in M2 and M3 generations in comparison with the control mean, might be due to elimination of aberrant plants and also due to genetic nature of the changes induced after mutagenic treatments of gamma radiation (Khan, 1981).

The number of fertile branches and pods per plant are the most important yield components, as they determine the ultimate crop yield (Khan, 1982).

Table 4. *Estimates of mean values* ($\bar{X}$), *standard error of mean* ($S\bar{x}$), *within-plot variance* ($\delta^2 p$), *genetic variance* ($\delta^2 g$) *and heritability* (h^2) *for three quantitative characters after gamma irradiation in M3 generation*

Doses (kR)	N	Range	$\bar{X} \pm S\bar{x}$	$\delta^2 p$	$\delta^2 g$	h^2
			Number of fertile branches			
0	203	3-6	3.94 0.0985	0.5004	—	—
10	200	3-8	4.36 0.1107	1.2689	0.77	0.61
15	200	3-9	4.47 0.1238	1.1514	0.65	0.57
20	195	3-8	4.66 0.1014	1.7206*	1.22	0.71
25	186	3-6	4.24 0.0760	0.8975	0.40	0.44
30	191	3-9	4.51 0.1156	1.0949	0.59	0.54
35	170	3-10	4.89 0.1264	1.1772	0.68	0.57
40	161	3-13	4.87 0.1966	2.6028**	2.10	0.81
			Number of pods			
0	203	12-39	12.65 0.6677	22.3643	—	—
10	200	7-50	22.53 0.7802	61.5293	39.17	0.64
15	200	11-58	27.99 1.0746	78.9104*	56.54	0.72
20	195	9-65	28.41 1.3096	89.0916*	66.73	0.75
25	186	10-71	29.66 1.7746	121.5222**	99.16	0.82
30	191	11-65	31.94 1.0966	71.4549*	49.09	0.69
35	170	11-83	34.56 1.2784	130.9588**	108.59	0.83
40	161	10-58	29.41 0.8949	75.9995*	53.64	0.71
			Pod length			
0	203	4.94-6.60	5.87 0.0594	0.0715	—	—
10	200	4.58-8.15	6.08 0.0780	2.2957*	0.22	0.76
15	200	4.12-7.99	6.06 0.0644	0.2071	0.14	0.65
20	195	4.74-7.71	6.03 0.0646	0.2052	0.13	0.65
25	186	4.36-7.18	6.02 0.0623	0.2383*	0.17	0.70
30	191	4.57-7.94	5.99 0.0618	0.2238*	0.15	0.68
35	170	4.67-7.46	6.12 0.0637	0.1866	0.12	0.62
40	161	4.84-7.94	6.12 0.0704	0.3888**	0.31	0.81

* Significant at 5 per cent.
** Significant at 1 per cent.

Table 5. *Estimates of mean values* ($\bar{X}$), *standard error of mean* ($S\bar{x}$), *within-plot variance* ($\delta^2 p$), *genetic variance* ($\delta^2 g$) *and heritability* (h^2) *for three quantitative characters after gamma irradiation in M3 generation*

Doses (kR)	N	Range	$\bar{X} \pm S\bar{x}$	$\delta^2 p$	$\delta^2 g$	h^2
			Seeds per pod			
0	203	6.30-11.80	9.00 0.1762	0.2025	—	—
10	200	5.10-13.10	9.48 0.2135	1.1522**	0.95	0.82
15	200	5.60-13.30	9.72 0.2072	1.1570**	0.95	0.82
20	195	4.70-12.90	9.86 0.2211	1.6177**	1.42	0.87
25	186	5.80-13.20	10.36 0.2080	1.0786**	0.88	0.81
30	191	5.60-13.10	10.02 0.3010	1.4573**	1.25	0.86
35	170	5.80-13.40	10.41 0.2177	1.8773**	1.67	0.89
40	161	4.50-12.90	10.10 0.2443	1.9348**	1.73	0.89
			100 seeds weight			
0	203	3.00- 3.60	3.01 0.0229	0.0148	—	—
10	200	3.00- 4.85	3.58 0.0464	0.0873**	0.07	0.83
15	200	3.00- 4.40	3.45 0.0332	0.0502*	0.03	0.71
20	195	3.00- 4.30	3.52 0.0454	0.0841**	0.07	0.82
25	186	3.00- 4.20	3.50 0.0330	0.0591*	0.04	0.75
30	191	3.00- 4.60	3.52 0.0395	0.0773**	0.06	0.81
35	170	3.00- 4.60	3.53 0.0398	0.0620*	0.05	0.76
40	161	3.00- 4.80	3.56 0.0323	0.0786**	0.06	0.81
			Plant yield			
0	203	3.50- 7.60	5.61 0.0996	0.7915	—	—
10	200	3.90-15.00	5.24 0.2141	3.9102**	3.81	0.80
15	200	3.00-16.20	6.39 0.2617	4.2364**	3.44	0.80
20	195	3.60-14.50	6.36 0.2993	3.9695**	3.18	0.80
25	186	3.70-14.75	6.27 0.2457	4.3498**	3.56	0.82
30	191	3.50-13.00	5.63 0.2339	3.6873**	2.19	0.79
35	170	4.10-13.00	6.42 0.2161	3.9046**	3.11	0.80
40	161	3.60-13.40	6.38 0.2293	4.9161**	4.12	0.84

