DEVELOPMENT OF SALT TOLERANT RICE LINES THROUGH MUTATION BREEDING

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ABSTRACT

The breeding efforts have resulted in the development of improved many rice cultivars, which currently occupy a large area in the North Delta, Egypt. Traditional Egyptian rice cultivars; viz., Sakha 101, Sakha 102, Egyptian Jasmine and the line, AC 1453, have superiority over other local ones due to their exclusive quality. However, some of cultivars have now become highly susceptible to blast disease, which is causing severe yield losses and most of them are susceptible to salinity conditions. The present investigation deals with the development of early maturity, non-lodging and high yielding with salinity tolerance, employing a mutation approach of gamma rays irradiation. Four mutant lines; viz., Sakha 101-M30, Sakha 102-M20, AC- M50 and Egyptian Jasmine M30 were developed from four Egyptian rice cultivars namely, Sakha 101, Sakha 102, Egyptian Jasmine and the line, AC 1453. These mutants were selected from M6 generation and evaluated for two years (2008 and 2009 seasons) to test their yield performance in the salt- affected soils with a pH 8.00 to 8.20 and EC= 6.00 to 6.50 dSm-1. Mutant lines, derived from the latter cultivars were found to be highly promising and far better than their respective control in the areas affected by salinity conditions. The promising mutant lines; i.e., Sakha 101-M30, Sakha 102-M20, AC- M50 and Egyptian Jasmine M30 produced 16.70 , 9.00 , 6.25 and 3.22 , respectively, higher paddy rice yield on salt -affected soils than the commercial cultivars , Giza 178. In addition many desirable traits, such as early maturity, non-lodging, quality traits and blast resistance, comparing with their respective control.

Key words: Rice, Promising mutants, Gamma rays.

INTRODUCTION

The global extent of salt-affected lands is considerable. Moreover, the expanded salinity area is expected to be more because climate change and water shortage, particularly in Egypt. Furthermore, salinity restricted agriculture production, particularly, rice production, whereas, rice is more suitable crop under such conditions. Ali *et al.* (2001) found that worldwide 100 million ha.

(37%) of irrigated land suffered from water logging and salinity, 20% of which was severely affected. They also, reported that annually, some 2–3 million ha. of potentially productive agricultural land were taken out of production due to salinization alone. Estimates for salt-affected land in India, ranged from 17 to 60% of the irrigated land, 40% in Pakistan, 20% in Australia, 15% in China, 50% in Iraq and 30% in Egypt of the irrigated land (Gleick, 1993 and Ghassemi *et al.*, 1995).

Salinization, also, occurs when crops are irrigated with pumped groundwater of marginal or poor quality, and, as a result of sea water intrusion when water tables, have been lowered by mining of groundwater in coastal areas, as has occurred, for example, in Bangladesh and in the State of Gujarat in India. The incidence of salinity is linked with water shortage. Irrigated agriculture concentrates salts because growing crop takes up water, while most of the salts are left behind in the root zone. Proper management must ensure that the salts are concentrated outside the root zone, and away from future water supplies for irrigation and for domestic or industrial use. Water shortage often interferes with this necessary curative action of leaching the salts from the root zone because the water, needed for leaching, is seen as a waste of water that could be used better to satisfy evapotranspiration by the crop.Salinity reduces photosynthesis rate, metabolism process, carbohydrate translocation, dry matter production, leaf area index, nutrient absorption, all yield attributes and rice grain yield , while it increases sterility percentage of rice.(Zayed et al.,2007).

Many physico-chemical and biological techniques are under investigations for the reclamation of such salt -affected soils in Egypt. Breeding for salt tolerance of rice cultivars seems to be one of the most promising solutions for utilizing such soils. Exploitation of salt tolerant rice cultivars had been in progress since 1943 in the sub-continent, but those rice cultivars were generally low yielding. Salt -affected lands provide avenues for testing rice genotypes for tolerance to salinity. As a consequence, sustained and profitable production of rice crop on salt -affected soil is only possible by evolving the salt -tolerant cultivars which possess high grow yield, early maturity and other desirable characteristics through the use of induced mutation. Induced mutations have been utilized for creation of genetic variability for the selection of mutant cultivars with improved agronomic traits (Micke *et al.* 1990; Hu, 1991; Maluszynske *et al.* 1991; Baloch *et al.* 1999 and Baloch *et al.* 2002). The present study was therefore, carried out to assess the performance for rice grain yield and components of mutation along with their parents and check cultivars and to induce some promising mutants tolerant to salinity conditions.

