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AN ASSESSMENT OF GAMMA RAY INDUCED MUTATIONS IN RICE (*ORYZA SATIVA* L.)

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ABSTRACT

Gamma ray seed treatment (10, 20 and 30 kR doses) of two cultivars, namely, MPRI-7 and Lanjhi was found to affect pollen and spikelet fertility in M_1 generation at higher dose. Chlorophyll and morphological mutations having wider spectrum were also obsrved in M_2 generation.

Key words : Rice, gamma rays, mutagenic effectiveness and efficiency, chlorophyll, morpholgical mutations.

For any mutation breeding programme, selection of effective and efficient mutagen(s) is very essential to produce high frequency of desirable mutations. The primary objectives of mutation breeding are to enlarge the frequency and spectrum of mutations and to increase the incidence of viable mutations as an approach towards directed mutagenesis. The present paper deals with the observations on effectiveness, efficiency, frequency and spectrum of chlorophyll and morphological mutations in rice (*Oryza sativa* L.) induced by gamma rays.

MATERIALS AND METHODS

The dry (moisture, 12%) seeds of two indigenous varieties of rice, namely, MPRI-7 and Lanjhi were used for mutagenic treatments. Lanjhi is a local variety grown around Jhansi in Uttar Pradesh. Its characteristic features are tall height, medium duration, nonpigmented foliage, medium long panicle, awnless spikelets, kernel-long and scented, very good cooking quality and medium yield. MPRI-7 is

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developed by MP Rice Research Institute, Raipur from a local collection of Dokra Dokri. The characteristic features are intermediate height, medium duration, grain superlong, bold and medium yield. A sample of 200 seeds of each variety was exposed to gamma rays (^{60}Co source) at Gamma Cell, I.A.R.I., New Delhi at 10, 20 and 30 kR doses. The unexposed and dry seeds were taken as control. The M_1 generation was grown during *kharif*, 1993 while the M_2 generation was taken during *kharif*, 1994 at Research Farm, Institute of Agricultural Scences, Banaras Hindu University, Varanasi. In the M_1 generation, the data on pollen and spikelet fertility were recorded in 100 plants each in both the varieties. For pollen fertility, anthers from the spikelets of the panicle which emerged first in each plant were collected in the morning and squashed in 2% iodine potassium iodide. The observations were made under low power microscope. Completely filled pollen grains as indicated by their stainability, were scored as fertile while others were treated as sterile. The percentage of spikelet fertility was determined by estimating the proportion of completely filled spikelets out of total number of spikelets of the main panicle. Various types of chlorophyll mutations with their frequencies in M_2 generation were scored at the seedling stage following the classification of Gustafsson [1]. Other morphological mutations were scored at or after flowering. The spectrum of chlorophyll and morphological mutations was scored treatment wise to study mutagenic effectiveness and efficiency of each treatment.

RESULTS AND DISCUSSION

Both the varieties showed varied influences of gamma ray radiation. However, the response was greater in the case of MPRI-7 indicating that the genotypes may differ towards their response to this mutagen. Cheng *et al.* [2] observed varietal differences for fertility in rice to mutagen treatments.

Two and three mutants in the cultivars MPRI-7 and Lanjhi, respectively were observed to have pollen fertility below 10%. Such mutants may be useful for exploitation in hybrid rice programme. These mutants are being maintained for their use in our future rice improvement programme. The pollen fertility got considerably reduced at higher dose in both the varieties Lanjhi and MPRI-7. The spikelet fertility alo showed relatively more reduction towards higher dose (Table 1). Both the varieties showed reduction in pollen and spikelet fertility in M_1 generation due to the mutagen. Also, the reduction in fertility increased with the increase in doses of mutagen which was in consonance of the earlier report [3]. Bekendum [4] found that the average fertility of M_1 spikes decreased with increased doses upto a certain level beyond which there was a saturation effect. Average score of pollen and spikelet fertility in the two varieties at different dose of mutagen has been given in Table 1.

