Minufiya J. Agric. Res. Vol.40 No. 4(1): 947 – 957 (2015)

MUTATION BREEDING FOR REDUCED SHORT STATURE, HIGH GRAIN YIELD UNDER WATER STRESS CONDITIONS IN RICE (Oryza Sativa L.)

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(Received: Jan. 4, 2015)

ABSTRACT: *The present study was carried out at the farm of the Rice Research and Training Center, Sakha Agriculture Research Station, Kafr El-Sheikh, Egypt during 2011, 2012 and 2013 rice growing seasons. Three rice varieties viz. Sakha 105, Sakha 102 and Giza 178 were used. Dry seeds of the above maintained rice varieties were treated with different doses of gamma rays (100 – 200 – 300 and 400 Gy) for raising M_1 generation. M_1 plants were established in the 2011 season to be grow as M_2 generation in 2012 season and the selected mutants have been advanced to M_3 generation in 2013 rice growing season. The results of the selected M_3 mutants indicated that there are significant variations between the mutants and their parents for plant height, grain yield as well as drought tolerance. It could be concluded that mutation technique have shown to be very useful in rice improvement, especially for characters controlled by closely linked` genes that are difficult to break by gene recombination. Using irradiation by gamma ray exhibited different genetic variability such as semi-dwarf, early heading and high grain yield. The induced genetic variability was more important as it can be used directly in rice breeding program through selection or by hybridization with the commercial cultivars.*

Key words: *Gamma-rays, drought tolerance, mutation, rice, yield and yield components.*

INTRODUCTION

Rice (*Oryza sativa* L.) is grown on 0.60 million hectares in Egypt which is about 20% of the total cultivated area in the summer season. All the area are cultivated by different japonica, indica and japonica /indica rice varieties which are highly acceptable to the rice farmers. The average grain yield is about 4.0 tones/feddan which mean almost 10.0 t/ha (TTP, 2013). Continuous efforts are needed by the plant breeders to increase or evolve the high yielding varieties of rice to meet the local as well as export requirements. Significant achievements have been made in developing new rice varieties which possess desirable characters. Gamma rays can be used to enhance the rate of genetic variability because the spontaneous mutation rate is very slow which previously has prevented breeders from using them in plant breeding programs (Jan *et al.*2013). However, the major drawbacks of these local varieties are that they grow tall and consequently lodge on fertile soil at the time of grain filling resulting in serious yield losses such as Sakha 102,Sakha 105 slender grain yield and Giza 178 that it grow very well under both normal and salinity conditions but it has indica grain type or indica short grain shape .The use of induced mutation has been considered as an appropriate method for developing short statured mutants for Sakha 102, high yield for Sakha 105 and excellent grain shape for Giza 178 accompanied by high yield. The results with regard to yield and its components of the above mentioned varieties are discussed in this paper.

MATERIALS AND METHODS

The present investigation was carried out at the Farm of Rice Research and Training Center (RRTC), Sakha Agriculture Research Station, Kafr El-Sheikh, Egypt, during 2011, 2012 and 2013 rice growing seasons to improve some characters in Sakha 105, Sakha 102 and Giza 178. In 2011 season the treated seeds of the three varieties were directly sown after treatments in germination plastic plates in order to raise M_1 plants. Seeds of three rice varieties Sakha 105, Sakha 102 and Giza 178 were treated with 100, 200, 300and 400 Gy of gamma rays from Co^{60} source at the National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt .

In 2012 season, the M_2 generation was planted in the field in randomized complete block design with three replications, each replicate had 30 rows per treatment and all the recommended agronomic practices were done during the growing season. Selection was carried out in M_2 generation which was raised from the seeds of the first formed panicle of each plant in each treatment.

In 2013 season M_3 generation was raised under normal condition to confirm the mutated traits selected from M_2 generation. These mutants were tested also under water stress conditions, to select the best performance under shortage of irrigation water.

