Egypt. J. Plant Breed. 26(2):279– 296 (2022)

UTILIZATION OF GAMMA RAYS TO INDUCE PROMISING RICE (*Oryza sativa* L.) MUTANTS

W.H. Elgamal, M.A. Elsayed, M.E. Selim and A.M. Elmoghazy*

Rice Research and Training Center, Field Crops Research Institute, ARC, Egypt.

*Corresponding author: drashrafmoghazy@gmail.com

ABSTRACT

This experiment was conducted at Rice Research and Training Center, Sakha, Kafr Elsheikh, Egypt in 2019, 2020 and 2021 seasons. Six late mature rice genotypes with high yield and excellent grain quality were used. The seeds were treated in 2019 season with three doses of gamma rays (250, 300 and 350 Gy) to study the effect of gamma radiation on morphological, yield and its components and select new promising mutants. The obtained results revealed highly significant variations among studied genotypes due to treatments by the three doses of gamma rays. The hard effect of gamma rays occurred by 350 Gy dose. The earlier genotype was GZ10789-2 for 350 Gy in M3 generation and had the longest panicle in M2 with a dose of 300 Gy. The shortest plant recorded in M3 with 350 Gy for mutant Sakha 108-m, while Sakha Super 300 showed the highest values for panicle weight, panicles plant^{-1} and grain yield plant^{-1} on M2 with 250 Gy and recorded high seed set % in M3. The highest 100-grain weight was recorded in M1 with 250 Gy for the mutant GZ10789-1. The mutants Sakha Super 300-m and GZ10789-2 were the best new genotypes in M3, which performed short duration and semi-dwarf with keeping high yield potential. High positive correlation coefficient was found between grain yield plant^{-1} and days to heading, number of panicles plant^{-1}, panicle weight and 100-grain weight for untreated genotypes with values of 0.347, 0.419, 0.446 and 0.694, respectively. For the mutant genotypes, high positive correlation coefficients were recorded also between grain yield plant^{-1} and each of panicle length, panicle weight and plant height with values of 0.652, 0.412 and 0.446, respectively. From presented results related to correlation, we can report that the mutation breeding could break the common correlation between traits, for example the relation between the yield and days to heading which turned from positive correlation under control to negative correlation after the mutated generations using 350 GY dose of gamma rays.

Key words: ***Rice, Mutation, Gamma Rays, Promising Mutants.***

INTRODUCTION

Rice is the primary cereal food staple for 3.5billionpeople around the world, providing 20%of the calories in their diets (International Rice Research Institute 2018). Global consumption of rice is projected to reach 852 million tons by 2035 (Khush 2013). It is consumed by half of the world's population and cultivated in more than 100 countries in every continent (Ashish *et al* 2018). Mutant varieties breeding is one strategy that has been used for increasing rice yield potential. Radiation-induced mutagenesis is an alternative source for induced genetic variability in rice and itis of great value in the search for materials that can withstand extreme conditions of drought or salinity (Clarke *et al* 2018 and Robertson *et al* 2018). The Joint Food and Agriculture Organization of the United Nations/International Atomic Energy Agency (FAO/IEAE 2018). Mutant Variety Database has registered the release of more than 3200 mutant crop varieties grown throughout the world (Prasanna and Jain 2017), including

821 entries for rice (FAO/IEAE 2018). Mutant rice varieties with differential characteristics for agronomic traits and consumer-defined quality are recognized (Tai 2007, Yan *et al* 2012 and Schiocchet *et al* 2014). The wide use of mutagenesis for plant genetic improvement can be explained by several factors: the varieties produced are readily accepted, new varieties can be developed in a shorter time than by conventional breeding methods and new varieties produced by transgenesis are less favorably accepted (Masoabi *et al* 2018). The production of varieties by mutagenesis requires the selection of large numbers of individuals.

Mutation may be used to establish genetic diversity and as a tool for gene functional studies. Mutation breeding involves the development of new varieties that are characterized by disease resistance, early maturity and high productivity (Shu *et al* 2012). There are different sources of ionizing radiation, viz. Ultraviolet, X-rays, Gamma rays, protons, neutrons, Alpha and beta particles. Gamma rays are commonly used in mutation studies as they have shorter wave length. Thus, they posses more energy per photon and penetrate deep into tissue (Khin 2006 and Zhu *et al* 2006)

In Egypt, Serry and Masoud started mutation-breeding method for rice from more than six decades when they subjected the old rice varieties Nahda and Agami using gamma rays (Serry and Masoud, 1970). High doses of gamma rays caused higher sterility in M1 plants, but low doses of gamma rays in some cases stimulated the growth and yield of M1 plants (El-Keredy 1990). Irradiating seeds with suitable doses of gamma rays produces physiological and genetic changes that may be affected the yield of plant (Hammad and El- Geddawi 1988).

The present study was conducted to induce mutation in six genotypes using three doses of gamma rays, viz 250, 300 and 350 Gy to obtain some variances and selecting promising mutants with favorable characters such as early maturing, semi-dwarf and high yielding rice.

MATERIALS AND METHODS

The present experiment was conducted at the experimental farm of Rice Research and Training Center, Sakha, Kafrelsheikh, Egypt during the three growing summer seasons from 2019 to 2021. Six different genotypes (Dianjingyou1(DJY1), Sakha Super300, Sakha 108, GZ10789-1, GZ10789-

2 and GZ10789-3) with high yield and excellent grain quality were used. On other hand, these genotypes are tall and having late maturity. Due to tall stature, they are prone to lodging. Hence, there is a need to reducing the plant height and growing duration without losing the yield potential and the related characters. Total 1000 seeds of each genotype were irradiated in the Co^{60} source at the National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt in 2019 season with different doses of gamma rays' radiation with rate of 250, 300 and 350 Gy along to 1000 untreaded seeds (control). The irradiated seeds were planted after treatments to get M1, M2 and M3 generations and selection was practiced during the growing seasons at the farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt.

