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Induction of Salt Tolerance in Basmati Rice (*Oryza sativa* L.)

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ABSTRAK

Tujuh mutan yang dianggap toleran terhadap garam telah dipilih dari populasi segregat (M2) di bawah keadaan larutan garam natrium. Setelah diuji mutan-mutan di bawah tegasan garam yang berbeza, didapati mutan RST-24 yang paling baik. Mutan itu juga ternyata toleran terhadap garam tersebut dalam kedua-dua keadaan iaitu di kultur kerikil dan di sawah bergaram natrium. Mutan tersebut lebih baik dari variati induk Basmati-370, bagi nisbah besar-panjang.(beras), nisbah pemanjangan dan kekonsistanan gel. Hasilan dan komponen-komponennya serta lain-lain ciri kualiti mutan dan induk di bawah tegasan garam telah juga dilaporkan.

ABSTRACT

Seven relatively salt tolerant mutants were selectedfrom segregating populations (M2) under saline sodic conditions. Further testing of mutants under different salt stresses proved the superiority of one mutant namely RST-24. The mutant also proved its salt tolerance potential under both the gravel culture and saline-sodic field conditions. The mutant slightly surpassed parantal variety Basmati-370, for length-breadth ratio (milled kernel), elogation ratio and gel consistancy. The yield and yield components and other quality traits of mutants and parent under salt stress are also presented.

Key words: *Oryza sativa*, Basmati rice, salt tolerant mutants.

INTRODUCTION

Basmati rice is grown predominantly in the province of Punjab, where about 5.87 m hectares of soil is deteriorated by salinity and alkalinity. Like other agricultural crops, the production of Basmati rice is also hamstrung by the menace of salt stress. Therefore, improving salt tolerance in Basmati rice may be the most pragmatic approach to utilise these salt affected lands more effectively.

Attempts to improve genetic salt tolerance by conventional breeding means has been accomplished for coarse grain rice (Sajjad 1984; Sajjad *et al.* 1987a, 1987b, 1988). However, little headway has been made in improving salt tolerance in fine Basmati rice.

Combination breeding techniques may not be effective in improving salt tolerance in Basmati rices from the quality point of view. The use of induced mutation technique has been successfully utilized for the improvement of salt tolerance in rice in India (Kaul and Sharma, 1983; Sreedharan and Misra 1976) and in Indonesia. (Ismachin *et al.* 1983).

Our study also uses this technique for the improvement of salt tolerance in Basmati rice.

MATERIALS AND METHODS

Dry and uniform seeds of Basmati 370 with moisture content of 14% were exposed to ^{60}Co source of Nuclear Institute for Agriculture and Biology, Faisalabad, Pakistan. Five thousand seeds per dose were used and doses of 0, 15, 20 and 25 kR were administered. At maturity of M_1 crop, the first three emerging panicles from each M_1 plant were harvested and seeds were bulked dosed. M_2 was space planted under artificially saline sedic· cemented field basin (6 x 6 x 1 m) conditions provided with drainage system at the bottom. These experiments were initiated in 1983.

Seven relatively salt tolerant mutants selected from M_2 were further grown under different salt stresses during 1984. The most promising mutant (the mutant exhibiting the highest LD^{50}) was comparatively tested under gravel culture during 1986. The experiment was conducted in cemented basins filled with quartz gravel saturated with Hoagland nutrient solution. Nutrient solution was replaced on weekly intervals. This experimental set up was maintained in a stagnant condition to stimulate growth conditions of a rice field. Forty-five day-old seedlings grown on non saline field conditions were transplanted in a randomized complete block design with four replications. A single seedling per hill was transplanted with a plant to row distance of 20 cm. One week after transplanting, saline treatment of a mild concentration was imposed. This was to avoid the compressing effects of higher salinities on the growth of different rice genotypes as reported by Kaddah (1963). More recently, researchers (Yea and Flowers 1984) have reported that the varietal differences in rice tended to be manifested only at a rather moderate salt concentration of 50 mol. m^{-3} NaCl*. The salt tolerance potential of genotypes was estimated by computations of salt-induced reduction percentages over a non-saline environment for yield and yield components. The mutant was comparatively yield tested under naturally salt-affected land (pH=8.7, EC=6.0 dS m^{-1}, SAR=30) of BSRS (Biosaline Research Sub-Station) of NIAB at Lahore, during 1987.