The seedlings were transplanted at a distance of 20x20 cm between rows and hills with only seedling per hill. The fertilizer was applied at the rate of 69 kg N/fed. in the form of urea and 100 kg/fed. Superphosphate. The yield and its components were recorded after flowering except days to heading which was recorded at 50% flowering and data were analyzed following Gomez and Gomez (1984). Genetic parameters were computed according to formula suggested by Burton (1952).

RESULTES AND DISCUSSION

The analysis of variance for growth characters viz. plant height (cm), days to heading (day), productive tillers plant^{-1} are presented in Table 1, 3 and 5, respectively.

For the changes in heading date as show in (Table 1), heading was delayed in all the studied varieties, Sakha 105, Sakha 102 and Giza 178 with 300 and 400 Gy by about 6-10 days, 3-5 days and 5-6 days for the three varieties, respectively.

While, low delay in heading was detected with 100 and 200 Gy by about 1-4days, 2-3 days and 3-5 days for the studied varieties, Sakha 105, Sakha 102 and Giza 178, respectively. The highest delay in heading was detected for 400 Gy treatment in all the varieties studied, while the lowest mean values was observed in 300Gy treatment. The most affected varieties by gamma rays were Sakha 105 and Giza 178, Gomma *et al*., (1995) and Shadakashi *et al*. (2001)

Genetic parameters for days to heading are shows in Table 2. Significant increase in genotypic variance by irradiation were obtained for all varieties studied. Genetic coefficient of variability values were increased by irradiation for all varieties and ranged from 2.16 to 3.44 %.

Estimates of heritability percentage in broad sense were moderate to high and the values ranged for 78.47 to 90.33 %. These results agreed with those obtained by Uttam *et al*. (2005).

The expected genetic advance values in irradiated populations indicating the possibility of selecting earliness of 3.75 days in the variety Sakha 102 and 6.82 in Sakha 105. Lee *et al*. (2003) and Uddin *et al*. (2007) indicated similar results.

For plant height (Table 3), plant height mean values were reduced by increasing the doses of gamma rays in all the varieties studied. Significant differences were found in plant height between the treatments and control. This indicating that the varieties affected by the different doses of gamma rays. The most effective treatment in plant height was 400 Gy for Sakha 105, Sakha 102 and Giza 178. The results indicated that, the most affected variety by gamma rays doses was Sakha 102 (-16 cm) followed by Giza 178 (-12 cm), the lowest reduction in plant height was detected in Sakha 105.The same results had been reported by Gomma *et al*., (1995), Labrada *et al*.,(2001) and El-Degwy (2013).

In order to assess the breeding value of the characters studied genetic parameters of a few yield contributing traits were computed (Table 4). Significant increases in genotypic variance by irradiation were obtained for all varieties studied. Genetic coefficient of variability values were increased by irradiation for all varieties and ranged from 3.41 to 4.23%.

Table 1: Means, minimum and maximum of unmber days to heading as affected by the different doses of gamma rays for the studied varieties in M_2 generation.

Cultivars	Dose	Cont.	100	200	300	400	L.S.D 0.05	L.S.D 0.01
Sakha 105	$\bar{X}$	95.95	97.40	99.90	102.3	105.6	1.87	2.48
	Minimum	93.20	94.00	95.90	97.00	100.0		
	Maximum	96.10	100.0	102.0	104.0	107.1		
Sakha 102	$\bar{X}$	94.79	95.93	97.65	98.03	99.87	1.73	2.30
	Minimum	93.59	93.00	94.00	95.00	96.00		
	Maximum	95.75	97.00	99.00	100.0	101.0		
Giza 178	$\bar{X}$	104.00	106.50	108.60	109.80	110.13	1.32	1.76
	Minimum	103.00	104.00	105.00	108.00	109.00		
	Maximum	105.00	108.00	109.00	113.00	114.00		

$\bar{X}$: The mean of the characters;
L.S.D 0.05: Least significant difference at 0.05 level;
L.S.D 0.01: Least significant difference at 0.01 level.

