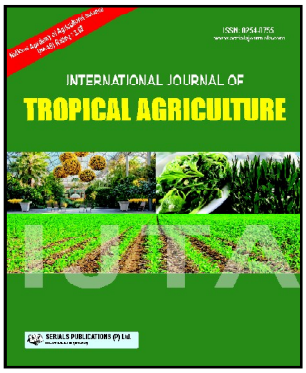

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JAIVA-the First Organic Rice (*Oryza sativa* L.) Variety for Non-stress Wetlands

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Abstract: Organic farmers need organic varieties that adapt well to specific soil and fertility conditions. In the current scenario, varieties having traits amenable for organic farming (organic varieties) are the missing link in the organic production chain. As organic agriculture is at its development stage, it currently reliant on conventionally bred varieties developed for farming systems in which artificial fertilizers and agro-chemicals are widely used. In the short and middle long run, organic market segment can utilize the best available varieties among the existing conventionally bred varieties which can also be propagated organically. But in the long term, organic agriculture should use organic varieties integrating organic traits. Here we report the development and release of the first high yielding organic rice variety suitable for organic farming in non stress wetlands of Kerala. The method adopted for cultivar development was a combined strategy of pedigree breeding, organic plant breeding and farmer participatory breeding approaches. Besides the yield potential of the cultivar, considering its other favorable traits including cooking and nutritional qualities it was commercially released in 2015 for the state Kerala in the name 'Jaiva'.

Key words: Organic farming, Organic plant breeding, Sustainable Agriculture, Participatory plant breeding.

INTRODUCTION

Organic farmers need robust varieties that adapt well to specific soil and fertility conditions and sensitive to natural variability in farm soils. Unlike conventional farmers, organic farmers value varieties that grow well at low fertility levels , that contribute

substantially to weed reduction, that have a high field tolerance to disease and pests, and often a unique product quality. Hence future of organic breeding may in fact include "organic varieties" bred solely for the intent of organic farming. Crop varieties currently used in organic agriculture are bred for conventional, high-input production. Organic farming systems aim at resilience and buffering capacity in the farm eco-system, by stimulating internal self regulation through functional agro biodiversity in and above the soil, instead of external regulation through chemical protectants[1]. 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[1]. Many breeding programs took yield potential as the primary target. With the increased living standard, the improvement in cooking, eating, and appearance quality of the rice grain has become a priority[2].

For further optimization of organic product quality and yield stability, new varieties are required that are adapted to organic farming systems[1]. In the current scenario, varieties having traits amenable for organic farming (organic varieties) are the missing link in the organic production chain. As organic agriculture is at its development stage, it currently reliant on conventionally bred varieties developed for farming systems in which artificial fertilizers and agro-chemicals are widely used. In the short and middle long run, organic market segment can utilize the best available varieties among the existing conventionally bred varieties which can also be propagated organically. But in the long term, breeders can influence further improvement of organic seed production by integrating organic traits in varieties[1]. The world umbrella organization for organic agriculture, IFOAM (International Federation for Organic Agricultural Movements) in August 2002 given directions to future developments with respect to organic plant breeding by presenting draft definitions and standards for organic plant breeding and techniques to be used[3]. Here we report the development and release of the first organic rice variety suitable for organic farming in non stress wetlands of Kerala christened as 'Jaiva', in 2015. We already reported the development and release of organic rice varieties suited to naturally organic saline stress rice tract of North Kerala- *Kaipad*[4,5,6].

MATERIALS AND METHODS

The principle of ecological sustainability is of great importance in organic agriculture taking care of the fertility of soil, rotation of crops, no use of chemical pesticides etc. To be able to prevent diseases, it is necessary to understand the coherence of the whole agrosystem[1]. A combined strategy of pedigree breeding, organic plant breeding and farmer participatory breeding approach was followed during the entire variety development programme. As research institutional set up was not tuned at that time of 2003 to take up organic farming, further fields of research stations were of fertilized by chemical fertilizers, farmers' fields being maintained under organic management was selected as experiment site for raising all filial generations, initial and preliminary yield trials. Further, special organic breeding programmes are economically not feasible at research stations, but feasible in farmers field for low cost. Involvement of farmers is necessary not only for lower costs but also at the development stage of organic plant breeding, knowledge of organic farming and the needs of organic farmers is a must which is very limited in the formal breeding sector[1].

