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Using Gamma Rays for Improving Water Deficit Tolerance in Rice

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ABSTRACT

The present investigation was carried out in Sakha research station in kafr el-sheikh governorate during the period from 2010 to 2014 (MO-M4) using two rice genotypes (GZ1368-S-5-4, Morobrokern) as check varieties beside selected plants of (M5) for mutant derived from the previous two genotypes before and after exposure it for two levels of gamma rays (300, 400 GY) under two water regime systems (Normal irrigation and irrigation every 15 day), respectively. Heading date, plant height, panicle length, number of panicles/plant, number of filled grains/panicle, 1000-grain weight, grain yield/pant and maximum root length were the most measurements calculated for the six genotypes under normal and drought conditions in addition to estimate some genetic parameters such as; (P.C.V, G.C.V, GV, PH V, E V, H^2B), drought tolerance indices and simple correlation coeffients, respectively. The final results revealed that the two check genotypes and its M5 derived mutants were recorded the best calculated data under the control treatments of radiations and water regimes inversely the two doses of gamma rays and water deficit treatment.

Kew words: Rice, Water stress, Radiation, Yield components, Mutation, Mutagenic genotypes.

Introduction

Rice is one of the most important food crops in the world and that for humans, as well as for animals and birds. For humans it is considered the most important crop and food for the provision of dry matter required energy and also to fill the mouths of millions of people in all around of world. this crop received too much attention is reflected in the production of hundreds of thousands of research which that would improve productivity and enhance the ability of plant rice to confront and withstand adverse environmental conditions such as salinity, water stress, resistance to disease, the bad effects of radiation and toxic of heavy metals Saleem *et al.* (2005). recent years had not only at the local level but also on the level global education program mutations with great interest, because the project of Education mutations have a significant role in improving the level of the genome rice in the face of bad or poor environmental conditions and the disappearance of genes harmful and also the emergence of useful genes that have the greatest impact on improving the rice crop in all directions, for example Reimei rice variety was released in Japan in 1966 as a national registered variety (Futsuhara, 1968). and produced by means of radiation , in 2003, 440 mutant rice varieties had been developed, 264 of which evolved through direct use of mutants and the other 176 developed by cross breeding with induced mutants. The main objective of the present study was to evaluate these two cultivars of rice which different reaction for drought resistance namely,(GZ1368-S-5-4 and Morobrokern and its selected lines of M5 derived mutants under normal and drought conditions) under two level of radiations with gamma irradiation) and that through five generations mutagenic after exposure to radiation for each level of radiation in addition to the control and irrigation was every 15 days for the mutant genotypes to estimate morphological and yield traits and the molecular variation among two lines of these three conditions using molecular markers to access rice strains mutagenic high productivity can be used in breeding programs to produce high-yield rice varieties and resistance for environmental stresses and high quality pressure.

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Materials and Methods

The seeds used in this study were imported and performed from the genetic stock of the Egyptian National Rice Research Program (RRTC) rice research and training center. three hundred pure seeds of (GZ1368-S-5-4 and Morobrokern) with a moisture content of 14% were subjected for gamma irradiation treatments dosages of 300 and 400 Gy using the Co source at the National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt. The natural and irradiated materials were grown and series of selections among the mutant population and were carried out during 2010 - 2014 seasons (M0 - M4) under two level of irrigation, where, the control level of rice irrigation were the normal irrigation of rice plants under Egyptian conditions for the six genotypes (two cultivars under control , GZ1368-S-5-4 and Morobrokern), two selected lines for the new genotypes of each generation mutagen for the same cultivars under level one of radiation of gamma rays and two selected lines for the new genotypes of each generation mutagen for the same cultivars under second level of radiation of gamma rays) , while, the same six genotypes after exposure to the two levels of radiation in addition to the control cultivars were grown under drought conditions (every 15 days) for a period of five years from 2010 (M0) to 2014(M4) to produce M5 derived mutants, Thus, the number of studied genotypes (natural and mutants) under all conditions were twelve genotype and divided in to:-

