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RICE BREEDING WITH INDUCED MUTATIONS

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Abstract. Mutation research was initiated in rice with the following aims: (1) to induce dwarfness in Dokri Basmati and Jajai-77, (2) to compare the effects of gamma rays and fast neutrons on the induction of chlorophyll mutations in IR8 and Mehran 69 (from IR6-156-2) (3) to improve the grain quality of IR8, and (4) to shorten the maturity period of Mehran 69. The preliminary findings are described in this report.

Both gamma-rays and fast neutrons gave rise to short-culm mutants in Dokri Basmati; early ripening and grain-size mutants in Jajai-77.

In M_3 each of the mutants from both the varieties was found to maintain its mutated characteristics with concurrent changes in some other agronomic traits. These changes occurred in both positive and negative directions. Preliminary yield tests of the M_4 lines showed that one of the short-culm mutants (S-10) of Dokri Basmati and two of the grain-size mutants (large grain-2 and large grain-3) of Jajai-77 retained the parent level of grain yield while in the rest of the mutant lines of both Dokri Basmati and Jajai-77, the grain yield was reduced significantly as compared to their respective parents.

The frequency of M_2 chlorophyll mutations was increased by gamma-rays and fast neutron treatments in both IR8 and Mehran 69. However, the rate of increase was not proportional to doses. The mutagenic efficiency of the two radiations was more or less the same. Mutagenic effectiveness, on the other hand, was generally highest at lower doses and that neutron is 10—30 times more effective than gamma-rays.

Dokri Basmati (a fine-grain variety) and Jajai-77 (a medium-fine variety) are two local rices that possess scented grains. However, both the varieties give a poor yield which is mainly due to their tall stature, nonresponsiveness to fertilizers and tendency to lodge heavily under highly fertilized soils.

The two introduced varieties, IR8 and Mehran 69 (from IR6-156-2) are short and sturdy and are highly resistant to lodging. IR8 has coarse grains and is not preferred by the consumer. Mehran 69 on the other hand, has finer grains than IR8, but it matures later than IR8. Keeping in mind all the merits and demerits of the local as well as the exotic varieties, mutation breeding was initiated with the following objectives:

(1) Induction of mutations for dwarfness in Dokri Basmati and Jajai-77, toward higher resistance to lodging, (2) comparison of the effects of gamma-rays and fast neutrons on the induction of chlorophyll mutations in IR8 and Mehran 69, (3) mutational rectification of grain size in IR8, and (4) induction of mutations for earliness in Mehran 69.

Although the investigation is still in progress, some useful data have been observed and the preliminary findings are reported in this paper.

Materials and Methods

Experiment with Dokri Basmati and Jajai-77

The experiment was initiated in 1967; results obtained in M_1 and M_2 generations have been reported in an earlier publication.[2]

Four short-culm mutants of Dokri Basmati, three early flowering and three grain-size mutants of Jajai-77, isolated in M_2, were grown as plant progenies in the paddy field in rows to see whether the changes observed in M_2 were heritable or not in M_3 generation. In M_4 a preliminary test was conducted at the Government Rice Research Station, Dokri, to evaluate the yield potentials of these mutants. The experimental field design was a randomized block with three replications. The size of each plot was 4.57×1.14 meters. Row to row and plant to plant distance was kept at 22.9 cm in each case. The first application of fertilizer was given a day before transplanting at the rate of 28.0 kg N_2+22.4 kg P_2O_5 per hectare. The second application was given 40 days after transplanting at the rate of 5.6 kg N_2 per hectare. The total amount of fertilizer applied in this experiment is generally recommended for the local tall varieties of rice.

At harvest data was recorded on grain yield.

Dunnet d-test was applied to the mean differences in the yield between the mutants and the parent to test their significace.

Experiment with IR8 and Mehran 69

Dry, dormant seeds of rice varieties IR8 and Mehran 69 were irradiated with different doses of gmma-rays and fast neutrons through the help of the International Atomic Energy Agency, Vienna. The radiation doses used in this experiment are given in Tables 3 and 4.