As per the principle of organic plant breeding, one parent can be a high yielding variety, but those produced before the period of high inputs of inorganic fertilizers which are capable of more efficient nutrient uptake under lower input conditions. The other parent can be from land races for a broader genetic basis as a source for adaptation ability[5]. Hence, in the current breeding programme, one of the parents of crosses effected was two land races namely, 'Kuthiru' and 'Orkayama' which are adapted

to a unique organic saline prone ecosystem of Kerala, India called, *Kaipad*[6] and having good cooking and nutritive qualities ,and resistance to major pests and diseases in the field condition. Two other parents included in the breeding programme were the varieties, 'Jaya' and 'Mahsuri' which are usually cultivated by farmers under low input conditions. Hybridization was carried out between these four parents in all possible combinations under organic system. Out of 12 possible cross combinations between four rice varieties/land races, F_1 seeds were obtained only from six cross combinations.

In organic agriculture, as the variety has to expect a large plant x environment x management interaction under the lower (organic) input conditions, the most efficient way is to select progenies from the filial generations under organic farming conditions as early in the selection process as possible[1]. Hence, six thousand two hundred and ninety two F_2 progenies obtained from the six cross combinations were raised in farmers' field under organic management. Seventy four promising F_2 progenies were selected out based on yield, lodging resistance, plant stature and other subjective traits. Single plant pedigree selection was followed in F_2 generation. In the succeeding filial generations, only those progenies responding well to organic management were carried forward to initial and preliminary yield trials. Separate comparative yield trials for organic and conventional management practices were conducted to select out the genotype which performs best under both managements. The design used for replicated trial was RBD with three replications for PYTs and four replications for CYTs. As organic farmers prefer yield stability to higher yield, Multi location/ Farm trials under organic management were carried out for seven seasons in various districts of Kerala at eight locations. National level testing was done through AICRP trials at 30-34 locations in various states of India.

Detailed cooking and nutritive quality analyses were also conducted as organic farming demands higher quality. As crop health has to be given due consideration in the case of variety developed for organic agriculture, pest and disease screening was started parallel to the initial yield trials itself. Initially absolute screening for pests and diseases was conducted for 12 cultures which were evaluated in the initial yield trials under organic management. Those cultures which showed better biotic stress tolerance, yield performance and belong to different parental combinations were carried forward to further yield trials under both organic and conventional managements. Once again screening for biotic stresses was done to select out the best culture which shows better tolerance for biotic stresses, at the same time stable yield performance. Standard evaluation system for rice was used for evaluating and description of cultures, and for scoring pest and disease incidence[7].

As organic plant breeding is an emerging strategy, people participation is a must as envisaged in the organic agriculture strategies. Besides, for the conversion of ecological key principles from farm level to the socio-economic level, a successful plant breeding programme is not only based on a close plant x environment interaction, but also on a close co-operation between farmers and breeders, optimizing the use of the mutual specialist knowledge and experience[8]. Hence, after hybridization and production of F_1 hybrids in organically maintained system, a farmer participatory approach[9] of raising all filial generations in farmers' field who started organic farming well in advance was carried out. Farmers were invited for selection of progenies along with scientists and farmers' valuable suggestions and perspectives were also considered while making the final decision of progeny selection.

