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* Induction of Positive Micro-Mutations in Cotton by Use of Gamma-Rays

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ABSTRACT

The mutagenic effects of gamma-rays in inducing mutations in cotton was studied with particular reference to micro-mutations. The varieties MCU 4 and MCU 5 (G. hirsutum) were treated with gamma-rays at doses ranging from 5 Kr. to 40 Kr. In the M1, reduction in plant, height, yield, mean number of bolls per plant, seed index and lint index were observed due to radiation injury. In M_2 an increased variability for these quantitative characters was observed. A significant difference between lines in a family with a positive shift in some line for characters under study was also recorded. The induction of micromutations, their detection and possible exploitation are discussed in this paper.

INTRODUCTION

Gaul (1964) has highlighted the importance of micro-mutations affecting polygenic traits. Mac Key (1956) in a review on the mutation breeding has stated that in adding a single characteristic to a delicate system of genic balance, in which recombination may cause a breakdown of the whole system, the mutation breeding would be of special use.

In breeding superier varieties of cottons, difficulty in combining various characters like lint length, ginning percentage, earliness and productivity are met with and a complex procedure is followed to combine those characters. In this paper, how far the use of gamma-rays can be of help in altering one or two economic characters in positive direction in cotton is discussed.

MATERIAL AND METHODS

Dry seeds of two improved varieties, MCU 4 and MCU 5 having complex pedigree and belonging to *G. hirsutum* were subjected to Gamma-irradiation at the Gobalt^{60} intensive gamma source installed at the Division of Genetics, Indian Agricultural Researce Institute' New Delhi. Seeds were delinted and dried before irradiation. The dosages used were 5 kr, 10 kr, 20 kr, 30 kr and 40 kr. One hundred seeds were used for each dose besides untreated control. A single seed was dibbled in each hole for raising the M_2 and the observation on various characters were made on single plant basis.

For M_2, five plants were selected from each treated group, based upon the fertility status of the M_1. In MCU 4, the progenies were raised from the treat-

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ments 5 kr, 10 kr and 15 kr while in MCU 5, the progenies consisted of 5 kr, 10 kr, 15 kr and 20 kr groups. As in M_1, study was made on single plant basis.

Analysis of variance and Co-efficient of variation were worked out wherever necessary.

RESULTS

In this paper, the effect on plant height, mean number of bolls per plant, mean yield per plant, mean halo-length, ginning per cent, lint index and seed index are alone presented and discussed.

(a) **Plant height**: A variation in plant height at maturity from different dosages of gamma-rays was observed in the M_1. In the treatment 20 kr and higher dosages, a significant reduction from control was observed in both MCU 4 and MCU 5 (Table 1).

In the M_2, the mean plant height of MCU 4 increased significantly in 5 kr and 15 kr treatments. There was significant difference between progenies in these two treatments. In MCU 5 also, the progenies differed significantly in 5 kr treatment. In these treatments, an increase in co-efficient of variation

TABLE 1 Effect of Gamma-rays on quantitative characters in M_1 generation

Dose	Mean plant height (cm)		Number of bolls/plant		Mean yield per plant (g)		Mean halo-length (mm)		Ginning per cent		Lint index (g)		Seed index (g)	
	MCU4	MCU5	MCU4	MCU5	MCU4	MCU5	MCU4	MCU5	MCU4	MCU5	MCU4	MCU5	MCU4	MCU5
0	42.5	42.5	14.8	13.5	52.4	50.8	29.3	30.5	33.6	33.7	5.7	5.0	11.0	9.9
5 kr	44.9	42.9	10.7	11.5	37.2	32.6	28.6	29.7	33.7	32.7	5.7	5.1	11.4	10.2
10 kr	40.4	45.8	8.5	11.5	25.5	34.7	29.0	30.0	34.0	33.4	5.5	5.3	10.8	10.7
15 kr	38.7	44.8	7.4	14.9	23.7	36.2	30.1	30.0	33.6	33.0	5.9	5.5	11.5	11.1
20 kr	32.9	37.9	3.3	7.5	12.8	18.5	28.8	29.3	—	32.9	—	5.2	—	10.5
25 kr	32.0	32.5	3.4	5.0	Low survival									
30 kr	—	30.7	—	—	Very low survival									
35 kr	—	—	—	—										
40 kr	—	—	—	—	No survival									
Mean	38.6	39.6	8.0	10.7	30.5	34.6	29.2	29.9	33.7	33.1	5.7	5.2	11.2	10.5
Whether significant by 'F' test	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	No	Yes

