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VTL 6: A semi-tall, non-lodging, and high yielding rice (*Oryza sativa* L.) variety for the coastal saline zones of Kerala

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Abstract

To evolve a lodging resistant, abiotic stress tolerant, and high yielding rice variety for the *pokkali* areas of Kerala, F_1 of the cross between 'Cheruvirippu' and IR 5 was crossed with 'Jaya'. Based on evaluation of the promising cultures at local, regional, and national levels, VTL 6, the first saline tolerat, semi-tall, non-lodging high yielding rice variety of Kerala was released for cultivation in the coastal saline areas of Kerala in October 2004. This variety has multiple tolerance to abiotic stresses like salinity, acidity, and submergence, and is a medium duration, red kernelled variety with good cooking quality. Average yield under close planting without chemical fertilizers and plant protection chemicals is about 4500 kg ha^{-1}.

Keywords: *Pokkali*, Stress tolerance, Submergence, Salt injury.

Introduction

Rice (*Oryza sativa* L.) production in the coastal saline zones of Kerala (the *pokkali* tracts) experiences special problems such as high levels of salinity and seawater incursion during the critical phases of crop growth. Evolving saline tolerant high yielding rice cultivars suitable for the *pokkali* lands of Kerala, therefore, assumes significance and with this objective rice breeding work was initiated at the Rice Research Station, Vyttila as early as in 1972. To date, five high yielding salinity tolerant rice varieties (VTL 1 to VTL 5) were released from this station (Shylaraj et al., 1998; Shylaraj and Sasidharan, 2005). All these are, however, tall varieties with high to very high degrees of lodging. Although VTL 3 to VTL 5 have an yield potential of 3500 kg ha^{-1} to 4000 kg ha^{-1}, the realized yields in the farmers' fields seldom exceed ~2000 kg ha^{-1} (Shylaraj and Sasidharan, 2005) – lodging being a major reason. According to some estimates, about 40-50% of the potential yield is lost because of lodging and associated damages caused by fish, tortoise, rats etc. Quite apart from such losses and the difficulties experienced in paddy harvesting, field clearing for the succeeding selective stocking of prawn, a usual practice in these localities, is also problematical under such situations. This necessitated evolving a lodging resistant, semi-tall, and high yielding rice variety suited for the *pokkali* areas for which a specific breeding strategy was launched.

Materials and Methods

'Cheruvirippu', a local genotype with abiotic stress tolerance and adaptability to costal submerged areas, and IR 5, a high yielding line, were selected as the female and male parents respectively. 'Jaya', the national yield check was used as the source of semi-tall stature, high yield potential, and wide adaptability. Hybridization was carried out between 'Cheruvirippu' and IR 5 during 1991. The F_1 was re-crossed with 'Jaya' in 1992 and the resultant F_1 generation ('Cheruvirippu'/ IR 5//'Jaya') was raised in pots. Fifty-nine semi-tall high yielding plant types were selected from the F_2 during *kharif* 1993 and advanced to F_3 (*kharif* 1994). Thirty-four promising non-lodging lines selected from

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F_3 were advanced up to F_8 (*kharif* 1999) through selfing and selection for desirable attributes such as high yield, semi-tall stature, non-lodging nature, and red kernel colour, besides tolerance to abiotic stresses such as salinity, acidity, and submergence.

Twenty-five promising lines from the F_8 were selected and bulked as most promising cultures and evaluated in a preliminary yield trial (PYT) in *kharif* 2000. The PYT was conducted as a non-replicated trial in plots of size 10 m^2. Selection based on yield and phenotypic performance was made and the top ranked eight cultures were promoted to comparative yield trials (CYT) and evaluated for three years (*kharif* 2001, 2002, and 2003). These trials were conducted in typical *pokkali* areas characterized by inflows and outflows of saline water. Field salinity level was about 8 dS m^{-1} throughout the cropping season and the CYTs were conducted in randomized block design with three replications in 40m^2 plots and adopting recommended practices (KAU, 1986).

