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VTL 5: A high yielding salinity tolerant rice variety for the coastal saline ecosystems of Kerala

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Abstract

VTL 5, a promising 'Mahsuri' mutant, was released in September 1996 for cultivation in the coastal saline ecosystems of Kerala. This variety has multiple tolerances to abiotic stresses such as salinity, acidity and submergence. It is a tall, medium duration, high yielding and white kernelled rice variety with good cooking quality. Average yield without chemical inputs is ~3500 kg ha^{-1}. The variety is ideally suited for the *pokkali* lands of Ernakulam and Alappuzha districts where 'organic farming' practices are *in vogue.*

Keywords: 'Mahsuri', mutant rice, *pokkali* system, acid tolerance, submergence.

Introduction

The *pokkali* system of rice cultivation in the acid saline soils of Kerala is a unique method of rice production. In this method, a single-crop of rice is taken in the low saline phase of the production cycle (June to mid-October) on mounds, to be followed by prawn farming during the high saline phase (November to April). A noteworthy feature of this traditional rice cultivation method is that neither chemical fertilizers nor plant protection chemicals are applied to the crop. The *pokkali* fields are also subjected to periodic submergence. The daily tidal inflows and outflows, besides the tremendous microbial activity owing to the presence of large quantities of organic matter (decomposed aquatic weed mass and paddy stubbles), make the *pokkali* fields particularly fertile. Despite this, the average rice yield realized by pokkali farmers is only ~2000 kg ha^{-1}, making rice cultivation in this region somewhat unprofitable. Therefore, evolving appropriate varieties with high yield potential and ability to perform well under the acid saline situations with little or no external inputs is essential to sustain rice cultivation in the *pokkali* areas of Kerala.

Although four *pokkali* rice varieties (VTL 1 to VTL 4) were released from the Rice Research Station, Vyttila, the export potential of these varieties *per se* is limited. In particular, the red bold grain type, preferred by the local consumers, is not considered a desirable trait by customers elsewhere. Our search for a widely adapted rice variety with universally accepted grain quality attributes, therefore, zeroed in on 'Mahsuri', a variety that possesses white, medium bold grains with intermediate gelatinization temperature and amylose content. Moreover, it could tolerate abiotic stresses like salinity, acidity and submergence. The relatively longer duration of 140 days, however, was a problem that it could not be fitted into the low saline phase of the *pokkali* cycle. Hence, a breeding programme was initiated to induce earliness in 'Mahsuri', as a strategy to escape the high-saline phase of the *pokkali* cycle.

Materials and methods

Induced mutagenesis, a widely accepted breeding strategy for changing plant characters (Yoshida, 1962; Rutger, 1992), was employed in this study to induce earliness in 'Mahsuri'. Seeds were treated with gamma

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rays at three different dozes *viz*., 10, 20 and 30 KR at the Botany Department, University of Kerala, Thiruvananthapuram during 1978. From the M_2 generation, 32 plants that matured within 120 days were selected. Selected M_2 plants were advanced to M_5 generation by selfing accompanied by selection at successive stages for earliness, higher yield, and tolerance to abiotic stresses like salinity, acidity and submergence. Seventy-five early mutant plants with high yielding ability were further evaluated in the Initial Evaluation Trial (IET) during *kharif* 1982 and 16 promising mutants were advanced to the Preliminary Yield Trial (PYT) in *kharif* 1983. From the PYT, six promising cultures were selected and tested for their consistent performance especially with respect to earliness in a second PYT during *kharif* 1984. These cultures were then advanced to the Comparative Yield Trial (CYT), which in turn, was conducted for four years (1987 to 1990) with VTL 1 as the check. The parent 'Mahsuri' could not be included in the CYT because of its long duration and the problem of saline water intrusion into the plots during the maturity phase. Three promising mutants of 'Mahsuri' (Cul. 701, 708 and 709) were further selected based on earliness and their yield potential was compared in CYT with three promising H4 mutant cultures along with VTL 1 and VTL 3 as checks during the *kharif* seasons of 1991 to 1994. The most promising 'Mahsuri' mutant (Cul. 655) was also evaluated in the farmers' fields at three locations in Alappuzha and seven locations in Ernakulam during *kharif* 1992 with VTL 3 as check.