RESULTS AND DISCUSSION

The grain yield performance of 'Jaiva' variety which was tested under the name Culture MK 157 in Preliminary, Comparative, Multi location and Farm trials of 5-6 years are given in table 1, 2, 3 and 4. All the cultures evaluated under Initial and preliminary trials were subjected to biotic stress screening. Those

high yielding cultures which showed better biotic stress tolerance and belong to different parental combinations were carried forward to comparative yield trials under organic management. Accordingly, cultures MK 157, JK 14 and JK 59 were carried forward to CYTs. The culture MK 157 which showed the highest yield in CYTs was carried forward to multi location/ farm trials. The culture MK157 showed the highest performance for grain yield under organic managements along with very high production of straw in all yield trials. Yields in organic agriculture can be 20% lower due to a lower nitrogen input and no split application of nitrogen, and in some cases due to pests and diseases[10]. Further, in organic agriculture yield should be expressed in financial return instead of Kg/ha which is for organic farmers the optimal combination of grain production and the premium price for high grain quality[11]. Organic farmer prefer yield stability to higher yield. They need a reliable variety which can cope up with the fluctuations in weather conditions and disease pressure without large fluctuations of yield and quality of both grain and straw. Organic farming means obtaining economically feasible yields without exhausting natural resources at and around the production site. Organic farmers aim to optimize yield while satisfying the conditions of organic production, and natural principles and methods are applied[1].

Table 1
Performance of Culture MK 157 in PYTs under organic management in farmer's field

Sl. No.	*Cultures*	*Parentage*	*PYT-1 Grain yield (t/ha)*	*PYT-2 Grain yield (t/ha)*	*Pooled PYT Grain yield (t/ha)*
1.	JO 74	Jaya × Orkayama*	5.40 [a a]	5.20 [a a]	5.30 [a a]
2.	MK 157	Mahsuri × Kuthiru*	6.40 [a]	6.54 [a]	6.47 [a]
3.	MK 129	-do-	4.20	4.40	4.30
4.	MK 121	-do-	3.90	3.81	3.85
5.	MK 134	-do-	3.65	3.81	3.73
6.	JK 14	Jaya × Kuthiru	5.40 [a a]	5.55 [a a]	5.47 [a a]
7.	MK 130	-do-	4.20	4.29	4.24
8.	JK 59	-do-	4.80 [a a]	4.83 [a a]	4.82 [a a]
9.	MK 125	-do-	3.20	3.92	3.56
10.	JK 28	-do-	3.52	3.81	3.66
11.	MK 132	-do-	4.50	4.53	4.51
12.	MK 136	-do-	3.90	3.84	3.87
13.	Jyothy	Check variety	1.85	2.10	1.98
	CD(0.01)		0.87	0.90	0.81

*Land races of a naturally organic ecosystem-Kaipad.

Table 2
Grain yield performance of culture MK 157 in CYTs under organic managements

			Pooled CYT Grain yield (t/ha)
Name of culture/ Variety	*CYT-1 (t/ha) Rabi 2009-organic*	*CYT-2(t/ha) Kharif 2010-organic*	*Organic management*
MK 157	6.67[a]	4.72[a]	5.98[a]
JK 14	3.3	3.02	3.96
JK 59	4.0[a]	2.23	3.69
Jyothy	2.0	2.2	2.1
CD(0.01)	2.89	1.96	1.20

Table 3
Performance of culture MK 157 in MLTs under organic management

	RARS, Pattambi		*ORARS, Kayamkulam*	
	Grain yield (Kg/ha)	*Straw yield (Kg/ha)*	*Grain yield (Kg/ha)*	*Straw yield (Kg/ha)*
Name of culture/ Variety	*Organic*	*Organic*	*Organic*	*Organic*
Culture MK 157	5023.1	9652.8	2325.0	6150.0
Check variety	6412.0 Samyuktha	9027.8	2130.0 Uma	4560.0

Table 4
Pooled Farm trial data of Culture MK 157 for grain yield (straw yield in parenthesis) under organic management