Note: S. E. & C. D. not furnished as variable due to difference in pouplation between t:eatments and a definite shift in the mean towards positive direction were in evidence. The progeny mean was as high as 44.0 cm in 5 kr treatment and 40.7 cm in 15 kr treatment in MCU 4 as against a maximum mean value of 34.9 cm in the control lines. In 5 kr of MCU 5 also, one of the lines recorded a mean of 53.4 cm as against a maximum of 42.3 cm recorded in control lines (Table 2).

TABLE 2　Effect of Gamma-rays in M_2 generation - Plant characteristics

Characteristics	Treatment Dose	MCU 4 Between lines Range		MCU 4 Between lines Mean	MCU 4 Maximum C. V. %	MCU 5 Between lines Range		MCU 5 Between lines Mean	MCU 5 Maximum C. V. %
1. Plant height (cm)	O	31.1	34.9	32.4	41.9	36.4	42.3	39.9	38.7
	5 kr	28.0	44.0	36.5*	52.1	33.9	53.4	42.8*	41.8
	10 Kr	30.7	38.5	34.9	37.7	40.2	45.5	42.1	39.2
	15 kr	30.4	40.7	36.6*	33.6	35.4	42.5	39.1	40.0
	20 kr	—	—	—	—	34.2	44.0	39.4	37.8
Between Treatments		15, 5, 10 0				5, 10, 0, 20, 15			
2. Number of bolls/plant	O	5.5	8.8	7.1	53.5	8.6	11.7	9.8	50.0
	5 kr	6.1	8.3	6.7	66.6	8.3	14.5	12.8*	68.7
	10 kr	4.5	9.8	7.0*	57.7	9.0	11.4	10.1	65.4
	15 kr	5.1	10.2	6.9	74.5	6.1	10.4	8.7	67.9
	20 kr	—	—	—	—	6.7	13.4	10.4*	73.6
Between Treatments		0, 10, 15. 5				5, 20, 10 0, 15			
3. Yield of seed cotton per plant (g)	O	19.0	31.5	25.0*	60.2	24.3	42.2	33.9*	61.4
	5 kr	16.8	25.7	21.3	78.9	24.6	62.2	40.9	75.7
	10 kr	14.0	28.5	22.1*	69.0	25.3	42.2	32.9	83.5
	15 kr	15.6	29.2	20.3*	97.6	20.3	32.8	26.2	82.5
	20 kr	—	—	—	—	17.3	47.0	33.7*	71.2
		0, 10, 5 15				5, 0, 20, 10, 15			

* Differences between lines significant

(b) **Number of bolls per plant:** In the M_2, the mean number of bolls per plant was significantly reduced even in 5 kr treatment in MCU 4. But in MCU 5 a significant reduction occurred only in 20 kr treatment (Table 1).

In the M_2, a positive shift in the mean was observed in 5 kr of MCU 5. In one progeny, the mean was 14.5 bolls/plant against 11.7 in the control. There was also significant difference between lines in 20 kr of MCU 5 and 10 kr of MCU 4. In these treatments, the co-efficient of variation was also higher than in control (Table 2).

(c) **Yield of Seed Cotton:** In the M_1, higest mean yield per plant was recorded in the controls of MCU 4 and MCU 5 with 52.4 g and 50.8 g respectively. The lowest yield was recorded in 20 kr treatments with 12.8 g in MCU 4 and 18.5g in MCU 5 (Table 1).