In 2019 season, irradiated and non-irradiated seeds of the six genotypes were grown on 1^{st} May as M_1 generation. The experimental design was split plot design with three replications, the main plots were devoted to the doses of gamma rays and sub plots were devoted to the six genotypes. Each sub – plot consisted of 25 rows, 5 m long, 20 cm between rows and 20 cm between hills. At harvesting time on October, the total plant number per plot was scored and 50 plants of each plot were selected to estimate the average of rice characteristics in M_1. In 2020 season, bulked seed from each dose were sown on 1^{st} May to give M_2 generation in the same design of experiment. At harvesting time, the total plant number per plot was scored and 50 plants of each plot were selected to estimate the average of rice characteristics in M_2. In 2021 season, bulked seed from each dose were sown on 1^{st} May to give M_3 generation in the same design of experiment. At harvesting time, the total plant number per plot was scored and 50 plants of each plot were selected to estimate the average of rice characteristics in M3.

All the cultural practices were done according to recommendations described by RRTC (2018). The data were recorded on morphological and yield characters as recommended by Standard Evaluation System (SES) of IRRI (2014). Data were recorded on individual plant base, the studied characters were heading date, plant height, number of panicles per plant, panicle length, panicle weight, seed set%, 100-grain weight, grain yield per plant. The statistical analysis of variance for split plot design was done as described by Steel *et al* (1997) using GenStat computer software package, Nineteenth Edition.

RESULTS AND DISCUTION

Analysis of variance

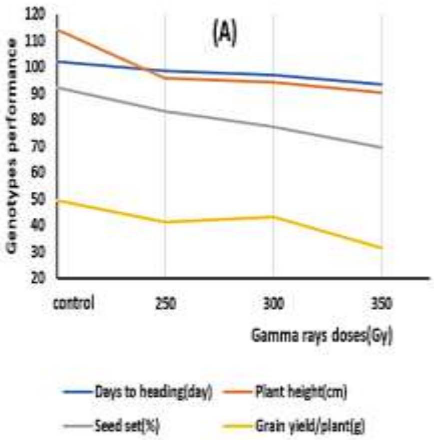
The mean squares due to genotypes and treatments (control and three doses of gamma rays) as well as their interaction were significant and highly significant for all studied traits of the mutated generations, indicating the existence of genotypic differences among studied genotypes and effective doses of gamma rays on genotypes (Table 1).

Table 1. Mean squares and analysis of variance model for all studied traits under all experimental treatments during three years 2019,2020 and 2021

	Source of variation	df	Days to heading	Panicle length	Panicles Plant1^{-1}	Panicle weight	Plant height	Seed set (%)	Yield Plant $^{-1}$	100-G. Weight
M1 (2019)	Reps	2	2.4879	1.1844	5.334	0.0237	0.579	17.322	16.949	0.0160
	Genotypes (G)	5	235.62**	12.206**	146.9**	8.1412**	1291.7**	781.64**	287.67**	1.2658**
	Treatments (T)	3	157.74**	34.542**	92.72**	5.9515**	2007.4**	1682.1**	1012.8**	0.1476**
	(G) * (T)	15	9.937**	4.1174**	5.868**	1.2725**	75.78**	333.65**	57.13**	0.0956**
	Error	46	0.8185	0.3396	1.011	0.0479	1.441	3.15	3.899	0.0014
M2 (2020)	Reps	2	0.244	1.8946	2.1125	0.4471	5.146	7.89	84.483	0.0010
	Genotypes (G)	5	238.82**	9.8321**	47.54**	4.3595**	1498.7**	261.74**	380.76**	0.5139**
	Treatments (T)	3	79.202**	37.396**	47.78**	3.3881**	222.8**	804.19**	241.20**	0.2928**
	(G) * (T)	15	22.481**	2.3126**	10.67**	1.2834**	174.6**	55.08**	37.01**	0.0536**
	Error	46	1.281	0.3533	0.7975	0.0395	2.581	1.565	3.002	0.0024
M3 (2021)	Reps	2	7.691	0.969	2.06	0.185	0.20	9.875	66.85	0.0013
	Genotypes (G)	5	174.77**	13.181**	66.81**	2.5552**	1025.8**	57.273**	51.62**	0.6373**
	Treatments (T)	3	333.37**	43.665**	101.4**	3.1431**	1033.9**	243.80**	313.49**	0.3190**
	(G) * (T)	15	13.747**	7.989**	2.913*	0.4532**	226.27**	34.282**	37.85**	0.1013**
	Error	46	1.713	1.033	1.379	0.1034	10.87	4.382	7.389	0.0042

The doses of gamma rays ranging from 200 to 400 Gy with an interval of 50 Gy were taken in previous studies by Achal *et al* (2020). The results of the present study agreed with El-Refaee *et al* (2017) and Ali *et al* (2022) who found that the used doses are effective on rice genotypes for most studied traits.

The gamma radiation doses affected all genotypes for all studied traits comparing with the control. The genotypes performance was decreased during 2019 season (M1) due to gamma rays' treatment. By contrast, the doses 350 and 300 Gy had more effect on genotypes than 250 Gy for all studied traits as shown in Figure 1.