Table 1. Comparison of pollen fertility and spikelet fertility over control in response to different doses of gamma rays in rice varieties

Variety and radiation dose	Total plants studied	Pollen fertility (%)	Spikelet fertility (%)
MPRI-7			
Control	100	84.0	85.0
10 kR	100	69.5	70.0
20 kR	100	66.0	66.5
30 kR	100	62.8	63.0
Lanjhi			
Control	100	90.0	90.0
10 kR	100	74.1	74.5
20 kR	100	72.3	72.5
30 kR	100	68.5	69.0

The chlorophyll mutants such as *albina*-white leaves without chlorophyll (lethal), *xantha* - complete yellow colour of leaves (lethal) and *striata* - longitudinal stripes of white/yellow colour on leaves (viable) were recorded in the M_2 generation at seedling stage. The *albina* and *xantha* mutants did not survive whereas *striata* was viable mutant. In case of MPRI-7, the higher doses of mutagen were quite effective in chlorophyll mutations. The chlorophyll mutations were induced maximally (1.56%) at 30 kR dose in MPRI-7 while in case of Lanjhi, the chlorophyll mutations were highest (2.04%) at 20 kR dose of gamma radiation (Table 2). Both the varieties showed varied influences of gamma rays for chlorophyll mutants. The variety MPRI-7 showed relatively better response for the induction of chlorophyll mutations at higher dose. A reverse trend was evident in case of variety Lanjhi where optimum dose of gamma rays (20 kR) was effective in inducing more chlorophyll mutations.

Induction of *albina* mutants was highest at 20 kR dose of gamma rays in variety Lanjhi; maximum *xantha* mutants were found in variety MPRI-7 at 30 kR dose and the maximum occurrence of *striata* mutants was at 20 kR dose in variety Lanjhi (Table 2). The chlorophyll mutations were observed at all the doses of mutagen in both the varieties. However, the spectrum of chlorophyll mutations was quite narrow as only three mutant types (*xantha, striata and albina*) could occur in different treatments of the variety Lanjhi, while only two types of chlorophyll mutants (*xantha* and *albina*) occurred in MPRI-7. The variety MPRI-7 showed relatively better response for the induction of chlorophyll mutations at higher dose.

Table 2. Frequency and spectrum of chlorophyll mutations per 100 M_2 seedlings of gamma ray treated rice varieties MPRI-7 and Lanjhi

Variety and radiation dose	Total no. of seedlings	Chlorophyll mutants	Mutation frequency (%)	Mutation specutrum (Number of events)		
				albina	xantha	striata
MPRI-7						
Control	3500	-	-	-	-	-
10 kR	3468	21	0.60	10	11	-
20 kR	3110	17	0.54	07	10	-
30 kR	3007	47	1.56	22	25	-
Lanjhi						
Control	3600	-	-	-	-	-
10 kR	3525	65	1.84	25	27	13
20 kR	3421	70	2.04	39	9	22
30 kR	3219	44	1.36	13	25	6

The frequency of chlorophyll mutants was found independent of mutagenic doses of gamma rays [4, 5]. Among the mutants scored, the *xantha* was the most frequent during the present investigation which was supported by the earlier report [6]. On the contrary, Kawai and Sato [7] found *albina* to be the most frequent type in rice.

Morphological mutants : The following types of morphological mutants were recorded in the M_2 generation (Tables 3 and 4) :

Dwarf : Short statured plant (62-75 cm in MPRI-7; 90-92 cm in Lanjhi)

Semi dwarf : Medium statured plant (100-105 cm in MPRI-7; 116-119 cm in Lanjhi)

Tall : Long statured plant (130-136 cm in MPRI-7; 161-168 cm in Lanjhi)

Early maturing : Mature early (118-120 days in MPRI-7; 113-118 days in Lanjhi)

High yielding : More yield than control (25.1-25.5 g in MPRI-7; 26.8-27.2 g in Lanjhi)

Sterile : No fertile grain.

The mean plant height, days to maturity and grain yield per plant were 118.5 cm, 140 days and 20.15 g in MPRI-7 and 144.4 cm, 132 days and 22.7 g in Lanjhi, respectively. High yield of mutants was not due to the presence of only one trait

Table 3. Characteristic features of morphological mutants in M_2 generation of MPRI-7

