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# BREEDING FOR HIGH GRAIN YIELD THROUGH MUTAGENESIS IN RICE (*ORYZA SATIVA* L.)

A.W. Baloch, A.M. Soomro, H.R. Bughio, M.S. Bughio, I.A. Odhano, M.A. Asad and S.J. Abbasi

Nuclear Institute of Agriculture (NIA), Tando Jam

## ABSTRACT:

A high yielding mutant IR6-25A was selected from gamma rays irradiated material of coarse (non-aromatic) rice variety IR6 and was evaluated at the experimental farm of Nuclear Institute of Agriculture (NIA) Tando Jam. The mutant strain IR6-25A was significantly ($P \leq 0.05$) better than its mother variety IR6 and check variety Shadab in the entire yield contributing parameters. It gave better paddy yield as compared to its parent, check other promising mutant strains in Micro, Preliminary and Station Varietal Trials at NIA, Tando Jam during 1996, 1997 and 1998. On the basis of three years average, it has shown 16% increase in paddy yield over its parent-IR6 as well as check variety Shadab. In Zonal Varietal Trials, conducted for three subsequent years at 9 different locations with diverse agro-climate conditions, it maintained superiority over all the entries by yielding 6816, 6208 and 6530 kg of paddy per hectare during 1999, 2000 and 2001 respectively. It gave 20% and 23% higher paddy yield than IR6 and check variety Shadab.

## INTRODUCTION:

Use of induced mutation for crop improvement has proved to be a profitable approach. The development of high yielding varieties of crops, particularly of rice, has significantly enhanced the yield per hectare and uplifted the socio-economic condition of the rice farmers. Rice is a diploid and self pollinated crop, possesses enormous possibilities of improvement through mutation breeding. Significant achievements have been made in developing new rice varieties with desirable characteristics through mutation breeding. This approach was followed to create genetic variability in IR6 through gamma rays for selecting new genotypes with improved grain quality and high yield potentials. Mutation breeding of rice started at NIA, Tando Jam with the objectives of high yield, early maturity and good grain quality. As a result very productive mutants were obtained and released as new cultivars (Baloch *et. al.*, 1999, 2001, 2002, 2004, 2005 and Lieu *et. al.*, 2004). Therefore, the present study was conducted to induce genetic variability in IR6 through gamma rays for selecting new genotypes with high grain yield potential.

## MATERIALS AND METHODS:

The homogenous seeds of IR6 were irradiated with different doses of gamma rays (150, 200, and 250 Gy of $^{60}$Co source). The irradiated seeds were sown in nursery beds along with non-irradiated control during 1992. Four weeks old seedlings were planted at uniform distance of 10 x 10 cm between hills and rows, at maturity two main primary tillers were harvested from each $M_1$ plant of the treated population and the control. The $M_2$ progeny was grown during 1993 from each selected panicle of $M_1$ material. In $M_2$ generation, mutants with productive traits such as synchrony in flowering, high tillering, increased fertility percent, panicle size,

seed index and plant heights were selected. Mutants with desirable attributes in $M_3$ and $M_4$ were retained. Finally, five high yielding mutants viz., IR6-25A, IR6-25B, IR6-15-A, IR6-15B and IR6-15-1 were selected. For confirmation, these mutants were tested along with parent IR6 and check Shadab in Micro Yield Trial, Preliminary Yield Trial and Station Varietal Trial for yield during 1996, 1997 and 1998, respectively.

After confirming in local trials, the mutant IR6-25A along with other genotypes/checks was evaluated in Zonal Varietal Trials for three years (1999-2001) over 9 different sites in Sindh and Balochistan. Experimental design was RCB with four replications at each site, each year, with a plot size of 5 x 3 m. All other recommended agronomical and cultural operations were followed upto maturity. Data on number of fertile panicles per hill, panicle length (cm), number of fertile grains per panicle, fertility percentage per panicle, 1000 grain weight (g), grain yield per hill (g) and length breadth ratio were recorded at Tando Jam site. Data for paddy yield (kg/ha) and mean yield performance of genotypes at individual site was recorded during each year. ANOVA of the data of paddy yield was performed to determine the significant differences among the genotypes included in trials.