The M_I plants grown from the irradiated seeds of both IR8 and Mehran 69 were harvested individually and sterility of the longest spike from each plant was studied. Three ears were selected at random from each M_I plant for chlorophyll mutation studies. The M_2 population was raised as ear to row progeny basis and was carefully screened for chlorophyll mutants. Mutation frequency was calculated both as the percentage of M_I plant progeny and M_I spike progeny segregating for mutations. The relative mutagenic efficiency and effectiveness of the different treatments were measured by the method suggested by Konzak *et al.*[1]

Results and Discussion

Experiment with Dokri Basmati and Jajai-77

(a) *Short-culm Mutants of Dokri Basmati.* M_3 studies on the four short-culm mutants confirmed that all of them had shorter plant height than the parent (Table 1). The reduced plant height was accompanied by a general reduction in panicle length, panicle (or spikelet) fertility and 100-grain weight. The tillering character, on the other hand, changed in positive as well as in negative directions. The high tillering ability is specially striking in S-10. The grain quality of all short-culm mutants deteriorated except that of S-10 which had similar to that of parent variety. The preliminary yield test of the M_4 lines of the short-culm mutants shows that S-10 closely approached the parent in kernel production while in the remaining three lines the kernel production was reduced significantly (P: 0.01 according to Dunnet d-test) as compared to the parent.

(b) *Early Flowering and Grain-size mutants in Jajai-77.* The M_3 and M_4 data of early flowering and grain-size mutants of Jajai-77 are presented in Table 2. All the early flowering mutants flowered earlier than the parent variety. The earliest mutant showed ear emergence 26 days earlier than the parent. The tiller number was drastically reduced in all the three early flowering mutants. The other two characters, panicle length and spikelet fertility changed towards plus and minus directions.

The three grain-size mutants were found to have possessed with increased length and breadth of grains as well as 100-grain weight. The grain length/breadth ratio increased in long grain-15 and decreased in large grain-2 and large-grain-3 indicating that the long grain-15 mutant is finer and the large grain-2 and large grain-3 mutants are coarser than the parent. The three mutants also exhibited an increase in tiller number (except long grain-15) and panicle length and a decrease in spikelet fertility as compared to the parent.

The yield data of the M_4 lines of both early flowering and grain-size mutants reveal that there was significant reduction of yield in the mutant lines except

TABLE 1. STUDIES ON FOUR SHORT-CULM MUTANTS OF RICE VARIETY DOKRI BASMATI.

Mutant lines	M_3 generation					M_4 generation
	Plant height (cm)	Tiller No.	Panicle length (cm)	Spikelet fertility (%)	100-grain wt (g)	Average yield/plot (kg)
Dokri Basmati (Parent)	119.6	19.9	29.4	83.2	2.26	1.90
S-7	84.5	14.7	24.8	84.9	2.16	1.08*
S-8	93.1	19.4	26.3	61.1	1.88	1.05*
S-9	87.5	22.9	25.9	25.7	1.81	0.29*
S-10	77.8	35.1	22.4	66.1	2.24	1.76

*Significant at 0.01 level by comparison with average yield of the parental variety (according to Dunnet d-test)

TABLE 2. STUDIES ON THREE EARLY FLOWERING AND THREE GRAIN-SIZE MUTANTS OF RICE VARIETY JAJAI-77.

Mutant lines	M_3 generation									M_4 generation
	Tiller No.	Days to heading	Days earlier than parent	Panicle length(cm)	Spikelet fertility (%)	100-grain wt (g)	Grain length (mm)	Grain breadth (mm)	Grain length/ breadth ratio	Average yield/ plot (kg)
Jajai-77 (Parent)	33.5	120.4	—	33.1	60.2	2.20	9.50	2.20	4.32	2.47
Early flower-1	19.2	98.3	22.1	34.0	37.0	—	—	—	—	1.14*
Early flower-2	21.9	94.4	26.0	30.3	62.4	—	—	—	—	1.30*
Early flower-3	22.2	101.7	18.7	34.3	53.4	—	—	—	—	0.82*
Large grain-2	40.5	—	—	34.7	53.8	2.27	9.92	2.31	4.29	2.42
Large grain-3	36.1	—	—	36.5	34.7	2.36	9.98	2.37	4.21	2.20
Long grain-15	26.3	—	—	38.1	39.9	2.60	11.10	2.30	4.83	0.86*

* Significant at 0.01 level by comparison with average yield of the parental variety (according to Dunnet d-test)

TABLE 3. FREQUENCY OF CHLOROPHYLL MUTATIONS IN THE M_2 OF RICE VARIETIES IR8 AND MEHRAN 69.

