Pak. J. Bot., 35(5): 791-795, 2003.

EFFECT OF GAMMA RAYS ON M_1 GENERATION IN BASMATI RICE

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Abstract

To estimate the sensitivity to gamma rays in Basmati rice, five varieties namely Basmati 370, Basmati Pak, Basmati 385, Super Basmati and Basmati 2000 were exposed to different doses of gamma rays ranging 150–350 Gy with an increment of 50 Gy among the doses. Plant growth parameters such as seedling shoot and root lengths were measured in the laboratory. Highly significant differences were observed among the varieties for seedling shoot and root lengths. Radiations showed highly significant negative correlations with seedling shoot length (–0.998), seedling root length (–0.941) showing dose dependent responses. Highly significant negative correlations with panicle fertility (–0.941) and grain yield (–0.971), and significant negative correlation for seedling emergence (–0.941) showed detrimental dose dependent responses. Seedling emergence, panicle fertility and grain yield declined with increasing dose level in all the varieties. The dose at which panicle fertility halved was 260.37 Gy. Basmati 2000 was observed to be the most sensitive followed by Basmati 370, Super Basmati and Basmati Pak, but Basmati 385 was found to be the least sensitive variety to gamma rays.

Introduction

Rice (*Oryza sativa* L.) is one of the important cereal crops in Pakistan. Pakistan produces and exports Basmati rice fetching high prices in the domestic as well as in the international rice markets that ultimately raise the ex-chequer. Due to the paucity of genetic variation in the Basmati rice, broadening the genetic base of the crop is an important breeding goal. The shortest method is possible through induced mutations disturbing the genetic base least. Maluszynski *et al.* (1995) reported that most of the mutants were developed after irradiation of the seeds with gamma rays (166 cultivars). Semidwarfness and earliness are the characters most frequently described in released rice mutant cultivars. As a consequence of the paucity of local variation in Basmati rice, broadening the genetic base of the crop in the region is extremely difficult. This may be possible through the induction of mutations in such land races. To-date, mutation breeding in Basmati rice resulted in the release of one variety 'Kashmir Basmati' in Pakistan and several other mutants (Awan *et al.*, 1977, 1982). The present studies were conducted to test the effect of gamma rays on Basmati varieties.

Materials and Methods

Dry dormant paddy seeds of five Basmati rice varieties namely Basmati 370, Basmati Pak, Basmati 385, Super Basmati and Basmati 2000 with an average moisture content of 13 % were exposed to 150, 200, 250, 300 and 350 Gray (Gy) doses of ^{60}Co

gamma rays. The treated seeds (one hundred per treatment), along with untreated controls were sown in Petri dishes in the laboratory with three repeats. Data on seedling shoot and root lengths were recorded two weeks after sowing.

In the nursery field, one hundred seeds of each dose along with untreated control were sown. Thirty days old seedlings were transplanted to the field as M_1 generation. The experiment was conducted in a randomized complete block design with three replications by keeping plant to row distance of 10 cm. Data on seedling emergence ten days after sowing, plant height (cm), panicle fertility (%) and grain yield per plant at maturity were recorded. The data collected were subjected to analysis of variance and correlation analysis.

Results and Discussion

Studies under laboratory in the M_1 generation: Highly significant differences among varieties as well as among radiation doses were observed for seedling shoot and root lengths. Seedling shoot and root lengths declined with increasing doses in all the varieties (Table 1). There was a highly significant effect of variety x dose interaction for seedling shoot length, showing that the varieties differed in their response to irradiation. Radiations showed highly significant negative correlations (Table 3) with seedling shoot length (–0.998) and seedling root length (–0.941) exhibiting a dose dependent response. Root length was more affected than shoot length. Reduced growth has been explained on the basis of auxin destruction, changes in ascorbic acid content, and physiological and biochemical disturbances (Gunckel & Sparrow, 1954; Gordons, 1957; Singh, 1974; Usuf & Nair, 1974). The retardation in root length has been described due to the cessation on cell division. Majeed (1997) and Wang *et al.* (1993) working on Japonica/Indica rice varieties reported similar effects on root length. Wu *et al.* (1993) also observed severe effects of radiations on seedling growth in rice.

