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Induction of Salt Tolerance in Rice Through Mutation Breeding

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Abstract: One mutant variety Shua-92 and two mutants of rice, derived through mutation breeding from the two standard varieties IR8 and Pokkali, were evaluated for two years for their yield performance in salt affected soils with pH 7.63 to 7.68 and EC 7.11 to 8.0 dSm^{-1}. The mutant variety Shua-92 produced 40 and 49% higher paddy yield on salt affected soils than the famous salt tolerant varieties Nona Bokra and Pokkali.

Key words: Mutants, salt affected soils, high yield, tolerance in rice

Introduction

The predominate constrain in rice production is soil salinity in Pakistan because the area ranging from 2.2 to 6.5 million hectares have become saline and 40000 hectares of fertile lands are becoming saline annually (Gareth and John, 1986). This is the most serious problem in Sindh province, where about 48% of the cultivated areas have been affected one way or other. This situation is becoming worse day by day (Aslam *et al.,* 1987; Boje-Klein, 1986; Bui and Do, 1988; Gregorio and Senadhira, 1993; Jones, 1985; Mishra, 1990; Narayanan and Rangasamy, 1990; Yamanouchi *et al.,* 1987; Massoud, 1974; Akber, 1986, 1987).

Many physico-chemical and biological techniques are under investigations for the reclamation of such salt affected soils in the country. Breeding for salt tolerance of rice varieties seems to be one of the most promising solutions for utilizing such soils. Exploitation of salt tolerant rice varieties had been in progress since 1943 in the sub-continent, but those rice varieties 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 varieties, which possess high 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 varieties with improved agronomic traits (Micke *et al.,* 1990; Hu, 1991; Maluszynske *et al.,* 1991; Baloch *et al.,* 1999; Baloch *et al.,* 2001, 2002). The study was therefore, carried out to assess the performance for yield and yield components of mutation along with their parents and check varieties under saline conditions.

Material and Methods

Two mutants (IR8-202 and Pokkali-M) and one mutant variety (Shua-92) of rice, developed from varieties IR8 and Pokkali through mutation breeding, were tested at Nuclear Institute of Agriculture Farm, Tandojam, during Kharif 1998 and 1999 for grain yield and yield components under the saline conditions along with well known salt tolerant rice varieties (Nona Bokra and Pokkali) and check variety (DR-83). The layout of the experiment was 4 times replicated randomized complete block designed (RCBD) design. The plot size was 5x3 m^2. Soil of the experimental area was analyzed for pH (7.68 and 8.63) and EC (7.11 and 8.00) during 1998 and 1999. The data for paddy yield and yield 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 DMR test.

Results and Discussion

The performance of varieties with respect to days to heading, plant height, number of fertile panicle per plant, number of fertile grains per panicle, fertility percentage per panicle, 1000-grains weight, grain yield per plant and grain yield kg ha^{-1} were significantly ($P<0.05$) different from each other in both the years. The salinity affected the grain formation more than the vegetative growth as reported by Bari and Hamid (1988) and Akber (1986). The mutant of pokkali, headed earlier (112 days) followed by the variety DR83 (113.50 days) as compared with the five other genotypes during 1998 (Table 1).

Results indicated that the mutant variety Shua-92 was significantly ($P<0.05$) shorter in stature (71.11 cm^2), higher in fertile panicles per plant (16.33), fertile grain per panicle (129.50), panicle fertility (96.00), 1000-grains weight (24.24 g), grain yield per plant (28.11 g) and paddy yield kg ha^{-1} (4467) than salt tolerant varieties Pokkali and Nona bokra.

Table 1: Performances of rice mutants/varieties for yield and yield components under saline conditions during 1998

Mutants/ Varieties	Heading date (50%)	Plant height (cm)	Fertile panicles per plant	Increase (%)	Fertile grains per panicle	Increase (%)	Panicle fertility %
Shua-92	120.50b	71.11e	16.33a	**	129.50a	**	96.00a
IR8-202	118.00c	72.57e	14.56c	11	119.51b	08	95.21b
DR-83	113.50d	79.45d	11.20d	31	113.50c	12	94.79b
Pokkali-M	112.00d	88.26c	14.99b	08	109.94d	15	95.49ab
Pokkali-P	132.00a	146.70a	09.32e	43	092.10f	29	92.46d
Nona-Bokra	120.75b	134.35b	11.32d	31	101.50e	22	93.35c

	Increase (%)	1000 grains weight (g)	Increase (%)	Plant grain yield (g)	Increase (%)	Paddy yield kg ha^{-1}	Increase (%)
Shua-92	**	24.24a	**	28.11a	**	4467a	**
IR8-202	01	24.10a	00	25.52b	09	3993b	11
DR-83	01	23.15c	04	23.74c	16	3473c	22
Pokkali-M	00	24.11a	00	23.66c	16	2900d	35
Pokkali-P	04	23.67b	02	19.23e	32	2333e	48
Nona-Bokra	03	24.15a	00	20.72d	30	2733d	39*

Table 2: Performances of rice mutants/varieties for yield and yield components under saline conditions during 1999