1) Means :- (GZ1368-S-5-4) under normal conditions without radiations.
2) Means: - (Morobrokern) under normal conditions without radiations.
3) Means:-Selected lines of M5 mutant derived from (GZ1368-S-5-4) after treated its with level one of gamma rays under normal conditions.
4) Means: - Selected lines of M5 mutant derived from (Morobrokern) after treated its with level one of gamma rays under normal conditions.
5) Means: - Selected lines of M5 mutant derived from (GZ1368-S-5-4) after treated its with level two of gamma rays under normal conditions.
6) Means: - Selected lines of M5 mutant derived from (Morobrokern) after treated its with level two of gamma rays under normal conditions.
7) Means: - (GZ1368-S-5-4) under drought conditions without radiations.
8) Means: - (Morobrokern) under drought conditions without radiations.
9) Means: - Selected lines of M5 mutant derived from (GZ1368-S-5-4) after treated its with level one of gamma rays under drought conditions.
10) Means: - Selected lines of M5 mutant derived from (Morobrokern) after treated its with level one of gamma rays under drought conditions.
11) Means: - Selected lines of M5 mutant derived from (GZ1368-S-5-4) after treated its with level two of gamma rays under drought conditions.
12) Means: - Selected lines of M5 mutant derived from (Morobrokern) after treated its with level two of gamma rays under drought conditions , respectively.

All genotypes (Treatment of radiation under normal and drought conditions) were grown with three replications in a randomized complete block design (RCBD) and Fertilizer was added at a recommended rate and hand weeding was done when needed. This experiment was done in the farm of the Agricultural Research Center in Giza, Egypt. During growth period, all the data concerning morphological, yield and its component traits were recorded namely. Heading date, plant height, panicle length, number of panicles/plant, number of filled grains/panicle, 1000-grain weight, grain yield/pant and maximum root length, respectively.

Note:

The two experiment of irrigation (normal and drought) were conducted in two fields isolated for each experiment during five years and growing location was the research station in Sakha city, Kafr el-sheikh governorate.

A.Genetic Parameters:

The data obtained were subjected to the statistical analysis to estimate means and standard error according to Gomez and Gomez (1984). For comparison of the mean values and variance, the analysis

of variance was done for each character of each genotype to estimate genotypic variances (GV), phenotypic variances (PV),environmental variances (EV), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sence ($H^2B.S$) and genetic advance (GA), separately as suggested by Panse and Sukhatme (1957).

A.1.Drought tolerance indices:

Drought tolerance indices were calculated using the following researchers (Hossain *et al*., 1990), (Fernandez, 1992), (Gavuzzi *et al*., 1997; Lin *et al*., 1986), (Bouslama and Schapaugh, 1984), (Golestani and Assad,1998) , (Fischer & Maurer, 1978).

A.2.Simple phenotypic correlation (r) coefficients:

Estimates of the simple phenotypic correlation (r) coefficients among all traits for the entries means were calculated according to Kearsey and Pooni (1996).

Results and Discussion

A. Mean performance:

In light of the results obtained from Table (1), Note that there were significant differences in all of the traits studied under normal and drought conditions and also between the two treatments of radiation of gamma rays in addition to the control as follows, The check genotypes (GZ1368-S-5-4, Morobrokern) and M5 derived mutants from its under two levels of radiation under water stress

Table 1: Mean performance for all traits studied of the two promising genotypes (GZ1368-S-5-4 and Morobrokern) and its M5 derived Mutants under all conditions.

Genotypes	Heading date	Plant height	Panicle length	Number of panicles/plant	Number of filled grains/panicle	1000-grain weight	Grain yield/plant	ROOT Length
Normal Conditions								
G1	97.20	99.80	21.33	19.50	225.50	28.07	58.83	43.50
G2	91.53	91.73	22.50	23.50	208.50	23.50	51.00	38.67
G3	90.18	87.54	24.50	15.17	209.17	25.30	52.17	38.33
G4	85.0	72.50	23.50	20.50	190.50	20.67	46.67	27.67
G5	87.30	79.56	27.50	12.13	192.17	23.50	44.17	34.50
G6	80.0	64.52	25.80	16.83	186.17	17.75	37.33	23.83
Drought Conditions								
G1	92.14	96.02	17.02	16.41	198.65	25.02	55.23	51.16
G2	85.67	85.43	19.0	20.0	190.82	19.0	45.50	44.18
G3	86.14	80.63	16.40	12.50	206.03	22.08	49.18	46.63
G4	80.34	65.0	17.05	16.30	187.0	17.14	40.0	52.11
G5	81.07	70.12	15.16	9.50	180.97	20.0	39.06	48.54
G6	75.12	59.51	13.58	13.0	173.0	15.50	32.44	45.98
LSD 0.05	1.48	1.12	1.30	1.12	1.71	0.37	1.19	1.53
LSD 0.01	2.02	1.53	1.76	1.52	2.32	0.50	1.61	2.08
F test	**	**	**	**	**	**	**	**

