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'Ezhome -3'- A high yielding rice (*Oryza sativa* L.) variety for enhancing the varietal diversity of saline prone tidal farming ecosystem of Kerala

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ABSTRACT: *In Kerala state of India, the coastal wetlands of North Kerala grown with rice crop is popularly known as Kaipad and that of south Kerala is known as Pokkali. Even though crop improvement for Pokkali tracts began long before, Kaipad ecosystem which is naturally organic was left unattended with respect to variety development till 2001. Traditional cultivars tolerant to low and medium salinity are cultivated in various Kaipad fields of Kerala. The average rice yield of these local cultivars is about 2000 kg ha $^{-1}$, making rice cultivation in this region unprofitable. Development of high yielding, saline and lodging tolerant, varieties with favourable grain and cooking qualities for the Kaipad ecosystem was the demand of the farmers for long. Hence a challenging breeding project was begun in 2001 utilizing saline tolerant land races of Kaipad in breeding programme as donor parent, and adopting a combined strategy of pedigree breeding, organic plant breeding and farmer participatory breeding approaches. Sustained and systematic research efforts resulted in, for the first time, the development of an array of high yielding rice cultures, having distinct traits, to the sea coastal saline organic rice tracts of Kerala as per the farmers' demand. Out of these cultures, two were released in 2010 for commercial cultivation in saline prone Kaipad tracts christened as 'Ezhome -1' and 'Ezhome -2'. Here we report development and release of 'Ezhome -3' variety for varietal diversity to the unique ecosystem of Kaipad as well as Pokkali tracts of south Kerala.*

Keywords: *rice land race, salinity tolerance, tidal farming, naturally organic tract*

INTRODUCTION

The earth's resources are getting reduced due to exploitation of human leading to new problems. Hence to feed the growing population it became essential to device newer methods to enhance the production of risk prone areas which otherwise left fallow. One such case is breeding for abiotic stresses. A major stress leading to yield loss can be due to inland and coastal salinity. Development of saline tolerant variety has great importance in the present era of increasing salinization of soil, not only due to natural soil forming process but also due to secondary salinization due to man made factors (Rains and Goyal, 2003). Rice is the most important cereal food crop of India. In Kerala state of India there is 93730.5 ha of saline prone coastal wet lands. Development of salt tolerant varieties has been considered as one of the most important strategies to increase rice production in saline prone coastal areas. The success achieved in producing salt-tolerant varieties of crops has been very limited due to the reason that, crop responses to salt stress are made up of a number of complex and interrelated morphological, physiological, and biochemical process (Flowers and Yeo, 1995). As the global climate changes makes difference in the microclimate environment, the adaptation and mitigation strategy should be for development of location specific varieties. To attain this, the breeder should utilize locally adapted genetic resources in breeding programme.

Coastal wetlands of North Kerala are popularly known as *Kaipad* and that of south Kerala is known as *Pokkali.* Even though method of rice farming is similar in both tracts, the suitability of rice genotypes

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was different as there is difference in soil structure. Even though variety development for *Pokkali* tracts began long before, *Kaipad* ecosystem was left unattended with respect to variety development till 2001.Development of saline tolerant high yielding varieties for *Kaipad* ecosystem with favourable grain and cooking qualities was the demand of the farmers for long. Hence a challenging breeding project was begun in 2001.Rice farming is carried out in a peculiar way in *Kaipad and Pokkali,* purely in a natural way relying on the monsoon and the sea tides. Here we report development of a medium duration saline tolerant rice variety suitable to the saline coastal wetlands of Kerala utilizing a local land race of *Kaipad* in breeding programme.

MATERIALS AND METHODS

Traditional land races named, 'Kuthiru' and 'Orkayama' of saline prone naturally organic sea coastal ecosystem of North Kerala, India popularly known as *Kaipad* are the main genetic resources utilized in this breeding programme as donor parents for salinity tolerance and cooking qualities. Both 'Kuthiru' and 'Orkayama' are having multiple favourable traits like salinity tolerance, biotic stress tolerance, enhanced cooking and nutritive qualities (Vanaja and Mammootty, 2010) .'Jaya' and 'Mahsuri', improved varieties which are widely cultivated in the non saline wetland fringed to *Kaipad* ecosystem are taken as the female parent in the inter-varietal hybridization programme conducted in 2001. A combined strategy of pedigree breeding, organic plant breeding (Bueren, 2003) and farmer participatory breeding (Morris and Bellon, 2004) approaches was followed during the entire variety development programme, and conducted the whole experiment directly at the saline sea coastal problem area of farmers to harvest the genetic potential under field condition. All the filial generations as per pedigree breeding, and yield trials were raised as on-farm trials in the *Kaipad* fields under the test name culture MK22, ensuring the participation of farmers in the selection process of promising progenies suitable to the saline flooded areas. The multi location trials were conducted from 2008 -2011 at different locations including in *Pokkali* tracts. Salinity level varied between 4 to 8 dS m^{-1}during the cropping season. Culture MK22 was 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 AND DISCUSSION

