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Heterosis in Rice Under Salt Affected Environments

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Abstract : Thirty six hybrids along with their thirteen parents were raised in three different salt affected environments of Tamilnadu and Pondichery. Per cent standard heterosis was worked out keeping CORH2 as standard parent for nine different yield and salt tolerance related traits. The pooled environment standard heterosis was taken into consideration because it is the collective response of hybrids in various environments. Based on *per se, sca* and standard heterosis, hybrid TS 29/BTS 24 was found good because, it recorded high mean values for all the traits taken for study except 100 grain weight and also had high standard heterosis percentage for days to 50 per cent flowering, productive tillers plant^{-1}, leaf proline content, Na^+ : K^+ ratio, chlorophyll stability index and grain yield m^{-2} along with high *sca* effect for leaf proline content, productive tillers plant^{-1} and grain yield m^{-2}. In addition, hybrids TS 29/Jaya, TS 6/Pokkali and IR 58025 A/Vytilla 1 were also recorded high mean, *sca* effect and standard heterosis value mainly for grain yield m^{-2} and for the traits related salt tolerant mechanism such as leaf proline content, chlorophyll stability index, Na^+ : K^+ ratio and found suitable to salt affected soils.

Key words : environment, heterosis, rice hybrids, salt tolerance

Introduction

Exploitation of hybrid vigour is one of the possible ways for increasing production and productivity to meet out the growing demand of the food and raw materials. Hybrid rice breeding holds promise to make a breakthrough in rice production. The potentiality of a rice hybrid is judged by magnitude and direction of heterosis value. Selection based on high heterosis value for more than one yield component will be more desirable. Several workers have reported exploitation of heterosis commercially in rice crop. However reports on commercial exploitation of heterosis in rice under salinity and study on the magnitude of heterosis in different environments are very much limited. Hence a study was under taken to assess the extent of exploitable heterosis in hybrid rice developed for salt affected environment and the impact of soil salinity on its expression over environments.

Materials and Methods

To obtain salt tolerant rice hybrids four male sterile lines *viz.*, TS 6, TS 29, COMS 9A and IR 58025A were crossed with known salt tolerant varieties namely CSR 13, CSR 27, Pokkali, Vytilla 1, TRY 1, CO 43, Jaya, BTS 24 and Vytilla 2 in a line x tester model. Hybrids were raised at a spacing of 20 x 15 cm in a randomized block design with two replications at three different salt affected areas *viz.*, Anbil Dharmalingam Agriculture College and Research Institute, Trichy with soil and irrigation water EC of 7.25 and 1.84 ds/m respectively; Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal with EC of 4.81 and 0.86ds/m and a farmer field at Konthagai - Elanthakulum, Madurai with EC of 4.26 and 2.38 ds/m during *Rabi* 2001. In each replication 15 plants were marked and observations were recorded on days to 50 per cent flowering, productive tillers plant^{-1}, number of grains panicle^{-1}, spikelet fertility,

100 grain weight and grain yield m^{-2}. In addition, three biochemical observations related to salt tolerance namely leaf proline content, $Na^+ : K^+$ ratio and chlorophyll stability index were also made as per the standard procedures recommended by Bates *et al.* Standard heterosis percentage was worked out (Fonseca and Patterson, 1968) keeping the rice hybrid CORH 2 as standard parent.

Result and Discussion

Among the 36 hybrids subjected for heterosis analysis in different salt affected areas keeping CORH 2 as standard parent for different traits were highlighted in Table 1. For days to 50 per cent flowering, TS 29 / CSR 27 registered high standard heterosis percentage in Karaikal, Madurai followed by TS 29 / BTS 24 in Madurai were adjudged as early maturing hybrids with around 75 days duration. For the trait productive tillers per plant, hybrids TS 29/ CSR 27, TS 29 / Vytilla 1 and COMS 9A / Vytilla 2 in Trichy; TS 6 / Pokkali, TS 29 / BTS 24, COMS 9A / Pokkali and IR 58025 A / Vytilla 1 in Karaikal; TS 29 / Jaya and IR 58025 A / CSR 13 in Madurai and TS 29 / BTS 24 and IR 58025 A / Vytilla 1 in pooled condition had high magnitude of positive standard heterosis over their standard check CORH 2.

Less number hybrids *viz.*, three, thirteen, nine and two only recorded high standard heterosis values for number of grains per panicle in Trichy, Karaikal, Madurai and pooled environment respectively. Hybrids IR 58025 A / Jaya, IR 58025 A/BTS 24 in Trichy; TS 6/Jaya, TS 29/CO 43, IR 58025 A / BTS 24, IR 58025 A / Vytilla 2 in Karaikal; TS 6 / CSR 27, IR 58025 A / TRY 1, IR 58025 A / BTS 24 in Madurai and TS 29 / TRY 1 and IR 58025 A / BTS 24 in pooled environment recorded high standard heterosis value for this trait.