**RESULTS AND DISCUSSION:**

The significant ($P \leq 0.05$) differences were observed amongst the genotypes for the traits under study (Table-1). The mutant IR6-25A had produced the highest fertile panicles per hill (20.38), longer panicle (27.30 cm), more fertile grains per panicle (220), high fertility percent per panicle (92.00), high 1000 grain weight (25.75 g) and grain yield per hill (84.66 g) than all other entries. The results of micro yield trial (1996) indicated that mutant strain IR6-25A gave higher paddy yield of 8868 kg/hr with increase of 14% and 10% than its parent IR6 (7767 kg/ha), check Shadab (8029 kg/ha) and other mutants (Table-2). In Preliminary Yield Trial (1997), the mutant IR6-25A had produced higher paddy yield of 8733 kg/ha as compared with parent IR6 (7458 kg/ha) and check variety Shadab (7441 kg/ha) indicating an increase of 17% and 19% over parent and check varieties IR6 and Shadab respectively (Table-2). The results of Station Varietal Trial (1998) indicated that mutant IR6-25A had produced higher paddy yield of 8666 kg/ha with an increase of 15% and 21% over its parent IR6 and check variety Shadab respectively (Table-2). The mutant IR6-25A secured first position in paddy yield of three years trials indicating its superiority over other entries in yield potential. On the basis of three year's average, the yield of IR6-25A was found as 8754 kg/ha as compared with parent IR6 (7530 kg/ha) and check variety Shadab (7535 kg/ha.). Thus mutant IR6-25A produced 16% more than the parent IR6 and check Shadab.

Results of Zonal Varietal Trials 1999 indicated that the mutant IR6-25A maintained its superiority in paddy yield over all sites and ranked first (Table-3). It gave average paddy yield of 6816 kg/ha followed by genotype IR6-15-1 (6643 kg/ha) while the parent and check varieties IR6 and Shadab had produced 5983 and 5823 kg/ha respectively, mutant IR6-25A also displayed an increase of 14 and 17% in paddy yield over the mother variety IR6 and check variety Shadab.

Results of Zonal Varietal Trials 2000 showed that the mutant IR6-25A produced significantly higher average paddy yield of 6208 kg/ha which was followed by the mutant IR6-15-1 (5769

kg/ha) (Table-4). Results further demonstrated that the mutant IR6-25A showed an increase of 24 and 26% over mother variety IR6 and check variety Shadab respectively.

Average paddy yield of Zonal Varietal Trials 2001 confirmed that the mutant IR6-25A secured first position among eight genotypes at 9 sites (Table-5). It produced significantly higher average paddy yield of 6530 kg/ha followed by the mutants IR6-15-1 (6453 kg/ha) and IR6-15A (6180 kg/ha), the mutant IR6-25A gave 22 and 27% higher average paddy yield than its mother variety IR6 and check variety Shadab respectively.

Data on the basis of three year's average paddy yield of Zonal Varietal Trials (1999-2001) revealed that the mutant IR6-25A secured first position by producing higher paddy yield than other genotypes. It gave 20 and 23% higher paddy yield than the mother variety IR6 and check variety Shadab. Our results are in agreement with the rice workers around the world Bari et. al.,. (1981 & 1887), Mustafa et. al., (1997), Rutger, (1983), Hu et. al., (1991), Maluszynski et. al., (1986), Mckenzie and Rutger (1986) and Wen and Qw (1996). Present studies have confirmed the improvement for high paddy by mutation breeding.

## CONCLUSION:

The high yielding rice variety (IR6-25A) with fine grain was developed from coarse variety IR6 through gamma rays (150 Gy). It has given consistently better paddy yield as compared to its parent, check and other promising mutants. On the basis of three year's average of zonal trials, IR6-25A produced 20% and 23% higher paddy yield than parent IR6 and check Shadab. The rice mutant IR6-25A will contribute significantly towards income and in socio-economic uplift of the farming community in Pakistan.