	Mean Grain yield (t/ha)													
	Kharif							*Rabi*						
Name of culture/ variety	*2008*[a]	*2009*	*2010*[b]	*2011*[c]	*2012*[d]	*2013*[e]	*Pooled mean over years*	*2007*	*2008*	*2009*	*2010*	*2014*	*Pooled Mean over years*	*Pooled Mean over years and seasons*
Jaiva (Culture MK 157)	5.0 (9.9)	5.1 (9.4)	4.7 (8.6)	5.9 (9.9)	4.3 (9.5)	5.9 (10.5)	5.2 (9.6)	3.5 (6.5)	3.5 (6.1)	6.3 (9.1)	5.6 (8.4)	5.6 (9.1)	5.2 (8.3)	5.2 (9.0)
Check variety	2.1 (2.0)	2.6 (2.4)	3.0 (4.0)	3.6 (3.6)	3.5 (3.4)	3.4 (3.5)	3.1 (3.1)	1.9 (1.8)	2.0 (1.9)	4.2 (4.2)	3.2 (3.0)	3.1 (3.2)	2.8 (2.7)	3.0 (2.9)

[a]Pooled over 3 locations, [b]Pooled over 5 locations, [c]Pooled over 6 locations, [d]Pooled over 7 locations [e] Pooled over 3 locations.

Check variety: 2007 Rabi, 2008 Kharif and Rabi-Jyothy; 2009 and 2010 Kharif-Athira and Uma; 2009 and 2010 & 2014 Rabi, 2011-12 Kharif-Uma

N.B: The low pooled yield of HY check variety is due to the low performance of some of the check varieties under organic management in all seasons, and low performance of other check varieties in some seasons under organic management.

In farm trials of kharif season, the average yield exhibited by the culture under organic management was 5.2 tones/ha and during rabi season it was 5.2 tones/ha. Conventionally bred different check varieties were used in farm trials depending upon the popularity of the variety in that locality. The average grain yield of culture MK 157 in farm trials during kharif and rabi seasons under organic management was more than the conventional check variety by 68% and 73% respectively. The results of initial yield trials, comparative yield trials and farm trials from different farmers field show that, the yield performance of conventionally bred varieties used in this experiment widely varies with seasons and locations unlike the organically bred culture MK 157 which showed a stable yield irrespective of season and location. Lammerts van Bueren *et al.*[1] pointed out that , organically bred variety in the future will benefit not only for organic farming systems, but also for conventional systems moving away from high inputs nutrients and chemical pesticides. The average straw yield of culture MK 157 in farm trails during kharif and rabi was 210% more than the check variety. Yield performance of culture MK 157(Jaiva) was tested at national level in AICRP trials in various states of India in 30-34 locations during 2013 and 2014 kharif seasons. The results showed 8% yield increase over the best check in western regions of India(table not given). It was released in 2015 in the name 'Jaiva' as the first high yielding organic rice variety for ordinary non stress wetlands of Kerala.

Cooking quality and sensory evaluation results are given in table 5. 'Jaiva' out ranked the popularly consumed conventionally bred variety 'Jyothy' of Kerala, for all the parameters tested. The taste and acceptability of cooked rice were confirmed through an organoleptic test conducted by a team involving farmers, people representatives, millers, extension officials and scientists. The milling recovery of the culture in the commercial mill is 74.4% with 62% head rice recovery. Volume expansion is 68% , water uptake 270%, and kernel elongation 33% more than the check variety 'Jyothy'. In addition to the very good cooking qualities, which are very much

Table 5
Cooking qualities of culture MK 157 in comparison with the widely consumed rice variety, Jyothy