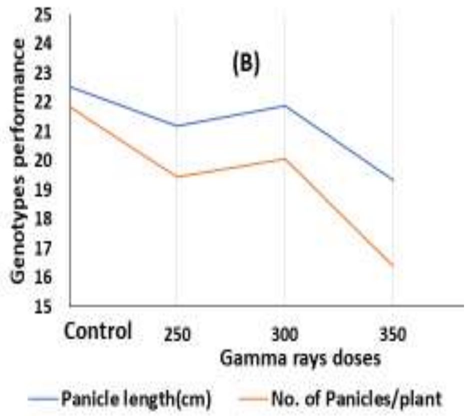
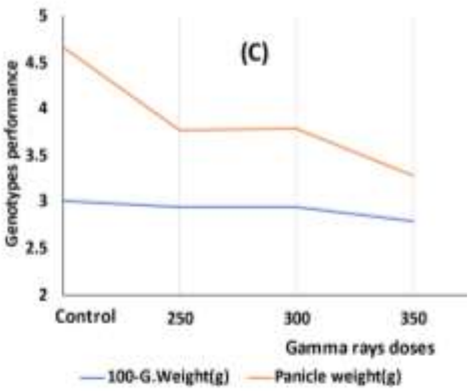


Fig. 1. Effect of gamma ray doses on the genotypes performance in 2019 (M1). A: Effect of gamma rays on days to heading, plant height, seed set% and grain yield/plant; B: panicle length (cm) and no. of panicles/plant; C: 100-grain weight (g) and panicle weight (g).



Similarly Figure 2 illustrates a similar trend of Gamma radiation doses which were effective on the genotypes for all studied traits comparing with the control. All studied genotypes performance was decreased during 2020 season (M2) affecting by gamma rays; the doses 350 and 300 Gy had more effect on genotypes than 250 Gy for all studied traits.

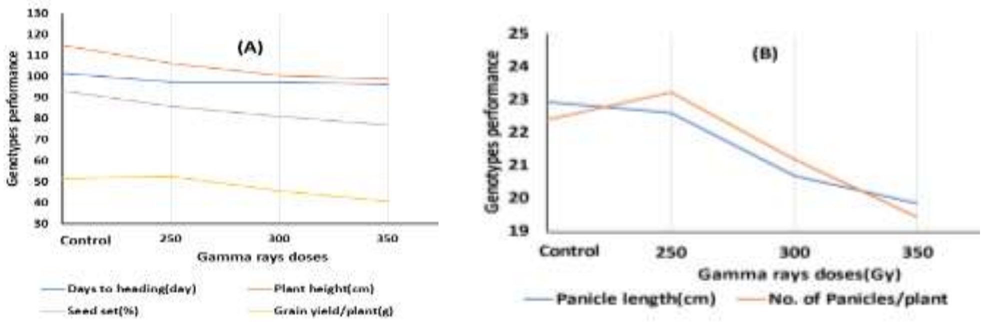
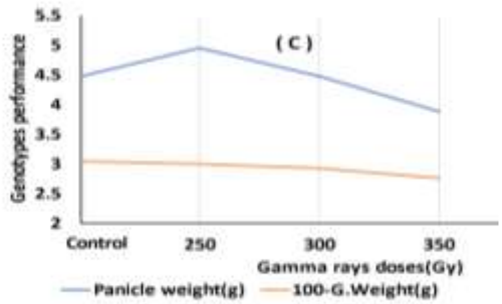


Fig. 2. Effect of gamma ray doses on the genotypes performance in 2020 (M_2). A: Effect of gamma rays on days to heading, plant height, seed set% and grain yield/plant; B: panicle length (cm) and no. of panicles/plant; C: panicle weight (g) and 100-grain weight (g).



The results presented in Figure 3 revealed the effect of gamma rays on rice genotypes for all studied traits during 2021 season (M_3). The effect of gamma doses was transmitted from M_1 to M_3 and the harder effect was for the doses 350, 300 and 250 in a descending order. These results are in the same trend with results obtained by Ali *et al* (2022), El-Refaee *et al* (2017) and Pallaie *et al* 1993, they reported that Gamma rays were effective for inducing mutation in rice and could be useful to induce a variation and produce a new promising -mutated genotypes.

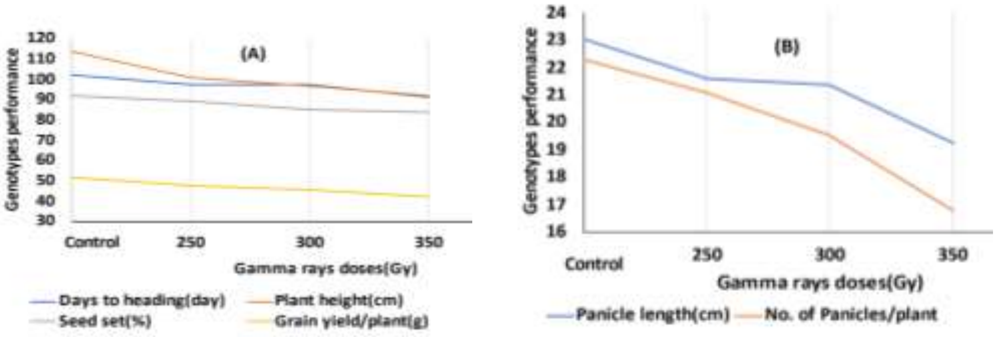
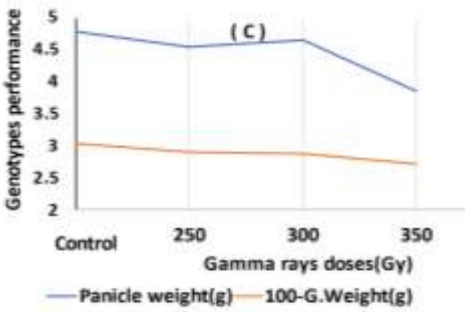
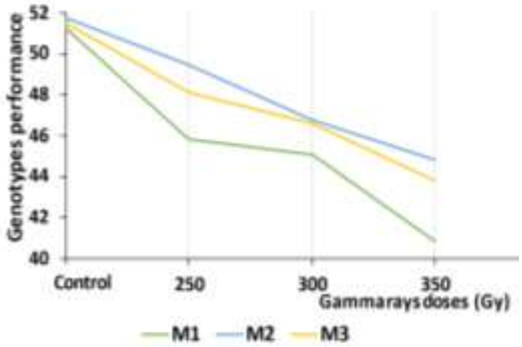