Table 2: Genetic parameters of days to heading of the studied rice varieties in M_2 irradiated populations compared with the control.

Populations	Trait	GV	PV	PCV%	GCV%	h^2b	Gs	Gs%
Sakha 105	Control	0.11	0.61	0.81	0.35	18.03	0.29	0.30
	Irrad.	12.14	13.44	3.62	3.44	90.33	6.82	6.74
Sakha 102	Control	0.01	0.07	0.28	0.11	14.29	0.07	0.08
	Irrad.	4.23	5.39	2.37	2.10	78.47	3.75	3.83
Giza 178	Control	0.10	0.50	0.68	0.30	20.00	0.29	0.28
	Irrad.	5.50	6.17	2.28	2.16	89.14	4.56	4.20

GV: genetic variance; **PV:** Phenotypic variance; **PCV%:** Phenotypic coefficient of variability**; GCV%:** Genetic coefficient of variability**; H^2_b:** Broad sense heritability
Gs: the expected genetic advance; **Gs%:** the expected genetic advance percentage.
Irrad. : Irradiation.

Table 3: Means, minimum and maximum of plant height as affected by the different doses of gamma rays for the studied varieties in M_2 generation.

Cultivars	Dose	Cont.	100	200	300	400	L.S.D 0.05	L.S.D 0.01
Sakha 105	$\bar{X}$	96.78	94.20	93.81	91.19	90.73	1.27	2.15
	Minimum	95.54	90.00	89.00	88.50	87.50		
	Maximum	97.32	98.00	97.00	97.45	96.50		
Sakha 102	$\bar{X}$	110.1	101.6	96.72	94.18	93.59	1.39	2.07
	Minimum	108.4	98.00	92.50	91.50	89.50		
	Maximum	111.5	105.0	100.0	101.0	99.00		
Giza 178	$\bar{X}$	100.1	97.90	92.15	91.96	88.37	2.21	3.75
	Minimum	98.52	94.00	88.00	87.50	84.50		
	Maximum	101.4	100.0	95.50	95.00	94.00		

$\bar{X}$: The mean of the characters;
L.S.D 0.05: Least significant difference at 0.05 level;
L.S.D 0.01: Least significant difference at 0.01 level.

Table 4: Genetic parameters of plant height of the studied rice varieties in M_2 irradiated populations compared with the control.

Cultivars	Traits	GV	PV	PCV%	GCV%	h^2b	Gs	Gs%
Sakha 105	Control	0.08	0.48	0.72	0.29	16.67	0.24	0.25
	Irrad.	9.93	11.93	3.73	3.41	83.24	5.92	6.40
Sakha 102	Control	0.18	1.17	0.98	0.38	15.05	0.33	0.30
	Irrad.	15.48	18.82	4.49	4.08	82.25	7.35	7.62
Giza 178	Control	0.08	0.68	0.82	0.28	11.42	0.19	0.19
	Irrad.	15.31	19.68	4.79	4.23	77.79	7.11	7.68

GV: genetic variance; **PV:** Phenotypic variance; **PCV%:** Phenotypic coefficient of variability**; GCV%:** Genetic coefficient of variability**; H^2_b:** Broad sense heritability
Gs: the expected genetic advance; **Gs%:** the expected genetic advance percentage.
Irrad. : Irradiation.

Estimates of heritability percentage in broad sense were high by irradiation and amounted from 77.79 for the variety Giza178 to 83.24 for the variety Sakha 105. These results indicated that selecting short stature plants would be possible in irradiated populations, as shown by Lee *et al*. (2003) and Uddin *et al*. (2007).

The expected genetic advance under selection for shorter plants as percent of the means (Gs %) were increased by irradiation and ranged from 5.92 to 7.35, Shereen *et al*. (2009).