Reports showed that spikelet fertility was highly affected by increased salt concentration (Akbar *et al.*, 1972). Hybrids identified as tolerant and registered high standard heterosis were TS 29/ Pokkali, TS 29/Vytilla 1 and IR 58025 A/BTS 24 in Trichy. Whereas, IR 58025 A / Jaya and TS 29 / Vytilla 1 in Karaikal and Madurai registered highly significant positive heterosis value. Under pooled condition TS 29/Vytilla 1 alone register significantly low spikelet fertility percentage. The trait 100 grain weight is directly correlated with the grain yield. Hence positive heterosis is normally the one preferred to improve the yield under saline condition. TS 6/Vytilla 1 and TS 6/Jaya were the crosses recorded high standard heterosis values for this trait in Karaikal and pooled environments. Similarly, TS 29/Vytilla 1 and IR 58025 A/Jaya were found suitable for Karaikal and Madurai conditions. Among that TS 6/Vytilla 1 was adjudged as good for this trait based on its overall performance in all the salt prone conditions of the environments selected for study.

Proline is one of the amino acid produced by the plant under stress situation to overcome the stress. A plant which is capable of producing high amount of proline is said to be tolerant (Meenakshi, 1995). In this study the following hybrids *viz.*, TS 6/CSR 27, TS 6/Pokkali, TS 6/BTS 24, TS 29/ BTS 24 and IR 58025 A/Vytilla 2 were useful.

Lower the $Na^+ : K^+$ ratio is the indication that the Na^+ absorption in the plant system is affected by the higher amount of K^+ content already present in the plant and thereby the plants showing tolerance to the sodium toxicity (Thirumeni and Subramanian, 2000). Hence, negative standard heterosis is desirable for this trait. Based on this the following hybrids *viz.* TS 29/BTS 24, TS 6/BTS 24 and IR 58025 A/BTS 24 in Trichy, TS 6/Vytilla 1, TS 6/ TRY 1, TS 29/TRY 1, IR 58025 A/BTS 24 in Karaikal, TS 6/TRY 1, TS 29/TRY 1, TS 29/Jaya, TS 29/BTS 24 in Madurai and TS 6/Vytilla 1, TS 6/

Table 1. Hybrids showing high standard heterosis percentage for each character in all environments

Character	Environment	Hybrids
Days to 50 per cent flowering	Trichy	TS 29/TRY 1(-28.9), TS 29/Jaya (-31.3), TS 29/Vytilla 2 (-30.3), COMS 9A/Vytilla 1 (-29.9)
	Karaikal	TS 29/CSR 27 (-15.5)
	Madurai	TS 29/CSR 27 (-17.1), TS 29/CO 34 (-17.1), TS 29/BTS 24 (-17.1)
	Pooled	TS 29/CSR 27 (-20.6), TS 29/BTS 24 (-19.5)
Productive tillers plant^{-1}	Trichy	TS 29/CSR 27 (16.6), TS 29/Vytilla 1 (18.0), COMS 9A / Vytilla 2 (16.0)
	Karaikal	TS 6/Pokkali (28.5), TS 29/BTS 24 (34.0), COMS 9A / Pokkali (37.0), IR 58025 A/Vytilla 1 (38.9)
	Madurai	TS 29/Jaya (24.0), TS 29/BTS 24 (36.0), IR 58025 A/CSR 13 (24.0)
	Pooled	TS 29/BTS 24 (26.3), IR 58025 A/Vytilla 1 (17.5)
Number of grains panicle^{-1}	Trichy	IR 58025 A/Jaya (53.7), IR 58025 A/BTS 24 (60.4)
	Karaikal	TS 6/Jaya (16.6), TS 29/CO 43 (15.5), IR 58025 A/BTS 24(19.3), IR 58025 A/Vytilla 2(29.8)
	Madurai	TS 6/CSR 27(29.2), TS 29/BTS 24 (28.1), IR 58025 A/TRY 1 (23.0), IR 58025 A/BTS 24 (22.5)
	Pooled	IR 58025 A/BTS 24 (33.3)
Spikelet fertility	Trichy	TS 29/Pokkali (10.5), TS 29/Vytilla (13.2), IR 58025 A/BTS 24 (10.7)
	Karaikal	IR 58025 A/Jaya (8.9), IR 58025 A/BTS 24 (7.8)
	Madurai	TS 29/Pokkali (11.4), TS 29/Vytilla 1 (19.0), TS 29/CO 43 (12.0), TS 29/BTS 24(11.1)
	Pooled	TS 29/Vytilla 1 (17.9)
100 grain weight	Trichy	------
	Karaikal	TS 6/Vytilla 1 (13.8), TS 6/Jaya (20.3), TS 29/Vytilla 1 (13.4), IR 58025 A/Jaya (20.6)
	Madurai	TS 6/Vytilla 1 (13.8), TS 6/Jaya (20.3), TS 29/Vytilla 1 (13.4), IR 58025 A/Jaya (20.6)
	Pooled	TS 6/Vytilla 1 (6.5), TS 6/Jaya (12.6)
Leaf proline content	Trichy	TS 6/CSR 27 (61.7), TS 6/Pokkali (58.3), TS 6/BTS 24 (53.3), TS 29/BTS 24 (80.0)
	Karaikal	TS 6/CSR 27 (57.8), TS 6/Pokkali (78.1), TS 6/Vytilla 1 (64.4, TS 6/BTS 24(59.4), TS 29/BTS 24 (103.1), IR 58025 A/CSR 13 (78.1), IR 58025 A/Vytilla 1 (59.4), IR 58025 A/Vytilla 2 (59.4)
	Madurai	TS 6/CSR 27 (91.8), TS 6/Pokkali (81.6), TS 6/BTS 24 (75.5), TS 29/Pokkali (81.6), TS 29/Vytilla (75.5), TS 29/Jaya (78.6), TS 29/BTS 24 (61.2), IR 58025 A/Vytilla 1 (65.3), IR 58025 A/CO 43 (77.6), IR 58025 A/BTS 24(91.8), IR 58025 A / Vytilla 2 (81.6)
	Pooled	TS 6/CSR 27 (67.2), TS 6/Pokkali (72.4), TS 6/Vytilla 1 (51.7), TS 6/BTS 24 (60.3), TS 29/Jaya (44.8), TS 29/BTS 24 (98.3), IR 58025 A/Vytilla 2 (56.9)