Fig. 3. Effect of gamma rays' doses on the genotypes performance in 2021 (M_3). A: Effect of gamma rays on days to heading, plant height, seed set% and grain yield/plant; B: panicle length (cm) and no. of panicles/plant; C: panicle weight (g) and 100-grain weight (g).



Gamma rays affect on genotypes for all the three mutated generations which decreased all genotypes performance by using any dose comparing with the control. From the Figure (4), the biggest gab between control and the mutated generations occurred in the first generation with high drop for the doses 250 Gy and 350 Gy. The second mutated generation (M_2) followed the first mutant generation (M_1) and the third mutated generation (M_3), respectively.

Fig. 4. Effect of gamma rays' doses on genotypes during three seasons 2019 (M_1), 2020 (M_2) and 2021 (M_3).



The mean values of days to heading, plant height and panicle length are presented in Table (2). The data obtained with respect to days to heading, revealed that in comparison with the control, the gamma ray dosses accelerated the heading occurred gradually by increasing the dosses of gamma rays and the earliest heading was for GZ10789-2 with 350 Gy in M3 with a value of 88.42 days compared with 99.82 days for the control on the same season 2021. The obtained results are in agreement with Gomma *et al* (1995) and El-Refaee *et al* (2017).

Plant height was decreased by increasing gamma radiation doses and the hardest effect of dosses was done by 350 Gy on all studied genotypes during the three mutated generations. The shortest genotype was Sakha 108 with a value of 76.82 cm with 350 Gy in M2 generation compared with 92.27 days under control on the same season (2020). In addition, panicle length at maturity stage was decreased by increasing the dose of gamma rays. In general, the data indicated clear differences between the control and the treatments 300 and 350 Gy for all generations (M1-M3). The most effective dose of gamma rays of panicle length was 350 Gy treatment on Sakha 108 with a value of 16.88 cm in 2021 season (M3) compared with 22.61cm for untreated Sakha 108. While the longest panicle was for GZ10789-2 which treated with 300 Gy in M2 with a value of 24.10 cm. In general, there was an inconsistent trend in mean values of different treatments for panicle length. These results are in agreement with reports of Abdallah (2000) and El-Refaee *et al* (2017).

Table 2. Mean performance of studied genotypes for days to heading, panicle length and panicles/plant under control and three doses of gamma rays during M_1, M_2 and M_3 generations

Genotypes	Treatment	Days to heading			Plant height			Panicle length		
		M1	M2	M3	M1	M2	M3	M1	M2	M3
DJY1	control	104.5	105.6	103.2	119.2	119.78	115.97	22.9	22.52	23.05
	250	98.29	93.14	93.33	93.41	92.94	86.44	20.54	21.15	21.06
	300	92.62	95.84	94.82	87.59	96.19	82.81	21.06	20.64	20.51
	350	95.85	92.45	92.77	91.48	89.12	86.00	16.57	17.95	18.40
GZ10789-1	control	99.74	99.93	100.1	111.5	113.79	115.91	23.08	23.89	21.95
	250	96.6	96.96	96.15	100.33	111.52	92.94	22.11	22.08	19.41
	300	96.84	97.36	96.22	97.63	100.45	100.85	21.46	22.78	22.15
	350	93.78	98.67	90.77	84.48	100.41	87.12	18.71	20.67	20.70
GZ10789-2	control	100.7	98.96	99.82	115.0	116.45	109.45	24.50	24.27	24.61
	250	97.21	96.4	96.92	93.17	108.73	111.12	22.89	22.56	24.3
	300	97.24	96.77	96.96	92.27	108.53	103.14	21.82	24.10	22.58
	350	93.15	99.08	88.42	88.67	105.83	100.50	17.93	20.72	19.62
GZ10789-3	control	99.1	99.29	98.15	125.13	125.47	122.77	23.56	24.32	24.25
	250	97.4	96.92	96.45	109.43	121.17	117.78	22.11	23.22	23.61
	300	95.81	94.33	95.52	115.41	112.85	113.57	22.67	22.45	21.49
	350	90.22	89.78	89.52	108.87	104.85	100.71	17.88	19.793	18.52
Sakha 108	control	97.77	96.63	96.42	90.65	92.27	91.87	20.91	21.74	22.61
	250	95.6	95.46	97.44	77.22	79.25	88.34	21.28	22.08	21.38
	300	92.03	94.89	91.74	82.81	79.45	87.49	23.05	22.85	21.94
	350	93	97.63	89.78	79.46	76.82	79.98	20.45	20.71	16.88
Sakha Super 300	control	111.7	109.8	113.3	123.2	121.5	127.2	20.27	20.89	21.77
	250	106.4	105.9	104.4	102.2	113.8	105.2	18.24	22.47	19.58
	300	104.7	102.1	101.0	95.41	100.1	98.08	21.36	21.23	20.36
	350	105.8	100.7	96.78	89.26	85.15	85.56	17.47	18.38	18.41
LSD 0.05		1.487	1.86	2.151	0.957	0.5285	1.973	0.641	0.957	0.977