In the M_2, a positive shift in the mean value was recorded in 5 kr of MCU 5. A maximum of 62.2 g per plant was recorded in one line as against a maximum of 42.2 g in control lines. In 15 kr treatment, a negative shift in mean was observed both in MCU4 and MCU 5. The progenies in control lines also differed from each other, but the co-efficient of variation was higher in treated progenies than in the control (Table 2).

(d) **Seed and fibre character :** In the M_1, the mean halo-length and ginning percentage were unaffected. But in lint index a significant increase was observed in MCU 5 under 10 kr and 15 kr treatments. A similar trend was observed in seed index also (Table 1).

In the M_2, a significant shift in mean halo-length was observed in 15kr treatment in MCU 4 and in 10 kr and 20 kr treatments in MCU 5. In MCU 4, the mean halo-length was as high as 30.0 mm as against 28.7 mm recorded in the control. In MCU 5, a maximum of 30.6 mm was recorded as against a maximum of 29.1 mm in the controls. But only a slight increase in co-efficient of variation was observed (Table 3).

In ginning percentage, a positive shift in mean was recorded in 10 kr and 15 kr treatments MCU 4. The progenies in 5 kr treatment also differed significantly in their mean values. There was also increase in co-efficient of variation in treated progenies compared to control in MCU 5 (Table 3).

In MCU 4, a positive shift in mean values of lint index in some of the treatments and lines was observed though the co-efficient of variation was not increased. In 15 kr treatment, one progeny recorded 7.2 g as against a maximum of 6.4 g in the control. In MCU 5 also, one of the progeny in 20 kr treatment recorded a mean of 6.2 g as against a maximum of 5.7 g in the control (Table 3).

In seed index, the co-efficient of variation was higher in treated progenies of both MCU 4 and 5. A shift in the negative direction was observed in 5 kr, 15 kr and 20 kr treatments in MCU 5 (Table 3).

DISCUSSIONS AND CONCLUSIONS

In this experiment, an attempt has been made to study the effect of gamma-rays on two varieties of cotton and the relative responsiveness of the two varieties and consequent variability in different economic attributes with selection potential.

The criterion to be chosen for establishing positive effect of mutagen on the quantitative traits like plant height, number of bolls per plant, yield, ginning outturn, halo length, seed and lint indices is beset with difficulties in view of large environmental influence on these characters. Gregory (1956) has stated that normal appearing members of irradiated populations may be variously mutated with a large number of small individually inconsequential changes which, on the whole, form a

TABLE 3 Effect of Gamma-rays in M_2 generation-Lint and seed characteristics

Characteristics	Treatment dose	MCU 4 Between lines Range		MCU 4 Between lines Mean	MCU 4 Maximum C. V.	MCU 5 Between lines Range		MCU 5 Between lines Mean	MCU 5 Maximum C. V.
Mean halo-length (mm)	0	27.7	28.7	28.3	8.1	26.9	29.1	28.8	6.0
	5 kr	24.7	27.6	26 4*	9.2	26.9	30.4	28 5*	8.2
	10 kr	25.3	29.2	27.7*	8.4	28.0	30.7	29.1*	5.8
	15 kr	28.0	30.0	29.0*	9.6	23.5	29.8	27.7*	8.8
	20 kr	—	—	—	—	28.1	30.6	29.3*	8.6
Between treatments		15, 0, 10, 5,				20, 10, 5, 0, 15			
2. Ginning per cent	0	34.0	35.6	34.4	7.5	33.0	34.4	33.8	9.7
	5 kr	33.9	35.8	34.6*	7.3	32.6	35.5	34.5*	11.6
	10 kr	34.2	35.8	35.0	8.0	33.4	34.9	34.2*	7.3
	15 kr	34·7	35.5	35.2	9.4	33.2	34.6	34.1*	6.2
	20 kr	—	—	—	—	34.0	34.5	34.3	7.3
Between treatments		1, 5, 10, 5, 0				5, 20, 10, 15, 0			
3. Lint index (g)	0	5.8	6.4	6.1	23.5	6.3	5.7	5.5	14.5
	5 kr	5.7	6.6	6.0*	17.4	5.2	5.9	5.6	26.1
	10 kr	5.6	6.4	6.1*	15.9	5.2	5.8	5.6	15.4
	15 kr	6.2	7.2	6.5*	23.6	5.2	5.7	5.5	50.3
	20 kr	—	—	—	—	5.5	6.2	5.8*	10.1
Between treatments		15, 10, 0 5				20, 10, 5, 15, 0			
4. Seed index (g)	0	10.6	11.4	10.8	14.1	10.5	11.8	11.0	11.0
	5 kr	10.5	11.4	10·9	19.7	9.8	10.7	10.3*	14.5
	10 kr	9.9	11.4	10.8	15.5	10.4	11.3	10.8*	15.1
	15 kr	10.8	11.9	11.2	22.3	10.1	10.7	10.5	15.3
	20 kr	—	—	—	—	10.0	11.4	10.6*	13.6
Between treatments		15, 5, 10, 0				0, 10, 20, 15, 5			