Mutants/ Varieties	Heading date (50%)	Plant height (cm)	Fertile panicles per plant	Increase (%)	Fertile grains per panicle	Increase (%)	Panicle fertility %
Shua-92	119.00c	69.34f	15.51a	**	124.25a	**	94.95a
IR8-202	116.75d	71.30e	14.33b	08	114.26b	08	94.49a
DR-83	115.50d	75.42d	10.80d	30	108.25c	13	94.22a
Pokkali-M	111.50e	83.23c	14.34b	08	104.69d	16	94.87a
Pokkali-P	129.50a	138.40a	13.30c	14	86.85f	30	91.27c
Nona-Bokra	124.00b	132.51b	09.57e	38	96.25e	23	92.53b

	Increase (%)	1000 grains weight (g)	Increase (%)	Plant grain yield (g)	Increase (%)	Paddy yield kg ha^{-1}	Increase (%)
Shua-92	**	24.21a	**	27.96a	**	4580a	**
IR8-202	**	24.05a	**	25.69b	08	3787b	17
DR-83	**	23.10c	05	23.85c	15	3387b	26
Pokkali-M	**	24.05a	**	21.71d	22	3900b	15
Pokkali-P	04	23.59b	03	19.48f	30	2240c	51
Nona-Bokra	03	24.13a	0.3	20.92e	25	2640c	42*

Table 3: Average performances of the two years of rice mutants/varieties for yield and yield components under saline conditions during 1998 and 1999

Mutants/ Varieties	Heading date (50%)	Plant height (cm)	Fertile panicles per plant	Increase (%)	Fertile grains per panicle	Increase (%)	Panicle fertility %
Shua-92	119.75c	70.23f	15.92a	**	126.87a	**	95.47a
IR8-202	117.38d	71.94e	14.44b	09	116.88b	08	94.85bc
DR-83	114.50e	77.43d	11.00d	31	110.88c	13	94.51c
Pokkali-M	111.75f	85.75c	14.66b	08	107.32d	15	95.18ab
Pokkali-P	130.75a	142.55a	11.31c	29	89.47f	29	91.86e
Nona-Bokra	122.38b	133.43b	10.44e	34	98.88e	22	92.94d

	Increase (%)	1000 grains weight (g)	Increase (%)	Plant grain yield (g)	Increase (%)	Paddy yield kg ha^{-1}	Increase (%)
Shua-92	**	24.23a	**	28.03a	**	4524a	**
IR8-202	**	24.08b	**	25.61b	09	3890b	14
DR-83	0.01	23.13d	05	23.80c	15	3430c	24
Pokkali-M	**	24.08b	**	22.68d	19	3400c	25
Pokkali-P	04	23.63c	02	19.36f	31	2287e	49
Nona-Bokra	03	24.14ab	0.35	20.82e	26	2687d	41

Means followed by the same letters are not significantly different from each other at 5% level of significance

This mutant variety showed an increase of 43 and 31% in fertile panicles per plant, 29 and 22% in fertile grains per panicle, 4 and 3% in panicle fertility percentage, seed index 2 and 0.4% in 1000-grains weight, 32 and 36% in grain yield per plant and 46 and 39% in paddy yield per ha^{-1} over pokkali and Nona Bokra, respectively. Salinity significantly reduced plant height, root length and biomass in rice cultivars indicated by Salim, *et al.* (1990).

Results of the second year (1999) head confirmed that the mutant Pokkali-M was found early in heading (111.5 days) (Table 2). The mutant variety Shua-92 again produced significantly ($P< 0.05$) shorter in stature (69.34 cm), higher in fertile penicle per plant (15.51), fertile grain per penicle (124.25), penicle fertility (94.95%), 1000-grains weight (24.21 g), grain yield per plant (27.96 g) and paddy yield kg ha^{-1} (4580) than salt tolerant varieties Pokkali and Nona-

Bokra. This mutant variety showed an increase of 14 and 389% in fertile penicle per plant, 30 and 23% in fertile grain per penicle, 4 and 3% in penicle fertility, 3 and 0.3% in seed index per 1000-grains weight, 30 and 25% in grain yield per plant and 51 and 42% in paddy yield ha^{-1} over the well known designated salt tolerant varieties Pokkali and Nona-Bokra, respectively.

Pooled averages of two years showed significant differences ($P< 0.05$) among the six genotypes under evaluation (Table 3). The mutant Pokkali-M possessed earliness in days to heading (111.75 days) among the other genotypes. While the mutant variety Shua-92 maintain its superiority in various characteristics, such as found shorter in plant height (70.23 cm), higher number of fertile penicles per plant (15.92), more fertile grains per penicle (126.87), high penicle fertility(97.47%), having heavy thousand grain weight (24.23 g), high plant yield (28.03 g) and produced higher paddy yield of 4524 kg ha^{-1}. The mutant variety Shua-92, showed an increase of 29 and 34% in fertile penicles per plant 29 and 22% in fertile grains per penicle, 4 and 3% in fertility percentage per penicle, 2 and 0.35% in seed index per 1000-grains weight, 30 and 25% in grain yield per plant and 49 and 41% in paddy yield ha^{-1} than the mother variety, Pokkali and Nona-Bokra, respectively.

It is evident from results of 2 years presented here that there are marked differences in relative salt tolerance among the varieties and mutants tested under saline conditions of pH 7.68 with EC 7.11 dSm^{-1} had produced higher values for yield parameters than the higher pH 8.63 with EC 8.00 dSm^{-1}. These studies suggest that the induced mutation can be successfully employed not only for high yield, but also for induction of salt tolerance in rice.

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