conditions were recorded the lowest mean values of all traits studied compared to the control treatments of irrigation and radiations especially the second level of gamma radiation, On the contrary of root length trait where the six genotypes studied recorded the highest mean values under water stress conditions for this trait, where the M5 derived mutants from (GZ1368-S-5-4,Morobrokern) under level one of gamma rays were highly resistance for drought conditions under water stress for all traits studied, where these mutant lines were shorter and earlier of flowering time compared to the control, also yield and its components was not affected too much and maximum root length trait was appropriate to the conditions of drought where it was more taller than that under normal conditions of

irrigation, respectively. The results clearly showed there is a great role of significant differences between normal and mutagens genotypes, which illustrates the importance of plant breeding using mutations program in promoting the importance of genetic variation to improve the ability of rice for resistance of water stress. These results were agreement with those reported by Gomma *et al*. (1995a, b), Abdul-Majeed (1997); Abdallah (2000); Elayaraja *et al.* (2005); Suriyan *et al*.(2012); El-Mouhamady *et al.* (2016); Esmail *et al.* (2016 a); Esmail *et al.* (2016 b).

B. Genetic parameters:

Obtained data in Table (2), presented the estimated genetic parameters for (GZ1368-S-5-4 and Morobrokern) and its M5 derived mutants under normal and drought conditions. The data revealed that the expected genetic advance values were so high in all studied traits under all conditions especially grain yield/plant where it was recorded the highest values (25.70% for normal conditions) and (21.03% for drought conditions), while root length trait showed the lowest values where it was (8.34%,6.13%) under normal and drought conditions, respectively, indicating that using two levels of gamma rays had high affinity to induce remarkable improvement in rice growing even under water stress conditions. Genotypic variances (GV) ranged from medium to high among studied traits under normal and drought conditions in the different mutants. The highest values of genetic variance were (177.5% and 171.4%) for plant height under both of treatments of irrigation followed by (46.34% and 39.77%) for heading date under normal and water stress conditions, respectively. Genetic variances were greater than environmental variances (EV) in all of the studied traits, indicating the prospect of phenotypic selection of these characters in the breeding program since the heritable portion of variances were high and more distinctive and strength. Genotypic coefficients of variation (GCV, %) were higher in all studied traits under all conditions and ranged from (4.30 to 16.45) for normal irrigation and ranged from (3.58 to 11.34) for water stress conditions, respectively, This also reflects the possibility of efficient selection and genetic improvement of these traits using such set of genotypes. Broad sense heritability (*h2* b) calculated were showed to be high in all the characters studied under normal and water stress conditions especially grain yield/plant which was ranged from (88.60% to 92.0%) under all conditions, while number of filled grains/panicle were moderate which was moderate and ranged from (65.54%, 53.73%) for both conditions respectively. The results indicate also the possible improvement of these traits using early selection since the phenotype could be more authoritative during selection of these traits. Similar results as high assessment of genetic parameters for genotypes derived from irradiation under natural and water stress conditions were found by Meheter *et al*. (1996); Bordoli and Talukder (1999), Elayaraja *et al*. (2005); El-Mouhamady *et al.* (2016); Esmail *et al.* (2016 a); Esmail *et al.* (2016 b).

Table 2: Genetic parameters of some morphological and yield traits characters in twelve natural and mutant genotypes under all conditions after five generations.