The productive tillers plant^{-1} character (Table 5) was reduced by increasing the doses of gamma rays in all the varieties studied. Significant differences were found in productive tillers plant^{-1} between the treatments and control. This indicating that the varieties affected by the different doses of gamma rays, Sarawagi and Soni, 1993 and Uddin *et al*., 2007 which obtained the similar results. The most effective treatment for this trait was 300 Gy for the varieties Sakha 105, Sakha 102, while 100 Gy for Giza 178. The results indicated that, the most affected varieties by gamma rays doses were Sakha 102 (+4 tiller) followed by Sakha 105 (+3 tiller), the lowest reduction in the productive tillers plant^{-1} was detected in Giza 178, Lee *et al*. (2003) obtained similar results .

Genetic parameters for productive tillers plant^{-1} are presented in Table (6). Significant increases in genotypic variance by irradiation were obtained for all the varieties studied. Genetic coefficient of variability values were increased by irradiation and ranged from 8.59 to 9.75%, Gomma *et al*., (1995) and Basak and Ganguli, (1996).

Estimates of heritability percentage in broad sense were high by irradiation and amounted from 72.27 % for the variety Giza178 to 80.17 %for Sakha 105. These results indicated that selecting short stature plants would be possible in irradiated population, Shereen *et al*. (2009) came to similar results.

Table 5: Means, minimum and maximum of number of productive tillers/plant as affected by the different doses of gamma rays for the studied varieties in M_2 generation.

Cultivars	Dose	Cont.	100	200	300	400	L.S.D 0.05	L.S.D 0.01
Sakha 105	$\bar{X}$	22.51	23.24	24.06	25.33	26.01	0.70	1.06
	Minimum	18.25	19.50	21.50	22.50	23.59		
	Maximum	23.65	26.20	27.00	28.00	29.00		
Sakha 102	$\bar{X}$	20.59	21.17	23.60	24.30	25.10	1.10	1.43
	Minimum	18.50	19.00	20.50	21.00	22.50		
	Maximum	21.45	24.00	26.00	27.50	29.00		
Giza 178	$\bar{X}$	25.58	24.46	23.63	22.58	21.78	1.00	1.16
	Minimum	22.42	20.50	19.50	19.10	18.00		
	Maximum	26.60	26.00	25.00	24.00	23.00		

$\bar{X}$: The mean of the characters;
L.S.D 0.05: Least significant difference at 0.05 level;
L.S.D 0.01: Least significant difference at 0.01 level.

Table 6: Genetic parameters of number of productive tillers/plant of the studied rice varieties in M_2 irradiated populations compared with the control.

Cultivars	Traits	GV	PV	PCV%	GCV%	h^2b	Gs	Gs%
Sakha 105	Control	0.03	0.26	2.25	0.73	10.39	0.11	0.48
	Irrad.	4.49	5.60	9.59	8.59	80.17	3.91	15.84
Sakha 102	Control	0.05	0.41	3.12	1.12	12.90	0.17	0.83
	Irrad.	5.27	7.06	11.28	9.75	74.63	4.08	17.35
Giza 178	Control	0.08	0.53	2.85	1.13	15.63	0.24	0.92
	Irrad.	4.07	5.63	10.26	8.73	72.27	3.53	15.28

GV: genetic variance; **PV:** Phenotypic variance; **PCV%:** Phenotypic coefficient of variability**; GCV%:** Genetic coefficient of variability**; H^2_b:** Broad sense heritability
Gs: the expected genetic advance; **Gs%:** the expected genetic advance percentage.
Irrad. : Irradiation.

Significant increase in the expected gain from selection were obtained for this character by irradiation.

Data presented in Tables (7 and 11) showed that the mutagenic treatments did not cause changes in 100-grain weight. Therefore, all treatments and nearly the same value of 100-grain weight and the range of variability for irradiated plants were similar to that of the control of all the varieties studied. The last finding agreed with that obtained by Mohamed *et al,* 2006 obtained similar results. Grain yield was significantly affected by gamma rays treatments. The non-treated plants recorded significantly higher grain yield than the treated plants. However, the differences among the four treatments were not significant. The measurements of range of variability in the treated plants were higher than those of the control. Similar findings were reported by El-Degwy (2013).