MATERIALS AND METHODS

Six rice cultivars and lines namely, Sakha 101, Sakha 102, AC 1606, AC 1157, AC 1159, AC1404, AC 1453, Egyptian Jasmine and Giza 178, were used in the present study to induce some useful mutants. Seeds of the such genotypes were irradiated with five doses of gamma rays (100 , 200 , 300, 400 and 500 Gy) from Co^{60} source at the National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt.

Two- hundred and fifty seeds at 14% moisture content were used for each treatment and the same number of seeds was kept untreated as a control for each cultivars. Seeds of all treatments were directly sown after radiation treatment in order to raise M_1 to M_6 plants. The selection of the best mutant lines from M_1 to M_5 was carried out, based on individual plants.

Four mutants viz., Sakha 101-M30, Sakha 102-M20, AC- M50 and Egyptian Jasmine M30 were developed from Sakha 101, Sakha 102, AC 1453 and Egyptian Jasmine, respectively, through mutation breeding program. These mutants were tested, at the farm of the Rice Research and Training Center, EL Sirw Research Station during 2002 to 2009 rice growing seasons for grain yield and its components under the saline conditions along with well known salt tolerant rice M_1 (Giza 178 and GZ 1368-S-5-4). The layout of the experiment was three times replicated randomized complete block designed design (RCBD). The plot size was 5 x 5 = 25 m. Soil of the experimental area was analyzed for pH (8.00 and 8.20) and EC (6.00 and 6.50) during 2008 and 2009 summer seasons, respectively. All data for paddy grain yield and its components were recorded at maturity, except 50% heading date. The data were analyzed according to Gomez and Gomez (1984) and mean values were compared by Duncan's Multiple Range (DMR).

Statistical analysis:

The analysis of variance for the randomized complete block design was done for each studied trait in the last two generations (M_7 and M_8) under salinity conditions. The combined analysis was calculated over the two years (2008 and 2009 seasons) to test the interaction of the different genotypes with the two seasons. The homogeneity of error variance was tested as described by Bartlett (1937).

Path coefficient analysis was made among values of grain yield per plant and the most important characters responsible for salinity tolerance, according to Dewey and Lae (1959). Means of the different mutants were compared with their respective control, using the least significant differences (L. S.D.) test.

RESULTS AND DISCUSSION

The analysis of variance for the studied characters ; namely , number of days to heading, plant height, panicle length, number of panicles per plant, number of grains/panicle, grain yield/plant, milling %, amylose content%, 100 -grain weight, sterility % and grain shape are presented in Table (1). Seasons mean squares were significant and highly significant for all studied traits, which would indicate of overall wide differences among the tested genotypes. The genotypes and seasons interaction were not significant for all studied characters studied. It could be considered that some genotypes surpassed the others if the interaction of genotypes was highly significant than the interaction of genotypes with seasons and, therefore, the most superior genotypes might be recommended.

Table 1: Combined analysis of variance of the characters studied of rice mutants under salinity conditions.

S.O.V	df	Number of days to heading	Plant height	Panicle length	No. of panicles/ plant	No. of grains/ panicle	Grain yield	Milling (%)	Amylose content (%)	100 -grain weight	Grain shape	Sterility %
Seasons	1	3.680	3.130	2.640	1.190	2.751	2.640	4.250	2.954	0.001	4.210	2.50
Reps/seasons	4	4.531	5.166	5.300	6.217	8.326	0.125	6.120	3.365	0.002	5.515	3.165
Genotype/seasons	8	32.10*	295.36**	28.41*	42.11*	58.21*	0.345	.10* 38	25.54	0.021	36.11*	18.00
Genotypes	4	88.50**	491.25**	57.29**	92.25**	74.32**	89.00	45.00	52.01	0.25**	25.32**	35.00
Genotypes x seasons	4	0.530	0.594	0.810	1.851	1.114	0.758	0.415	0.687	0.002	0.210	0.150
Error/years	16	0.303	0.263	0.410	0.265	0.149	0.235	0.185	0.218	0.001	0.201	0.112

* and ** = Significant at 0.05 and 0.01 levels, respectively.