The IET, PYTs and farm trials were non-replicated experiments (plot size: 5, 10 and 200 m^2 respectively). The CYTs were, however, conducted in a randomized block design with three replications in plots of size 40 m^2 and following the general recommendations for rice (KAU, 1986). All experiments were conducted under typical *pokkali* situations that experience saline water influxes. The field salinity level was, however, below 8dS m^{-1} during the cropping season.

In all experiments, panicles alone were harvested, as is typically the case with the *pokkali* crop. Analysis of variance (ANOVA) was used to compare grain yields (Gomez and Gomez, 1984). The cultures were also scored for abiotic stress tolerance (salinity, acidity and submergence) as per the Standard Evaluation System of Rice (IRRI, 1988). Quality analysis (percentage of hulling, milling, head rice recovery, amylose content, gelatinization temperature, gel consistency, water uptake and elongation ratio) was done as per GEU skill series (IRRI, 1987). Raw and parboiled milled samples were cooked and evaluated for optimum cooking time and other organoleptic qualities such as appearance, colour, texture and taste by a panel of selected judges.

Results and discussion

A comparison of the pooled grain yield data of the six cultures presented in Tables 1 and Table 2 indicate that Cul. 655 consistently outperformed other entries. For instance, this culture recorded the highest yield of 3331 kg ha^{-1} (27% higher than VTL 3 and 53% higher than VTL 1) in CYT. Likewise, in the second CYT comparing 'Mahsuri' and H4 mutants, it recorded the highest mean yield of 3562 kg ha^{-1}, which was 26.40% more than VTL 1 and 21.5% more than VTL 3 (Table 2). In farmers' fields also, Cul. 655 maintained the highest mean grain yield of 2753 kg ha^{-1}, which was

Table 1. Grain yield of early 'Mahsuri' mutant cultures in yield trials at Vyttila during the *kharif* seasons of 1983, 1988, 1989 and 1990

Culture/variety	Grain yield (kg ha^{-1})		
	IET	PYT	CYT
Cul. 650 (M-10-7-1)	2900	2339[b]	2612[b]
Cul. 651 (M-20-6-3)	3450	2273[b]	2762[b]
Cul. 652 (M-10-5-4)	3386	2832[a]	2400[b]
Cul. 653 (M-20-3-7)	3486	2983[a]	2924[a]
Cul. 654 (M-10-2-6)	3366	2975[a]	2482[b]
Cul. 655 (M-20-7-3)	3700	3017[a]	3331[a]
'Mahsuri'	2100	1488[c]	na
VTL 1	2083	2755[a]	2170[c]
VTL 3	NA	NA	2618[b]

IET= initial evaluation trial (1983); PYT= preliminary yield trial (pooled data for 1983 and 1984 seasons) and CYT= comparative yield trial (pooled data for 1988, 1989 and 1990) IET data were not statistically analyzed as it was an un-replicated trial. Means followed by the same superscript are not significantly different. NA - not available

41.8% more than the local variety and 12.96% greater than VTL 3 (Table 3). As regards to duration, Cul. 655 was 20 days earlier than its parent, 'Mahsuri' (Table 4), implying a distinct advantage that it could be conveniently fitted into in the *pokkali* production system. The plant stature of Cul 655, however, was taller than 'Mahsuri' and hence there may be potential danger of lodging. In addition, this culture was found to be intermediate with respect to other agronomic traits. The poor yield of parent 'Mahsuri' in IET and PYT (Table 1) was primarily due to salinity intrusion during the fag end of the crop period.

Cul. 655 also possesses good organoleptic qualities such as appearance, colour, flavour and taste on cooking (scorecard data), besides having acceptable quality parameters such as white medium bold kernel with intermediate amylose content and gelatinization temperature (Table 5). Considering the superiority of this culture, the 18th State Seed Subcommittee (September 1996) released it as VTL 5 for general cultivation in the *pokkali* lands of Kerala (Ernakulam and Alappuzha districts).

