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DEVELOPMENT OF THE FIRST ORGANIC RICE VARIETIES TOLERANT TO SALINITY

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Abstract: Sea coastal tracts often confront the combined menace of salinity and flood. Compared to any other development approach, breeding for salt stress tolerance is a more promising, energy efficient, economic, and socially acceptable approach. Varieties having traits amenable for organic farming (organic varieties) are the missing link in the organic production chain. Here we report development and commercial release of four saline tolerant organic rice varieties which are first of its kind, christened as 'Ezhome -1' , 'Ezhome -2', 'Ezhome -3' and 'Ezhome -4'. They are also non lodging, high yielding, and having good cooking and nutritional qualities. They are suited to saline flooded sea coastal ecosystem as well as non-saline tracts. The varieties were developed by adopting conventional breeding linked with novel strategies of organic plant breeding and participatory plant breeding, and growing the entire filial generations and all yield trials in the problem area of farmers.

Introduction: Breeding for salt tolerance is a more promising, energy efficient, economic, and socially acceptable approach than major engineering processes and soil amelioration which had gone beyond the reach of marginal farmers. In spite of a significant amount of research on the effect of salinity on plants, there has been little success in putting salt resistant plants in farmers' field (Flowers & Yeo,1995). Further, the focus of the present era is upon organic farming for health as well as environment protection. As organic farming management and environments are fundamentally different from conventional, organic farmers need specific varieties that are adapted to their lower input farming system and can perform higher yield stability than conventional varieties (Lammerts van Bueren *et al.*,2003). Even though organic varieties were developed in wheat and vegetables (Bueren *et al.*, 2011), the varieties mentioned in this report are the first of its kind in rice crop having salinity tolerance.

Material and methods: A combined strategy of pedigree breeding, organic plant breeding (Bueren, 2003, Nuijten et al., 2017) and farmer participatory breeding approach (Morris and Bellon, 2004) was followed during the variety development programme. Organic plant breeding aims sustainability and cooking and nutritional qualities of produce. Strategies of Organic plant breeding include use of traditional variety as one of the parents and carrying out variety development and testing stages under organic cultural management. Only those progenies which show high yield performance in the low input organic management will be carried forward to next generation. Participatory plant breeding is for easy and early adoption of the varieties. In this approach, experiment fields at developing and testing stages will be raised at target area of farmers field rather than confining to research station's field which is the general procedure in existing plant breeding methodology.

Further, farmers will be invited in selection procedure of progenies from filial generation itself, while in ordinary variety development, farmers involvement is only at last farm trial. Perception of the farmers will be also considered along with perception of scientists' in deciding selection of progenies. Conducted the entire experiment directly at the target area of saline sea coastal problem area of farmers to harvest the genetic potential under field condition. Traditional land races named, 'Kuthiru' and 'Orkayama' of saline prone naturally organic sea coastal ecosystem of Kerala (Vanaja and Mammootty, 2010), India popularly known as *Kaipad* are the main genetic resources utilized in this breeding programme as donor parents for salinity tolerance and for cooking qualities. The other parents used were 'Jaya' and 'Mahsuri'. Hybridization between selected parents were done in 2001.

The F_2 filial generations comprising 6292 progenies were raised in the field adjacent to the saline problem area having intruded slight salinity (2dS m^{-1}), and adopted organic rice farming practices. Single plant pedigree selection was followed in F_2 generation. One thousand twenty eight F_2 progenies survived in the slight saline condition were carried forward to F_3 generation in the problem area of *Kaipad,* the target site. From F_3 generation onwards, all advanced filial generations were evaluated directly in the target area having medium salinity (6-8dS m^{-1}). Fourteen high yielding early stabilized rice cultures were selected for advancing generations. The design of yield trials was RBD with three replications. Salinity level varied between 4 to 16dS m^{-1}during the cropping season. Cultures were also tested at 16 locations of different states of India through the National Saline Alkaline Screening Nursery (NSASN) of the All India Coordinated Rice Improvement Programme.

Results: Pedigree of selected saline tolerant rice cultures and their grain yield in PYT, CYT, and farm trials in saline *Kaipad* fields of farmers are given in table 1. Preliminary Evaluation trial was conducted separately for both non-lodging and lodging genotypes. Comparative evaluation trial was conducted for good performing non-lodging and lodging genotypes together. In comparative yield trials, five non-lodging cultures, namely, JK 70, JO 345, MK 22, JO 532-1 and JO 583, and one lodging culture, JK 59 showed on par yield performance and significantly higher yield than that of *Kaipad* and *Pokkali* local checks. These cultures have wide genetic base because, one of the parents is a local cultivar having abiotic and biotic stress resistance. These cultures have more grain and straw yield, and higher harvest index than that of local land races. These hybrid derivatives are tolerant to all kinds of pests and diseases at *Kaipad* field condition. Screening in ordinary wetland condition revealed that they were invariably found to be resistant and moderately resistant to many pests and diseases. Besides their proven yield potential, pest and disease resistance and other preferable traits to saline and flooded areas, they possess desirable grain qualities as per the farmers need, like absence of awn on grains and non-shattering unlike local land races, better taste and more acceptable appearance of cooked rice, appealing to both consumers and millers. Further they are nutritionally rich also. The cooking qualities of all the cultures are above or on par with traditional land race 'Kuthiru' whose cooking qualities are much appreciated by farmers.

