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Identification of rice genotypes best suited for the development of organic varieties and identification of current varieties best suited for organic farming

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Abstract

Organic farming is at a growth stage and an increasing number of farmers are in the process of conversion from chemical farming to organic farming. However, varieties developed for organic farming are few. The experiment was conducted at Kerala Agricultural University, India, with the aims of identifying parents having organic varietal traits suited for development of organic varieties through hybridization, and of selecting the best ones among conventional rice varieties suitable for organic farming for the immediate future until enough organic varieties are developed. Out of 65 rice genotypes evaluated under organic management, considering grain yield and other organic varietal traits, 'Jaiva', the first organic rice variety released by Kerala Agricultural University, suited for non saline wetlands, and developed based on the concepts and strategies of organic plant breeding, ranked first. The conventional varieties which can be considered for organic farming for use in the immediate future are the photo-sensitive long-duration varieties 'Anashwara' and 'Dhanu', and the photo-insensitive medium-duration variety 'Aishwarya' along with the pre-release Culture MK 115. Parents suited for different organic varietal traits namely, straw yield per plant, number of productive tillers per plant, number of tillers per plant at harvest, number of grains per panicle, volume expansion ratio, sensory evaluation, and pest and disease incidence, were identified.

Keywords: Organic agriculture, organic variety, breeding, selection, yield, yield components, India, Asia.

Introduction

An ecological aim for the present era is fostering an evergreen revolution with organic farming for health as well as for environmental care. Organic farming is gaining importance in the world with 160 countries already practicing it and with the global area under organic agriculture production accounting for more than 37.2 million hectares. India has a reported 1,178,289 hectares of organic agriculture, and India and China are the only countries that were ranked in the top ten countries for both actual increase in organic agriculture hectares and relative increase of organic agriculture hectares over a decade (Paull, 2011). The annual organic rice production in India is 3,500 tonnes (Deshpande & Devasenapathy, 2010). Rice has immense potential under organic farming as it is the staple food for about 60% of the population of India.

However, it is estimated that more than 95% of organic production is based on crop varieties that were bred for the conventional high-input sector (Bueren et al., 2011). Such varieties may lack important traits required under organic and low-input production conditions. This is primarily due to selection in conventional breeding programmes being carried out under a regime of high inorganic fertilizer and a catalogue of chemical crop protection inputs (Bueren et al., 2011).

Currently, plant varieties that have been bred specifically for organic systems are few. To increase organic farmers' success, we must increase the number of varieties bred specifically for organic systems. Any successful hybridization programme for varietal improvement depends mainly on the selection of suitable parents. The aims of the present study were to identify the best rice genotypes suited as parents among a collection of traditional as well as conventionally bred rice genotypes of Kerala for the development of organic rice varieties, and the identification of the best varieties, among conventionally bred varieties, suitable for organic farming as a short and medium term strategy until enough organic varieties are developed and released.

Materials and Methods

The present study was conducted by the Department of Plant Breeding and Genetics, College of Agriculture, Padannakkad, Kerala Agricultural University. Field trials were laid out during rabi season in the field of an established organic rice farming group (Arayidam Padasekharam) in Mayyil Panchayath of the Kannur district of Kerala state.

Materials included 65 rice genotypes (Table 1) comprising a collection of traditional rice cultivars of Kerala, a collection of conventionally bred varieties, and varieties/cultivars developed by Kerala Agricultural University adopting strategies of organic plant breeding. Seeds of the 65 rice genotypes were sown during September 2013 in plastic trays which were filled with organic soil. Transplanting of seedlings maintained inter and intra row spacing of 15 cm and 10 cm respectively. Plots consisting of 7 rows of 10 plants each were laid out in a randomized block design with two replications.

All cultural operations were carried out as per organic agricultural management practices followed by the farming group for the last five years. Observations on 23 parameters were recorded on ten randomly selected plants in each replication for each treatment after excluding the border rows. Out of the 23 parameters studied, seven organic varietal traits namely, straw yield per plant, number of productive tillers per plant, number of tillers per plant at harvest, number of grains per panicle, volume expansion ratio, sensory evaluation, pest and disease incidence are reported in this study. Observations were taken as per the “Standard evaluation system for rice” (IRRI, 1996).