Sustained and systematic research efforts resulted in, for the first time, the development of an array of high yielding rice cultures, having distinct traits, to the sea coastal saline organic rice tracts of north Kerala. Grain yield of the selected promising cultures in PYT, CYT, and farm trials in saline *Kaipad* fields of farmers are presented in Table 1. The mean yield from comparative yield trials showed that six cultures are on par with respect to grain yield. All these six cultures performed well in farm trials also. These cultures will have wide genetic base because, one of the parents is a local cultivar having abiotic and biotic stress resistance, and preferable cooking qualities to provide varietal diversity to the salt stress prone *Kaipad* field. These cultures have more grain and straw yield, and higher harvest index than that of local land races. These hybrid derivatives are resistant to all kinds of pests and diseases at *Kaipad* field condition. Screening in ordinary wetland condition 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 and non-shattering unlike local land races, better taste and more acceptable appearance of cooked rice, appealing to both consumers and millers. The cooking qualities of all the cultures are above or on par with traditional land race 'Kuthiru'. Out of these cultures, two were released in 2010 for commercial cultivation in saline prone *Kaipad* tracts christened as 'Ezhome -1' (Culture JK 70) (Vanaja *et al*., 2015) and 'Ezhome -2' (Culture JO 345).

Varietal diversity with broad genetic base is required in *Kaipad* saline tracts because the tract is highly heterogeneous with respect to salinity for which varieties of different resistance mechanism are essential. 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 is a must. Heterogeneous breeding populations have to be developed in situations where agriculture is risk prone, complex and require low input like *Kaipad* 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 imperative. Carbon dioxide

Table 1
Grain yield of culture MK 22 in PYT, CYT and regional trials (*Kharif* season)

Genotypes	*Parentage*	*PYT (pooled mean of 2 years; 2006-'07)*	*CYT (Pooled mean of 3 years 2008-'10)*	*Farm trial(pooled mean of 3 years; 2010-2012)*
MK 22	Mahsuri x Kuthiru	6.61 [a]	5.69 [a]	4.9
JK59	Jaya x Kuthiru	4.71 [aa]	4.9 [a]	4.4
JK 70	Jaya x Kuthiru	7.54 [a]	6.0 [a]	4.5
JO 345	Jaya x Orkayama	7.20 [a]	5.86 [a]	3.5
JO 532-1	Jaya x Orkayama	6.89 [a]	6.23 [a]	5.2
JO 583	Jaya x Orkayama	7.30 [a]	4.70 [a]	4.4
Kuthiru (local check)		2.10	2.10	2.0

PYT – Preliminary yield trial; CYT – Comparative yield trial
Farm trial data are means for five locations in Kannur, Kasaragode, Kozhikode districts of Kerala state; Means followed by the same superscript are not significantly different

locking capacity of varieties may vary (Flowers and Yeo,1995). Out of the remaining good performing four cultures, considering the diversity in parental combination compared to previously released 'Ezhome -1' and 'Ezhome -2',culture MK 22 whose parents are 'Mahsuri' and 'Kuthiru' was decided to commercially release to impart varietal diversity to the unique ecosystem of *Kaipad*.

Culture MK22 gives an average yield of 4.9 0 tones ha^{-1} (Table 1) in low-medium saline condition which is 116 percentage increase over local check variety 'Kuthiru'of *Kaipad* tract and 22 - 34 percentage increase over high yielding check varieties , 'Ezhome-1' and 'Ezhome -2'.It was also seen good performing in *Pokkali* tracts giving an average yield of 4.05tones ha^{-1}. In the National Saline Alkaline Screening Nursery (NSASN) of the All India Coordinated Rice Improvement Programme of AICRP trials conducted at 16 locations of different states of India during *Kharif* 2011(AICRIP Trials-2011- IVT-1M), culture MK 22 showed higher performance than the national check in all different types of soils tested namely, alkaline, alkaline normal, coastal saline, coastal saline normal and inland saline soils (Table 2).