The results presented in Table (2) showed that the gamma ray treatments had different effects depending on the dose for number of panicles/plant. Differences were observed between the control and most of the other treatments on one hand and among the treatments on the other hand. The doses of gamma rays decreased the number of panicles/plant. The highest effect of gamma doses observed on the lowest number of panicles/plant (14.44) under 250 Gy for GZ10789-2 during 2019 season (M1). On the other hand, the highest number of panicles/ plant was recorded for Sakha Super 300 under 250 Gy on M2 generation with value 25.51 compared with 24.37 for untreated Sakha super 300. These results indicated that the effectiveness of gamma rays was found with the increase of the doses with either plus or minus effect. These results are in close agreement with those obtained by El-Degwy (2013). Regarding Panicle weight there is a big difference between the treated genotypes and the control; the highest effect follows the high dose of gamma rays by decreasing the panicle weight. By contrast, the lowest value of panicle weight was recorded on the genotype DJY1 treated with 350 Gy in 2021 season(M3) with a value of 2.16 g. While the highest value of panicle weight (5.06 g) was observed for Sakha Super 300 treated with 250 Gy without difference by the control(untreated) during 2019 season. The obtained results are agreed with the results reported by Abdallah (2000) and Ali *et al* (2022).

Its clear from Table 3 that the seed set percentage was affected by the gamma rays treatments negatively. The seed set percentage was decreased by increasing the dose of gamma rays. The lowest seed set was 46.79% for GZ10789-2 under 350 Gy during 2019 season (M1). While the highest rate of seed set was 93.83% for Sakha Super 300 with 250 Gy treatment without insignificant differences to the control (93.81%). Similar results were obtained by Abdallah *et al* (2009) and Abo-Youssef *et al* (2018).

Table 3. Mean performance of studied genotypes for panicle weight, plant height and seed set% under control and three doses of gamma rays during M_1, M_2 and M_3 generations

Genotypes	Treatment	Panicle weight (g)			Panicles/Plant			Seed set%		
		M1	M2	M3	M1	M2	M3	M1	M2	M3
DJY1	control	3.460	3.517	4.030	24.4	25.45	24.17	92.64	91.35	92.88
	250	2.621	3.357	3.907	23.56	25.33	24.12	87.76	78.18	88.41
	300	3.117	3.643	3.583	22.53	20.85	22.22	82.67	82.74	81.09
	350	2.813	2.860	2.161	19.11	21.45	18.33	71.61	67.49	76.15
GZ10789-1	control	4.993	4.353	5.217	19.25	20.19	19.94	91.24	94.19	92.97
	250	3.853	4.347	4.127	16.59	19.11	20.15	78.93	89.21	89.42
	300	2.963	3.487	4.122	18.21	19.27	17.97	66.03	80.94	81.25
	350	3.455	3.881	3.927	14.76	17.07	15.21	79.25	78.98	81.79
GZ10789-2	control	4.86	4.673	5.04	17.12	18.79	19.46	90.96	92.23	92.57
	250	2.913	5.003	5.593	14.44	22.58	17.75	84.44	91.12	89.31
	300	3.013	4.713	4.907	15.87	24.61	16.48	76.78	81.55	80.91
	350	3.443	4.317	4.28	12.52	21.11	14.77	46.79	80.12	79.08
GZ10789-3	control	5.497	5.331	5.113	21.95	21.78	21.77	91.32	68.79	86.85
	250	3.841	4.217	4.083	14.59	19.86	19.52	66.23	70.56	80.97
	300	4.462	4.787	4.940	18.88	20.45	18.64	73.63	73.48	81.56
	350	2.660	3.732	3.867	13.45	18.46	13.92	48.67	71.31	79.67
Sakha 108	control	4.117	4.217	4.377	24.33	23.77	23.78	90.93	86.77	91.84
	250	3.907	4.83	4.317	24.47	25.03	23.16	88.29	90.12	91.95
	300	3.547	3.773	4.937	24.15	20.56	21.79	72.46	80.01	85.81
	350	3.113	3.167	3.353	18.89	19.55	17.22	59.63	80.20	82.78
Sakha Super 300	control	5.072	4.823	4.923	24.12	24.37	24.55	96.14	79.44	93.81
	250	5.061	4.427	4.193	21.12	25.51	24.78	91.83	92.76	93.83
	300	4.667	5.045	4.493	20.8	21.06	21.74	81.74	93.12	86.74
	350	3.593	3.227	3.913	17.74	18.98	18.25	70.22	74.76	70.38
LSD 0.05		1.487	0.361	0.3266	0.5285	1.653	1.468	1.93	2.917	3.44

Results in Table 4 showed that the treatments of gamma rays affected on all studied genotypes by different degrees depending on doses and the mutated generation for grain yield/plant and 100-grain weight. Regarding to grain yield /plant, the results indicated that the mean values of grain yield/ plant decreased by increasing the gamma rays' dose up to 350 Gy, the lowest value of grain yield/plant recorded for GZ10789-1 (27.11 g) with the dose 350 Gy during M1.