Genetic parameters for grain yield (g) plant $^{-1}$ as presented in Table (8). Significant increases in genotypic variance by irradiation were obtained for all the varieties studied. Genetic coefficient of variability values were increased by irradiation for all and ranged from 5.20 to 5.57%.

Estimates of heritability percentage in broad sense were high for grain yield by irradiation and amounted from 56.35 % for the variety Sakha 105 to 47.22 % for the variety Giza 178. These results indicated that selecting short stature plants would be possible in irradiated populations. (Uddin *et al*. 2007).

The expected gains from selection as percent of the mean (Gs %) were increased in irradiated populations and ranged from 7.37 % to 8.46 %.Similar results were found by El-Degwy IS. (2013).

Significant increases in genotypic variance for 100 grain weight (Table 12) by irradiation were obtained for all varieties studied. Genetic coefficient of variability values were increased by irradiation for all and ranged from 9.64 to 23.13%.

Estimates of heritability percentage in broad sense were high by irradiation and ranged from 77.86 % for the variety Sakha 102 to 58.55 % for the variety Sakha 105, indicating the possibility of selection short plants in the next generation to improve this trait in Giza 178 particularly, Lee *et al*. (2003), also reported high heritability estimates for another varieties.

The expected genetic advance from selection as percent of the mean (Gs %) were increased in irradiated populations and ranged from 17.53 % to 40.21%. Similar results were found by El-Degwy (2013).

The effect of gamma ray doses on grain yield and its components characters for the studied varieties (Sakha 105, Sakha 102 and Giza 178) are presented in Tables (7 and 11). The sterility percentage (Table 9) was increased by increasing the doses of gamma rays in all the varieties studied Mehetre *et al.,* (1996) indicated the similar results . Significant differences were found between the treatments and control for sterility percentage. This indicate that the varieties affected severing by the different doses of gamma rays. The most effective treatment in the sterility percentage was 300 Gy for all the varieties studied (Sakha 105, Sakha 102 and Giza 178).

Significant increases in genotypic variance by irradiation were obtained for all the varieties studied as shown by, Basak and Ganguli, (1996). The values of genetic coefficient of variability values were increased by irradiation and ranged from 22.68 to 28.07%.

Heritability percentage values in broad sense were high by irradiation (Table 10). Moderate to high Hb % values were obtained for this trait and ranged from 76.39 % for the variety Sakha 102 to 89.82 % for the variety Giza178. Similar results were obtained by El-Degwy (2013).

It could be concluded that mutation technique have shown to be very useful in rice improvement, especially for the characters controlled by closely linked genes that are difficult to break by gene recombination. Using irradiation by gamma ray exhibited different genetic variability such as semi-dwarf plants, early heading and high grain yield. The induced genetic variability was more important as it can be used directly in rice breeding program through selection or by hybridization programe with the commercial cultivars.

Table 7: Means, minimum and maximum of grain yield per plant as affected by the different doses of gamma rays for the studied varieties in M_2 generation.

Cultivars	Dose	Cont.	100	200	300	400	L.S.D 0.05	L.S.D 0.01
Sakha 105	$\bar{X}$	41.85	43.54	45.18	46.37	46.54	1.20	2.10
	Minimum	40.63	40.90	42.20	44.80	43.60		
	Maximum	42.35	44.80	47.00	49.50	49.30		
Sakha 102	$\bar{X}$	40.52	40.81	42.89	43.37	44.91	1.34	2.18
	Minimum	39.25	39.93	41.70	42.33	43.47		
	Maximum	41.55	44.26	45.48	46.86	47.78		
Giza 178	$\bar{X}$	47.42	46.19	43.08	42.64	41.67	1.43	2.25
	Minimum	46.25	42.05	40.16	40.31	40.33		
	Maximum	48.33	48.54	47.58	46..82	45.42		

$\bar{X}$: The mean of the characters;
L.S.D 0.05: Least significant difference at 0.05 level;
L.S.D 0.01: Least significant difference at 0.01 level.