The agronomic characteristics, physico-chemical traits, cooking and nutritive qualities of culture MK 22 in comparison with the popular land race of the ecosystem 'Kuthiru' is given in table 3.

It is a medium duration variety with deep red kernel colour without much loss of red colour even after milling, and with good nutritive qualities with higher content of Ca (6-34%), K(9-39%), and crude fiber (16-26%) than other high yielding *Kaipad* varieties and local cultivar, and higher Fe and Zn

Table 2
Performance of Culture MK 22 in National Saline Alkaline Screening trials of AICRP trials (NSASN 2011)

Name of culture/ Variety	*Mean yield under different situations(Kg/ha)*					
	IET No	*Alkaline [a]*	*Alkaline Normal [b]*	*Coastal Saline [c]*	*Coastal Saline normal[d]*	*Inland saline[e]*
Ezhome-1(JK 70)	22604	3058	4342	3677	3617	1094
Ezhome -2(Jo 345)	22607	2321	4332	3210	4512	1044
JK 59	22606	2415	3046	498	2156	721
JO 532-1	22608	2384	3754	3118	1857	1726
JO 583	22609	2415	4929	3781	2468	2203
MK 22	22610	2752	4525	3942	3967	3662
coastal check(CST 7-1)	—	2644	3538	3321	2466	1709

[a]Mean of 4 locations (Kanpur, Karnal, Karaikal, & Lucknow)

[b]Mean of 4 locations (Nawagam, Annamalainagar, Trichy, & Masodha)

[c]Mean of 3 locations (CRRI, Canning, & Machilipatnam)

[d]Mean of 3 locations (Chinsurah, Panvel, & Navasari)

[e]Mean of 2 locations (Karnal & Gangavati)

Table 3
Agronomic characteristics, physico-chemical traits, cooking and nutritive qualities of culture MK 22 in comparison with the popular land race of *Kaipad* ecosystem 'Kuthiru'

Item	*Culture MK 22*	*'Kuthiru' (Kaipad-local check)*
Agronomic traits		
Duration (days)	120-125	120-125
Average grain yield (t/ha)	4.90	1.98
Straw yield (t/ha)	5.61	5.13
Harvest index	0.43	0.28
Plant height (cm)	110-115	140-142
No.of tillers	16.0	7.7
No. of productive tillers*	18.0	10.6
Panicle length (cm)	24.2	27.1
Grains / panicle	178	91
1000 grain weight (g)	26.0	31.3
Physico-chemical & cookingqualities		
Lemma and Palea colour	Brown furrows on straw back ground	Brown furrows on straw back ground
Kernel colour	Deep red	Deep red
Awning	Awn less	Long & partly awned
Shattering	Fair shattering	Shattering
Hulling %	75.9	81.1
Milling % (In lab)	74.3	74.8
Milling % (In commercial mill)	63.7	69.7
Head rice recovery %	62.6	68.9
L/B ratio of grain	2.8	2.6
Classification	Medium	Medium
Volume expansion	2.0	3.5
Kernel elongation ratio	1.45	1.52
Water uptake	2.61	1.69
Nutrient qualities	65.6	121
Fe content (mg /Kg)		
Zn content (mg/Kg)	20.0	21.1
Ca (mg/Kg)	206	154
K (mg/Kg)	11610	8359
Crude fiber (% by wt.)	13.4	10.7

* In *Kaipad* ecosystem, number of productive tillers is seen more than number of tillers due to branching habit of tillers in *Kaipad* soil

content than high yielding *Kaipad* varieties- 'Ezhome -1' and 'Ezhome -2'.Grain, cooking and eating qualities are on par or above that of the local land race, 'Kuthiru' whose qualities are well appreciated long before.

There is no problem 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 (Table 4 & 5) to assess its genetic potential, it is revealed that culture MK22 is resistant to pests - gall midge and leaf folder, and diseases sheath blight and BLB; moderately resistant to pests- whorl maggot and case worm, diseases- brown spot and blast. Besides the proven yield potential, pest and disease tolerance and other preferable characteristics of 'culture Mk22'to saline coastal areas, it possess desirable grain qualities like awn-less, fair shattering and medium bold grains unlike awned, shattering and bold grains of traditional landraces.