Multilocational trials (MLT) were laid out in the farmer's fields in Ernakulam district at Kumbalam, Chellanam, and Elamkunnapuzha during *kharif* 2002. Following the CYT and MLT, a farm trial also was conducted with four promising cultures at two locations in Alappuzha district (Thuravoor and Thykkattusseri) and three locations in Ernakulam district (Kumbalam, Elamkunnapuzha, and Varapuzha). The multilocational trials and farm trials were conducted in typical *pokkali* situations in plots of size 200 m^2. Salinity level varied between 4 to 8 dS m^{-1} during the cropping season. Three promising cultures were also simultaneously tested at 10 locations through the National Saline Alkaline Screening Nursery (NSASN) of the All India Coordinated Rice Improvement Programme. Agronomic attributes such as plant height, duration, productive tillers, panicle length, grain number/panicle, and sterility percentage besides grain yield were monitored in all trials and the data were statistically analyzed using analysis of variance (Gomez and Gomez, 1984).

The cultures raised on perforated pots lined with cloth were also scored *in vitro* for tolerance to abiotic stresses (salinity, acidity, and submergence) as per the Standard Evaluation System of Rice (IRRI, 1988). Twenty-one day old seedlings were subjected to saline bath (EC 8 dS m^{-1}) for 45 days. The modified Standard Evaluation Score (SES) of visual salt injury at seedling stage was used for scoring the cultures. Acid tolerance screening was done by raising the seedlings hydroponically. Two weeks after germination, nutrient solution (quarter strength MS medium; Murashige and Skoog, 1962) of varying pH (3.0, 3.5, and 4.0) was supplied to the seedlings. The pH of the nutrient solution was adjusted with 1N HCl. Survival percentage and green leaf area were taken as the tolerance index. Tolerance to submergence was evaluated by scoring 21 day old seedlings after immersing them in water tanks containing muddy water to 1 m depth (to simulate the field condition that arrest the passage of sunlight). Relative percentage of survival after stress treatments was computed as,

$$\textit{Comparative survival (\%)} = \frac{\textit{survival of a particular entry x 100}}{\textit{survival in control}}$$

Quality attributes such as hulling percentage, milling, head rice recovery, amylose content, gelatinization temperature, gel consistency, water uptake, and elongation ratio were evaluated as per GEU skill series (IRRI, 1987). Raw and parboiled samples of rice were cooked and assessed for optimum cooking time and other organoleptic qualities like appearance, colour, texture, and taste by a panel of 30 selected judges.

Results and Discussion

Grain yield of the selected promising cultures in station, regional, and national trials are presented in Table 1. Culture CIRJ 9 recorded the highest grain yield of 5903 kg ha^{-1} in PYT, closely followed by CIRJ 7 (5725 kg ha^{-1}), which incidentally gave 57% and 52.7% more yield than the check, VTL 4 (3749 kg ha^{-1}). Statistical analysis of the pooled grain yield data from CYT over three years, however, revealed a clear superiority of CIRJ 7 (5627 kg ha^{-1}), which was about 70% more productive than VTL 4. In MLT also, CIRJ 7 showed yield stability at all three locations – with first rank at two locations (Kumbalam and Chellanam) and with an overall second position (4418 kg ha^{-1}). Consistent with

this, CIRJ 7 out-yielded VTL 4, and the most popular local variety at each location in the farm trials giving about double the yield (p<0.01). In the National Saline Alkaline Screening Nursery also, CIRJ 7 recorded a modest yield increase (9.2%) over the nation's best salinity check variety, CST 7-1, but gave the top yield at Faizabad (4840 kg ha^{-1}), implying its wide adaptability throughout the coastal saline areas of the country (DRR, 2003).

Overall, the superior performance of CIRJ 7 can be attributed to its non-lodging character, which in turn, is due to the relatively lower plant height compared to the check variety VTL 4 (~35% less; Table 2). Moreover, it is early by 10 days, thus facilitating cultivation of two prawn crops after rice. Higher number of productive tillers (10 to 12) and filled grains per panicle and low sterility percentage (5.3%) coupled with its non-lodging stature are other positive traits of this particular cultivar. It is also tolerant to abiotic stresses like salinity up to 8 dS m^{-1}, submergence of 7 to 10 days, and acidity up to a pH level of 4.0 (Table 3). The culture has good organoleptic qualities such as appearance, colour, flavour, and taste, besides acceptable nutritional quality attributes such as red, medium bold kernel with intermediate amylose content and gelatinization temperature (Table 4). Considering the superiority of this culture, the 22nd State Seed Subcommittee released this culture during 2004 as VTL 6 for general cultivation in the *pokkali* areas of Kerala.