Table 4. Mean performance of studied genotypes for Grain Yield/Plant and 1000_G weight under control and three doses of gamma rays during M_1, M_2 and M_3 generations

Genotypes	Treats	Grain yield/Plant (g)			100-grain weight (g)		
		M1	M2	M3	M1	M2	M3
DJY1	control	45.27	46.97	45.5	2.79	2.82	2.80
	250	44.46	54.71	48.42	2.55	2.72	2.41
	300	39.86	44.78	48.46	2.51	2.51	2.69
	350	32.46	37.08	41.41	2.20	2.43	2.31
GZ10789-1	control	53.97	52.82	52.43	3.42	3.58	3.42
	250	39.79	43.05	37.85	3.29	3.15	3.06
	300	40.15	44.93	45.54	3.03	3.00	2.96
	350	27.11	31.12	43.41	2.50	2.50	2.38
GZ10789-2	control	52.27	55.64	55.64	2.91	3.00	3.03
	250	42.95	53.20	50.06	2.61	2.97	3.28
	300	43.48	51.27	51.81	2.94	2.88	3.03
	350	36.82	50.82	44.44	2.55	2.76	2.92
GZ10789-3	control	45.69	47.72	49.80	3.29	3.07	3.23
	250	31.58	41.30	47.46	3.38	2.93	2.93
	300	41.45	41.20	50.09	3.17	2.85	2.80
	350	29.21	35.42	40.30	2.92	2.78	2.48
Sakha 108	control	46.97	48.97	48.93	2.79	2.91	2.89
	250	41.15	50.17	51.45	2.75	3.00	2.83
	300	43.19	39.48	42.46	2.79	2.96	2.87
	350	36.84	43.67	40.74	2.78	2.82	2.43
Sakha Super 300	control	53.12	56.27	56.59	2.86	2.96	2.85
	250	48.56	55.67	47.55	2.86	3.00	2.86
	300	51.06	50.67	50.39	2.90	2.96	2.92
	350	46.21	50.44	40.48	2.83	2.78	2.75
LSD 0.05		3.487	3.245	2.848	0.067	0.062	0.081

While the highest grain yield/plant recorded for Sakha Super 300 (55.67g) in the second mutated generation (M2) compared with 56.27g for untreated Sakha super 300. On the other hand the results showed that the yield had a great drop in M1 compared with control then began to recovery during mutated generations M2 and M3 due to selection, adaptation and stability. Thes results showed a high similarity with results reported in previous studies by Shehata *et al* (2009), El-Refaee *et al* (2017), Kato *et al* (2020) and Ali *et al* (2022).

Regarding 100-grain weight, the results showed some differences between the control and the gamma rays' treatments. However, the range extremes indicated the possibility of selecting promising heavy grain mutants from the different doses of gamma rays of the studied rice genotypes. The heaviest grain weight was recorded on the low doses of gamma rays 250 Gy and 300 Gy, while the light weight of grains was on 350 Gy dose. The highest 100-grain weight was 3.29 g for GZ10789-1 compared with untreated genotype with a value of 3.42 g. These results were in agreement with those reported by Saragawa and Soni (1993) and Sanjeev (2000). In conclusion the mutated Sakha Super 300 and GZ10789-2 were the best new Mutated genotypes after three generations (M3) which performed short duration and dwarfism with keeping high yield potential.

Correlation coefficient

The results in Table 5 showed the estimates of correlation coefficients among all studied traits to compare between two cases; the untreated genotypes (above) and mutant genotypes after three generation (below). The results revealed high positive correlation between grain yield plant^{-1} and each of days to heading, number of panicles plant^{-1}, panicle weight and 100-grain weight for untreated genotypes with values 0.347, 0.419, 0.446 and 0.694, respectively. For the mutated genotypes, high positive correlations were recorded also between grain yield plant^{-1} and each of panicle length, panicle weight and plant height with values of 0.652, 0.412 and 0.446, respectively. While a negative correlation was recorded between grain yield and both days to heading and number of panicles for the mutant genotypes with values of -0.457 and -0326, respectively. From presented data related to correlation, we can report that the mutation breeding could break the common correlation between traits, for example the relation between the yield and days to heading which turned from positive correlation under control to negative correlation after three mutated generations using 350 GY dose of gamma rays.

Table 5. Correlation coefficients among the studied traits after Gama ray treatments M3 (above) and untreated genotypes (below).

	HD	PL	NPP	PW	PH	F %	GY	100GW
HD	1	-0.514	0.447	-0.033	0.580	0.132	0.347	-0.349
PL	-0.122	1	-0.673	0.192	0.198	-0.143	-0.037	0.348
NPP	0.617	-0.365	1	-0.496	-0.058	-0.054	0.419	-0.577
PW	-0.380	0.179	-0.795	1	0.367	-0.261	0.446	0.501
PH	-0.751	0.239	-0.857	0.581	1	-0.156	0.171	0.174
F %	0.042	0.698	0.207	-0.378	-0.346	1	0.106	0.001
GY	-0.457	0.652	-0.326	0.412	0.446	0.267	1	0.238
100GW	-0.081	0.904	-0.494	0.525	0.261	0.470	0.694	1

Table labels: Control (untreated) — top and right; Mutations in M3 by 350Gy — left and bottom.

HD: heading date, PL: panicle length, NPP: number of panicles/plant, PW: panicle weight, PH: plant height, F%: fertility percentage, GY: grain yield/plant and100GW: 100 grains weight.

REFERENCES

Abdallah, A. A. (2000). Breeding studies on rice (*Oryza sativa* L.). Ph.D. Thesis, Department of Agronomy, Faculty of Agriculture, Menofiya University.

Abdallah, A. A., M. H. Ammar, S. M. Shehata and A. F. Abdelkhalik (2009). Agronomic and molecular evaluation of Induced mutants in rice (Oryza sativa L.). African Journal of Biotechnology, 8(22), 6082 – 6090.