Table 8: Genetic parameters of grain yield of the studied rice varieties in M_2 irradiated populations compared with the control.

Cultivars	Traits	GV	PV	PCV%	GCV%	h^2b	Gs	Gs%
Sakha 105	Control	0.04	0.45	1.60	0.46	8.21	0.11	0.27
	Irrad.	5.87	10.42	7.11	5.34	56.35	3.75	8.25
Sakha 102	Control	0.07	0.57	1.86	0.64	11.76	0.18	0.45
	Irrad.	5.73	10.53	7.55	5.57	54.43	3.64	8.46
Giza 178	Control	0.05	0.44	1.40	0.49	12.03	0.17	0.35
	Irrad.	5.10	10.8	7.57	5.20	47.22	3.20	7.37

GV: genetic variance; **PV:** Phenotypic variance; **PCV%:** Phenotypic coefficient of variability**; GCV%:** Genetic coefficient of variability**;** H^2_b**:** Broad sense heritability
Gs: the expected genetic advance; **Gs%:** the expected genetic advance percentage.
Irrad. : Irradiation.

Table 9: Mean, minimum and maximum of sterility percentage as affected by different doses of gamma rays for the studied varieties in M_2 generation.

Cultivars	Dose	Cont.	100	200	300	400	L.S.D 0.05	L.S.D 0.01
Sakha 105	$\bar{X}$	5.56	6.47	6.65	8.22	10.47	1.59	2.11
	Minimum	4.10	4.56	5.17	6.01	7.56		
	Maximum	7.45	8.83	9.81	11.19	13.92		
Sakha 102	$\bar{X}$	4.82	6.89	8.98	9.59	10.28	1.83	2.43
	Minimum	4.05	5.15	5.58	6.39	9.38		
	Maximum	6.42	9.88	10.19	11.53	12.58		
Giza 178	$\bar{X}$	8.52	9.82	12.01	14.30	18.51	1.78	2.36
	Minimum	6.45	7.31	9.16	11.10	12.57		
	Maximum	9.30	12.45	14.01	16.72	19.63		

$\bar{X}$: The mean of the characters;
L.S.D 0.05: Least significant difference at 0.05 level;
L.S.D 0.01: Least significant difference at 0.01 level.

Table 10: Genetic parameters of sterility percentage of the studied rice varieties in M_2 irradiated populations compared with the control.

Cultivars	Traits	GV	PV	PCV%	GCV%	h^2b	Gs	Gs%
Sakha 105	Control	0.01	0.2	8.04	1.80	5.00	0.5	0.83
	Irrad.	4.98	5.95	30.69	28.07	83.68	4.21	52.90
Sakha 102	Control	0.02	0.32	11.74	2.93	6.25	0.07	1.51
	Irrad.	4.11	5.38	25.95	22.68	76.39	3.65	40.83
Giza 178	Control	0.03	0.29	6.32	2.03	10.34	0.11	1.35
	Irrad.	10.85	12.08	25.44	24.11	89.82	6.43	47.08

GV: genetic variance; **PV:** Phenotypic variance; **PCV%:** Phenotypic coefficient of variability**; GCV%:** Genetic coefficient of variability**; H^2b:** Broad sense heritability
Gs: the expected genetic advance; **Gs%:** the expected genetic advance percentage.
Irrad. : Irradiation.

Table 11: Means, minimum and maximum of 100-grain weight (g) as affected by different doses of gamma rays for the studied varieties in M_2 generation.