Genetic Parameters	Heading date		Plant height		Panicle length		Number of panicles/plant		Number of filled grains/ panicle		1000-grain weight		Grain yield/ plant		Root length	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
P V	47.12	40.0	207.0	190.7	3.23	2.70	2.15	2.04	1.19	0.67	6.88	4.34	3.89	2.76	8.67	6.55
G V	46.34	39.77	177.5	171.4	3.11	2.43	1.99	1.50	0.78	0.36	6.58	3.22	3.45	2.55	7.88	6.12
E V	0.78	0.23	29.5	19.3	0.12	0.27	0.16	0.54	0.41	0.31	0.30	1.12	0.44	0.21	0.79	0.43
PCV	11.60	8.55	5.45	3.77	9.44	7.14	18.33	15.44	6.75	4.66	9.23	8.13	11.50	8.45	8.22	6.89
GCV	11.32	6.12	4.99	3.58	8.65	7.05	16.45	11.34	4.30	4.24	9.11	7.80	9.18	6.21	7.39	5.80
H2B.S	98.34	99.42	85.74	89.87	96.28	90.0	92.55	73.52	65.54	53.73	95.6	74.2	88.6	92.0	91.0	93.4
GA	14.88	11.09	18.56	12.3	4.66	3.12	5.35	2.77	10.44	7.32	4.50	3.20	2.56	2.13	7.87	5.88
EXGA	24.6	17.86	11.0	9.12	13.7	11.4	22.78	13.70	13.0	10.60	18.4	16.0	25.70	21.03	8.34	6.13

N:Normal irrigation , D:- drought conditions, PV:-Phenotypic Variance, GV:-Genotypic Variance, EV:-Environmental Variance, PCV:-Phenotypic coeffient, GCV:-Genotypic Coeffient, Hb:-Heritability in broad sense ,GA:-Genetic Advance

This reverberate obviously the fact that irradiation not only induces the highest attribution of chromosomal and physiological changes but also prepare about of high frequency of gene mutations. It is apparent that gene mutations using irradiation could beget a major amount of genetic variability and opens a new avenue for rice improvement and diversification for resistance stresses.

C. Tolerance indices:

After a thorough and extended the results of averages and genetic parameters estimates review, we note the importance of the study of Tolerance indices for drought (Table 3), and this so that we can make a real test of resistance to water stress, especially in light of the use of two levels of gamma rays under normal and drought conditions for natural and mutants genotypes. The results revealed that the lines with low (DSI) values (less than I) can be considered to be water stress resistant (Bruckner & Frohberg, 1987), because they recorded smaller yield reductions under water stress compared with normal condition than the mean of all genotypes, These breeds are GZ1368-S-5-4(normal) and its M5 derived mutants using level one of gamma rays However, the low (DSI) values may not needs give a good indication of water stress tolerance of genotype. Low (DSI) values of a variety could be due to lack of yield production under normal conditions rather than an indication of its ability to tolerate water stress. There is no doubt that drought and lack of water resources problems are considering the most important problems and obstacles that slow down the agricultural development of the countries and also disruption of economic progress because they simply effect on the productivity of strategic crops, which represent an important source of energy and food for the blackness of the greatest of human beings such as rice crop. That set off thousands of research to improve yield level to overcome the problem of water shortage and deriving new varieties for this purpose , then the aim of this study is to test two lines of rice known of drought tolerance (GZ1368-S-5-4 and Morobrokern) and exposed to two levels of gamma rays (300 and 400 GY) during the normal irrigation and irrigation every 15 days over five years of exposure to radiation and were selected the M5 derived mutants lines which are modifying through genetic mode of action level, high resistant for water stress, a good and stability yield and to continue to cultivate this mutagenic lines can be accessed for class highly yielding and resistant to drought. Resistant mutagenic lines for water stress under the radiation conditions indicating the effect of additive, additive X additive types of gene action and the appearance of hybrid vigor. In the light of the findings note that the above-mentioned the genotypes (GZ1368-S-5-4 and Morobrokern) under normal and drought conditions in addition to the two new mutagenic lines of its M5 derived mutants under all conditions (normal and water stress) using level one of gamma rays were highly resistance for water stress by observing the results of mean performance, genetic parameters and tolerance indices where it is considered promising lines to improve rice program in Egypt.

Table 3: Tolerance indices of two rice genotypes and its M5 derived mutants through two levels of gamma rays under stress and non-stress conditions.

