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Effect of Gamma Rays on Various Physio-Morphological Characters in the M_1 Generation of Scented Rice

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Abstract Seeds of local scented rice cultivar Tulaipanja were germinated in the laboratory and sown in the pot immediately after treatment with 2 doses (200 Gy and 300 Gy) of gamma rays. Thirty-day old seedlings were transplanted in the main field. Biological effects of gamma irradiation on different physiological parameters related to growth and development were studied. The germination ability of treated seeds and growth and survival ability of seedlings were affected considerably. Significant reduction in the the length of radicle and plumule, plant height, number of panicles per plant and survival ability of plants was observed with increasing doses of gamma rays. The flowering was also delayed due to radiation treatment. The growth and development of plants was greatly impaired as reflected on different physio-morphological characters studied in the above scented rice cultivar.

Keywords Gamma rays, Induced mutation, M_1 generation, Scented rice.

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Introduction

Induced mutation is an important complementary and often unique approach in plant breeding. The induced mutation can provide useful alternative to natural variation particularly to improve one or few easily identifiable characters of well adapted variety specifically in scented rice. Tulaipanja, a non-basmati traditional aromatic tall *indica* rice cultivar is very popular in northern parts of West Bengal, an important rice growing province of India, due to its excellent grain quality and aroma. But this cultivar is handicapped by low yield potential. Therefore, there is urgent need to improve the yield potential of such rice. However, improvement in yield and

Table 1. Germination percentage, plumule length and radicle length in the M_1 generation.

Treat-ments	Germi-nation percentage	After five days of germination Plumule length (cm)	Radicle length (cm)	Percentage of reduction in respect of control Plumule	Radicle
Control	98.0	1.58	2.9	–	–
200 Gy	89.4	1.58	1.92	0.00	33.79
300 Gy	80.2	0.77	1.01	51.26	65.17

Table 2. Plant height at different stages and survival percentage in the M_1 generation.

Treat-ments	% of survival ability at maturity	Mean height at 60 days (cm)	Mean height at 90 days (cm)	Mean height at 130 days (cm)	Range of height at maturity (cm)	% of reduction in height in respect to control
Control	84.50	50.43	109.90	136.46	102-162	–
200 Gy	82.14	52.34	114.07	138.34	100-175	1.38* (increase)
300 Gy	45.00	42.09	85.37	110.70	92-130	18.88

its component characters through hybridization and recombination often becomes difficult due to break-down of aroma and cooking quality characters in such rice. Therefore, generation of variability through mutagenic treatments is important for improvement of this crop. An attempt has been made to study the various effects of two doses of gamma rays 200 Gy and 300 Gy on physio-morphological characters in the M_1 generation in the present investigation. Such knowledge would be helpful to improve the scented rice through induced mutation.

Materials and Methods

Dry, healthy and unhusked seeds with about 14% moisture were irradiated with 2 different doses of gamma rays, 200 Gy and 300 Gy. The irradiated seeds following gamma rays treatment along with control were soaked with water for 48 h at room temperature for germination. Data on germination percentage, length of radicle and plumule were recorded. The seeds were sown in pots and single seedling per hill was transplanted in the field with a spacing of 20 cm × 50 cm. Standard cultural practices were followed to raise a good healthy crop. Number of plants survived was recorded after 1 month of transplantation and also at maturity. Data on plant height, number of panicles per plant, heading time and spikelet fertility were recorded in the M_1 generation.

Results and Discussion

In the present investigation, germination was affected following gamma ray treatment (Table 1). The percentage of germination was 89.40% in 200 Gy and 80.20% in 300 Gy as compared to 98% in control. The reduction in the per cent of germination was higher in the higher dose. Reduced germination in induced rice mutant was reported. (Kumar et al. 2013, Cheema and Atta 2003). Reduced germination might be due to higher physiological damage in seeds resulting from inhibition of auxin synthesis (Gordon 1955) and catalase, peroxidase and cytochrome oxidase (Klinhofs et al. 1974).

