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# INDUCTION OF USEFUL MUTATIONS IN BASMATI RICE

G. BARI

*Atomic Energy Agricultural Research Centre, Tandojam,*

AND

M.A. AWAN

*Nuclear Institute for Agriculture and Biology, Lyallpur, Pakistan.*

**Abstract**

Dry seeds of rice variety Basmati-370 were exposed to 15, 20, 25 and 30 kR of gamma-rays, and 1.0, 1.5, 2.0 and 2.5 kR of fast neutrons. In $M_1$ generation, the pollen and spikelet fertility decreased with corresponding increase in radiation exposure. In $M_2$ the frequency of chlorophyll mutations increased as the radiation dose increased up to 2.0 kR of fast neutrons and 25 kR of gamma-rays, whereafter it decreased sharply. A linear relationship was observed between the viable mutation frequency and the radiation dosage. A large number of desirable mutant plants were selected in $M_2$ generation and their further performance regarding morphological characters and grain quality was studied in $M_3$ generation. Some early flowering mutant lines possessing good grain quality were selected.

## Introduction

Rice crop has received considerable attention in recent years for its improvement through induced mutations (Futsuhara *et al.*, 1967; Tanaka, 1969; Bari *et al.*, 1971; Haq *et al.* 1971; Li *et al.*, 1971).The Basmati varieties of rice grown in Pakistan are well-known for their excellent grain quality, but possess some undesirable characteristics like low yield potential, late maturity, tall growth habit, weak stem and drooping leaves. In the present studies, successful attempts were made to induce some useful mutations in Basmati rice through seed irradiation.

## Materials and Methods

Dry seeds of the most popular aromatic variety Basmati-370 of rice (*Oryza sativa* L.) were irradiated with 15, 20, 25 and 30 kR of gamma-rays and 1.0, 1.5, 2.0 and 2.5 kR of fast neutrons. Five hundred irradiated seeds per treatment were soaked in water for 24 hours at room temperature and were then sown in seed bed. Non-irradiated seeds were used as control. The seedlings were transplanted in the main plots after one month of their germination. Planting distance was 25 × 10 cm in the $M_1$ and 25 × 25 cm in successive generations.

The $M_1$ plants were studied for pollen and spikelet fertility. The pollen fertility was determined by staining the pollen grains with 1% acetocarmine solution and by pollen germination. About 500 pollen grains per treatment were studied for testing the pollen fertility. For spikelet fertility, the number of spikelets in which grain setting took place were counted and the viability of seeds was tested by germinating them in Petri dishes. From each $M_1$ plant, three first formed panicles were bagged at the flowering stage and each panicle was harvested separately at maturity. The $M_2$ generation was raised as spike to row progeny with 30 plants per line.

The $M_2$ population was screened for chlorophyll mutations at the seedling stage, while the viable mutations were screened at the adult plant stage. Mutation frequency was expressed as number of mutants per 1,000 $M_2$ seedlings. Chlorophyll mutations in $M_2$ generation were grouped into four classes *viz.*, albina, xantha, viridis and others. The segregation ratio for each treatment was grouped and expressed as percentage of mutants in total M2 seedling population. The viable mutations were classified as (i) early flowering *i.e.*, more than a week earlier than control, (ii) short-culm *i.e.* 21 to 40 per cent shorter than control, (iii) dwarf *i.e.* 41 to 80 per cent shorter than control, (iv) fine grain, and (v) others *i.e.* stiff-stem, deformed, sterile etc. Seeds of each desirable mutant were collected separately. The M3 generation was grown as plant progenies from the seed of all selected M2 plants. Bulk seeds from the normal looking M2 plants with no phenotypically detectable mutations were also grown as M3 generation on a large area.

## Results and Discussion

### *$M_1$ generation*

The data on pollen and spikelet fertility are given in Table 1. Pollen fertility in fast neutron treatments ranged from 43.73 to 77.05 per cent, and in gamma-ray treatments from 72.56 to 84.69 per cent, as compared to 95.92 per cent pollen fertillity in non-irradiated control plants. Likewise, the spikelet fertility was 31.83 to 48.43 per cent in fast neutron treatments, and 46.63 to 57.18 per cent in gamma-ray treatments as compared to 74.80 per cent spikelet fertility in control plants. The coefficient of linear correlation was very high ($r > 0.96$) in all the treatments. It was found that with the increase in radiation dose the fertility decreased correspondingly.