Studies under field conditions in the M_1 generation: Highly significant differences among varieties as well as among radiation doses were observed for seedling emergence, panicle fertility and grain yield while for plant height radiation dose showed significant effects. Seedling emergence, panicle fertility and grain yield declined with increasing dose level in all the varieties (Table 2). Significant effects of variety x dose interaction for seedling emergence and plant height showed dose dependent response. Nonsignificant effects of interaction of variety with dose for panicle fertility and grain yield showed that the varieties were independent in their response to irradiation. Radiations showed highly significant negative correlations with panicle fertility (– 0.941) and grain yield (– 0.971), and significant negative correlation for seedling emergence (– 0.941) showing detrimental dose dependent response (Table 3).

Drastic detrimental effects were observed for panicle fertility (42.51 % reduction at 350 Gy) which consequently caused reduction in grain yield (50.31 % reduction at 350 Gy; Table 3). Low panicle fertility following exposure to gamma rays may be attributed to meiotic disturbance/chromosomal aberrations at cellular level. Miyahara (1997) described that panicle fertility decreased with the increase in radiation dose.

Table 1. Effect of gamma rays on different plant growth parameters under laboratory conditions of different Basmati rice.

Parameter	Variety	Gamma Ray Dose (Gy)						Mean
		0	150	200	250	300	350	
Seedling shoot length	Basmati 370	7.57	7.44	7.10	7.32	7.49	7.31	7.37^{C}
	Basmati Pak	8.41	7.91	7.92	7.32	7.49	7.31	7.73^{B}
	Basmati 385	8.39	8.28	8.37	8.33	8.23	8.07	8.28^{A}
	Super Basmati	7.55	7.52	7.42	7.24	6.55	6.45	7.12^{D}
	Basmati 2000	8.15	7.27	6.82	7.07	6.01	6.85	7.15^{D}
	Mean	7.99^{A}	7.68^{B}	7.54^{BC}	7.46^{CD}	7.31^{DE}	7.20^{E}	
Seedling root length	Basmati 370	3.00	2.90	2.95	2.74	2.61	2.60	2.80^{D}
	Basmati Pak	3.76	3.55	3.54	3.53	3.49	3.49	3.56^{C}
	Basmati 385	4.55	4.52	4.09	3.92	3.97	4.36	4.24^{A}
	Super Basmati	4.66	3.64	3.80	3.78	3.78	3.76	3.90^{B}
	Basmati 2000	4.69	4.60	3.81	3.72	3.58	3.55	3.99^{B}
	Mean	4.13^{A}	3.84^{B}	3.64^{B}	3.54^{B}	3.49^{B}	3.55^{B}	

Figures of means both in columns and rows followed by letters in common do not differ significantly at 5 % level of significance according to DMRT.

Table 2. Effect of gamma rays on different plant characters under field conditions of different Basmati rice.

Parameter	Variety	Gamma Ray Dose (Gy)						Mean
		0	150	200	250	300	350	
Seedling emergence	Basmati 370	94.75	92.59	89.82	88.96	85.19	84.67	89.33^{A}
	Basmati Pak	95.37	92.59	91.08	87.04	83.33	83.33	89.79^{A}
	Basmati 385	89.51	87.34	87.65	86.42	78.40	75.62	84.16^{C}
	Super Basmati	95.06	94.44	94.13	89.82	71.61	69.44	80.75^{B}
	Basmati 2000	91.36	89.25	88.89	87.04	86.11	78.40	86.84^{B}
	Mean	93.21^{A}	91.24^{B}	90.31^{B}	87.86^{C}	80.93^{D}	78.29^{E}	
Plant height	Basmati 370	118.93	114.17	116.07	118.80	113.13	116.80	116.32^{A}
	Basmati Pak	98.47	102.87	104.60	103.26	96.73	101.06	101.17^{B}
	Basmati 385	94.73	97.06	92.40	93.66	93.46	93.33	94.11^{D}
	Super Basmati	90.26	86.46	83.46	82.80	85.20	83.26	85.24^{E}
	Basmati 2000	94.20	104.86	100.86	96.46	94.33	93.33	97.34^{C}
	Mean	99.3^{AB}	101.08^{A}	99.56^{AB}	99.00^{ABC}	96.57^{C}	97.56^{BC}	
Panicle fertility	Basmati 370	94.80	85.06	69.04	73.60	58.09	54.80	72.57^{A}
	Basmati Pak	95.30	83.50	75.74	62.29	59.48	59.39	72.62^{A}
	Basmati 385	73.28	68.04	66.32	58.84	53.14	44.05	60.61^{B}
	Super Basmati	85.66	70.17	74.47	56.00	55.03	52.15	65.58^{A}
	Basmati 2000	81.39	74.08	75.46	65.42	58.14	37.08	65.31^{A}
	Mean	86.09^{A}	76.17^{A}	72.21^{A}	63.23^{B}	56.88^{BC}	49.49^{C}	
Grain yield	Basmati 370	4.36	3.12	3.16	3.14	2.63	2.47	3.15^{C}
	Basmati Pak	4.17	3.92	3.88	2.92	2.69	1.89	3.24^{C}
	Basmati 385	5.43	4.48	4.36	3.94	3.83	2.83	4.15^{A}
	Super Basmati	4.96	4.38	4.31	3.23	2.76	2.67	3.72^{B}
	Basmati 2000	5.04	4.27	4.08	3.77	3.45	2.05	3.78^{AB}
	Mean	4.79^{A}	4.03^{B}	3.96^{B}	3.40^{C}	3.07^{C}	2.38^{D}	

