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STABLE GENOTYPES OF RICE FOR SODIC SOILS

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ABSTRACT

Stability parameters based on 24 promising rice genotypes were estimated under sodic soil for various traits. The genotypes were severely influenced by the varying levels of sodicity and the G × E interaction was highly significant for all the characters indicating the differential response of the rice genotypes in different sodic environments. Both linear and non- linear components of variation were significant for days to 50% flowering, height and grain yield, while only non-linear component of variation was found to be significant for ear bearing tillers. The salt tolerant rice variety CSR 18 appeared to be the most stable and ideally adaptable cultivar in all the varying stress enviornments. Other rice genotypes like CSR 11 and CSR 10 proved to be the best adaptable genotypes in highly deteriorated sodic soils. Hence these genotypes could judiciously be used in breeding programme for improving the productivity of rice in sodic soils.

Key words : Rice, salt tolerance, stable genotypes, sodic soils.

This is well known that stability, i.e. least phenotypic variation in response to fluctuations in environments is a genetic trait [1]. Rice varieties suited to normal soil conditions may rarely or mostly may not adapt under sodic soils. Few screening studies have been reported based on stability of the rice genotypes across salinity stress and non stress environments [2, 3], while no such study has been reported for sodicity stress. Sodicity being a specific agroedaphic environment spread over 2.5 M ha [4] area of the country for which rice is recommended as the first crop of reclamation, a strong need arises to identify a group of rice genotypes which could be fit as suitable varieties for such ecologies or could be used as donor for future breeding programme. Therefore, present study was undertaken to evaluate rice varieties for the sodic soil environments differing in degree of sodicity and to assess the nature and magnitude of genotype × sodic stress interactions. Thus, it will lead to a successful breeding strategy for sodicity tolerance.

MATERIALS AND METHODS

Experimental material comprising twenty four rice genotypes including best salt tolerant high yielding released variety CSR 10 as check [5] were laid out in a randomised block design with three replications each under three soil edaphic environments during the rainy seasons of 1987 and 1988. All the three environments can be summarised as (i) normal soil with soil $pH_2 \leq 9.0$ and exchangeable sodium percentage (ESP) ≤ 25; (ii) partially deteriorated sodic soil with soil pH_2 9.1 - 9.7 and ESP $\approx$ 30-60; and (iii) highly deteriorated sodic soil having soil pH_2 9.8-10.1 and ESP $\approx$ 65-75. (pH_2 denotes the $pH_{1:2}$ i.e. pH of one part soil and two part water mixture. It is a standard procedure to measure the soil pH).

The net plot size was 3 rows of 3 m length. Two to three plants/hill were transplanted at each experimental site with the spacing of 15×15 cm^2. All the normal crop management practices were followed. Observations for number of ear bearing tillers/plant (EBT/P) and plant height (cm) were recorded on five randomly selected competitive plants from each soil stress environment. Moreover, days to 50% flowering and grain yield (g) were recorded on a whole plot basis. The stability parameters of different genotypes were computed as per Eberhart and Russell [6].

RESULTS AND DISCUSSION

Significant differences for almost all the characters were observed among the genotypes in all the different diverse stress environments during both the years. The joint regression analysis also indicated that variance due to genotype was significant

Table 1. ANOVA (mean squares) for stability parameters of the studied traits under sodic stress conditions in rice

Source	d.f.	50% flowering	Height	EBT/P	Grain yield
Genotypes(G)	23	509.6^{+*}	782.9^{+*}	3.7*	27989.9*
Environments(E)	5	2547.6^{+*}	2738.6^{+*}	39.5^{+*}	795833.6^{+*}
G × E	115	39.2^{+*}	54.8^{+*}	3.8*	23405.9*
Env. (Linear)	1	12738.3^{+*}	13693.5^{+*}	197.4^{+*}	3979177.0^{+*}
G × E (Linear)	23	124.5^{+*}	125.6^{+*}	2.8	30811.7*
Pooled deviations	96	17.2*	35.5*	3.8*	20656.9*
Pooled error	276	12.2	15.4	2.1	7203.3

$^{+}$Significant at 5% levels from pooled deviation

*Significant at 5% levels from pooled error for all the four characters suggesting the presence of genetic variability (Table 1). The variance due to environments were also significant for all the four traits indicating that these characters were influenced by sodic stress environments too. Varying magnitude of variance indicated the presence of larger variation among stress environments than the genotypes for all the traits. The variance due to G × E was significant for all the character depicting the differential response of the rice genotypes in different stress soil environments for these traits. Both linear and non-linear components were significant for grain yi :ld, days to 50% flowering and height while it is not so for ear bearing tillers which showed non-significant linear response. Linear component of G × E interaction was relatively greater than the non-linear component for all the characters except ear bearing tillers where the non-linear component was greater, suggesting that the performance of the genotypes for all characters could be predicted except ear bearing tillers.