Genotype	Mutagenic dose	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches panicle^{-1}	Secondary branches panicle^{-1}	100 grain weight (g)	Panicle length (cm)	Effective tillers plant^{-1}	Grain yield plant^{-1} (g)
Control	0	112	140	118.5	15	28	2.50	26.5	7	20.15
MM-1[a]	10 kR	113	143	62.0	15	25	2.50	23.5	7	19.20
MM-2[a]	10 kR	114	141	75.0	16	24	2.50	25.5	7	20.61
MM-3[b]	10 kR	110	140	100.0	15	26	2.50	25.0	6	19.52
MM-4[b]	10 kR	112	142	105.0	14	26	2.51	26.0	8	19.81
MM-5[b]	10 kR	115	144	102.0	16	27	2.51	26.5	7	20.15
MM-6[c]	10 kR	113	141	136.0	16	27	2.52	28.5	6	21.01
MM-7[d]	10 kR	92	118	122.0	16	29	2.51	27.0	3	08.22
MM-8[e]	10 kR	108	146	121.4	18	35	2.52	27.5	9	25.50
MM-9[e]	10 kR	102	142	120.5	17	34	2.52	27.2	9	25.20
MM-10[f]	10 kR	126	-	122.0	14	25	-	26.0	-	-
MM-11[a]	20 kR	114	144	64.0	14	23	2.50	24.5	7	19.51
MM-12[a]	20 kR	113	143	65.0	15	24	2.50	23.5	7	18.52
MM-13[a]	20 kR	115	145	66.0	14	24	2.50	23.6	6	19.22
MM-14[b]	20 kR	114	146	102.0	16	26	2.51	25.5	8	20.18
MM-15[b]	20 kR	116	142	103.0	15	25	2.51	26.0	8	20.51
MM-16[b]	20 kR	112	144	102.0	17	26	2.51	25.0	8	20.83

(*Contd. on next page*)

Genotype	Mutagenic dose	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches panicle^{-1}	Secondary branches panicle^{-1}	100 grain weight (g)	Panicle length (cm)	Effective tillers plant^{-1}	Grain yield plant^{-1} (g)
MM-17[b]	20 kR	113	143	105.0	16	26	2.51	25.5	9	21.06
MM-18[d]	20 kR	93	120	120.0	16	29	2.51	26.5	3	08.12
MM-19[d]	20 kR	92	118	121.0	15	28	2.51	26.0	4	16.01
MM-20[e]	20 kR	106	144	123.0	20	34	2.52	27.4	9	25.25
MM-21[a]	30 kR	113	142	66.0	14	26	2.50	25.5	8	19.55
MM-22[b]	30 kR	114	143	101.0	16	26	2.50	26.0	7	18.63
MM-23[b]	30 kR	115	142	102.0	15	26	2.51	25.5	7	19.82
MM-24[b]	30 kR	116	144	101.0	15	26	2.50	25.6	8	20.53
MM-25[b]	30 kR	114	143	105.0	15	27	2.51	26.0	8	21.01
MM-26[c]	30 kR	115	146	136.0	14	28	2.52	26.5	6	18.52
MM-27[c]	30 kR	116	145	130.0	16	28	2.52	28.0	6	19.51
MM-28[f]	30 kR	124	-	123.0	16	25	-	25.0	-	-
MM_29[f]	30 kR	128	-	121.0	15	26	-	25.5	-	-

MM - Mutant of MPRI-7. [a]Dwarf, [b]Semi-dwarf, [c]Tall, [d]Early maturing, [e]High yielding, [f]Sterile

but due to cummulative effect fo all yield attributing traits. There was a proportional decrease in leaf length of dwarf mutants and they possessed smaller panicle coupled with reduction in the length of last internode. The reduction in plant height appeared to be due to reduced internode length, particularly that of last internode in dwarf and semidwarf mutants of both the varieties. Early maturing mutants, phenotypically alike parents, were observed in both the varieties and occurred independent of the doses of the mutagen.

The frequency of morphological mutants in case of MPRI-7 was maximum at 20 kR, i.e., 1.67% and lowest at 30 kR dose, whereas in case of Lanjhi, the maximum morphological mutation frequency was recorded as 1.3% at 20 kR dose and the lowest as 0.83% at 10 kR dose of gamma rays (Table 5). On the basis of comparison of two varieties for different doses of gamma rays it was found that 20 kR dose was the most effective dose in inducing morphological mutations.