*Differences between lines significant

sound basis for artificial and natural selection. But the detection of such small changes is possible only on the basis of greater variability that is created in the M_2 populations of the irradiated material. A measure of such a variability is the co-efficient of variation. Any shift in the mean as a result of the increased variability to the positive or negative direction indicates the direction of the mutational event. According to Gregory (1966), artificially induced mutation increases in frequency with decreasing magnitude of change. Oka *et al.* (1958) working on rice, have shown that irradiation induces changes in the mean and variability of polygenic traits.

On examination of the results in the present investigation, it is seen that values in respect of plant height, yield, mean number of bolls per plant and seed and lint indices for treatments in M_1 were significantly different. In respect of plant height, number of bolls per plant and yield, there was a reduction, especially in a higher dose of 20 kr and above. This reduction is mainly due to radiation injury resulting in retarded growth and sterility resulting in lesser number of bolls per plant and leading to reduction in yield. In respect of seed and lint indices, due to partial fertility, the number of seeds per boll is lesser, thereby the weight per seed might have increased and perhaps produced more number of lint hairs on enlarged seeds resulting in increased seed and lint indices. Excepting these changes, mostly due to physiological causes, the genetic changes that might have occurred in the M_1 could be variable from plant to plant and this change can be detected in the M_2 by the increased variability for the different quantitative traits. It is seen that higher coefficient of variations do occur in plant height, number of bolls per plant, plant yield, mean halo-length and seed index in M_2 lines with shifts in mean values. The shifts in the mean is positive in some lines and negative in some lines.

Increased variability for plant height was evident, conspicuously in one line of MCU 4 subjected to 5 kr of gamma rays with positive shift in the mean. The mean was as high as 44.0 cm with a coefficient of variation of 52.1 per cent as against a maximum mean value of 34.9 cm in the control.

In respect of numbers of bolls per plant, marked increase in coefficient of variation is noted in 15 kr dose in MCU 4 and 20 kr dose of MCU5. A positive shift in the mean value is seen in MCU 4 with a mean of 10.2 bolls per plant as against 8.8 in the control. In 5 kr of MCU 5, a positive shift in the mean with 14.5 bolls per plants as against 11.7 for the control is seen. This line also recorded the highest mean yield per plant (62.2 g) and far higher than in control (42.2 g): but the character itself is highly variable. In MCU 4, the shift was in the negative direction in irradiated lines.