Table 1. Grain yield of cultures in PYT, CYT and regional farm trials:

Genotypes	Parentage	PYT (pooled mean) Grain yield (t/ha)	CYT (Pooled mean of 5 trials) Grain yield (t/ha)	*Farm trial(pooled mean) Grain yield (t/ha) (Straw yield t/ha on

				parenthesis)
MK 22	Mahsuri x Kuthiru	6.61 a	4.97 a bc	4.17(6.4)
JK59	Jaya x Kuthiru	4.71aa	4.64bc	3.67(7.6)
JK 70	Jaya x Kuthiru	7.54 a	5.52 a b	4.3(7.3)
JO 345	Jaya x Orkayama	7.20 a	5.4 a b	4.27(5.3)
JO 532-1	Jaya x Orkayama	6.89 a	6.42 a	5.2(10.7)
JO 583	Jaya x Orkayama	7.30 a	5.28 a b	5.15(9.7)
Kuthiru (local check)		2.10	1.86 d	1.58(5.8)
Vytilla -6		1.91	1.75d	1.45 (3.05)
CD (0.01)		0.72	2.27	----

*polled over 27 locations in 6 years

PYT – Preliminary yield trial; CYT – Comparative yield trial

In regional farm trials 'Ezhome -1' (Culture JK 70) gives an average yield of 4.3 tones ha^{-1} , 'Ezhome -2' (Culture JO345) gives an average yield of 4.27 tones ha^{-1} ,'Ezhome -3' (Culture MK 22) gives an average yield of 4.17 tones ha^{-1} , and 'Ezhome -4' (Culture JO 532-1) gives an average yield of 5.2 tones ha^{-1} in low-medium saline condition (Vanaja *et al* 2017 & 2018). The yield of newly developed varieties is 75% to 160% more yield than local check variety 'Kuthiru' of *Kaipad* tract. Among these new varieties, 'Ezhome -3' and 'Ezhome-4' are seen more suitable in Pokkali tracts – a synonymous saline tract in south Kerala - with variation in soil structure.

In national saline alkaline screening trial of AICRP, all the four varieties performed well compared to their local check in various alkaline-saline conditions.

In addition to saline flooded tracts, all these four varieties are also suited to non-saline wetlands. Further 'Ezhome -1' and 'Ezhome -4'are also suitable for non-saline submerged tracts and 'Ezhome -2' and 'Ezhome -3'are also good for upland cultivation.

Sensory evaluation for cooking qualities showed that new varieties possess better taste and more acceptable appearance of cooked rice appealing to both consumers and millers. Except 'Ezhome-4' all varieties have red kernel pericarp.

Discussion: Crop improvement efforts adopting new frontiers resulted in development of an array of high yielding saline tolerant organic rice cultures, having distinct traits, for the first time to the unique sea coastal saline organic rice tracts of north Kerala, *Kaipad* . The details of performance of diverse rice cultures at various trials are summarized below. Four cultures namely, Culture JK 70, Culture JO345, Culture MK22, and Culture JO 532-1 were released for commercial cultivation in Kerala state of India in the name 'Ezhome-1', ' Ezhome-2', ' Ezhome-3' and 'Ezhome-4' respectively. Varietal difference in stress resistance is mainly due to difference in regulatory pathway which in turn is under the control of stress induced signal transduction. Hence varietal diversity in an abiotic stress prone area which is highly heterogeneous is imperative. Heterogeneous breeding populations have to be developed in situations where agriculture is risk prone, complex and require low input tract. Varietal diversity is also required to fight against break down of pest and disease resistance. Further, to outweigh the negative impact of micro-climate change and to help mitigate risk in agriculture sector, crop varietal diversity to a particular micro climate is essential. Carbon dioxide locking capacity of varieties may vary (Flowers and Yeo,1995).

There is no incidence of pests and diseases in saline *Kaipad* ecosystem, may be due to high potassium content of soil and salinity induced biotic stress tolerance. Further, when screened at wet land condition of RARS Pattambi, it is revealed that these varieties are resistant or moderately resistant to many pests and diseases. Besides the proven yield potential, pest and disease tolerance and other preferable characteristics of these varieties to saline and non-saline flooded areas, it possesses desirable grain qualities like awn-less, fair shattering and medium bold grains unlike awned, shattering and bold grains of traditional land races.

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