**Table: -1.** Yield and yield components of mutant strains of rice and check varieties.

| Mutants/ varieties | 50% flowering from seeding | Plant height (cm) | Fertile panicles per hill | Panicle length (cm) | Fertile grains per panicle | Panicle fertility (%) | 1000 grain weight (g) | Grain yield per hill (g) |
|---|---|---|---|---|---|---|---|---|
| IR6-25/A (Shaandar) | 116 b | 94.00 bc | 20.38 a | 27.30 a | 220 a | 92.00 a | 25.75 a | 84.66 a |
| IR6-25B | 113.75 c | 92.25 cd | 19.50 b | 25.28 bc | 142.25 b | 88.00 bc | 24.78 b | 72.26 bc |
| IR6-15A | 116.50 b | 97.00 b | 16.48 c | 24.48 d | 140.52 b | 87.30 bcd | 25.71 a | 76.90 ab |
| IR6-15B | 118.75 ab | 98.25 b | 16.32 c | 25.50 b | 139.30 b | 86.00 de | 23.76 c | 65.57 c |
| IR6-15-1 | 114.50 c | 99.82 a | 16.51 c | 24.46 cd | 145.25 b | 87.25 bcd | 24.28 bc | 74.32 b |
| IR6 (Parent) | 120.62 a | 94.26 bc | 17.14 c | 24.78 cd | 130.24 c | 85.36 e | 25.25 ab | 66.55 bc |
| Shadab (Check) | 117.50 b | 88.28 d | 16.24 c | 24.22 d | 122.85 c | 87.85 b | 24.38 bc | 67.00 bc |

DMR test (0.05) means followed by the same letters are not significantly different from each other.

**Table: - 2.** Average paddy yield (kg/ha) of mutants/genotypes of rice in different Varietal Trials evaluated during 1996, 1997 and 1998.

| Mutants/ Varieties | Micro Yield Trial 1996 | Preliminary Yield Trial 1997 | Station Varietal Trial 1998 | Average of Three Years | % increase of paddy yield over other mutants |
|---|---|---|---|---|---|
| R6-25A (Shaandar) | 8863a | 8733a | 8666a | 8754a | ** |
| IR6-25B | 8209cd | 8149c | 8131b | 8163bc | 7 |
| IR6-15A | 8286c | 8316c | 7555c | 8052c | 9 |
| IR6-15B | 7764e | 7458e | 7426c | 7549e | 16 |
| IR6-15-1 | 8514b | 8559b | 8116b | 8396b | 4 |
| IR6 (Parent) | 7767e | 7458e | 7364c | 7530e | 16 |
| Shadab (Check) | 8029d | 7441e | 7134c | 7535e | 16 |

DMR test (0.05) means followed by the same letters are not significantly different from each other.

**Table: -3.** Paddy yield (kg/ha) of non-aromatic rice mutants/varieties conducted in Zonal Trials during kharif 1999

| Mutants/ varieties | NIA Tando Jam | Sanghar | Badin | Thatta | Dadu | Larkana | Shikar-pur | Jacob-abad | Jafar abad | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| IR6-25/A | 6196 a | 6463 a | 6423 a | 5989 a | 6609 a | 7637 a | 7156 a | 7263 a | 7603 a | 6816 a |
| IR6-25-B | 5129 e | 5235 d | 5429 e | 4775 f | 5656 d | 6483 f | 5982 d | 6009 b | 6116 d | 5683 i |
| IR6-15-A | 5429 d | 5796 c | 5950 cd | 5189 de | 6089 c | 7150 cd | 6456 c | 6603 b | 6589 d | 6143 f |
| IR6-15-B | 5802 bc | 5796 c | 6129 bc | 5402 cd | 6163 c | 7196 bcd | 6563 c | 6643 b | 7050 c | 6310 d |
| IR6-15-1 | 6103 a | 6203 b | 6316 ab | 5749 b | 6409 ab | 7397 b | 6850 b | 7270 a | 7510 ab | 6643 b |
| IR6-1.0-2 | 6061 ab | 6129 b | 6236 ab | 5469 c | 6216 bc | 7343 bc | 6783 b | 7297 a | 7350 b | 6537 c |
| IR6 (Parent) | 5309 de | 5696 c | 5803 d | 5242 cde | 5996 c | 6890 e | 6083 d | 6269 c | 6549 d | 5983 g |
| Shadab (Check) | 5289 de | 5442 d | 5582 e | 5082 e | 5682 d | 6736 e | 6061 d | 6043 b | 6543 d | 5823 h |

DMR test (0.05) means followed by the same letters are not significantly different from each other