**TABLE 1. Effect of fast neutrons and gamma rays on pollen and spikelet fertility in M1 generation of Basmati'370.**

| Treatment | Pollen fertility (%) | Coefficient of linear correlation (r) | Spikelet fertility (%) | Coefficient of linear correlation (r) |
|---|---|---|---|---|
| Fast neutrons | | | | |
| 0.0 kR | 95.92 | | 74.80 | |
| 1.0 kR | 77.05 | | 48.43 | |
| 1.5 kR | 72.58 | −0.9858* | 40.25 | −0.9664* |
| 2.0 kR | 58.51 | | 34.76 | |
| 2.5 kR | 43.73 | | 31.83 | |
| Gamma-rays | | | | |
| 0 kR | 95.92 | | 74.80 | |
| 15 kR | 84.69 | | 57.18 | |
| 20 kR | 83.58 | −0.9875* | 50.00 | −0.9749* |
| 25 kR | 76.39 | | 49.87 | |
| 30 kR | 72.56 | | 46.63 | |

* Significant at $P < 0.001$ level.

*$M_2$ generation*

The data on the frequency of chlorophyll and viable mutations induced by fast neutrons and gamma-rays in M2 generation are given in Table2.

**TABLE 2. Frequency of Chlorophyll and Viable Mutations in M2 Generation of Basmati'370.**

| Treatment | Chlorophyll mutations | | | | Viable mutations |
|---|---|---|---|---|---|
| | Spike progenies segregating (%) | M2 seedl-ings studied | Mutants per 1,000M2 seedlings | Mean segregation ratio (%) | Mutants per 1,000 M2 plants |
| Control | — | 3134 | — | — | — |
| Fast neutrons | | | | | |
| 1.0 kR | 30.00 | 1277 | 28.97 | 9.92 | 23.25 |
| 1.5 kR | 32.00 | 1383 | 48.45 | 12.45 | 38.29 |
| 2.0 kR | 26.67 | 1250 | 51.87 | 13.85 | 41.89 |
| 2.5 kR | 50.00 | 1187 | 24.27 | 4.71 | 83.33 |
| Gamma-rays | | | | | |
| 15 kR | 10.26 | 2601 | 2.34 | 2.05 | 28.16 |
| 20 kR | 40.00 | 2365 | 22.36 | 5.72 | 46.34 |
| 25 kR | 25.00 | 2639 | 22.83 | 6.60 | 64.71 |
| 30 kR | 20.00 | 2054 | 4.00 | 1.25 | 95.23 |

a. Chlorophyll mutations

The frequency of chlorophyll mutations per 1,000 M2 seedlings increased proportionately from 28.97 at 1 kR to 51.87 at 2 kR of fast neutrons. and then dropped to 24.27 at the dose of 2.5 kR. Similarly in case of gamma-ray treatments, the mutation frequency increased from 2.34 at 15 kR to 22.83 at 25 kR, and then dropped to 4.00 at 30 kR. Consequently the segregation ratio increased with the increase in dosage up to 2.0 kR of fast neutrons and 25 kR of gamma-rays.

b. Viable mutations

The data on the frequency of viable mutations (Table 2) showed a linear relationship of mutation frequency to radiation dose. The frequency of mutants increased from

23.25 to 83.33 per 1,000 M2 plants with an increase in radiation dose from 1 kR to 2.5 kR of fast neutrons; and from 28.16 to 95.23 with an increase in gamma radiation dosage from 15 kR to 30 kR. The spectrum of viable mutations indicated that fast neutrons induced relatively more earliness (39.51 per cent) followed by short-culm (37.13 per cent) and dwarf (12.30 per cent) mutations. Conversely with gamma-ray treatments, short-culm (55.10 per cent) and dwarf (27.91 per cent) mutants were relatively more frequent than early flowering (14.30 per cent) mutants. Unlike chlorophyll mutations, the number of viable mutants induced by gamma-rays was higher than with neutron treatments. A wide spectrum of mutations with morphological and physiological changes was observed. Modifications in the characters of plant height, growth habit and flowering date were more common. In all, 62 early maturing, 240 short-culm, 40 dwarf and four stiff-stemmed mutant plants were isolated from the M2 generation.