Characteristics	*Culture MK 157*	*Jyothy (check variety)*
Volume expansion	4.0	2.38
Kernel elongation ratio	1.6	1.2
Water uptake	2.11	0.57
Alkali spreading value	4.0	4.0
Amylose content	25.7	25.67
Shattering	Non shattering	Non shattering
Taste, texture, aroma and appearance of cooked rice as per sensory and Cooking quality evaluation	Very delicious with appealing appearance of cooked rice, with volume expansion 68% more than 'Jyothy'. Kernel elongation and water uptake more than that of Jyothy. Cooked rice is non sticky. Good for temple prasadam and Payasam.	Very good and non sticky
Over all performance score in sensory evaluation	6.6	6.3

appreciated by farmers who did farm trials, they also certified that it is very good for making 'temple prasadam' and 'Payasam' (sweet gruel). Further, the culture has appreciable nutritive qualities: 106.9-121.8% more iron, 7.1-36.4% more zinc, 8.6-33.3% more protein, 33.6-35% more calcium, 20.1-41.8% more potassium, and 8.1-22.3% more phosphorus content than the popularly grown conventionally bred varieties 'Jyothy', 'Uma' and 'Athira'. This quality may be a combined effect of inheritance from it's male parent 'Kuthiru' which is a land race, and may be due to organic breeding and management practices. Similar case of enhanced quality traits was experienced by Heyden and Lammerts van Bueren[4] in their organic breeding programme of cabbage; and Kunz and Karutz[12] in organic wheat breeding.

In all experiment fields of the culture, there was field resistance for most of the pests. 'Jaiva' showed resistance to leaf folder and case worm, moderate resistance to gall midge, whorl maggot, sheath blight, brown spot, but susceptible to blast. The resistance nature might have transferred from the male parent land race, 'Kuthiru', and the blast susceptibility might have inherited from its female parent 'Mahsuri'. There was no root disease and pest attack in any of the experiment or farm trials in consistent with the report of Bruggen[13] that in organic crop production, root disease and pests are generally less of a problem than foliar diseases, because foliar disease development is much more determined by climatic factors. The consequences of losses due to pests and diseases in organic farming systems differ considerably depending on region, crop, and farm structure.

The height of seedlings of 'Jaiva' variety is short, making transplantation an easy process including using of machine, but two months after transplanting the height of the seedlings increases suddenly and forms a thick canopy over the soil. The dense crop canopy influenced by its canopy architecture of long and broad leaves; leaf stiffness and leaf shape, and its robust nature with large number of tillers improves the crop's ability to compete with weeds. The weed suppressive ability of varieties can contribute to the self regulation principle of the organic farming system. The organic farmers require varieties that have a rapid juvenile growth with a good tillering ability and the ability to

cover or shade the soil in an early stage of crop development to outcompete weeds for light[11].It was also observed that the variety comes up well in those wetlands which are shaded at the border due to conversion of paddy land for other plantation crops and for construction purpose. The variety is characterized by a long stay green index of the upper leaves, expressing the ability to use all available nutrients and light efficiently which is an important criterion for organic varieties[11].The plant architecture of culture 'Jaiva' with tall erect leaf canopy and druping panicles is of more productive type in terms of photosynthesis[12].

In the fields of organic management, the crop was seen to resist lodging, but in some conventionally managed trials the crop is seen partially lodged. Similar case was reported in the case of wheat also[14].In the organic farming fields of 'Jaiva' there was immense growth of micro-organisms on the soil which satisfies the organic varietal characteristic to interact with beneficial soil micro-organisms. During 2010 kharif season, in Arayidam padasekharam of Kannur district, Kerala which has been an organic farming tract for several years and one of our farm trial fields, we raised 'Jaiva' along with a conventionally bred rice variety, 'Uma'. The bad weather conditions during this period adversely affected the conventionally bred variety but 'Jaiva' remained unaffected. Similarly, in an iron toxic field when a conventionally bred high yielding variety 'Varsha' showed reduced root growth and there by yield reduction, the variety showed healthy roots and better yield. In a farmer's field which was left uncultivable due to secondary salinization, the variety showed better production. Hence, the variety satisfies the criteria of 'reliable variety' for organic farming[1].