Table 2: Performance of the promising mutants selected in M6 generation and evaluated in two successive generations (2008 and 2009 seasons) of the studied traits under salinity conditions.

Mutants	Number of days to heading (days)	Plant height (cm)	Panicle length (cm)	No. of panicles / plant	Increase (%)	No. of grains/ panicle	Increase (%)	100-grain weight	Increase (%)
Sakha 101-M30	91.00a	80.00a	24.00b	22.00a	18.18	138.00b	5.80	1.90b	0.00
Sakha 102-M20	95.00b	90.00c	26.00a	19.00b	5.26	135.00b	3.70	2.23a	14.80
AC1453-M50	93.00b	80.00a	26.00a	19.00b	5.26	130.00c	0.00	1.90b	0.00
E.Yasmine-M30	92.00b	82.00a	24.00b	18.00b	0.00	139.00a	6.50	1.90b	0.00
Giza 178	95.00c	85.00b	22.00c	18.00b	**	130.00c	**	1.90b	**
LSD (0.05)	2.00	2.50	0.85	1.20	-	2.50	-	0.12	-

Table 2: Continued.

Mutants	Sterility (%)	Blast reaction	Milling (%)	Amylose content (%)	Grain shape (mm)	Grain yield/plant (g)	Increase (%)
Sakha 101-M30	7.24	R	71.00a	19.00a	2.70a	36.00a	16.70
Sakha 102-M20	11.11	R	72.00a	18.00a	2.60a	33.00a	9.00
AC1453-M50	15.38	R	71.00a	20.00b	2.80b	32.00b	6.25
E.Yasmine-M30	16.00	R	70.00a	20.00b	3.04c	31.00b	3.22
Giza 178	23.00	R	70.00a	20.00b	3.00c	30.00c	**
LSD 0.05	2.30	-	0.10	2.00	0.25	0.11	-

Means followed by the same letter(s) are not significantly different.

The performance of mutants, with respect number of to days to heading, plant height, panicle length, number of panicles per plant, number of grains per panicle, 100-grain weight, sterility (%), milling (%), amylose content, grain shape and grain yield per plant were significantly different from each other in the combined data. The salinity affected the grain formation more than the vegetative growth, as reported by Bari and Hamid (1988) and Akbar *et al.* (1986). The mutant of Sakha 101-M30 headed earlier (91.00 days), followed by the mutant, Egyptian Yasmin-M30 (92.00 days), as compared with the other genotypes (Table 2). Results, also, indicated that the mutants, Sakha 101-M30, AC1453-M50 and Egyptian Yasmin-M30, were significantly shorter in stature (80.00, 80.00 and 82.00 cm, respectively) than the check salt- tolerant cultivar Giza 178 (85.00).

The mutants, Sakha 102-M20 and AC1453-M50, were higher in panicle length (26.00 cm) than the check cultivar and the other mutants. The highest significant number of grains per panicle was found in Egyptian Yasmin-M30(139.00), followed by Sakha 101-M30 (138.00) among the other genotypes under saline soil for the combined data. The mutants Sakha 101-M30 and Sakha 102-M20 produced the highest significant grain yield per plant (36.00 and 33.00 g) under salinity conditions for the combined data, comparing with the check saline tolerant cultivar Giza 178(30.00g).