Character	Environment	Hybrids
$Na^+ : K^+$ ratio	Trichy	TS 6/BTS 24 (-17.9), TS 29/CSR 27 (-17.9), TS 29/Pokkali (-17.9), TS 29/BTS 24 (-20.5), IR 58025 A/Vytilla 1 (-17.9), IR 58025 A/BTS 24 (-17.9)
	Karaikal	TS 6/Vytilla 1 (-54.5), TS 6/TRY 1 (-40.9), TS 29/TRY 1 (-43.2), IR 58025 A/Pokkali (-31.18), IR 58025 A/ BTS 24 (-31.8)
	Madurai	TS 6/TRY 1(-36.1), TS 6/BTS 24(-33.3), TS 29/TRY 1 (-27.8), TS 29/Jaya (-27.8), TS 29/BTS 24(- 36.3), IR 58025 A/Pokkali (-30.6)
	Pooled	TS 6/Vytilla 1 (-30.0), TS 6/TRY 1 (-27.5), TS 6/BTS 24 (-30.0), TS 29/TRY 1 -(27.5), TS 29/Jaya (-15.0), TS 29/BTS 24 (-36.1), IR 58025 A/Pokkali (-30.6), IR 58025 A/BTS 24 (-27.8)
Chlorophyll	Trichy	TS 29/CSR 27 (56.1), TS 29/BTS 24 (63.5), COMS 9A/BTS 24 (65.5), IR 58025 A/TRY 1 (42.0), IR 58025 A/BTS 24 (57.8)
	Karaikal	TS 6/TRY 1 (76.9), TS 29/CSR 27 (52.3), TS 29/Pokkali (67.9), TS 29/Vytilla 1(56.4), TS 29/TRY 1(62.3), TS 29/Jaya (45.), TS 29/BTS 24 (69.9), COMS 9A/BTS 24 (76.0), IR 58025 A/Vytilla 1 (60.1), IR 58025 A/TRY 1 (72.1), IR 58025 A/BTS 24 (90.5), IR 58025 A/Vytilla 2 (73.9)
	Madurai	TS 29/Pokkali (76.7), TS 29/Vytilla 1 (74.9), TS 29/Jaya (73.1), TS 29/BTS 24 (76.0), TS 29/Vytilla 2 (74.3), IR 58025 A/Vytilla 1(60.2), IR 58025 A/TRY 1 (51.7), IR 58025 A/CO 43 (54.5), IR 58025 A/Jaya (68.2), IR 58025 A/BTS 24 (74.0)
	Pooled	TS 29/CSR 13 (31.7), TS 29/CSR 27 (48.0), TS 29/Pokkali (52.5), TS 29/Vytilla 1 (56.5), TS 29/Jaya (47.3), TS 29/BTS 24 (69.9), IR 58025 A/Vytilla 1 (53.1), IR 58025 A/TRY 1 (54.2), IR 58025 A/BTS 24 (33.8), IR 58025 A/Vytilla 2(49.1)
Single plant yield	Trichy	TS 6/CSR 27 (13.8), TS 6/BTS 24(7.7), TS 6/Pokkali (15.2), TS 29/BTS 24(17.7)
	Karaikal	TS 6/Pokkali (19.4), TS 6/BTS 24 (11.7), TS 29/Jaya (22.5), TS 29/BTS 24(24.9), IR 58025 A/Pokkali (21.0)
	Madurai	TS 6/CSR 27 (17.3), TS 6/Pokkali (12.0), TS 6/BTS 24 (20.4), TS 29/Pokkali (18.9), TS 29/Jaya (23.2), TS 29/BTS 24 (38.1), IR 58025 A/CSR 13 (31.7), IR 58025 A/BTS 24 (27.1)
	Pooled	TS 6/CSR 27 (12.2), TS 6/Pokkali (15.5), TS 6/BTS 24 (13.2), TS 29/BTS 24 (26.9), TS 29/Jaya (10.9)