**Table: -4.** Paddy yield (kg/ha) of non-aromatic rice mutants/ varieties in Zonal Trials 2000

| Mutants/ Varieties | NIA Tando jam | Sanghar | Badin | Thatta | Dadu | Larkana | Shikar - pur | Jacob- abad | Balochi stan | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| IR6 25/A | 5399 a | 6106 a | 6439 a | 5753 a | 5466 a | 6519 a | 6753 ab | 6593 a | 6846 a | 6208a |
| IR6 25/B | 4473 c | 4966 c | 4966 c | 4620 e | 4280 def | 5453 d | 5239 e | 5093 e | 6119 b | 5023 e |
| IR6 15/A | 5106 ab | 5306 b | 5346 cd | 4773 de | 4560 cd | 5273 d | 5413 de | 5353 de | 5959 b | 5232 e |
| IR6 15/B | 5206 ab | 5373 b | 5579 bc | 5459 b | 4532 cde | 5846 bc | 5553 d | 6186 b | 6239 b | 5553 d |
| IR6 15-1 | 5279 ab | 5499 b | 5839 b | 5446 b | 4846 b | 6073 b | 6393 b | 5939 bc | 6606 a | 5769 b |
| IR6 1.0-2 | 5139 ab | 5466 b | 5619 bc | 5206 bc | 4779 bc | 5826 bc | 6333 b | 5886 c | 6213 b | 5607 c |
| IR6 (Parent) | 4393 c | 4746 cd | 5113 de | 4700 de | 4253 ef | 5326 d | 5519 d | 5386 d | 5646 c | 5009 e |
| Shadab (Check) | 4466 c | 4680 d | 5046 e | 4593 e | 4226 f | 5306 d | 5359 de | 5286 de | 5519 c | 4942 f |

DMR test (0.05) means followed by the same letters are not significantly different from each other

**Table: -5**. Paddy yield (kg/ha) of non-aromatic rice mutants/ varieties in Zonal Trials 2001

| Mutants/ Varieties | NIA Tando jam | Sanghar | Badin | Thatta | Dadu | Larkana | Shikar- pur | Jacob abad | Usta Mohd | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| IR6-25/A | 5789 a | 6650 a | 5343 a | 5850 a | 6730 a | 7284 a | 5990 a | 7944 a | 7190 a | 6530 a |
| IR6-25/B | 4822 d | 5296 c | 4342 d | 4596 e | 5196 d | 5529 e | 5062 d | 5836 e | 5556 d | 5137 c |
| IR6-15/A | 5456 bc | 6190 b | 5349 a | 5516 b | 6250 b | 6603 b | 5783 ab | 7857 a | 6617 b | 6180 ab |
| IR6-15/B | 4882 d | 5496 c | 4569 cd | 5003 cd | 5296 d | 5956 cd | 5216 d | 6510 d | 5543 d | 5386 c |
| IR6-15-1 | 5690 ab | 6717 a | 5289 a | 5856 a | 6603 a | 7030 a | 5930 a | 7897 a | 7064 a | 6453 a |
| IR6-1.0-2 | 5363 c | 5549 c | 5216 ab | 5063 e | 6083 b | 6203 c | 5236 d | 7330 b | 6483 bc | 5836 b |
| IR6-P | 4922 d | 5509 c | 4682 c | 4789 cde | 5670 c | 5836 d | 5083 d | 6056 e | 5676 d | 5358 c |
| Shadab (Check) | 4829 d | 5336 c | 4442 cd | 4762 de | 5269 d | 5503 e | 4589 e | 5823 e | 5589 d | 5127 c |

DMR test (0.05) means followed by the same letters are not significantly different from each other

**Table: -6.** Three years averages of paddy yield (kg/ha) of rice genotypes evaluated in Zonal Trials during 1999, 2000 and 2001

| Mutants/ genotypes | 1999 | 2000 | 2001 | Averages | % increase of paddy yield over genotypes |
|---|---|---|---|---|---|
| IR6-25/A | 6816 | 6208 | 6530 | 6518 | ** |
| IR6-25-B | 5683 | 5023 | 5137 | 5281 | 23.42 |
| IR6-15-A | 6143 | 5232 | 6453 | 5942 | 9.69 |
| IR6-15-B | 6310 | 5553 | 6180 | 6014 | 8.38 |
| IR6-15-1 | 6643 | 5769 | 5386 | 5933 | 9.86 |
| IR6-1.0-2 | 6537 | 5607 | 5836 | 5993 | 8.76 |
| IR6-P | 5983 | 5009 | 5358 | 5450 | 19.59 |
| Shadab (Check) | 5823 | 4945 | 5127 | 5298 | 23.03 |

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