Results in Table2, also, indicated that the mutant Sakha 101-M30 was significantly shorter in stature (80.00cm), higher in number of panicles per plant (22.00) and higher in number of grains per panicle (138.00) and higher in grain yield per plant (36.00g) than the salt tolerant cultivar, Giza 178. This mutant showed an increase of 18.18 % in number of panicles per plant, 5.80(%) in number of grains per panicle and 16.70(%) in grain yield per plant over the well known salt tolerant cultivar, Giza 178. The mutant Sakha 102-M20, was superior in various characteristics, such as panicle length (26.00cm), higher number of grains per panicle (135.00), heavier in 100- grains weight (2.23g), higher grain yield per plant (33.00 g) and produced higher milling (%) (72.00). This mutant showed an increase of 5.26(%) in number of panicles per plant, 3.70 (%) in number of grains per panicle, 14.80(%) in 100-grain weight and 9.00(%) in grain yield per plant.

Results further indicate that the mutant, AC1453- M50 was found early in heading (93.00 days), shorter in height (80.00cm), having long panicles (26.00 cm), high number of panicles per plant (19.00) and high grain yield per plant (32.00 g). This mutant showed an increase of 5.26(%) in number of panicles per plant and 6.25(%) in grain yield per plant comparing with the check cultivar, Giza 178. The data also indicated that all these mutants were superior in their grain quality characters studied (Table 2), such as milling (%), amylose content and grain shape. The mean values of milling (%) and grain shape for the mutants (71.00, 72.00, 71.00 and 70.00, respectively) were higher than that in Giza 178. On the other hand, all these mutants were found to have low amylose content (19.00, 18.00, 20.00 and 20.00, respectively). Presently, it is a universally recognized fact that plant architecture has evolutionary significance and practically reduced plant height and has contributed a lot in numerous crops to potentiate the grain yields. Therefore, the increased plant grain yield of the obtained mutants might be linked to the altered plant morphology, associated with increased grain yield per hill, total number of grains per panicle and 100 -grain weight. The plant morphology, accompanying with such modifications in quantitative traits has achieved great importance to make the plants fit in the mathematical models for increasing the plant grain yield........

All the induced mutants; viz., Sakha 101-M30, Sakha 102-M20, AC- M50 and Egyptian Jasmine M30 had sterility values (7.24, 11.11, 15.38, and 16.00, respectively, lower than the check cultivar, Giza 178(23.00) and all of them were resistant to blast. The use of induced mutation has been considered as an appropriate approach for developing short statured, salinity tolerant and blast resistant mutants accompanied by high grain yield and excellent grain quality (Bari *et al.*, 1981; Micke *et al.*, 1990; Hu, 1991; Maluszynske *et al.*, 1991; Baloch *et al.*, 1999).

Table 3: Path coefficient analysis and simple correlation coefficients for the most important characters studied with grain yield of induced mutants under salinity conditions

Characters	Growth duration (days)	Plant height (cm)	No. panicles /plant	No. of grains / panicle	Sterility (%)	100-grain weigh (g)	Simple correlation with grain yield
Growth duration(days)	**-2.20**	-0.36	3.38	-0.55	-0.19	-0.38	-0.18
Plant height(cm)	0.68	**1.35**	-2.20	0.60	0.09	0.10	0.58*
No. panicles/plant	-1.62	-0.63	**4.55**	-0.51	-0.73	-0.55	0.59*
No. of grains /panicle	1.12	0.83	-2.28	**0.99**	-0.30	-0.17	0.78*
Sterility (%)	0.33	0.08	-2.54	-0.17	**1.66**	0.64	-0.57*
100-grain weight(g)	0.77	0.16	-2.61	-0.19	0.87	**0.86**	-0.16

*: Significant at 0.05 level.

Path coefficient analysis indicated that plant height, number of panicles / plant, number of grains per panicle and sterility (%) obtained the largest direct effect on grain yield (bold values in Table 3). The simple correlation coefficient of plant height and number of panicles / plant with grain yield were almost equal to their direct effects. So, the correlation explained the true relationship and a direct selection, through these two characters, might be effective. Correlation of sterility (%) with grain yield was negative, but its direct effect was positive and high. So, a restricted simultaneous selection model could be followed; i.e., restrictions might be imposed to nullify the undesirable indirect effects. There was no effect of 100-grain weight on grain yield under saline soils for these mutants.