Growth and survival of the seedlings were affected adversely. Retardation of growth and survival of plants raised from irradiated seeds is a common phenomenon and has been widely used as an index in assessing the biological effects of various physical and chemical mutagens (Konzak et al. 1972). Considerable reduction in the length of radicle and plumule was observed in the higher dose of 300 Gy (Table 1). Cheema and Atta (2003) observed decrease in germination and seedling height with the increase in radiation dose. Reduction in seedling growth could be attributed to inhibitory action of enzymes and changes in the enzyme activity due to γ-irradiation.

Significant reduction (18.88%) in plant height was recorded in the higher dose of 300 Gy as compared to the control and slight increase in plant height over control was observed in the dose of 200 Gy (Table 2). Imam and Chakraborty (2018) reported that plant height decreased with increase in doses of gam-

Table 3. Range and mean number of panicles per plant in the M_1 generation.

Treat-ments	Frequency of plants in different classes							Mean number of panicles per plant
	0-20	21-30	31-40	41-50	51-60	61-70	71-80	
Control	7	23	39	25	6	–	–	35.90
200 Gy	21	41	27	6	5	–	–	28.25
300 Gy	14	20	26	14	9	5	2	26.44

ma radiation. Various explanations have been offered for growth inhibition due to mutagenic treatments like auxin destruction (Joshi and Gour 1974) or inhibition of auxin synthesis, disbalance in the maintenance of nutritional level, failure of assimilatory mechanisms, inhibition of mitosis and chromosomal damage with associated physiological chages (Riley 1953).

The survival of M_1 plants showed a gradual reduction with increasing doses of gamma rays while highest reduction in survival of 45% was observed in 300 Gy as compared to 82.14% in 200 Gy and 84.50% in control (Table 2) . Kumar et al. (1997) observed that mutagen treatment in rice showed reduced seedling survival in the M_1 generation.

The effect of irradiation was also manifested in the reduction in the number of panicles per plant as the frequency of plants with higher number of panicles was significantly higher in control than the two doses of radiation (Table 3). However, some plants in 300 Gy had increased number of panicles. Similar results were also reported (Imam and Chakraborty 2018). Increase in panicle number might have resulted from stimulatory effect of mutagen (Chakraborty and Kole 2008).

Flowering was delayed considerably in both the doses as compared to control (Table 4). More than 50% plants in both the doses of gamma rays came to flowering after 120 days, while the flowering was completed within 120 days in more than 90% plants in control. Delayed flowering due to radiation was also observed (Sharma 1986).

The reduction in spikelet fertility was observed, as the percentage of plants with more than 50% spikelet sterility was 27.39 and 63.33 in the doses of 200 Gy and 300 Gy, respectively (Table 5). The higher spikelet sterility (%) may be due to higher pollen sterility. Mutagenic treatments generally reduced the reproductive ability of plants and increased the number of sterile spikelets in panicles (Imam and Chakraborty 2018).

In general, the results indicates that the growth of M_1 plants was greatly impaired as seen from the reduction in the length of radicle and plumule, number of panicles per plant, plaant height in association with the delayed flowering and spikelet sterility which may be due to various biochemical and physiological changes after radiation. The mutational changes observed in the M_1 generation need to be studies in the M_2 and later generations for understanding radiation induced changes in the genetic architecture in this scented rice (Imam and Chakraborty 2018). The irradiated populations may be advanced by growing plant -progeny rows for selection of superior mutant plants following pedigree method in later generations.

Table 4. Range and mean number of days to flower in different treatments of gamma rays in the M_1 generation.

Treat-ments	Number of plants with duration of flowering (in days)				Mean days to flower
	110-115	116-120	121-125	126-130	
Control	22	142	5	NIL	117.36
200 Gy	11	77	108	34	121.54
300 Gy	8	25	43	14	121.41

Table 5. Spikelet sterility in different treatments of gamma rays in the M_1 generation.

Treat-ments	Number of plants in different spikelet sterility classes expressed as percentage					% of plants with more than 50% spike-let sterility
	51-60	61-70	71-80	81-90	91-100	
Control	NIL	NIL	NIL	NIL	NIL	–
200 Gy	32	7	10	8	6	27.39
300 Gy	12	2	3	8	12	63.33

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