Results and Discussion

Of the 65 rice genotypes evaluated under organic management, in the case of grain yield, ‘Anashwara’, a photo-sensitive conventionally bred variety and ‘Jaiva’, a photo-insensitive variety developed based on strategies of organic plant breeding (OPB), ranked first followed by conventionally bred varieties namely, ‘Aishwarya’, ‘Dhanu’, ‘Aruna’, ‘Hariyana Basmathi’, ‘Kanakom’, ‘Sagara’, and the organic Culture MK-115 (Table 1).

Comparing the top ranked two varieties (i.e. Anashwara and Jaiva) with respect to the important yield and physico-chemical traits which are significant and positively correlated with grain yield, and those that have significant and positive direct effects, the photo-insensitive organic variety ‘Jaiva’ ranked at the top with respect to eight yield contributing characters namely, straw yield per plant, number of panicles per plant, total biomass per plant, number of grains per panicle, number of tillers at harvest, seed setting percentage, plant height at 60 days after transplanting, and hulling percentage. ‘Anashwara’ the conventionally bred photo-sensitive variety which also top ranked for grain yield under organic management showed higher performance for six yield contributing characters namely, straw yield per plant, number of grains per panicle, total biomass per plant, number of tillers at harvest, plant height at 60 days after transplanting, and hulling percentage (Table 1).

Considering the cooking qualities namely, volume expansion, kernel elongation ratio, alkali spreading value, and sensory evaluation, ‘Jaiva’ ranked best in all four categories and ‘Anashwara’ ranked best only for kernel elongation ratio. With respect to pest and disease incidence, both ‘Jaiva’ and ‘Anashwara’ showed tolerance to the major pests and diseases studied by visual observation.

Out of the seven genotypes which ranked as second and with on par performance with respect to grain yield per plant, the conventionally bred photo-sensitive long-duration variety ‘Dhanu’, and the photo-insensitive medium-duration variety ‘Aishwarya’, and the flood-tolerant prerelease medium-duration photo-insensitive organic Culture MK-115, showed top performance for various yield component traits, cooking qualities, and pest and disease tolerance. Hence these three genotypes can also be considered for organic farming after ‘Jaiva’ and ‘Anashwara’.

Identification of conventional varieties for organic farming for short and medium term periods

Out of 99 varieties of Kerala Agricultural University developed for conventional farming in ordinary wetland using chemical fertilizers, 32 varieties were available and evaluated under organic management in this study. Out of these, photo-sensitive long-duration varieties ‘Anashwara’ followed by ‘Dhanu’ and photo-insensitive medium-duration variety ‘Aishwarya’ can be considered for organic farming for the time being. Until sufficient organic varieties are developed by organic plant breeding (OPB) strategies, organic seeds of those varieties which were developed for chemical farming using chemical fertilizers but which perform well under organic management can be used for organic farming. The remaining 67 varieties of Kerala Agricultural University developed for chemical farming have yet to be tested under organic management and this may be a future line of work.

Identification of genotypes for organic varietal traits

Selection of parents is an important criterion for a successful breeding programme. In order to develop a high-yielding organic rice variety through hybridization, identification of parent genotypes having promising organic varietal traits is imperative. The result of the analysis of variance of seven organic varietal traits of 65 rice genotypes grown under organic farming is given in Table 1.

The analysis of variance revealed high significant differences at 5% level of significance for all the genotypes studied for all the seven organic varietal characteristics indicating the existence of a significant amount of variability among the genotypes. Grain yield per plant varies from 4.3g to 26.6g. As previously reported, the genotypes, which produced the higher number of effective tillers per plant and higher number of grains per panicle also showed higher grain yield in rice (Dutta, Baset-Mia, & Khanam, 2002).

In the current experiment the varieties ‘Anashwara’ and ‘Jaiva’ recorded significantly higher grain yield per plant, perhaps because of the higher number of productive tillers and number of grains per panicle. ‘Anashwara’ is a conventionally bred variety of Kerala. ‘Jaiva’ is the first organic rice variety released by Kerala Agricultural University, suited for non saline wetlands and developed based on the concepts and strategies of organic plant breeding.