Forty-five day-old nusery grown seedlings on a non-saline field were transplanted, two seedlings per hill with a plant to row distance of 20 cm. The experiment was a complete randomized block design with three replications. The crop was irrigated with the saline-sodic water of tubewell (EC=1.1 dSm^{-1} , R.S.C - 9.7, S.A.R. = 7.5). A relatively higher dose of fertilizers (NPK: 80 - 40 = 0) was used to rectify the nutrient imbalance of salt affected land. Ten randomly selected plants per replication per genotype were used for recording data on yield components. For paddy yield, 125 plants per replication per genotype were harvested. The data were analysed according to Duncan's multiple range test.

The mutants RST-24, BSRS-1-85 and parental variety, Basmati 370, were also evaluated for physiochemical traits.

RESULTS AND DISCUSSION

The influence of four salt stresses on yield per plant is presented in Table 1. It is evident from the table that the mutant RST-24 exhibited the highest LD_{50} of 6.0 d S^{-1}. The mutant showed 0.3

TABLE 1
Influence of different salinity levels on yield per plant of different relatively salt tolerant mutants of Basmati - 370

Mutant/ variety	Salinity levels dS/m					Regression equation	LD (EC assoicated with 50% reduction in yield over minimum salinity)
	4.3	4.5	4.9	5.2	5.5		
Basmati 370	15.2	14.2	14.0	13.0	6.5	Y = 41.5273-5.9318X	5.7
RST-2	16.6	15.2	15.0	10.7	8.2	Y=46.3926-6.8140X	5.5
RST-7	19.1	15.3	14.4	8.9	7.0	Y=60.4091-9.7273X	5.2
RST-12	19.8	14.8	14.3	10.4	6.5	Y=60.8711-9.7769X	5.3
RST-15	18.4	14.3	11.9	9.9	9.3	Y=47.7165-7.1632X	5.4
RST-21	20.3	16.7	15.4	14.0	10.3	Y=50.3570-7.1756X	5.6
RST-24	20.5	17.6	17.0	15.5	12.4	Y=44.7810-5.7748X	6.0
RST-31	19.1	17.2	16.3	14.3	10.4	Y=47.0388-6.4711X	5.8

* When dissolved in a nutrient solution, the total salt concentration in the solution will be = 7.0 dsm^{-1}.

dS m higher salt tolerance as compared to parent variety, Basmati 370. The yield of rice starts declining beyond threshold electrical conductivity (EC) value of 3.0 d S m $^{-1}$ (Hoffman 1981) and a drastic reduction in yield occurs a t EC-10 dS m^{-1} (Khan *et al.* 1987)

The comparative salt tolerance study of RST-24 along with other genotypes conducted under gravel culture revealed (Table 2) that the salt-induced reduction percentages of the mutant were 28.0, 21.0, 37.0 18.0 and 30.0 for plant height, number of productive tillers per plant, number of grains per panicle, panicle fertility percent and yield per plant, respectively. These reduction percentages were statistically less than those of parental variety, Basmati 370. Also, the absolute values for the mutant under saline environment were compartively higher for panicle fertility percent and grain yield per plant.

A micro (6 m^2 per entry) yield trial of 11 rice genotypes conducted at a naturally salt affected land revealed that the mutant RST-24 has also shown a comparatively higher salt tolerance potential than Basmati 370 (Table 3). It is evident that values for number of productive tillers per plant, number of grains per panicle, panicle fertility % and yield were significantly higher than the parent. The other mutant namely BSRS-1-85, derived from Basmati 370, also perfomed better than the parent variety Basmati 370 in a saline environment.

Quality Traits and Milling Recovery

Both the mutants were at par with Basmati 370 for kernel dimension, chalkiness, cooked kernel dimension, aroma, amylose contents, alkali spreading value and gel consistency and milling characteristics (Table 4).

TABLE 2

Influence of salinity on yield and yield components or genotypes of rice under gravel culture.