Table 4. Characteristic features of morphologicl mutants in M_2 generation of Lanjhi

Genotype	Mutagenic dose	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches panicle^{-1}	Secondary branches panicle^{-1}	100 grain weight (g)	Panicle length (cm)	Effective tillers plant^{-1}	Grain yield plant^{-1} (g)
Control	0	104	132	144.4	17	32	2.26	27.5	8	22.70
LM-1[a]	10 kR	103	134	90.0	15	28	2.26	26.0	8	22.18
LM-2[b]	10 kR	106	136	116.0	16	31	2.26	27.6	8	23.01
LM-3[d]	10 kR	88	113	143.0	17	31	2.26	27.6	5	15.21
LM-4[d]	10 kR	90	114	142.0	16	32	2.26	27.2	4	13.82
LM-5[e]	10 kR	101	136	146.0	19	36	2.26	28.5	9	26.81
LM-6[a]	20 kR	100	132	90.0	14	29	2.26	26.0	8	21.25
LM-7[b]	20 kR	102	131	119.0	16	29	2.27	27.1	7	20.55
LM-8[c]	20 kR	105	133	161.0	17	30	2.27	27.5	7	21.58
LM-9[d]	20 kR	90	116	143.0	17	31	2.26	27.2	6	17.55
LM-10[d]	20 kR	88	114	145.0	17	31	2.26	27.4	6	17.28
LM-11[d]	20 kR	91	118	143.5	18	31	2.26	27.5	6	18.15
LM-12[e]	20 kR	100	136	148.0	18	40	2.27	28.1	9	26.80
LM-13[e]	20 kR	101	138	142.5	19	38	2.27	28.7	9	27.25
LM-14[a]	30 kR	106	136	91.0	14	29	2.25	26.2	8	21.94
LM-15[a]	30 kR	108	138	91.0	15	28	2.25	26.8	8	22.23
LM-16[b]	30 kR	104	134	117.0	16	30	2.26	27.2	8	22.62
LM-17[c]	30 kR	106	138	167.0	17	31	2.27	27.5	7	20.81
LM-18[c]	30 kR	102	132	168.0	17	31	2.27	27.3	8	22.18
LM-19[f]	30 kR	118	-	144.5	16	28	-	27.1	-	-

LM - Mutant of Lanjhi, [a]Dwarf, [b]Semidwarf, [c]Tall, [d]Early maturing, [e]High yielding, [f]Sterile

Table 5. Spectrum and frequency of morphological mutations/100 M_2 plants in two indigenous varieties MPRI-7 and Lanjhi of rice

Variety and treatment	Total plants studied	Morphological mutants	Mutation frequency (%)	Mutation spectrum (number of events)					
				Dwarf	Semi dwarf	Tall	Early maturing	High yielding	Sterile
MPRI-7									
Control	600	-	-	-	-	-	-	-	-
10 kR	600	10	1.66	2	3	1	1	2	1
20 kR	598	10	1.67	3	4	-	2	1	-
30 kR	597	9	1.50	1	4	2	-	-	2
Lanjhi									
Control	600	-	-	-	-	-	-	-	-
10 kR	599	5	0.83	1	1	-	2	1	-
20 kR	597	8	1.3	1	1	1	3	2	-
30 kR	597	6	1.0	2	1	2	-	-	1

The maximum number of dwarf mutants in MPRI-7 was found at 20 kR dose whereas in case of Lanjhi, it was at 30 kR dose. For semidwarf and tall mutants, the maximum number was obtained at 30 kR dose in MPRI-7 whereas in case of Lanjhi, the semidwarf mutants were found in equal number at all doses, but for tall mutant it was maximum at 30 kR dose. The sterile plants were maximally recorded in each variety at 30 kR. The maximum number of high yielding and early maturing plants were obtained at 20 kR in case of Lanjhi, whereas in case of MPRI-7, maximum high yielding plants were obtained at 10 kR and early maturing plants at 20 kR dose. Farooq and Awan [8] reported that dwarf plants were common among viable M_2 plants and the lower concentrations were the best doses for inducing mutations in Basmati 370 variety of rice. Early maturing mutants have been obtained by gamma irradiations in rice [9-11]. Chung *et al.* [12] found the typical mutant characteristics as dwarf, dense panicle, *lax* panicle, bushy dwarf habit, early maturing, *chlorina*, narrow leaves, small grain, large grain and grain sterility induced by gamma radiation in rice. Further, the tall, semidwarf, early and late flowering mutants have been procured in rice by azide treatment [13]. Thaware *et al.* [14] reported that 20 kR dose was the most effective and useful for yield components. The early maturing, short clum and finer grain rice mutants could be obtained at higher doses of gamma rays [11].

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