On a final note, VTL 5 is a tall, medium duration (115

Table 2. Performance of early mutants of 'Mahsuri' and H4 in a comparative yield trial at Vyttila in the *kharif* seasons of 1991to '93

Culture/variety	Grain yield (kg ha $^{-1}$)			
	1991	1992	1993	Pooled mean
Cul. 651	2360^{c}	3206^{a}	4000	3189^{b}
Cul. 653	2840^{b}	2850^{a}	3146	2945^{b}
Cul. 655	3400^{a}	3354^{a}	3933	3562^{a}
Cul. 701	2520^{b}	2397^{b}	3607	2841^{c}
Cul. 708	3400^{a}	3440^{a}	3787	3542^{a}
Cul. 709	2100^{c}	2934^{a}	3540	2858^{c}
VTL 1	2160^{c}	2660^{b}	3633	2818^{c}
VTL 3	2040^{c}	3120^{a}	3633	2931^{b}

Cul. 651, 653 and 655 are 'Mahsuri' mutants, while Cul. 701, 708 and 709 are H4 mutants. Means followed by the same superscript are not significantly different.

Table 3. Performance of Cul. 655 in farmers' field of Ernakulam and Alapuzha districts (*kharif* 1992) compared to check varieties

Location[1]	Grain yield of Cul. 655 (kg ha^{-1})	Difference from check varieties	
		VTL 3	Local
Kumbalangi	2800	400*	800**
Vyttila	2520	178^{ns}	470**
Chellanam	2750	350*	730**
Cheranelloor	2500	300*	700**
Kuzhippilly	3680	580**	1480**
Parur	3920	520**	1570**
Kadamakkudy	3600	400*	1350**
Vayalar	1860	160^{ns}	300*
Thuravur	1800	200^{ns}	380*
Vettackal	2100	-75^{ns}	280^{ns}
Pooled mean	2753	301*	806**

Paired 't' test: ** = significant at 1% level; * = significant at 5% level; ns = not significant. [1]Kumbalangi, Vyttila, Chellanam, Cheranelloor, Kuzhippilly, Parur and Kadamakkudy are in Ernakulam district. Vayalar, Thuravur and Vettackal are in Alapuzha district.

Table 4. Agronomic attributes of 'Mahsuri' mutants at Vyttila (mean of six years data)

Culture/variety	Plant height (cm)	Duration (days)	Productive tillers (no.)	Panicle length (cm)	Grains/panicle (no.)	Sterility (%)
Cul. 650	149.0^{b}	110.3^{c}	12.3^{b}	22.3^{c}	195.0^{a}	47.6^{b}
Cul. 651	138.7^{c}	115.0^{b}	13.6^{a}	23.6^{c}	183.6^{a}	20.7^{d}
Cul. 652	144.5^{b}	116.7^{b}	10.8^{c}	24.9^{b}	150.2^{b}	29.1^{c}
Cul. 653	145.0^{b}	116.7^{b}	13.5^{a}	25.3^{b}	140.1^{c}	28.6^{c}
Cul. 654	141.2^{c}	117.0^{b}	13.1^{a}	24.4^{b}	149.0^{b}	17.3^{d}
Cul. 655	139.3^{c}	115.0^{b}	13.1^{a}	24.5^{b}	143.5^{b}	13.7^{e}
'Mahsuri'	127.3^{d}	135.0^{a}	12.6^{b}	21.6^{d}	100.5^{d}	53.1^{a}
VTL 1	157.0^{a}	115.0^{b}	12.2^{b}	29.9^{a}	107.0^{d}	16.8^{e}

Means followed by the same superscript are not significantly different.

to 120 days) photoinsensitive variety suited for *kharif* cultivation in the coastal saline ecosystems of Kerala (Figs 1 and 2). It has a mean plant height of 140 cm and the number of productive tillers per hill is 13. The mean panicle length is 24.5 cm with 143.5 grains/ panicle. It has a milling outturn of 78% with 60% head rice recovery (Table 5). The medium bold grains with white kernel colour and good cooking quality like its parent 'Mahsuri' probably make this variety acceptable to consumers elsewhere too. Furthermore, this variety is tolerant to abiotic stresses like salinity (up to 8dS m^{-1}), submergence (5 to 7 days) and soil acidity (pH 4 to 5).

Fig.1. A 'VTL 5' rice hill in heading stage

Fig. 2. A general view of the 'VTL 5' field

Table 5. Quality attributes of Cul. 655

Quality attributes	Estimates
Hulling %	82.0
Milling %	78.30
Head rice %	60.50
Length (L) mm	5.90
Breadth (B) mm	2.50
L/B ratio	2.36
Classification	medium bold
Abdominal white	slightly present
Kernel length after cooking	8.30mm
Volume expansion	4.00
Elongation ratio	1.41
Gelatinization temperature	intermediate
Amylose content	intermediate
Cooking quality	very good

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