Straw yield per plant varied from 9.6g to 45.8g .The genotypes ‘Kanakom’, ‘Dhanu’, ‘Anashwara’, ‘Jaiva’, ‘Culture MK-115’, ‘Makam’, ‘Remanika’, and ‘Vytilla-4’ recorded significantly higher straw yields per plant. Similar observations under conventional management were reported by Vanaja et al. (1998).

The number of grains per panicle is an important plant trait which should be considered in any breeding program for higher paddy yield in rice (Akhtar et al., 2011). In this study it varied from 12 to 282. The genotype ‘Mahsuri’ recorded significantly the highest number of grains per panicle. Similar observations were reported in rice by Ashrafuzzaman et al. (2009), Akhtar et al. (2011), and Idris et al. (2012).

The number of productive tillers per plant varied from 5.0 to 16.6. The number of panicles was the result of the number of tillers produced and the proportion of effective tillers which survived to produce panicles (Hossain et al., 2009). The genotypes ‘Badhra’, ‘Dhanu’, ‘Anashwara’, ’ Makam’ and ‘Jaiva’ recorded higher numbers of tillers, and this may be the reason for the significantly higher number of productive tillers per plant. In the same way, Ashrafuzzaman et al. (2009) while working with six aromatic rice varieties reported that there had been significant variation in the number of productive tillers per plant. The number of tillers per plant varied from 4.1 to 14.7 at 30 days after transplanting, 5.3 to 17.2 at 60 days after transplanting, 6.5 to 17.8 at 90 days after transplanting, and 6.8 to 18.3 at harvest stage. Bueren et al. (2002) stated that a higher number of plant tillers at early stages leads to increased ground cover to suppress the weed occurrence. During the period of transplanting to 30 days after transplanting, the number of tillers was higher for ‘Dhanu’, ‘Anashwara’ and ‘Badhra’. Between 30 days after transplanting to 60 days after transplanting, the number of tillers was found to be higher for ‘Kalladiyaran’ followed by ‘Aruna’.

The cooking quality trait of volume expansion ratio which indicates the measure of how many people can be fed when one cup of rice is cooked varies from 1.97 to 4.07. The genotypes ‘CO-47’, a Coimbatore variety, ‘Culture MK 157’ (‘Jaiva’) - the organic variety of Kerala Agricultural University (Vanaja, et al., 2013), ‘Valankunhivithu’ a traditional land race of Kerala, and ‘Culture MK-115’ recorded significantly higher volume expansion ratio.

'Umadevi et al. (2010) and Manonmani et al. (2010) recorded similar results in various sets of rice genotypes.

Sensory evaluation techniques have been used by several researchers to evaluate the effects of storage (Perez & Juliano, 1979), processing and variety, on end-use quality of rice. In the current experiment, out of 65 genotypes, the variation in sensory evaluation score ranged from 5.3 to 8.6. The highest sensory evaluation score was recorded by 'Pusa Basmathi' an aromatic rice variety, followed by 'Ezhome-3', 'Culture Mk115', 'Dhanu', 'Jaiva', 'Gandakasala', 'Mahsuri', 'Asha', 'Haryana Basmathi', 'Swarnaprabha', and 'Aishwarya'.

Table 1. Mean performance of 65 rice genotypes for organic varietal traits.