Variety	Treatment/dose	No. of plants studied	M_I plant progeny: No. of plants segregating	M_I plant progeny: Plant progeny segrating (%)	No. of paincle analysed	M_I panicle progeny: No. of panicle segregating	M_I panicle progeny: Panicle progeny segregating (%)
IR8	Control	58	1	1.7	174	1	0.6
	Gamma-rays						
	15 kRad	116	19	16.4	342	29	8.5
	25 kRad	167	23	13.8	486	37	7.6
	35 kRad	101	19	18.9	295	40	13.5
	45 kRad	29	5	17.2	86	13	15.1
	Fast neutron						
	864 rad	206	45	21.8	616	59	9.6
	1283 rad	162	38	23.4	482	58	12.0
	1743 rad	178	25	14.5	533	33	6.2
	2218 rad	118	16	13.6	351	29	8.3
Mehran 69	Control	103	8	7.8	309	10	3.2
	Gamma-rays						
	15 kRad	170	21	12.3	502	23	4.6
	25 kRad	131	26	19.8	392	33	8.4
	35 kRad	118	17	14.4	346	33	9.5
	45 kRad	86	16	18.6	249	37	14.9
	Fast neutron						
	864 rad	106	18	17.0	316	25	7.9
	1283 rad	121	13	10.7	361	16	4.4
	1743 rad	194	30	15.5	580	39	6.7
	2218 rad	144	29	20.1	430	40	9.0

TABLE 4. MUTAGENIC EFFECTIVENESS AND EFFICIENCY IN RICE VARIETIES IR8 AND MEHRAN 69.

Variety	Treatment/ dose	Percentage of sterility(S)	Percentage of mutated panicle (MP)	Mutagenic effectiveness (MP/kRad)	Mutagenic efficiency MP/S	Variety	Treatment/ does	Percentage of sterility(S)	Percentage of mutated panicle (MP)	Mutagenic effectiveness (MP/kRad)	Mutagenic efficiency MP/S
IR8						Mehran 69					
	Gamma rays						*Gamma rays*				
	15 kRad	40.2	8.5	0.57	0.21		15 kRad	36.5	4.6	0.31	0.15
	25 kRad	56.0	7.6	0.30	0.13		25 kRad	61.9	8.4	0.34	0.14
	35 kRad	76.1	13.5	0.38	0.18		35 kRad	69.4	9.5	0.27	0.14
	45 kRad	77.8	15.1	0.33	0.19		45 kRad	65.3	14.9	0.33	0.23
	Fast neutron						*Fast neutron*				
	846 rad	36.1	9.6	11.11	0.26		864 rad	25.2	7.9	9.14	0.31
	1283 rad	52.9	12.0	9.35	0.23		1283 rad	31.1	4.4	3.43	0.14
	1743 rad	53.7	6.2	3.36	0.11		1743 rad	58.0	6.7	3.84	0.11
	2218 rad	65.1	8.3	3.74	0.13		2218 rad	64.5	9.0	4.06	0.13

large grain-2 and large grain-3 (P: 0.01 according to Dunnet d-test). The unreduced grain yield in these two mutants could be attributed to their increased grain-size and higher tillering ability.

Experiment with IR8 and Mehran 69

In both IR8 and Mehran 69 spike sterility as expressed in per cent, decreased with the increase in doses of gamma and neutron irradiations (Table 4). The frequency of chlorophyll mutations observed in M_2 generation is summarised in Table 3. In both varieties the mutation frequency increased in the irradiated populations over the respective controls. However, the rate of increase was not proportional to the doses. The data also show that the mutation frequency is always higher when calculated on plant rather than paincle progeny basis. This is due to the fact that not all tillers give rise to mutations. The results agree with the findings of Osone, Siddiq and Swaminathan. [3,4]

The mutagenic efficiency of both gamma-rays and fast neutrons was more or less the same. Mutagenic effectiveness, on the other hand, was generally highest at lower doses and that neutron was 10–30 times more effective than gamma-rays (Table 4). Similar results have been reported by Swaminathan *et al.*[5] in rice.

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References

1. C.F. Konzak, R.A. Nilan, J. Wagner and R. J. Foster, *The Use of Induced Mutation in Plant Breeding* (Pergamon, London, 1964), p. 49.
2. A. J. Miah, I.M. Bhatti and Afsar Awan, Pakistan J. Bot., **1**, 77(1969).
3. K. Osone, Jap. J. Breeding, **13**(1), 1(1963).
4. E.A. Siddiq, and M.S. Swaminathan, *Rice Breeding with Induced Mutations* (IAEA Technical Reports Series 1968), No. 86, p. 25-51.
5. M.S. Swaminathan, E.A. Siddiq, C.B. Singh, and R.A. Pai, *Rice Breeding with Induced Mutations II* (IAEA Technical Reports Series, 1970), No. 102, p. 25-43.