The environmental indices indicated both the favourable and unfavorable environments for all the characters (Table 2). Moderate stress (partially deteriorated sodic soils) was found to be most favourable environment particularly for grain yield in both the years. Since the genotypes chosen for this experiment are mostly promising salt tolerant lines/varieties they exhibited better performance in partially reclaimed sodic soil than in any other environment.

Table 2. Values of environmental indices for grain yield and yield components under edaphic stress conditions in rice

Year	Env.	Environmental Index			
		50% Flowering (days)	Plant height (cm)	EBT/P (no.)	Grain yield (g/plot)
1987	E1	–9.134	–5.045	–0.185	–42.971
	E2	–7.440	7.989	2.398	157.723
	E3	–9.648	–4.291	–0.074	–27.527
1988	E1	15.533	–16.768	–0.519	–328.179
	E2	5.727	6.107	–0.157	148.557
	E3	4.963	12.009	–1.463	92.404

The persual of data in tables 3 and 4 revealed that the salt tolerant rice variety CSR 18 was found as most stable and ideally adaptable variety for sodic soils having high mean value for grain yield, regression coefficient (bi) non-significantly different from 1 and lowest non-significant deviation from regression (S^2_{di}). This variety has

Table 3. Per se performance and stability parameters in rice under different soil stress conditions

Genotype	Grain yied			Days to 50% flowering			EBT/plant			Plant height		
	Mean,g/ plot (q/ha)	bi±SE	S^2_{di}	Mean	bi±SE	S^2_{di}	Mean No.	bi±SE	S^2_{di}	Mean (cm)	bi±SE	S^2_{di}
NDR 5006	720.8(53.4)	1.69* ± 0.40	20066.3**	122.0	1.32* ± 0.29	20.79*	9.0	1.81** ± 0.29	-1.48	106.9	1.62** ± 0.24	16.5
NDR 5007	729.7(54.1)	1.65** ± 0.34	12410.7*	126.9	1.02** ± 0.16	1.92	9.4	1.14 ± 0.77	2.66	110.1	2.17** ± 0.26	24.2*
M1-2-2	611.4 (45.3)	1.27* ± 0.55	43672.8**	99.6	0.79** ± 0.14	-0.19	9.3	0.67 ± 1.08	7.43**	77.8	0.90* ± 0.27	26.4*
IR 30864	674.7(50.0)	0.74 ± 0.32	9849.7*	108.8	0.67* ± 0.20	9.42	8.3	1.58* ± 0.45	-0.46	89.1	0.73* ± 0.26	23.9*
RP 1810-413-349	633.8(46.9)	0.52 ± 0.38	17515.2**	112.3	1.38** ± 0.14	-1.67	9.6	0.08 ± 0.50	-0.07	80.7	0.94** ± 0.20	7.3
Pusa RAC-10	515.0(38.1)	0.18 ± 0.35	13211.9*	107.3	0.90** ± 0.17	2.29	8.6	0.44 ± 1.13	8.37**	76.5	0.82* ± 0.18	3.3
CR 235-4	645.5(47.8)	1.94* ± 0.43	23931.0**	130.7	0.48 ± 0.22	12.59	10.7	1.62 ± 0.64	1.16	113.4	2.06* ± 0.52	140.5**
NDRK 5012	563.2(41.7)	0.64 ± 0.28	6408.9	102.1	-0.17 ± 0.11	-5.56	9.8	0.35 ± 0.94	5.15*	85.4	2.83** ± 0.15	-1.9
SAR 48	562.2(41.6)	0.97* ± 0.34	11883.6*	112.5	1.36** ± 0.11	-5.81	8.7	1.10 ± 0.90	4.55*	78.5	1.02** ± 0.08	-11.9
SAR 59	661.4(49.0)	1.19** ± 0.25	3405.9	113.0	1.10** ± 0.21	11.48	9.4	0.32 ± 1.13	8.45**	79.7	1.05* ± 0.27	26.7*
SAR 59-1	565.0(41.9)	0.96 ± 0.36	14207.1*	115.6	1.51** ± 0.16	1.7	8.3	1.35** ± 0.18	-0.68	74.8	1.07* ± 0.27	25.5*
CSR 9	711.9(52.7)	1.15* ± 0.34	12921.0*	117.8	1.66** ± 0.15	0.33	8.2	0.70 ± 0.33	-1.26	75.7	1.41** ± 0.25	20.4*
81-H8-42-14-15	629.2(46.6)	1.12** ± 0.23	1660.9	109.7	0.90* ± 0.22	13.32	9.3	0.59 ± 0.58	0.65	84.8	1.08** ± 0.12	-7.1
CSR 18	728.1(53.9)	0.44 ± 0.22	1028.6	97.8	0.34* ± 0.12	-4.22	8.0	1.25 ± 0.55	0.34	87.4	1.01** ± 0.17	1.5
M2-2-1	611.1(45.3)	1.54** ± 0.32	10578.5*	102.7	1.50** ± 0.30	35.00**	7.7	1.28* ± 0.42	-0.69	77.2	0.97 ± 0.39	70.0**
CSR 5	623.3 (46.2)	1.13* ± 0.34	12275.8*	103.4	0.71** ± 0.11	-5.77	9.2	0.88* ± 0.26	-1.6	78.3	0.54* ± 0.17	1.2
CSR 11	773.2(57.3)	1.07* ± 0.38	17160.3**	105.6	1.26** ± 0.16	1.92	9.7	0.70 ± 0.36	-1.1	71.2	0.75 ± 0.37	61.9**
RP 2274-443-348-152	756.7(56.1)	1.02* ± 0.30	7915.5	113.5	1.45** ± 0.12	-7.86	8.8	0.09 ± 0.63	5.27*	75.8	1.49** ± 0.17	3.9
RP 2271-434-324	609.4(45.1)	0.49 ± 0.39	18099.5**	104.9	0.45* ± 0.14	- 4.85	9.7	0.76 ± 0.60	1.17	79.5	0.68* ± 0.28	0.9
RP 2273-397-332-136	609.2(45.1)	1.08** ± 0.23	1590.3	90.6	0.58 ± 0.30	-2.09	9.2	1.04* ± 0.30	0.79	76.8	0.67** ± 0.14	29.2*
RP 2273-441-331-134	651.9(48.3)	0.91* ± 0.30	8714.9	105.1	1.94** ± 0.23	36.40**	7.9	0.47 ± 0.69	0.32	81.5	1.04* ± 0.28	-4.7
RP 2274-442-337-143	698.0(51.7)	1.04** ± 0.17	-2550.6	104.8	0.82** ± 0.14	16.91*	8.0	1.74* ± 0.38	1.73	79.0	0.32* ± 0.08	28.9*
RP 2271-391-326	583.6(43.2)	0.55 ± 0.26	3846.1	101.2	0.84** ± 0.14	-2.2	10.3	2.20* ± 0.62	-0.94	78.5	0.70* ± 0.20	-11.8
CSR 10(Check)	709.4(52.5)	0.64 ± 0.60	53082.4**	105.0	1.12** ± 0.09	-1.46	9.7	1.77 ± 0.95	0.99	71.2	0.68* ± 0.18	8
Mean	649.1(48.0)			109.0			9.1			82.9		