	Genotype	Parentage / Pedigree	Grain yield per plant (gm)	Straw yield per plant (gm)	Number of productive tillers per plant	Number of tillers per plant	No. of grains per panicle	Volume expansion ratio	Sensory evaluation score
	Traditional genotypes of Kerala								
1	Ayirankana	Traditional cultivar	13.8	22.6	7.1	8.1	43.5	3.13	6.4
2	Chembav	Traditional cultivar	12.5	20.4	6.5	8.1	46.5	2.27	6.4
3	Gandakasala	Traditional cultivar	19.1	9.6	9.7	8.3	132.5	2.77	8.1
4	Kalladiyaran	Traditional cultivar	13.0	27.4	9.0	12.8	78.5	2.63	6.3
5	Kandoorkutty	Traditional cultivar	4.3	30.9	7.8	14.0	12.0	1.97	6.5
6	Kuthiru	Traditional cultivar	8.3	18.3	5.9	9.1	50.0	3.77	7.5
7	Kuttoos	Traditional cultivar	11.6	19.6	8.8	12.3	98.0	2.7	6.4
8	Njavara	Traditional cultivar	17.4	27.2	10.3	11.4	61.0	2.57	6.8
9	Orkayama	Traditional cultivar	8.3	15.6	5.4	8.2	53.0	3.87	7.7
10	Red Mahsuri	Traditional cultivar	17.9	34.4	5.6	8.6	200.0	3.53	7.9
11	Valan kunhivithu	Traditional cultivar	6.1	16.9	6.3	9.3	46.0	4.03*	6.5
12	Valicha	Traditional cultivar	16.7	27.6	10.8	12.1	66.5	4	7.2
13	Valichoori	Traditional cultivar	10.0	20.5	5.3	6.8	70.0	3.2	6.5
14	Velambalan	Traditional cultivar	8.3	16.2	9.1	8.7	72.5	3.13	5.8
15	Vellathondi	Traditional cultivar	14.2	24.2	9.3	12.7	68.5	2.43	7.8
	Conventionally bred varieties								
16	Aishwarya	Jyothi x BR 51-46-1	23.2	29.9	10.5	13.0	51.0	3.23	8
17	Anashwara	PTB 20	26.6*	39.7*	14.9*	15.6*	75.5	3.23	7.8
18	Aathira	BR 51-46-1 X Culture 23332-2	19.5	25.8	7.9	11.2	181.5	3.03	6.4

19	Annapurna	TN 1 x PTB 10	8.7	19.2	7.0	8.6	77.5	3.30	7.4
20	Aruna	Jaya x PTB 33	22.6	32.3	7.6	12.3	167.5	3.07	6.5
21	Asha	IR 11-1-66 x Kochuvithu	16.9	23.4	9.2	10.0	118.5	3.73	8.1
22	Badhra	IR 8 x PTB 20	15.1	32.8	16.6*	18.0*	120.0	3.2	6.9
23	Bhagya	Tadukkan x Jaya	15.7	27.2	11.3	12.7	66.5	2.41	7.1
24	CO-47	IR 50 x CO 43	17.3	22.5	11.8	13.8	92.5	4.07*	7.8
25	Dhanu	PTB 20	7.9	24.1	8.5	18.3*	71.5	3.33	8.2
26	FL-478	IR 29 x Pakkali B	13.0	21.4	7.7	10.5	49.5	2.87	6.9
27	Gouri	MO 4 x Cul. 25331	20.8	33.3	8.0	10.8	139.0	2.7	7.6
28	Haryana basmathi	Sona x Basmathi-370	12.7	13.1	7.2	9.2	63.5	3.03	8.1
29	IR-28	IR 833-6-2-1--1 x IR 2040	17.8	13.5	6.7	10.7	129.5	3.5	7.8
30	Kanakam	IR 1561 x PTB 33	20.6	45.8*	9.7	12.5	128.5	3.37	6.6
31	Kanchana	IR 36 X Pavizham	17.4	24.8	10.3	11.1	69.5	3.43	6.9
32	Karishma	MO 1 x MO 6	18.4	23.7	9.9	11.3	95.5	2.83	7.5
33	Karthika	Triveni x IR 1539	19.4	30.0	6.6	12.7	79.0	2.63	7.9
34	Karuna	IR-8 x ADT-27	11.9	25.4	7.3	9.1	72.5	2.9	7.1
35	Kasthuri	CO-25 X H4	11.2	25.1	8.1	8.1	81.5	3.7	7.2
36	Krishnanjana	MO 1 x MO 6	14.7	28.6	5.4	12.4	112.0	3.8	7.5
37	Mahsuri	Taichung 65 x ME 80	16.4	30.5	6.1	7.3	282.0*	3.97	8.1
38	Makom	ARC 6650 x Jaya	19.1	35.5*	13.4*	15.5*	114.0	2.87	5.4
39	Neeraja	IR 20 X IR 5	11.9	23.9	7.5	9.7	111.0	2.43	6.1
40	Onam	Kochuvithu x TN 1 x Triveni	13.1	23.9	9.6	10.4	41.5	3.33	5.9
41	Prathyasha	IET 4786 x Aruna	19.5	24.8	10.5	11.9	29.0	3.4	6.7
42	Pusa Basmathi	Pusa 1301 x Pusa1121	11.0	18.3	6.1	11.6	31.0	3.57	8.6
43	Remanika	Mutant of MO 1	12.5	35.2*	7.5	14.8*	66.0	2.5	7.3
44	Remya	Jaya x PTB 33	16.9	32.3	8.6	14.4	71.5	3	6.2
45	Renjini	MO 5 x M 28-1-1	14.1	23.4	7.3	10.5	101.0	3.07	6.8
46	Revathy	Cul. 12814 x MO 6	12.5	20.8	5.9	7.9	87.5	2.87	6.5
47	Sagara	Oorumundakan local	20.5	31.8	10.6	12.6	124.0	2.67	7.5