Cultivars	Dose	Cont.	100	200	300	400	L.S.D 0.05	L.S.D 0.01
Sakha 105	$\bar{X}$	2.81	2.80	2.84	2.85	2.90	0.13	0.18
	Minimum	2.79	2.77	2.79	2.82	2.87		
	Maximum	2.85	2.85	2.90	2.95	2.98		
Sakha 102	$\bar{X}$	2.70	2.70	2.70	2.75	2.85	0.24	0.32
	Minimum	2.67	2.65	2.64	2.69	2.81		
	Maximum	2.77	2.76	2.75	2.80	2.92		
Giza 178	$\bar{X}$	2.24	2.20	2.18	2.15	2.05	0.12	0.16
	Minimum	2.20	2.18	2.10	2.10	2.00		
	Maximum	2.26	2.24	2.21	2.18	2.10		

$\bar{X}$: The mean of the characters;
L.S.D 0.05: Least significant difference at 0.05 level;
L.S.D 0.01: Least significant difference at 0.01 level.

Table 12: Genetic parameters of 100-grain weight of the studied rice varieties in M_2 irradiated populations compared with the control.

Cultivars	Traits	GV	PV	PCV%	GCV%	h^2b	Gs	Gs%
Sakha 105	Control	0.03	0.33	20.44	6.16	9.09	0.11	3.83
	Irrad.	0.29	0.50	24.80	18.98	58.55	0.85	29.91
Sakha 102	Control	0.01	0.06	9.32	4.28	21.05	0.11	4.04
	Irrad.	0.07	0.09	10.93	9.64	77.86	0.48	17.53
Giza 178	Control	0.05	0.34	26.03	9.98	14.71	0.18	7.89
	Irrad.	0.24	0.34	27.41	23.13	71.21	0.86	40.21

GV: genetic variance; **PV:** Phenotypic variance; **PCV%:** Phenotypic coefficient of variability**; GCV%:** Genetic coefficient of variability**; H^2_b:** Broad sense heritability
Gs: the expected genetic advance; **Gs%:** the expected genetic advance percentage.
Irrad. : Irradiation.

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التربيه باستحداث الطفرات للحصول على قصر طول النبات والمحصول العالي وتحمل ظروف الإجهاد المائي في الأرز

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الملخص العربي

أجريت هذه الدراسة بمزرعة مركز البحوث والتدريب في الأرز– محطة البجوث الزراعيه بسخا– كفر الشيخ– مصر خلال المواسم الزراعية من ٢٠١١ حتى ٢٠١٣ حيث تم تعريض بذور ثلاثة أصناف من الأرز وهم سخا ١٠٥ ، سخا ١٠٢ ، جيزه ١٧٨ الى أربعة جرعات من أشعة جاما وهي ١٠٠ جيراي ، ٢٠٠ جيراي ، ٣٠٠ جيراي ، ٤٠٠ جيراي وتم زراعة تلك البذور للحصول على الجيل الأول . نباتات الجيل الأول في الموسم التالي للحصول على الجيل الثاني الطفري وتم انتخاب افضل النباتات من الجيل الطفوري الثاني لزراعتها والحصول على نباتات الجيل الطفوري الثالث . وتشير النتائج المتحصل عليها من تلك النباتات المنتخبه من الجيل الطفوري الثاني والتي زرعت في الجيل الطفوري الثالث أنه كان بها اختلافات معنوية بينها وبين آباءها في طول النباتات ومحصول الحبوب وقدرتها على تحمل الإجهاد المائي. وأن استحداث الطفرات باستخدام اشعة جاما يمكن ان يستخدم في تحسين انتاجية الأرز كهدف من أهداف التربيه لمحصول الأرز خاصة في الصفات التي يتحكم فيها اكثر من جين ومن الصعب كسر العلاقه ما بين الجينات وبعضها البعض ولكن باستحداث الطفرات تنتج تباينات وراثيه عاليه تنتج عنها صفات مرغوبه مثل قصر في طول النبات ، التبكير وارتفاع محصول الحبوب وبالتالي يمكن استخدام تلك الطفرات الناتجه في برامج تربية الارز مباشرة من خلال الانتخاب أو التهجين مع الأصناف التجاريه المنزرعه.

الكلمات الداله: أشعة جاما، تحمل الجفاف، الطفرات، الأرز، المحصول ومكوناته.