Abo-Youssef, M.I., M. S. Abd El aty, I. A. Talha and S. A. Hammoud (2018). Response of some rice varieties to different doses of X rays on the yield and its related characters. Journal of Plant Biotechnology, 4: 105-114.

Achal, K., N. R. Chakraborty and B. K. Das (2020). Immediate radiation effects and determination of optimal dose of gamma rays on non-basmati aromatic rice (*Oryza sativa* L.) of eastern India. Journal of Experimental Biology and Agricultural Sciences, 8(5): 586 – 604

Ali, A. A., O. A. Galal, A. M. Elmoghazy and M. M. Abd Elrazek (2022). Use of Gamma rays for inducing short stature and early maturing mutants in Egyptian Jasmine rice variety. Fresenius Environmental Bulletin, 31(6):5783-5787.

Ashish, K. T., D. Sharma, B. K. Das, V. Kumar, S. Parmeshwar, B. Samrath and S. Singh (2018). Improvement of Traditional Local Rice Varieties through Induced Mutations Using Gamma Radiations. Online International Interdisciplinary Research Journal, ISSN 2249-9598, Volume-08, Dec. Special Issue (02).

Clarke, D., A. N. Lázár, A. F. Saleh and M. Jahiruddin (2018). Prospects for agriculture under climate change and soil salinisation. In: Nicholls RJ, Hutton CW, Adger WN, Hanson SE, Rahman M, Salehin M (eds) Ecosystem services for well-being in deltas. Palgrave Macmillan, Cham, pp 447–467.

El-Degwy, I. S. (2013). Mutation induced genetic variability in rice (*Oryza sativa* L.), *Int.* J. Agri.Crop Sci., 5(23): 2789 – 2794.

El-Keredy, M. S. (1990). Induced useful mutations of some field crops in Egypt. Proc. 4th Conf. Agron., Cairo, l: 237-253.

EL-Refaee, Y. Z., A. A. Hadifa and R. A. S. EL-Shafey. (2017). Induction of genetic variability for some agronomic traits and blast disease. J. Plant production, Mansoura Univ., 8(12):1373-1381.

Food and Agriculture Organization of the United Nations/International Atomic Energy Agency (FAO/IAEA) (2018). Mutant Variety Database. http://mvdiaeaorg/ Cited 5 October 2018

Gomaa, M. E., A. A. El-Hissewy; A. B. Kattab and A. A. Abd-Allah. (1995). Days to heading and plant height of rice (*Oryza sativa* L.) affected by gamma-rays. Menofiya J. Agric. Res., 20 (2): 409-421.

Hammad, D.H.A. and I.H. EL-Geddawi (1988). Effect of gamma irradiation on yield and chemical constituents of sugar beet. Paper presented at the fourth conf. of Nuclear Sciences and application 6-10 March.

IRRI (2014). Standard Evaluation System for rice. 3rd Edition, International Rice Testing Program.

IRRI (2018). World rice statistics online.

Kato, H., F. Li and S. Akemi (2020). The selection of gamma-ray irradiated higher yield rice mutants by directed evolution method. Plants, (9): 1004- 1020; doi:10.3390/plants9081004.

Khin, T.N. (2006). Rice mutation breeding for varietals improvement in Myanmar. Plant Mutation Reports, 1(1): 34-36.

Khush, G.S. (2013). Strategies for increasing the yield potential of cereals: case of rice as an example. Plant Breed, 132: 433–436. https://doi.org/10.1111/pbr.1991

Masoabi, M., J. Lloyd, J. Kossmann and C. D. Vyver (2018). Ethyl methanesulfonate mutagenesis and in vitro polyethylene glycol selection for drought tolerance in sugarcane (*Saccharum spp*.). Sugar Tech., 20:50–59. https://doi.org/10.1007/s12355-017-0524-8.

Pialli, M.A., M. Subramanian and S. Murugan (1993). Effectiveness and efficiency of gamma rays and EMS for chlorophyll mutation on upland rice. Annals of Agricultural Research, 14 (3): 302-305.

Prasanna, S. and S. M. Jain (2017). Mutant resources and mutagenomics in crop plants. Emir J Food Agric, 29:651–657. https://doi.org/10.9755/ejfa.

Robertson, A.D., Y. Zhang, L.A. Sherrod, S.T. Rosenzweig, L. Ma, L. Ahuja and M. E. Schipanski (2018). Climate change impacts on yields and soil carbon in row crop dryland agriculture. J Environ Qual 47:684–694. https://doi.org/10.2134/jeq2017.08.0309

RRTC (2018). Proceeding of the 10th National program work shop final results of (2017).

Sanjeev, S. (2000). Gamma-rays induced mutating in Basmati rice (*Oryza sativa* L.). Indian Journal of Genetics and Plant Breeding, 66(2): 143-144.

Saragawa, A. K. and D. K. Soni (1993). Induced genetic variability in M1 and M2 population of rice (*Oryza sativa* L.). Advances in Plant Sciences, 6(1): 24-33.

Schiocchet, M. A., J. A. Noldin, J. V. Raimondi, A. T. Neto, R. Marschalek, E. Wickert, G. N. Martins, E. Hickel, R. Knoblauch, K. K. Scheuermann, D. S. Eberhardt and A. D. Andrade (2014). SCS118 Marques - New rice cultivar obtained through induced mutation. Crop Breeding and Applied Biotechnology 14: 68-70

Serry, E.S. and M. A. Masoud (1970). Mutations induced by irradiation and their significance in rice breeding. Rice Research Committee, Ministry of Agriculture and Agrarian Reform, 24th-26 th Jan, 1970, Egypt.