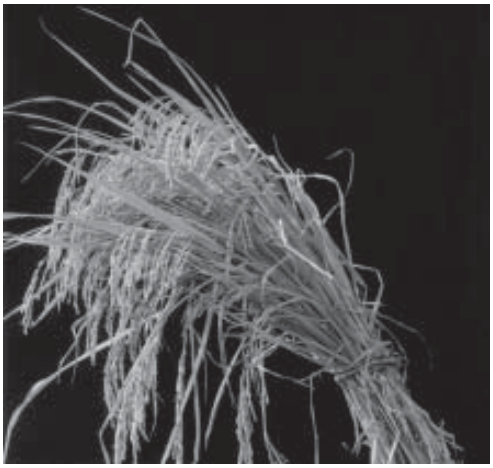

Figure 1. High yielding, lodging resistant, saline tolerant VTL 6 plant at heading stage at Vyttila, Kerala.

Figure 2. A *pokkali* field with non-lodging VTL 6 variety at Vyttila, Kerala.

Table 1. Grain yield of the promising cultures in the station, regional and national yield trials (*kharif* season).

Cultures	Mean grain yield (kg ha^{-1})				
	PYT 2000	CYT (pooled mean of 3 years: 2001-'03)	MLT 2002	Farm trial 2003	NSASN2003
CIRJ 3	3756	5343^{a}	4158^{a}	4017	3020
CIRJ 7	5725	5627^{a}	4418^{a}	4348**	3320
CIRJ 9	5903	5212^{a}	4410^{a}	3654	3230
Yield check	3749	3311^{b}	2927^{b}	2200	3070
Local check	na	na	2193^{b}	1704	na
Salinity check	na	na	na	na	3040

PYT – Preliminary yield trial; CYT – Comparative yield trial; MLT – Multi-locational trial ; NSASN – National Saline Alkaline Screening Nursery; Yield check for PYT, CYT, MLT, and Farm trial was VTL 4; 'Jaya' was yield check and CST- 7-1 the salinity check for the NSASN trials (source: DRR, 2003). Farm trial data are means for six locations in Ernakulam (Varapuzha, Kadamakkudy, Vypin, and Chellanam) and Alappuzha (Thuravoor and Thykkattusseri) districts of Kerala state.

Means followed by the same superscript are not significantly different; **paired *t* test significant at 1% over VTL 4 and local check; na – not applicable.

Table 2. Agronomic attributes of promising cultures (mean of 4 years) evaluated in the comparative yield trials at Vyttila, Kerala.

Culture/Variety	Plant height (cm)	Duration (days)	Productive tillers (no.)	Panicle length (cm)	Grains/panicle (no.)	Sterility (%)
CIRJ 3	117.3[b]	109.3[b]	12.0	22.8[b]	124.3	8.6
CIRJ 7	115.3[b]	109.7[b]	11.2	22.5[c]	134.0	5.3
CIRJ 9	116.0[b]	109.0[b]	10.6	23.3[c]	115.3	5.9
VTL 4	176.8[a]	120.0[a]	10.6	26.6[a]	111.3	8.2

Means with the same superscript do not differ significantly.

Table 3. Abiotic stress tolerance of the cultures and checks at seedling stage.

Cultures	Salt injury score	Acid tolerance (pH 4.0)		Submergence tolerance score	
		Comparative survival value (%)	score	Comparative survival value (%)	score
CIRJ 3	3	80	3	80	3
CIRJ 7	3	100	1	100	1
CIRJ 9	3	100	1	85	3
Pokkali (RC)	1	80	3	100	1
'Uma' (RC)	-	100	1	-	-
MI 48 (SC)	9	40	9	45	9

RC: Resistant check; SC: Susceptible Check; Score 1 – 3: tolerant; 4 – 6: moderate and 7 – 9: susceptible.

Table 4. Quality attributes of culture CIRJ 7.

Quality attributes	Estimate
Hulling	80.0%
Milling	76.2%
Head rice	62.0%
Length (L)	6.30 mm
Breadth (B)	3.10 mm
L/B ratio	2.27
Classification	Medium bold
Abdominal white	< 20%
Kernel length after cooking	8.9 mm
Volume expansion	3.1
Elongation ratio	1.41
Gelatinization temperature	Intermediate
Amylose content	20%
Protein	7.71%
Cooking quality	Very good

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