also proved to be stable for ear bearing tillers showing statistically unit bi value and S^2_{di} = 0 and also lower deviation from regression for 50% flowering. The magnitude of regression and deviation from regression varied from genotype to genotype. The genotypes NDRK 5012 and RP 2271-391-326 were also observed as stable genotypes for grain yield but the lower mean value of yield demonstrated the less adaptable to productivity in problem soils as the farmers are more interested in the high grain yield.

Table 4. Categorisation of stability response of genotypes for studied traits in rice

Trait	Stability response of genotypes		
	Mean	bi =1; S^2_{di} = 0	bi ≠ 1; S^2_{di} = 0
Grain yield	$> \bar{X}$	CSR 18	SAR 59
			RP 2274-443-348-152
			RP 2273-441-331-134
			RP 2274-442-337-143
	$< \bar{X}$	NDRK 5012	81-H8-42-14-15
		RP2271-391-326	RP 2273-397-332-136
Days to 50% flowering	$> \bar{X}$	CR 235-4	NDR 5007
			RP 1810-413-349
			SAR 48
			SAR 59
			SAR 59-1
			CSR 9
			81-H8-42-14-15
			RP 2274-443-348-152
	$< \bar{X}$	NDRK 5012	M 1-2-2
		RP 2273-397-332-136	IR 30864
			Pusa RAC-10
			CSR 18
			CSR 5
			CSR 11
			RP 2271-434-324
			RP 2271-391-326
			CSR 10

(*Table cont. on next page*)

EBT/plant	$> \bar{X}$	NDR 5007	CSR 5
		RP 1810-413-349	RP 2273-397-332-136
		CR 235-4	RP 2271-391-326
		81-H8-42-14-15	
		CSR 11	
		RP 2271-434-324	
		CSR 10	
	$< \bar{X}$	CSR 9	NDR 5006
		CSR 18	IR 30864
		RP 2273-441-331-134	SAR 59-1
			M 2-2-1
			RP 2274-442-337-143
Plant height	$> \bar{X}$		NDR 5006
			NDRK 5012
			81-H8-42-14-15
			CSR 18
	$< \bar{X}$		RP 1810-413-349
			Pusa RAC-10
			SAR 48
			CSR 5
			RP 2274-443-348-152
			RP 2271-434-324
			RP 2273-441-331-134
			RP 2271-391-326
			CSR 10