48	Samyuktha	Culture C2	12.0	26.6	7.8	9.9	70.0	3.47	5.9
49	Swarnaprabha	Bhavani x Triveni	18.1	24.8	8.0	9.0	130.5	3.2	8.1
50	Swetha	IR 50 X C 14-8	17.9	29.7	5.5	7.8	207.5	3.7	7.8
51	Uma	MO 6 x Pokkali	18.4	25.7	7.4	9.7	96.5	3.6	7.9
52	Vaishakh	Swarnaprabha	19.9	15.8	7.15	8.6	142.5	3.67	6.6
53	Vytila-1	Choottupakkali	13.8	21.2	9.4	12.5	68.5	3.3	7.4
54	Vytila-4	Chettivirippu x IR 4630-22-2-17	19.0	34.6*	7.4	9.8	130.5	3.4	7.2
	Organic Varieties & cultures of KAU								
55	Culture JK-14	Jaya x Kuthiru	8.1	23.8	6.0	10.3	126.5	3.73	7.1
56	Culture JK-15	Jaya x Kuthiru	13.2	22.7	10.0	13.1	55.0	3.33	7.1
57	Culture JK-59	Jaya x Kuthiru	12.0	20.8	5.0	7.8	61.5	3.93	7.1
58	Culture JK-71	Jaya x Kuthiru	13.8	23.4	7.6	8.5	63.0	3.33	7.1
59	Culture Jo-583	Jaya x Orkayma	22.0	36.3*	8.4	8.3	119.0	3.33	7.6
60	Culture MK-115	Mahsuri x Kuthiru	24.6*	37.1*	11.8	9.2	201.5	4.03*	8.3
61	Jaiva	Mahsuri x Kuthiru	22.7	45.0*	16.5*	14.8*	78.0	3.47	8.1
62	Ezhome-1	Jaya x Kuthiru	9.0	21.9	6.1	13.1	110.0	3.5	7.9
63	Ezhome-2	Jaya x Orkayma	16.0	23.4	7.1	8.0	148.5	3.6	7.7
64	Ezhome-3	Mahsuri x Kuthiru	19.4	21.3	6.1	10.3	157.0	3.53	8.3
65	Ezhome -4	Jaya x Orkayma	19.3	27.4	6.7	8.4	104.5	3.83	7.3
	Mean		15.36	25.76	8.38	10.86	96.45	3.46	7.21
	Range	Min.	4.3	9.6	5.0	6.8	12.0	1.97	5.4
		Max.	26.6	45.8	16.6	18.3	282.0	4.07	8.6
	CoV		10.44	21.67	24.31	16.14	9.05	5.71	2.16
	CD (5%)		3.20	11.16	4.07	3.50	17.43	0.37	0.14

CoV, coefficient of variation; CD, critical difference; *Significant and on par.

Incidence of pests and diseases

Scoring of the incidence of pests and diseases at growth and grain filling stages was done under natural field conditions with the results reported below.