Figures of means both in columns and rows followed by letters in common do not differ significantly at 5 % level of significance according to DMRT.

Table 3. Correlation of varieties with radiation and their response to gamma rays.

Plant character	Correlation	Control	Reduction (%)
Seedling shoot length	(–0.998)**	7.99	9.89
Seedling root length	(–0.941)**	4.13	14.04
Seedling emergence	(–0.890)*	93.21	16.01
Plant height	(–0.629)	99.32	1.77
Panicle fertility	(–0.941)**	86.09	42.51
Grain yield	(–0.971)**	4.79	50.31

*Significant, **Highly Significant,

Seedling emergence decreased with a corresponding increase in the radiation dose in all the varieties. More pronounced adverse effects were observed at the highest dose. Plant height was observed to be the least affected character in all the varieties. Nonsignificant correlation also proved that even at high doses, this character was not much affected.

Sensitivity to radiation was determined as the lethal dose for 50 % reduction (LD_{50}) in the M_1 generation by relating percentage panicle fertility to radiation dose. Panicle fertility was expressed as a linear function of irradiation dose, which accounted for 88.55 % of the observed variability. The dose at which panicle fertility halved was 260.37 Gy very similar to 250 Gy reported by Miyahara (1997). Based on the sensitivity of panicle fertility to gamma rays, Basmati 2000 was observed to be the most sensitive followed by Basmati 370, Super Basmati and Basmati Pak, but Basmati 385 was found to be the least sensitive variety to gamma rays.

References

Awan, M.A., G. Bari, A.A. Cheema and M. Akbar. 1977. List of mutant varieties. *Mut. Breed. Newsl.*, 10: 14-15.

Awan, M.A., M. Ahmad and A. Cheema. 1982. Evaluation of short stature mutants of Basmati 370 for yield and grain quality characteristics. *Pak. J. Sci. Ind. Res.*, 25: 67-71.

Gordons, S.A. 1957. The effects of ionizing radiation on plants: biochemical and physiological aspects. *Q. Rev. Biol.*, 32: 3-14.

Gunckel, J.E. and A.H. Sparrow. 1954. Aberrant growth in plants induced by ionizing radiations. *Brookhaven Symp. Biol.*, 6: 252-279.

Majeed, A. 1997. Varietal differences in the effects of gamma irradiation on rice seed. *Sarhad J. Agric.*, 13: 363-369.

Maluszynski, M., L.V. Zanten, A. Ashri, H. Brunner, B. Ahlouwalia, F.J. Zapata and E. Weck. 1995. Mutation techniques in plant breeding. In: *Proc. Induced Mutations and Molecular Techniques for Crop Improvement*. IAEA/FAO, Vienna, p. 489-504.

Miyahara, K. 1997. Mutation induction in rice by soft X-ray irradiation. *Tech. News, Inst. Rad. Breed.*, Japan. 58: 2 pp.

Singh, B.B. 1974. Radiation induced changes in catalase, lipase and ascorbic acid of safflower seeds during germination. *Rad. Bot.*, 14: 195-199.

Usuf, K.K. and P.M. Nair. 1974. Effect of gamma irradiation on the indole acetic acid synthesizing system and its significance in sprout inhibition of potatoes. *Rad. Bot.*, 14: 251-256.

Wang, C.L., M. Shen, K.N. Zhao and I.F. Chen. 1993. Mutagenic effects of combined treatment of ^{137}Cs gamma rays and sodium azide on *Oryza sativa* L. *Acta Agric. Nud. Sinica.*, 7: 21-28.

Wu, G.T., Z.Y. Wang, Z.Y. Zhou, Y.W. Xia and Q.Y. Shen. 1996. Biological effects of Pingyangmycin and gamma rays treatments on rice (*Oryza sativa* L.). *Chinese Rice Res. Newsl.*, 4: 6-7.