* Significant at 5 per cent.
** Significant at 1 per cent.

The mean number of branches increased in M2 and M3 generations whereas pod numbers are reduced at 25 and 40 kR in the M2 generation. But at other radiation doses, mean number of pods increased, confirming the findings of Mujeeb (1970), Bhatti *et al.* (1970) and Rajput (1974). The number of pods increased concurrently with the increase of number of fertile branches. Within-plot variances in all the irradiated populations were higher than the within-plot variances in the control. There was a promissing increase in genetic variability and estimates of heritability for these traits, indicating that these characters can be transmitted in future generations and a potential gain could possibily be achieved through selection in early generations. The rangess of heritability values were much higher than those calculated for *Arabidopsis thaliana* by Daly (1973). The increase in heritability after treatment with gamma radiation showed that it might be possible to obtain plants with a higher number of branches and pods by selection in early generations (M2 generation).

The within-plot variance increased in the treated populations in M2 and M3 generations for the parameters, pod length and seeds per pod. The mean values increased slightly over the control. However, the genetic variability increased manyfld, confirming the findings of Bhatti *et al.* (1970), Rajput (1974) and Khan (1982). Heritability estimates increased more in the M3 generation as compared to M2, and selection for this character will be more effective if it is applied in later generations (Borojevic and Borojevic, 1972).

Although the variability increased in all the irradiated populations as compared to control, the mean 100 seeds weight was not significantly altered. Similar results have been reported earlier by Ghafoor *et al.* (1968), Abidi and Haq (1971) and Rajput (1974). Bhatia and Swaminathan (1962) working on wheat have also reported depressive effects in the irradiated populations and suggested such declines to be result of frequent occurrence of mutations with detrimental effects. Increased heritability in M2 generation indicates that selection should be made in early generations.

Yield in pulses is a complex character and is influenced by many characters. With the increase of number of fertile branches, number of pods, and 100 seeds weight, the yield of the plant increases simultaneously. The range of morphological variations shifted in negative and positive directions but more towards the positive side, increasing the mean yield in all radiation doses in M2 and M3 generations. The treatments are significantly different. The heritability estimates and genetic variances increased and found to be more in M2 generation as compared to M3. It indicates that the character could be transmitted to future generations and significant gains could possibily be achieved through selection in early generations. The present results suggests that the medium dose (20 kR) of gamma rays can be useful from breeding point of view for selecting higher yielding plants in early generations.

The maximum variability was recorded for number of fertile branches, number of pods, 100 seeds weight and total plant yield in the M2 generation and for pod length and seeds per pod in the M3 generation. Differences in the expression of variability in different generations have been reported by Borojevic and Borojevic (1968) in wheat. Efficient use of induced variability in breeding through selection would be possible when the generations in which maximum variability is likely to be released is known.