Incidence of pests

All the genotypes were screened for important pests and diseases under natural field conditions. The genotypes namely, ‘Culture JK-59’, ‘Culture MK-115’, ‘Remya’, ‘Badhra’, ‘Dhanu’, ‘Kalladiyaran’, ‘Aruna’, ‘Karuna’, ‘Culture JK-15’, ‘Sagara’ and ‘FL-478’ recorded as free from BPH attack indicating that, these can be used as parental material for breeding for the development of BPH tolerant varieties.

The varieties, ‘Mahsuri’, ‘Aathira’, ‘Anashwara’, ‘Culture MK-115’, ‘Dhanu’, and ‘Karuna’ were free from leaf roller/leaf folder infestation and these can be used as parental material for breeding for the development of leaf roller/leaf folder tolerant varieties.

‘Makom’, ‘Aathira’, ‘Jaiva’, ‘Pusabasmathi’, ‘Red Mahsuri’, ‘Culture JK-59’, ‘Chembav’, ‘Ayirankana’, ‘Vytilla-4’, ‘Swetha’, ‘Njavara’, Ezhome-4,Culture JK-71, ‘Remya’, ‘Revathi’, ‘Prathyasha’, ‘Anashwara’, ‘Neeraja’, ‘Aruna’, ‘CO-47’, ‘Valicha’, ‘Sagara’, and ‘Aishwarya’ were free from rice bug/ear head bug indicating that these can be used as parental material for the development of rice bug/ear head bug tolerant organic rice varieties.

The tolerance exhibited by these genotypes may indicate their genetic potential, which has to be confirmed through artificial screening, or it may be due to field tolerance as a consequence of organic cultural management.

The genotypes that can be selected as parents for tolerance to major pests are: ‘Anashwara’, Athira, ‘Mahsuri’, ‘Dhanu’, ‘Culture Mk115’, ‘Remya’, and ‘Culture JK15’.

Incidence of diseases

The genotypes namely, ‘Jaiva’, ‘Kasthuri’, ‘Pusa Basmathi’, ‘Red Mahsuri’, ‘Chembav’, ‘Ayirankana’, ‘Njavara’, ‘Kuthiru’, ‘Ezhome-1’, ‘Karishma’, ‘Anashwara’, ‘CO-47’ and ‘Valicha’ showed tolerance to blast disease, indicating that, these can be used as parents for the development of blast tolerant organic rice varieties.

The genotypes which showed tolerance to sheath blight disease are: ‘Krishnanjana’, ‘Jaiva’, ‘Mahsuri’, ‘Kuthiru’, ‘Kasthuri’, ‘Pusa Basmathi’, ‘Culture JK59’, ‘Ayiramkana’, ‘Swetha’, ‘Culture MK115’, ‘Ezhome-2’, ‘Ezhome-3’, ‘Ezhome-4,’ ‘Vytilla-1’, ‘Bhagya’, ‘Prathyasha’, ‘Karishma’, ‘Anashwara’, ‘Kalladiyaran’, ‘Kandorkutty’, ‘Kuttose’, ‘Annapoorna’, ‘Aruna’, ‘CO-47’, ‘Gandakasala’, ‘Haryanabasmathi’, ‘Culture JO 583’, ‘Culture JK 15’, ‘Remanika’, ‘FL 478’, ‘IR 28’, and ‘Renjini’.

The parents that can be adopted for tolerance to major diseases are ‘Jaiva’, ‘Kasthuri’, ‘Pusa Basmathi’, ‘Anashwara’, ‘Ayirankana’, ‘CO-47’ ‘Kuthiru’, and ‘Karishma’. Validation through artificial screening is necessary.

Conclusion

The increasing uptake of organic agriculture in India, and elsewhere, calls for the development of crop varieties bred specifically for organic growing. This means a need for developing varieties that are not dependant on high-input regimes of chemicals, so that the crops are not reliant on the application of synthetic fertilisers and pesticides. The outcome of the development of organic-suited varieties and the uptake of organic farming can help reclaim farmer sovereignty, increase food security, and avoid farmer indebtitude to moneylenders and chemical companies. Where the farmers achieve organic certification they can also take advantage of the premiums which organic products achieve in the market place. The results of the present study indicate potentially fruitful directions for the development of such organic varieties of rice specifically suited for organic farming.

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