The salt tolerant high yielding dwarf genotype CSR 11 with highest average mean yield (773.28 g/plot) alongwith the stable ear bearing tillers and 50% flowering indicated most adaptable variety for higher productivity under sodic soil environments. The released national check variety CSR 10 has shown high mean grain yield but lower and non-significant bi value from unit and thus confirmed again its better suitability and adaptability to highly deteriorated sodic soils. Similar results have been reported by other workers too [7, 8]. The high yielding genotypes like NDR 5007 and NDR 5006 have shown poor adaptability for both the stability parameters. These genotypes may be adapted to normal soil (non-stress) or moderate sodic soil but will not be suitable to high sodicity. Further persual of the data for 50% flowering duration reveal that the genotypes NDRK 5012 and RP 2273-397-332-136 with lower mean value, unit regression coefficient and non-significant deviation from regression were most suitable for these part of India as farmers are interested for early maturing salt tolerant rice variety. The genotype CR 235-4 having high mean value for flowering along with both stable parameters may be suitable for others states of the country where the requirement of late maturing rice varieties have been preferred by the farmers. There were seven rice genotypes having high mean value for ear bearing tillers (NDR 5007, RP 1810-413-349, CR 235-4, 81-H8-42-14-15, CSR 11, RP 2271-434-324 and CSR 10) along with unit regression coefficient and non-significant deviation from regression. None of the genotype could show the stability for plant height in sodic soils, probably the trait was much effectively influenced by adverse effect of sodicity in varying stress environments. The genotypes near to unit bi value or less were more stable (CSR 18, CSR 10, IR 30864, NDRK 5012, RP 2271-434-324, RP 2271-391-326 & SAR 59-1), however among these, genotypes with higher mean grain yield can be utilised for better productivity in problem soils.

Prediction of phenotypic mean performance across genotypes as well as varying sodic stress environments established the practical utility of studies on parameters of stability which will help to develop the breeding strategies for high productivity in salt affected soils. This kind of studies help a breeder in selecting the most stable genotypes along with a desired response which would largely depend on the stress level of sodicity with which he is confronted. Thus from the experimental findings, it can be concluded that CSR 18 was most stable and adaptable variety for all types of changing environments including normal (non-stress) soil while the high yielding salt tolerant varieties CSR 11 and CSR 10 have shown their suitability and adaptability for higher sustainable productivity in highly deteriorated sodic soils and can be recommended for general cultivation as biological management of salt affected soils. The genotypes NDRK 5012 and RP 2271-391-326 are suggested to be involved in the breeding programme to develop improved genotypes having better yield stability. The other high yielding genotypes like NDR 5007 and NDR 5006 were highly unpredictable due to very high significant linear and non-linear stability parameters and may be useful only in non-stress soils or may be involved in breeding programme for the improvement of their stability parameters.

REFERENCES

1. R.W. Allard and A. D. Bradshaw. 1964. Implications of genotype-environment interactions in applied plant breeding. Crop Sci., 4: 503-507.

2. F. J. Zapata, M. S. Alejar, L. B. Torrizo, A.U. Novero, V. P. Singh and D. Senadhira. 1991. Field performance of anther culture derived lines from F_1 crosses of indica rices under saline and non-saline conditions. TAG., 83(1): 6-11.

3. K. S. Shylaraj, K. M. George, N. K. Shashidharan and K. C. Nair. 1994. IR 4630 derived lines are stable high yielders under saline conditions in Kerala, India, IRRN., **19**(2): 21.
4. I. P. Abrol and D. R. Bhumbla. 1971. Saline and alkali soils in India - their occurrence and management. FAO World Soil Resour. Rep., **41**: 42-51.
5. B. Mishra, R. K. Singh and R. K. Bhattacharyya. 1992. CSR 10, a newly released dwarf rice for salt affected soils. IRRN., **17**(1): 19.
6. S. A. Eberhart an W. A. Rusell. 1966. Stability parameters for comparing varieties. Crop Sci., **6**: 36-40.
7. B. Mishra, M. Akbar and D. V. Seshu. 1990. Genetic studies on salinity tolerance in rice towards better productivity in salt affected soils. Proc. Rice Research Seminar, July 12, 1990. IRRI, Philippines. 26.
8. B. Mishra and R. K. Singh. 1989. Annual Report 1989-90. Central Soil Salinity Research Institute, Karnal: 121-128.