DISCUSSION

It is clear from the data that Sakha 101-M30, Sakha 102-M20, AC1453-M50 and Egyptian Yasmine-M30 were dwarf non-lodging mutants, earlier in heading, having more panicles/plant, more grains/panicle, low sterility (%), heavier grains, resistant to blast, as well as high grain yield / plant that derived from Sakha 101, Sakha 102, AC 1453 and Egyptian Jasmine. They, also, had the desirable quality characters (that were closer to Sakha 101, whose grains commanded a premium in the market) that meet the criteria required for export purposes. In so far as grain yield is concerned, , it has consistently outperformed Sakha 101, Sakha 102, AC 1453 and Egyptian Jasmine; the cultivars that currently command the largest area in the growing regions. The advantages of these mutants, over their respective parents, included grain yield and quality and could be taken as true mutants. The consistent performance of induced mutants in the original cultivars demonstrated that it was possible to employ mutation breeding to obtain high yielding mutants under salinity conditions with desirable quality characters in the background of traditional cultivars and evolved basmati types that are currently being grown. The mutants in the background of their respective control, especially Egyptian Jasmine could, also, be considered as traditional cultivars and might find favors with the international market. The mutants, also, fit into the original cultivars. These mutants might be recommended to be new rice cultivars tolerant to salinity conditions to be grown under the area in the North Delta affected by salinity conditions to overcome that problem.

The other mutants generated under the program had the requisite grain yield potential, but could not be classified as original cultivars due to a deficiency in one or more quality characters that are present in their respective control. This implies that attention should be given to salinity tolerance with quality characteristics even, using mutation techniques for rice improvement.

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الملخص العربي

أستنباط سلالات من الارز متحملة للملوحة عن طريق التربية بالطفرات

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نجحت الجهود المبذولة فى مجال تربية الأرز باستنباط وتحسين العديد من الأصناف والتى احتلت مساحات واسعة فى شمال الدلتا فى مصر. وقد تفوقت مجموعة من تلك الأصناف على غيرها فى صفات عديدة وخاصة صفات جودة الحبوب ولذا فانها احتلت المساحة الأكبر من المساحة المنزرعة.

وأصبحت بعض هذه الأصناف تفتقد الى صفات هامة منها صفة المقاومة لمرض اللفحة بالاضافة الى حساسيتها الشديدة للملوحة.

ولذلك أجريت هذه الدراسة بمزرعة محطة البحوث الزراعية بالسرو خلال المواسم الزراعية ٢٠٠٢ وحتى ٢٠٠٩ بهدف استحداث سلالات مبكرة فى النضج و مقاومة للرقاد و مقاومة لمرض اللفحة وذات انتاجية مرتفعة تحت ظروف الأراضى الملحية باستخدام طريقة التربية بالطفرات(خمس جرعات من أشعة جاما) .وقد تم الحصول على أربع سلالات طفرية من الجيل الأشعاعى السادس وهى سخا١٠١ ام ٣٠ ، سخا ١٠٢ ام ٢٠ ، أى س ام ٥٠ وياسمين المصرى ام ٣٠ ناتجة من أصناف الارز المصرية المنزرعة سخا ١٠١ ، سخا ١٠٢ ،ياسمين المصرى والسلالة آى س ١٤٥٣.

وقد تم تقييم تلك الطفرات لمدة موسمين متتاليين (٢٠٠٨ ، ٢٠٠٩) تحت ظروف الاراضى المتأثرة بالملوحة . وأظهرت النتائج أن تلك السلالات الطفرية المذكورة قد تفوقت فى محصول الحبوب على الصنف المعروف بتحمله للظروف الملحية (جيزة ١٧٨) بنسب ١٦% و ٩% و٦,٢٥% و٣,٢٢% على التوالى.

كما تفوقت تلك السلالات الطفرية على الأصناف الناتجة منها فى صفات أخرى منها النضج المبكر وعدم الرقاد و صفة المقاومة لمرض اللفحة وصفات جودة الحبوب.