A combined persual of the effects of data with respect to gamma radiation doses upon different quantitative characters; number of fertile branches, number of pods, pod length, seeds per pod, 100 seeds weight and total plant yield would reveal that within-plot variances were greater than that of their respective controls at all radiation levels and 28 within-plot variances out of 42 for all characters in M2 and 33 out of 42 for the different traits in M3 are significantly different than the respective controls, confirming the results of earlier investigations (Bhatia and Swaminathan, 1962; Matsuo and Onozawa, 1961; Oka *et al.*, 1958; Goud, 1967 and Khan, 1981). However, there was no relationship between the magnitude of irradiation and the amount of genetic variability in all the characters, the pattern being irregular like within-plot variances (Daly, 1973 and Kasim *et al.*, 1977). Genetic variance was enhanced for all the characters and so also the values of heritability for the two generations; i.e. mutations of polygenes governing the quantitative characters. Increase in genetic variability following mutagenic treatments was reported by Oka *et al.* (1958), Yamaguchi (1964), Sharma and Saini (1970), Brock (1971), Nair (1972), Borojevic and Borojevic (1972), Daly (1973), Rajput (1974), Ramulu (1974), Rao and Siddiq (1976), Larik (1978 & 1979), Siddique *et al.* (1979) and Khan (1979). Genetic variability was reported to increase in barley with increase in doses of gamma rays (Gupta, 1970) and in rice, the relationship between dose and variance was not linear (Yamaguchi, 1964). Gonzalez and Frey (1965) concluded that the magnitude of induced genetic variability was influenced by the character and the genotype treated. According to Gaul (1961), the larger the number of genes involved in a character, the higher is the probability of obtaining an alteration by mutations of one of the multiple genes concerned. Nair (1972) reported the increase in variability which was symmetrical for all characters except the number of ears per plant. This symmetrical increase without alteration of the mean indicated that micro-mutations with positive and negative effects occurred with equal frequencies. In the present studies, the results show that the variance increased in all the characters in M2 and M3 generations, but was not proportional to the dose. Lack of a consistent dose-response relationship for gamma rays may be due to additional uncontrlled environmental variation, for the response to ionizing radiation is notably modified by environmental variables such as seed moisture and oxygen availability (Conger *et al.*, 1966). Daly in two separate studies (1960 & 1973) on *Arabidopsis thaliana*, has contested that the genetic alterations induced by gamma rays reflected by increased variance in quantitative traits was oxygen dependent. If oxygen was excluded from the water during post-irradiation treatments of seeds in the chilled water than the genetic variance was not proportional to the dose.

The present studies conclude that breeders point of view, selection for agronomically important traits, plant yield and its components, number of fertile branches and pods and also 100 seeds weight can be made in the early generations which reveal high heritability values. The present studies have also provided an evidence on the induction of genetic variability in the quantitative characters after gamma irradiation. Thus, induced genetic variability can effectively be exploited for improving yield and its attributes.

Acknowledgements

I wish to place on record my grateful thanks to Prof. M. Hashim, Department of Botany, Osmania University, Hyderabad, India for his guidance throughout the course of this investigation and to Prof. Jafar Nizam, ex Head, Department of Botany, currently Vice-Chancellor, Kakatiya University, Warangal, India for the facilities that I enjoyed in the Department. I am also thankful to my wife, Dr. Atiya Irfan for going through the manuscript and giving the valuable suggestions.

References

Abidi, Z. H. and M. I. Haq. 1971. Radiation induced mutation in *Brassica compestris* L. Effect of gamma irradiation upon seeds per pod and seed index. Sci. Ind. (Karachi) **8**: 156-160.

Bhatia, C. R. and M. S. Swaminathan. 1962. Induced polygenic variability in bread wheat and its bearing on selection procedures. Z. Pflanzenzucht., **48**: 317-326.

Bhatti, I. M., M. A. Rajput, and M. A. Awan. 1970. Variability of quantitative characters in gram as affected by gamma irradiation. J. Agr. Res. (Punjab) **8**: 269-273.

Bateman, A. J. 1959. Induction of polygenic mutations in rice. Int. J. Radiat. Biol., **1**: 425-427.

Baur, E. 1924. Untersuchungen iiber das Wesen, die Entstehung und die Vererbung von Rassenunterschieden bei *Antirrhinum majus*. Bibl. Genet., **4**: 1-170.

Borojevic, K. 1965. The effect of irradiation and selection after irradiation on the number of kernels per spike in wheat. The use of induced mutations in plant breeding. Suppl. to Rad. Bot., **5**: 505-513.