Genotypes	GYP	GYS	YSI	YI	GMP	STI	MP	YR	DSI
(G1)	58.83	55.23	0.93	1.26	56.96	0.048	57.03	0.06	0.61
(G2)	51.00	45.50	0.89	1.04	48.17	0.041	48.25	0.10	1.08
(G3)	52.17	49.18	0.94	1.12	50.65	0.043	50.67	0.05	0.57
(G4)	46.67	40.0	0.85	0.91	43.26	0.037	43.33	0.14	1.43
(G5)	44.17	39.06	0.88	0.89	41.53	0.035	41.61	0.11	1.16
(G6)	37.33	32.44	0.86	0.74	34.79	0.029	34.88	0.13	1.32

D. Correlation coefficients:

The results in table (4), revealed that highly significant positively of correlations coefficients were found between grain yield/plant and each of panicle length, number of panicles/plant ,number of filled grains / panicle, 1000.grain weight and root length, while, highly significant and negatively of correlations coefficients were found between plant height and of each of 1000-grain weight, grain yield / plant and root length, but plant height was positively and highly significant positively of correlations coefficients with panicle length and number of panicles / plant under normal irrigation ,respectively. On the other hand, the results in table (5), showed that panicle length trait was highly significant and positively of correlations coefficients with all traits except heading date and plant height, in addition to grain yield / plant was revealed highly significant positively of correlations coefficients with all traits except heading date and plant height ,while, plant height was highly significant positively of correlations coefficients with panicle length and number of panicles / plant under drought irrigation respectively. These results are in general agreement with those reported by

Nazari and Pakniyat (2010), Abdi *et al.* (2012), Muhammad *et al.* (2012), El-Mouhamady *et al.* (2016), Esmail *et al.* (2016 a), Esmail *et al.* (2016 b).

Table 4: Simple correlation coefficients between all traits studied for the six genotypes of rice under normal irrigation.

Traits	1	2	3	4	5	6	7	8
1	1.00							
2	0.78**	1.00						
3	-0.63**	0.55**	1.00					
4	0.61**	0.54**	0.50**	1.00				
5	0.70*	0.45**	0.75**	0.68*	1.00			
6	-0.57*	-0.66*	0.85**	0.55*	0.90**	1.00		
7	-0.70**	-0.52**	0.60**	0.50**	0.77*	0.70**	1.00	
8	-0.80**	-0.80	0.75**	0.90**	0.58**	0.64*	0.70**	1.00

**: Significant at 5% levels of probability **: highly Significant at 1% levels of probability 1:-Heading date 2:-Plant height 3:-Panicle length 4:-No. of panicles /plant 5:-No. of filled grains / panicle 6:-1000-grain weight 7:-Grain yield/ plant 8:-Root length*

Table 5: Simple correlation coefficients between all traits studied for the six genotypes of rice under drought irrigation.

Traits	1	2	3	4	5	6	7	8
1	1.00							
2	0.67*	1.00						
3	-0.55**	-0.45*	1.00					
4	-0.70*	-0.60*	0.85**	1.00				
5	0.80**	0.56*	0.90*	0.75**	1.00			
6	-0.55*	-0.45*	0.75*	0.60*	0.90*	1.00		
7	-0.65**	-0.64*	0.95**	0.87**	0.54**	0.73**	1.00	
8	-0.58**	-0.50**	0.89**	0.77**	0.83**	0.60**	0.86*	1.00

**: Significant at 5% levels of probability **: highly Significant at 1% levels of probability 1:-Heading date 2:-Plant height 3:-Panicle length 4:-No. of panicles /plant 5:-No. of filled grains / panicle 6:-1000-grain weight 7:-Grain yield/ plant 8:-Root length*

Conclusion

Two rice genotypes highly tolerance for salinity, water stress and diseases were irradiated with two gamma rays doses (300, 400 GY) and grown under two water regime systems (normal irrigation and water stress every 15 day) for five years (MO-M4) to produce (M5) derived mutants under the previous treatments in sakha research station in kafr el-sheikh governorate from 2010 to 2014 seasons. After calculated all traits studied under all treatments of radiations and irrigation treatments through some genetic parameters we observed that the (M5) derived mutants under the control dose of gamma rays beside the normal conditions of irrigation were exhibited the most desirable results compared with the second treatment of irrigation beside the two doses of gamma rays.

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