Shehata, S. M., M. H. Ammar, A. F. Abdelkhalik and B. A. Zayed (2009). Morphological, molecular and biochemical evaluation of Egyptian jasmine rice variety and its M5 derived mutants, *Afric. J. Biotech.*, 8(22): 6110 – 6116.

Shu, Q.Y., Forster, B.P. and H. Nakagawa (2012). Principals and applications of plant mutation breeding. In: Shu, Q.Y., Forster, B.P. and Nakagawa, H. Eds. Plant Mutation Breeding and Biotechnology. Wallingford CABI: 301-325.

Steel, R.G.D., J.H. Torrie and D.A. Dicky (1997). Principles and Procedures of Statistics, A Biometrical Approach. 3rd Edition, Hill M.G., Inc. Book Co., New York, 352-358.

Tai, T. H. (2007). Induced mutations in rice (*Oryza sativa* L.). Isr J. Plant Sci., 55:137–145. https://doi.org/10.1560/IJPS.55.2.137

Yan, W., B. Hu, Q. Zhang, L. Jia, A. Jackson, X. Pan, B. Huang and Z. C. Deren (2012). Short and erect rice (ser) mutant from 'Khao Dawk Mali 105' improves plant architecture. Plant Breed, 131:282–285. https:// doi.org/10.1111/j.1439-0523.2011.01943.

Zhu, X. D., H.Q. Chen and J.X. Shan (2006). Nuclear techniques for rice improvement and mutant induction in China National Rice Research Institute. Plant Mutation Reports, 1: 25-28.

إستخدام أشعة جاما في إستحداث طفرات أرز مبشرة

وليد حسن الجمل، محمود عبدالله السيد، محمود سليم وأشرف محمد المغازي*

قسم بحوث الأرز، معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، مصر

أجريت هذه الدراسة بالمزرعة البحثية بقسم بحوث الارز بسخا كفرالشيخ خلال ثلاث مواسم صيفية (من ٢٠١٩ إلي ٢٠٢١). تم إستخدام ستة تراكيب وراثية مختلفة عالية المحصول و ذات صفات جودة عالية ولكنها طويلة ومتأخرة النضج. تم معاملة البذور بثلاث جرعات مختلفة من أشعة جاما بتركيزات (٢٥٠، ٣٠٠ و٣٥٠ جراي) في موسم ٢٠١٩. بهدف دراسة تأثير أشعة جاما علي الصفات الظاهرية والمحصول ومكوناتة لثلاث أجيال من العشائر الطافرة وإنتخاب تراكيب وراثية طافرة مبشرة. النتائج المتحصل عليها تشير الي تباينات عالية المعنوية لكل الصفات المدروسة تعود الي المعاملات بالثلاث جرعات من أشعة جاما. التأثير الأكثر تأثير لأشعة جاما حدث بواسطة الجرعة ٣٥٠جراي. التركيب الوراثي الطافر GZ10789-2 كان الأكثر تبكيرا بين كل التراكيب الوراثية في الجيل الطفري الثالث وأظهر أطول سنابل في الجيل الطفري الثاني مع الجرعة ٣٠٠جراي. أقصر طول نبات سجل في الجيل الثالث مع الجرعة ٣٥٠جراي للتركيب الوراثي الطافر سخا ١٠٨، بينما أظهر التركيب الوراثي الطافر لسخا سوبر ٣٠٠ القيمة الأكبر لوزن السنبلة، عدد السنابل لكل نبات ومحصول النبات الفردي في الجيل الطفري الثاني عند المعاملة ٢٥٠ جراي وسجل أعلي نسبة عقد للبذور في الجيل الطفري الثالث. أعلى وزن لل ١٠٠ حبة سجل في الجيل الطفري الأول مع جرعة ٢٥٠ جراي للتركيب الوراثي الطفري GZ10789-2. التراكيب الوراثية الجديدة سخا سوبر ٣٠٠ و GZ10789-2 كانا أفضل التراكيب الوراثية الطافرة بعد ثلاثة أجيال طفرية بتوصيف أقل عمرا

وأقصر طولا مع الاحتفاظ بالقدرة المحصولية العالية. كان هناك معامل إرتباط موجب عالي المعنوية بين محصول الحبوبللنبات الفردي و كل من عدد الايام اللازمة للتزهير، عدد السنابل/نبات، وزن السنبلة ووزن ال١٠٠ حبة بالنسبة للتراكيب الوراثية غير المعاملة بقيم ٠,٣٤٧ ، ٠,٤١٩ ، ٠,٤٤٦ و٠,٦٩٤ علي التوالي. بالنسبة للتراكيب الوراثية الطافرة سجل إرتباط موجب عالي بين محصول الحبوب للنبات وبين كل من طول السنبلة، وزن السنبلة وطول النبات بقيم ٠,٦٥٢، ٠,٤١٢ و ٠,٤٤٦ علي التوالي. بينما سجلت قيم إرتباط سالب بين محصول الحبوب للنبات الفردى وعدد الأيام اللازمة للتزهير وعدد السنابل للتراكيب الوراثية الطافرة بقيم -٤٥٧,. و -٣٢٦,.علي التوالي.من النتائج المتعلقة بالارتباط يمكن الإستنتاج أن التربية بالطفرات يمكنها كسر الارتباط الشائع بين الصفات، علي سبيل المثال العلاقة بين المحصول وعدد الأيام اللازمة للتزهير حيث تحول الارتباط بينهم من موجب قبل المعاملة الي إرتباط سالب بعد المعاملة بأشعة جاما ٣٥٠ جراي والإنتخاب في الأجيال الطفرية.

المجلة المصرية لتربية النبات ٢٦(٢): ٢٧٩- ٢٩٦ (٢٠٢٢)