Borojevic, K. 1969. Genetic changes in quantitative characters of irradiated population. Suppl. Japan J. Genet., **44**: 404-416.

Borojevic, K. and S. Borojevic. 1968. Response of different genotypes of *Triticum aestivum* ssp. valgare to mutagenic treatments. Mutations in plant breeding II. (Proc. Panel. Vienna, 1967) IAEA/Vienna 16-18.

Borojevic, K. and S. Borojevic. 1972. Mutation breeding in wheat. In "Induced mutations and plant improvement". Proc. Panel, IAEA/FAO, Vianna 237-249.

Brock, R. D. 1971. The role of induced mutations in plant improvement. Rad. Bot., **11**: 181-196.

Conger, B. V., R. A. Nilan, C. F. Konzak and S. Metter. 1966. The influence of seed water content on the oxygen effect in irradiated barley seeds. Rad. Bot, **6**: 129-144.

Daly, K. 1960. The induction of quantitative variability by gamma radiation in *Arabidopsis thaliana*. Genetics, **45**: 983-988.

Daly, K. 1973. Quantitative variation induced by gamma rays and fast neutrons in *Arabidopsis thaliana*. Rad. Bot., **13**: 149-154.

Gaul, H. 1961. Use of induced mutations in seed propagated species. Mutation and plant breeding, NAS/NRC **891**: 206-250.

Gaul, H. 1965. The concept of macro-and micro-mutations and results on induced micro-mutations in barley. The use of induced mutations in plant breeding. Rad. Bot. (Suppl. 5) 407-428.

Goud, J. V. 1967. Induced polygenic mutation in hexaploid wheats. Rad. Bot., **7**: 321-331.

Gregory, W. C. 1955. X-ray breeding of peanuts (*Arachis hypogaea* L.). Agron. J., **47**: 396-399.

Ghafoor, A., G. Bari and M. A. Rajput. 1968. Radiation induced genetic variability in barley. The Nucleus (Pakistan) **5**: 95-100.

Gupta, A. K. 1970. Induced polygenic variability in diploid and tetraploid barley. Radiation and Radio-mimetic substances in mutation breeding (Proc. Symp. Bombay, 1969) Department of Atomic Energy, India, 324-337.

Gonzalez, C. and K. J. Frey. 1965. Genetic variability in quantitative characters induced by thermal-neutron treatment of diploid, tetraploid and hexaploid oat seeds. Rad. Bot., **5**: 321-335.

Kao, K. N., C. H. Hu, W. G. Chang and H. I. Oka. 1960. A biometrical genetic study of irradiated population in rice; genetic variances due to different doses of X-rays. Bot. Bull. Acad. Sinica N. S. I., 101-108.

Kasim, M. H., S. R. A. Shamsi and S. A. Sofajy. 1977. Increased genetic variability in the M2 generation of three gamma-irradiated broad bean (*Vicia faba* L.) varieties. Pak. J. Bot., **9** (1): 11-16.

Khan, Irfan A. 1979. Induced quantitative variability in mung bean (*Phaseolus aureus* Roxb.). J. Cytol. Genet., **14**: 142-145.

Khan, Irfan A. and M. Hashim. 1980. A comparative account of mutagenesis with gamma rays, EMS and HZ involving quantitative parameters in green gram (*Phaseolus aureus* Roxb.). In national symposium "Induced mutations in plant breeding". Osmania University, Hyderabad, India, 120-124.

Khan, Irfan A. 1981. Mutation studies in mung bean (*Phaseolus aureus* Roxb.). III. Variability and genetic advances after selection in quantitative parameters. Communicated to Japan J. Genetics.

Khan, Irfan A. 1982. Induced polygenic mutations in mung bean (*Phaseolus aureus* Roxb.). Communicated to Revista De Biologia.

Larik, A. S. 1978. An evaluation of wheat mutant for useful agronomic characters. Genetica Agraria, **23**: 237-244.

Larik, A. S. 1979. Evaluation of wheat mutants for yield and yield components. Wheat Information Service, **49**: 70-73.

Mujeeb, K. A. 1970. Gamma radiation effects on *Phaseolus vulgaris* L. and seed radiosensitivity determination for other species. Ph. D. Thesis, Kansas State University, U. S. A.