As there are increasing demands for organic rice across the world market, development of this type of rice variety, suited to organic production system like *Kaipad*, is the need of the hour. Considering the superiority of the culture over existing local cultivars as well as high yielding varieties, and its ability for imparting varietal diversity in saline *Kaipad* ecosystem, it was released for Kerala state in 2013 christened as 'Ezhome-3'.

'Ezhome -3' after its release for coastal tracts of Kerala was tested for upland performance and revealed that it is potential to produce an average grain yield of 2.7tones ha $^{-1}$ under organic management. Farmers who cultivated this variety as upland rice prefer because of its non-lodging trait and good cooking qualities. 'Ezhome -3' will have wide genetic base, as one of the parents(Kuthiru) is a local land race, having abiotic and biotic stress resistance

Table 4
Reaction of Culture MK 22 to important pests when screened at non-saline wet land condition of RARS, Pattambi*

Genotypes	*Gall midge (% SS)*		*Leaf folder (% DL)*		*Whorl maggot (% DL)*		*Case worm (% DL)*	
	30 DAT	*50 DAT*	*30 DAT*	*50 DAT*	*30 DAT*	*50 DAT*	*30 DAT*	*50 DAT*
MK 22	0 (R)	6.1 (R)	2.05 (R)	6.17 (R)	14.4 (M R)	29.5 (M R)	29.5 (M R)	0 (R)
Kuthiru (local check & male parent)	0 (R)	4.55 (R)	1.85 (R)	6.31 (R)	22.22 (M R)	3.88 (R)	11.11(M R)	0 (R)

*In *Kaipad* ecosystem there is no problem of pests
< 10% infection = resistant, 10 -30% infection = moderately resistant, >30% infection = susceptible

Table 5
Reaction of Culture MK 22 to important diseases when screened at non-saline wet land condition of RARS, Pattambi*

Genotypes	*Score (0-9 SES scale)*			
	Sheath blight	*Brown spot*	*BLB*	*Blast*
MK 22	1(R)	2 (M R)	1(R)	3 (M R)
Kuthiru (local check & male parent)	1(R)	4(MS)	1(R)	3 (M R)

*In *Kaipad* ecosystem there is no problem of diseases
Score 1 = resistant, Score 2 & 3 = moderately resistant, (20% infection = score 5; 10% infection = score 3)

Figure 1

and preferable cooking qualities, and which was not exploited so far in breeding programmes (Vanaja and Mammootty, 2010).

As the entire development stages of the variety were conducted in farmer's field adopting Participatory Plant Breeding, the emerging strategy in the area of plant breeding to integrate end user based participatory approach, which involves close farmer-researcher collaboration to bring about plant genetic improvement within a crop, the farmers are very much convinced about the yield potential of the variety in saline flooded conditions.

REFERENCES

Bueren, L.E.T. (2003), Challenging new concepts and strategies for organic plant breeding and propogation. Eucarpia Leafy Vegetables (eds. Th.J.L. van Hintum, A. Lebeda, D. Pink, J. W. Schut).

Flowers, T.J., and Yeo, A.R. (1995), Breeding for salinity resistance in crop plants where next? *Aust. J.Plant Physiol*. 22: 875-884.

Morris, M.L. and Bellon, M.R. (2004), Participatory plant breeding research: Opportunities and challenges for the international crop improvement system. *Euphytica* 136: 21-35.

Rains, D.W. and Goyal, S.S. (2003), Strategies for managing crop production in saline environments: An overview. *In* Crop production in saline environments. pp 1-8.

Vanaja, T. and Mammootty, K.P. (2010), 'Kuthiru' and 'Orkayama' – Newly Identified Genetic Resources from Kerala, India for Salinity Tolerance in Indica Rice. Online publication in Nature proceedings.

Vanaja, T., Neema, V.P., Mammootty, K.P., Balakrishnan, P.C., and Jayaprakash Naik. (2015), The first high yielding saline tolerant rice variety suited to the *Kaipad* tidal farming ecosystem of Kerala, India, and suited for flood prone and water scarce environments: 'Ezhome-1'. *Journal of Organics* (JO) 2(1): 21- 31.