## $M_3$ generation

Several mutant lines in M3 generation segregated for morphological and physiological characters. Final observations of some of the stable mutant lines were recorded for different plant characters. Five early flowering mutant lines were studied in detail and the relevant data are given in Table 3. One of these mutant lines, EF-29, flowered 28 days earlier than the parent variety Basmati-370, and gave an average yield of 65.2 g per plant as compared to 37.0 g in the parent variety. This mutant line retained all desirable grain characteristics of Basmati-370. A short-culm mutant line *i.e.* SC-4 showed uniformly reduced plant height of approximataly 90 cm as compared to 149 cm of the parent variety Basmati-370. Other short-culm mutants also showed encouraging field performance, but their grain quality was generally inferior to that of Basmati-370.

**TABLE 3. Earliness and Plant Yield of Mutant Lines in Comparison with the Parent Variety Basmati'370**

| Culture | No. of days from seeding to flowering | Days earlier than control | Average plant yield (g) |
|---|---|---|---|
| Control Basmati-370 | 128 | — | 37.0 |
| EF-29 | 100 | 28 | 65.2 |
| EF-28 | 108 | 20 | 50.5 |
| EF-2 | 110 | 18 | 60.4 |
| EF-54 | 110 | 18 | 54.3 |
| EF-6 | 111 | 17 | 48.0 |

The induction of earliness in maturity, as was evidenced in mutant line EF-29, is of special significance in Pakistan and many other countries, where rice is grown on irrigated lands. By the cultivation of early maturing varieties there can be tremendous saving of irrigation water and the land can be vacated in time for other crops. The earliness in maturity is generally associated with lower grain yield, but there have been instances where the grain yield of mutant strains was equal or even higher than that of the parent variety (Li *et al.*, 1961; Kawai, 1963 a, 1963 b).

## References


Bari, G., M.A. Awan and I.M. Bhatti, 1971. "Yield performance of promising rice mutants and hybrid selections". *In* Rice Breeding with Induced Mutations III, Tech. Rep. Ser. No. 131, IAEA Vienna, pp. 1-4.

Futsuhara, Y., K. Toriyama and K. Tsunoda, 1967. Breeding of a new rice variety "Reimei" by gamma-rays irradiation, Japan. J. Breed. **17**: 85-90.

Haq, M.S., M.M. Rehman, A. Mansur and R. Islam, 1971. "Breeding for early, high yielding and disease resistant rice varieties through induced mutations". *In* Rice Breeding with Induced Mutations III, Tech. Rep. Ser. No. 131. IAEA, Vienna, pp. 35-46.

Kawai, T., 1963 a. Mutations in rice induced by radiation and their significance in rice breeding I. Mutations by radiophosphorus. Bull. Nat. Inst. Agric. Sci. (Japan) **10**: 1-75.

Kawai, T., 1963 b. Mutations in rice induced by radiation and their significance in rice breeding. II. Mutations byX-ray irradiation of florets. Bull. Nat. Inst. Agric, Sci. (Japan) **10**: 77-137.

Li, H.W., C.H. Hu, W.T. Chang and T.S. Weng. 1961. The utilization of X-radiation for rice improvement. *In* Effects of Ionizing Radiations on Seeds (Proc. Symp. Karlsruhe, 1960), IAEA, Vienna, pp. 485-493.

Li, H. W., C.H. Hu and S.C. Woo, 1971. "Development of rice mutation breeding in Taiwan". *In* Rice Breeding with Induced Mutations III, Tech. Rep. Ser. No. 131, IAEA, Vienna, pp. 69-67.

Tanaka, S., 1969. "Some useful mutations induced by gamma-irradiation in rice." *In* Induced Mutations in Plants (Proc. Symp. Pullman, 1969), IAEA, Vienna,pp. 517-527.