The robust plant architecture with taller stem and erect leaf canopy and drooping panicles are of more productive type in terms of photosynthesis. Long stay green index of upper leaves even at the time of harvest express it's ability to use all available nutrients and light efficiently. Attractive plant architecture with long, compact panicles having large number of comparatively small grains with lemma and palea colour- gold furrows on straw back ground which can be very specifically distinguished from other varieties. The other favourable traits of the variety certified by farmers are, less chemical fertilizer required for conventionally managed crop, and excess fertilizer causes deleterious effect; less chaff production; high germination percentage; possible for ratoon crop; suitable for shaded wet lands, parboiling time 20 minutes less than other varieties; and lightly scented at the time of flowering and seedling. In homestead upland Farm trial under different cropping systems like black pepper, coconut, young cashew and rubber plantations the culture produced an average grain yield of 1000-2813 kg/ha under organic management during *Kharif* 2010.

In the organic farming fields of 'jaiva' variety, there was immense growth of micro-organisms on the soil which satisfies the organic varietal characteristic to interact with beneficial soil micro-organisms. There is slight shedding problem if harvest delayed, and slight neck blast attack under excess chemical fertilization during rabi season. These characteristics are inherited from it's female parent Mahsuri. Compared to conventional management, under organic management blast attack is not seen and plants are comparatively vigorous. During *Kharif* season, if there is heavy wind and water logging at the time of dough stage, because of moderate culm height the crop partially bends to one side, but during *rabi* season it is fully non-lodging.

The plant is tolerant to lodging with robust plant architecture; large number of strong sturdy culm with average height 119 cm; long and broad, many nice and vibrating leaf canopy and drooping panicles; and with comparatively high straw content. Long, compact panicles with large number of comparatively small grains with lemma and palea colour- gold furrows on straw back ground, and

attractive bold white kernel which can be very specifically distinguished from other varieties. Long stay green index of upper leaves even at harvest stage with attractive plant stature, tolerant to shade in the wetland, lightly scented at the time of seedling and flowering stages are other favorable traits of this organic variety.

This organic rice variety will have wide genetic base, as one of the parents is a land race having various stress resistance, and preferable cooking and nutritive qualities which was not exploited much through breeding. Most of the current new varieties are derived from a limited number of parental lines and are thus genetically related to each other. Broadening the genetic basis of a genotype is more important for adaptation to organic farming.

Participatory approach involving organic farmers and progressive farmers who were ready to accept organic farming, helped a lot the process of development and evaluation of the culture including analyses of minute and subjective traits. As the major part of the experiment was 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, quality, and suitability of the variety to organic cultural practices in wet land condition. Farmer participation ensured revival of rice cultivation without much extension efforts.

CONCLUSION

'JAIVA' is the first organic wetland rice variety suitable for both organic farming and conventional farming, developed through the combined plant breeding strategies like pedigree breeding, organic plant breeding and participatory breeding. It possesses the general criteria for desirable variety characteristics for organic farming systems. It is a high yielding photo insensitive medium duration (125-130 days for kharif and 115-120 days for Rabi) rice variety giving high yield under both organic and conventional managements. Under organic management it gives 73% higher grain yield and 211% more straw yield than the high yielding check variety bred and developed for conventional farming practices. Comparatively higher nutritional qualities than 'Jyothi', 'Uma' and 'Athira' –popular varieties of Kerala. Very good cooking qualities with volume expansion 68% more than 'Jyothy', and cooked rice is very delicious. The variety shows field resistance to major pests and diseases except for blast. It exhibits increased rooting density leading to adaptation to organic soil fertility management (low input). However, it responds very well to chemical fertilizers also. The short seedling height which become suddenly tall two months after transplanting and form a thick canopy over the soil to suppress weed growth.

Breeding programmes for new 'organic' varieties may benefit not only organic farming system, but will also benefit conventional systems moving away from high inputs of nutrients and chemical pesticides. As organic plant breeding and seed production activities are still in their infancy in the developing country like India, where organic agriculture area is in limited extent, there was very positive response from farmers as the adverse effect of chemical use in agriculture is a burning topic of discussion in the Kerala state of India. More stream lined approach in this area is essential as in the long run the organic sector can only benefit from breeding programmes specially focused on the requirements of organic farmers and processors, users and consumers.

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