Varieties/ variants/ mutants	Plants height (cm)	% R.O.C	No. of productive tillers/ plant	%R/I. O. C	No. of grains/ panicle	% R.O.C	Panicle fertility (%)	% R.O.C	Yield plant (g)	% R.O.C
NIAB Rice 1	132.5 (132.3)	i -0.2	23.5 (25.0)	a +6.0	128.4 (103.6)	f -19.0	88.8 (86.6)	h -3.0	52.3 (47.0)	i -10.0
C23-3-1	74.8 (72.3)	h -3.0	26.8 (20.5)	f -24.0	134.2 (122.3)	h -9.0	86.4 (81.5)	g -6.0	38.3 (30.6)	h -20.0
RSR-1-84	145.0 (107.5)	c -26.0	28.5 (21.0)	g -26.0	152.4 (82.2)	a -46.0	92.3 (71.3)	b -23.0	45.3 (14.1)	b -69.0
Pokkali	180.3 (143.0)	d -21.0	23.3 (18.5)	e -21.0	145.0 (82.0)	d 44.0	82.6 (65.4)	c -21.0	58.0 (16.6)	a -71.0
RST-24	139.5 (100.0)	b -28.0	17.8 (14.0)	e -21.0	105.3 (66.2)	d -37.0	78.0 (63.9)	d -18.0	16.8 (11.8)	g -30.0
Basmati-370	152.8 (101.3)	a -34.0	23.3 (17.0)	h -27.0	114.0 (65.2)	c -43.0	78.6 (58.6)	a -26.0	25.5 (7.1)	a -72.0
NIAB-6	47.3 (45.8)	h -3.0	19.6 (19.3)	b -2.0	60.8 (56.8)	i -7.0	88.2 (82.2)	f -7.0	11.6 (7.4)	f -36.0
IR-6	60.0 (51.3)	e -15.0	17.5 (14.3)	d -18.0	82.0 (78.2)	j -5.0	89.3 (69.1)	b -23.0	17.0 (6.9)	d -59.0
NIAB Rice-II	98.8 (86.7)	f -12.0	25.0 - (18.0)	i 28.0	82.3 (67.8)	g 18.0	51.5 (46.4)	e -10.0	14.4 (8.5)	e –41.0
Jhona 349 x IR-6	109.8 (100.0)	g -9.0	16.0 (15.0)	c -6.0	74.8 (60.2)	e -20.0	59.3 (45.6)	b -23.0	18.0 (6.9)	c -62.0

Upper row represents the data for non-saline (EC=2.4 dSm^{-1}) and the data in parentheses are of saline (EC=7.0 dSm^{-1}) environment.

Figures followed by different letters are significant at 5% level of significance according to DMRT.

* Percent reduction (-)/increment (+) over control.

TABLE 3
Performance of variants/mutants under saline-sodic field at BSRS, Lahore

Name of variety/ mutant	Plants height (cm)	No. of productive tillers/ plant	Panicle length (cm)	No. of grains per panicle	Panicle fertility %	Thousand kernel weight (g)	Yield kg/ha
Bas. 370	124.0 b	10.0 f	25.1 a	80.0 d	76.0 e	19.0 de	2125. Of
RST-24 (derived from Bas. 370)	122.7bc	16.5ab	25.4a	101.0 b	89.3abc	17.9 e	005.3d
BSRS-1-85 (derived from Bas. 370)	122.3bc	14.4bcd	24.8ab	101.0 b	88.0abc	19.3 d	2432.7 e
C23-S-1	64.3 d	14.8 bcd	18.6 d	111.7 a	84.6bcd	21.1 c	3728.3b
RSR-3-84	120.7 c	16.0 bc	21.3 c	114.7 a	80.7 de	19.2 de	3777.7b
J. 349	114.3de	11.0 ef	22.6 bc	100.0 b	89.6abc	21.8 c	3500.3c
J. 349 x	112.3 e	13.6 d	20.2 cd	60.0 e	83.9 cd	24.3 b	3022. 0d
IR6	68.3 f	13.0 de	21.2 c	96.7 b	80.7 de	22.3 c	2499.3 e
IR6 x B. 370, F6	122.0bc	18.5 a	22.3 bc	116.7 a	91.4 a	19.1 de	2994.3d
NR-I	117.0 d	14.0 cd	23.8 ab	110.7 a	90.5 ab	26.2 a	3920.3a
Pokkali	148.3 a	11.3 ef	24.2 ab	90.0 c	88.3 abc	24.0 b	3504.3c

Figures followed by different letters are significant

TABLE 4
Physico chemical traits of salt tolerant mutants and parental variety Basmati 370.

Traits	Varieties		
	RST-24	BSRS-1-85	Bas-370
I. Milled kernel			
Length (mm)	7.17	6.54	7.12
Breath (mm)	1.89	1.89	1.91
Thickness (mm)	1.73	1.69	1.73
Length Breath ratio	3.79	3.47	3.74
Chalkiness	T	T	T
II. Cooked kernel			
Length (mm)	13.50	13.40	13.20
Elongation ratio	1.89	2.05	1.85
Aroma	S	S	S
Amylose content	22.44	22.76	22.41
Alkali spreading value	4.60	5.00	4.70
Gelconsistency (mm)	58.00	56.00	54.00
III. Milling recovery			
Total recovery%	64.40	62.70	63.80
Head recovery	51.80	49.70	50.1

T : Translucent S : Strong

The mutant RST-24 and BSRS-1-85 slightly surpassed parent for length breadth radio, elongation ratio and gel consistency.

CONCLUSION

The mutant RST-24 seems to possess better salt tolerance potential than the parent variety Basmati 370. It is fortunate that the mutant possesses quality traits of Basmati 370.

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