Table 2. Standard heterosis, *sca* effects and *Per se* values of selected hybrids for heterosis breeding

Traits	IR 58025 A/ Vytilla 1			TS 6/Pokkali			TS 6/CSR 27			TS 29/BTS 24			TS 29/Jaya		
	SH	*sca*	*Per se*	SH	*sca*	*Per se*	SH	*sca*	*Per se*	SH	*sca*	*Per se*	SH	*sca*	*Per se*
Grain yield m^{-2} (g)	7.7	1.26	567.6	15.5	1.52	607.2	12.2	1.71	590.7	26.9	2.89	669.9	10.9	2.22	584.1
Leaf proline content (mg/g)	50.0	0.05	0.87	72.4	0.17	1.00	67.2	0.17	0.97	98.3	0.23	1.15	44.8	0.07	0.84
Chlorophyll stability index	53.1	2.32	73.2	33.3	3.08	63.8	29.1	4.23	61.8	69.9	-1.40^{NS}	81.3	-	-	-
$Na^+ : K^+$ ratio	-25.0	0.01	0.30	-15.0	0.02	0.34	-15.0	^{NS}	^{NS}	-30.0	0.01	0.28	-15.0	^{NS}	0.33
Productive tillers per plant	17.5	1.81	15.1	-	-	-	-	-	-	26.3	2.51	16.2	-	-	-
100 grain weight	-8.9	-0.13	2.2	-	-	-	-	-	-	-	-	-	-20.3	-0.29	2.0
Days to 50 per cent flowering	-	-	-	-12.2	-4.37	78.8	-	-	-	-	-	-	-	-	-

SH - Standard heterosis

TRY 1, TS 29/TRY 1, TS 29/Jaya, TS 29/BTS 24, IR 58025 A/Pokkali and IR 58025 A/BTS 24 in pooled environments were selected for this trait.

Chlorophyll stability index is the trait which helps the plant to withstand stress through better availability of chlorophyll. This leads to increased photosynthetic rate, more dry matter production and higher productivity. Keeping this in view hybrids were selected based on their magnitude of heterosis for various environments. Accordingly hybrids TS 29/BTS 24, IR 58025 A / TRY 1 and IR 58025 A/ BTS 24 which had recorded highly significant standard heterosis value in almost all the environments and pooled condition were selected along with some other hybrids TS 29/CSR 27, TS 29/Pokkali, TS 29/Vytilla 1, TS 2/Jaya and IR 58025 A / Vytilla 1 those registered high heterosis value in Karaikal, Madurai and pooled condition.

The performance of hybrids is pooled condition was given importance because it is the collective (stability) performance of the hybrids in the entire individual environment. From the above discussion it is evident that the hybrids earmarked for their importance in exploitation of heterosis in salt affected environments based on their highly significant standard heterosis, *sca* effects and *per se* value for traits related to salt tolerant mechanism along with yield. Based on this factors hybrid TS 29/ BTS 24 was found good, which recorded high mean values for all the traits taken for study except for 100 grain weight and also had high standard heterosis percentage for days to 50 per cent flowering, productive tillers plant^{-1}, leaf proline content, Na^+ : K^+ ratio, chlorophyll stability index and grain yield m^{-2}. Similarly it had also registered high *sca* effect for leaf proline content, productive tillers plant^{-1} and grain yield m^{-2}. Apart from this hybrids TS 29/Jaya, TS 6/Pokkali and IR 58025 A / Vytilla 1 were also recorded high mean, *sca effect* and standard heterosis value mainly for grain yield m^{-2} along with leaf proline content, cholorophyll stability index, Na^+ : K^+ ratio and days to 50 per cent flowering (Table 2). Hence selection and raising of these hybrids in the salt affect areas found to be good because they can tolerate the excess salt effect in the field.

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