In respect of mean halo-length' there was an increase in coefficient of variation with a positive shift in one line of MCU4 in each of 10 kr and 15 kr and in the case of MCU 5, in one line each of 5, 10, 15 and 20 kr treatments. In ginning percentage, there was no positive shift. There was increased coefficient of variation in seed index with a shift in the negative and positive sides. In lint index a positive shift in 15 kr treatment of MCU 4 and 20 kr of MCU 5 was observed but with lesser coefficient of variation than in the control. These lines with positive shifts in mean and lesser coefficient of variation have to be studied in M_3 to understand the exact nature of the mutational change in these lines. Gaul (1965) showed that irradiation in barley increased the genetic variability in many polygenic traits in M_2 but with greater effect in M_4 and M_5. He also emphasised the influence of micro-mutations in crop improvement. Many other studies have been carried out which underline the importance of small mutations to plant breeding (Aastveit and Gaul, 1967; Brook, 1965; Gregory, 1966 and Scossiroli, 1965).

Decrease in the mean values in the irradiated population of M_2 and M_3 has been shown by many authors (Gaul, 1964 and 1965: Swaminathan, 1963). Borojevic (1965) has also shown that the decrease in means in irradiated material is followed by an increase in variability in M_2 and subsequent generations. This variability has been shown to be due to increase in its genetic components. Borojevic (1966) also concluded that micro-mutations, due to their frequencies offer better opportunities to breeders to conduct selection and thus to direct the evolution of their plants.

Swaminathan (1961) has showed that in polyploids, the variations induced with regard to quantitative traits resulting from micro-mutations can be considered to be released for expression immediately due to the differential nature of action. The afore brought out evidences in the present case are clear indications of such changes and the event of their nature which have occurred are frequent enough to be detected for positive exploitation.

A study of the M_3 progeny of the selected plants from the progenies which show positive deviation from the normal with regard to the economic traits will also contribute to the development of superior germplasm in the tetraploid cotton.

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REFERENCES

AASTVEIT, K, and H. GAUL. 1967. Variation and selection of micro-mutations, *Radiation Botany*. 7 : 353-61.

BOROJEVICK, K. 1965. The effect of irradiation and selection after irradiation on the number of kernels per spike in wheat, *Radiation Botany*. 5 (Suppl.) : 505-13.

BOROJEVICK, 1966. Studies on irradiation induced mutations in quantitative characters of wheat *(Triticm vulgare)* in *Mutation in Plant Breeding*. Panel Proc. Series, I.A.E.A., Vienna : 15-38.

BROOK, R. D., 1965. Induced mutations affecting quantitative characters, in *Mutation in Plant Breeding*. Panel Proc. Series, I.A.E.A., Vienna : 451-64.

GAUL, H., 1964. Mutation in plant breeding, Radiation Botany, 4 : 155-232

GAUL, H. 1965. The concept of macro-and micro-mutations and results in induced micro-mutations in barley. *Radiation Botany*, 5 (Suppl) : 407-28.

GREGORY, W. C., 1956. Induction of useful mutations in the peanut, *Brookhaven Sym. Boil.*, 9 : 177-90.

GREGORY, W. C. 1955. Mutaiion frequency, magnitude of change, and the probability of improvement by adaptation. *Radiation Botany*, 5 (Suppl.) : 429-41.

GREGORY, W. C. 1966. *Mutation breeding in Plant Breeding*, Ed. K. J. FREY, Iowa State University Press., Amer., Iowa, pp. 189-218.

MAC KEY, J., 1956. Mutation breeding in Europe, *Brookhaven Symp. Biol.*, 9 : 141-52.

OKA, H. I., HAYASHI, J. and SHIOJIRI, I., 1958. Induced Mutations of Polygenes for quantitative characters in rice. *J. Heredity*, 49 : 11-14.

SCOSSIROLI, R. E., 1965. Value of induced mutations for quantitative characters in Plant Breeding, *Radiation Botany* 5 (Suppi.) : 443-50.

SWAMINATHAN, M. S., 1961. Effects of diplontic selection of the frequency and spectrum of mutations induced in poly-ploids following seed irradiation, in *Effects of Ionizing Radiation on seeds*, I. A. E. A., Vienna' 279-88.

SWAMINATHAN, M. S. 1963. Evaluation of the use of induced macro-and micro-mutations in the breeding of poly-ploid crop plants, in *L'energia nuclear in agriculture*, Vallecchi. Firenza, 241-77.