Matsuo, T. and Y. Onozawa. 1961. Mutations induced in rice by ionizing radiations and chemicals. Effects of ionizing radiations on seeds (Proc. Symp. Karlsruhe, 1960) IAEA, Vienna, 495-501.

Nair, Gopinathan V. 1972. Induction of variability in quantitative characters of rice through mutagenic treatments. Agri. Res. J. Kerala **10** (2): 119-124.

Oka, H., J. Hayashi and I. Shiojiri. 1958. Induced mutations of polygenes for quantitative characters in rice. J. Hered., **49**: 11-14.

Papa, K. E., J. H. Williams and D. G. Hanway. 1961. Effectiveness of selection for quantitative characters in the third generation following irradiation of soybeans seeds with X-rays and thermal-neutrons. Crop. Sci., **1**: 87-90.

Rawlings, J. G., D. G. Hanway and C. O. Gardner. 1958. Variation in quantitative characters of soybeans after seed irradiations. Agron. J., **50**: 524-528.

Rajput, M. A. 1974. Increased variability in the M2 of gamma-irradiated mung beans (***Phaseolus aureus*** Roxb.). Rad. Bot., **14**: 85-89.

Sree Ramulu, K. 1974. Radiation and chemical induced quantitative variation in Sorghum. Z. Pflzucht. (in press).

Rao, Madhusudana, G. and E. A. Siddiq. 1976. Studies on induced variability for amylose content with reference to yield and protein characteristics in rice. Environmental and experimental Bot., **16**: 177-188.

Scossiroli, R. E., D. L. Palenzona and S. Scossiroli-Pellagrani. 1966. Studies on induction of new genetic variability for quantitative traits by seed irradiation and its use for wheat improvement. Mutations in plant breeding, IAEA, Vienna., 197-229.

Scossiroli, R. E. 1968. Selection experiments in a population of ***Triticum durum*** irradiated with X-rays. In: mutations in plant breeding II. IAEA, Vienna., 205-217.

Sharma, D. and S. S. Saini. 1970. Differential effect of radiation doses on induced quantitative variability for various characters in two varieties of rice. Radiations and Radiomimetic substances in mutation breeding (Proc. Symp. Bombay, 1969) Department of Atomic Energy, India, 338-349.

Siddique, K. A., M. A. Rajput, M. A. Arain, and K. A. Jaffari. 1979. Induced variability for useful agronomic traits in bread wheat. Proc. 5th Int. wheat Genetics symp. New-Delhi, 547-558.

Stubbe, H. and F. Von Wettstein. 1941. Uber die Bedeutung von Klein and Grofbonutations in der Evolution. Biol. Zbl., **61**: 265-297.

Williams, J. H. and D. G. Hanway. 1961. Genetic variation in oil and protein content of soybeans induced by seed irradiation. Crop. Sci., **1**: 34-36.

Yamaguchi, H. 1964. Genetic effects of pile radiations in rice. Biological effects of Neutrons and Protons irradiation-1, IAEA, Vienna, 371-382.

綠豆種子經輻射線處理後其數量性狀的變異

IRFAN A. KHAN

印度海德堡奧斯馬尼亞大學植物系

本研究係將綠豆種子以伽瑪射線照射後以觀察其對於綠豆數種數量遺傳性狀之誘變效應。突變之細微調查期係從誘變後第一代至第三代其性狀包括有效莢梗數，莢數，莢長，每莢豆數，百粒重（豆實）。由性狀平均值比較中，處理後之第一子代，各性狀的變化方向並無一致的趨勢，然而在第二及第三代，各性狀平均值之變化皆趨於正的方向。所有的性狀經照射誘變後其遺傳變方與遺傳率都增加，不過不同的性狀對於誘變處理的反應並不相同。在第二子代時植株生長，有效莢梗數，莢數以及百粒重等性狀皆具有最大的變異情形，顯示該第二代爲綠豆伽瑪誘變選拔時最爲可能的時機，而在第三代則可進行莢長與每莢豆數之選拔。綠豆經由伽瑪射線誘變，觀察其所產生之遺傳變異的性質與變化量的結果，可知該法無疑是提高生產力之育種的有效途徑。