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Performance Evaluation of Some Native Rice Cultivars of the *Kaippad* Farming System of Kerala State of India

KT Chandramohanan[1,2], VV Radhakrishnan[1], KV Mohanan[1,*]

[1]Genetics and Plant Breeding Division, Department of Botany, University of Calicut, India
[2]Department of Botany, Government Brennen College, India

Abstract Complex and ecologically responsive rice-fish farming systems have evolved in the coastal wetland regions of India over centuries. *Kaippad* is such an indigenous rice-fish farming system of coastal North Kerala in India. It is a natural system utilizing indigenous knowledge and local resources. The proximity to sea and subsequent periodic sea inundation ensure the uniqueness of this system. However *kaippad* farms are decreasing in area and the traditional salt tolerant rice cultivars cultivated in the area are also slowly receding from the scene owing to low productivity. Performance evaluation of five popular rice cultivars was attempted based on performance index and cumulative performance index to find out the most promising among the traditional varieties. The study revealed that the cultivar *Kuthiru* ranked first based on the cumulative performance index calculated on the basis of thirteen characters including six growth characters and seven yield characters. The cultivars *Kuttusan* and *Orkazhama* ranked second and third. Selection and further improvement programmes using these cultivars will give rise to promising rice varieties suited for the needs of this special rice ecosystem.

Keywords Rice Cultivars, *Kaippad*, Participatory Breeding, Evaluation

1. Introduction

Rice (*Oryza sativa* L.) is one of the important cereal crops providing staple food for more than half of the world's population. Among low and middle income countries, rice is by far the most important crop worldwide. The developing countries contribute 96.24% of the total world rice production (1). The demand for rice is predicted to increase by 50% by 2050. FAO has predicted that rice production will need to increase from 600 million tonnes annually to 800 million tonnes by 2025 (2). However, average growths in rice yields per hectare have not kept up with population increases and demand, and have in fact decreased substantially over years. In South and South East Asia yield increase dropped to 1.45% per year between 1990 and 2005. Worryingly, population increase has overtaken the rate of grain yield. Furthermore, rapid urbanization and industrialization has created a situation where this increasing food demand is to be met on decreasing agricultural lands.

Rice is produced in a wide range of locations and under a variety of climatic conditions, from the wettest areas in the world to the driest deserts. It is produced along Myanmar's Arakan Coast, where the growing season records an average of more than 5,100 mm of rainfall, and at Al Hasa Oasis in Saudi Arabia, where annual rainfall is less than 100 mm. Temperature also varies greatly. In the Upper Sind in Pakistan, the rice season averages 33°C; in Otaru, Japan, the mean temperature of the growing season is 17°C. The crop is produced at sea level on coastal plains and in delta regions throughout Asia, and to a height of 2,600 m on the slopes of Nepal's Himalaya. Rice is also grown under an extremely broad range of solar radiation, ranging from 25% of potential during the main rice season in portions of Myanmar, Thailand, and India's Assam State to approximately 95% of potential in southern Egypt and Sudan. Rice occupies an extraordinarily high portion of the total planted area in South, South East, and East Asia. This area is subject to an alternating wet and dry seasonal cycle and also is nourished by many of the world's major rivers, each with their own vast deltas. Here, enormous areas of flat, low-lying agricultural land are flooded annually during and immediately following the rainy season. Rice adapts readily to production under these varied conditions. The highest rice yields have traditionally been obtained from plantings in high latitude areas that have long day length and where intensive farming techniques are practiced, or in low latitude desert areas that have very high solar energy levels. South Western Australia, Hokkaido of Japan, Spain, Italy, northern California and the Nile Delta provide the best examples. In portions of the rice world such as in South Asia, the crop is produced on miniscule plots using enormous amounts of human labour whereas at other locations such as in Australia and the United States, it is raised on huge holdings with a maximum of technology and large expenditure of energy from fossil fuels (3).

Explosive increase in the world population, deterioration of arable land and availability of quality irrigation water are forcing crop production into more and more marginal environments facing abiotic stresses, thus limiting the adaptation and productivity of staple food crops. In future, one cannot expect a major increase in land area available for cropping. At the same time, cultivated area is declining fast in most of the developing countries due to various reasons. It is estimated that half of the world's farms have been damaged by salt (4). To address these problems, the ability of crops to tolerate such conditions has become a key research issue in the world. Rice is a more amenable crop to marshy soils near sea coast, the unexploited areas where we have to pay more attention to extend the area of rice cultivation in future. This soil is saline due to saline sea water intrusion. At this context, salinity tolerant genetic resources and varieties of rice can play a major role to attain the goal of food security. Further, some degree of cultivar tolerance for salinity stresses available with certain traditional landraces not exploited so far has great relevance in crop improvement.

A complex and ecologically responsive rice-fish farming system has evolved in the coastal wetland regions of India over centuries. According to one estimate, it is about 0.7 million hectares. The rice culture in these lands takes place either under deep or floating water conditions. The rice varieties cultivated are traditional types with an average yield of about 1.5 to 2 tonnes per hectare. An important characteristic of this farming system is that to facilitate the cultivation of rice during the part of the year, the land has to be dewatered for sowing and subsequently protected from saline water intrusion for crop growth; rest of the year it remains under fresh or saline water depending on the ecological setting. For the organization of this farming, different types of water control, not only for the cultivation of rice but for the culture of fish as well, are required. There exist variations in these farming systems across regions depending on the ecological, technological, institutional, and organizational arrangements conditioning the wetland resources base (5).

Kaippad, the indigenous rice-fish farming system of coastal North Kerala in India is a natural system utilizing indigenous knowledge and ensuring efficient utilization of local resources. The proximity to sea and subsequent periodic seawater inundation ensure the uniqueness of the rice varieties cultivated and contribute to the high degree of specialization in the cultural practices followed in the region. The less remunerative rice cultivation compliments a profitable fish culture, making it a unique agro-ecological continuum. The farming system is traditionally organic, as farmers desist from the use of agrochemicals since it hampers the productivity of the succeeding fish crop. This system is similar to the *Pokkali* system of rice cultivation practiced in Central Kerala. *Kaippad* and *Pokkali* can be seen as efficient alternatives for the *in situ* conservation of indigenous rice varieties and cultivation practices. *Kaippad* farms are also decreasing in area. In the nineteen seventies about 2500 ha of *kaippad* rice fields existed in the Kannur district of Kerala, but now it has been restricted to about 600 ha (4).

The *kaippad* rice farming area is located in the coastal region of Kozhikode, Kannur and Kasaragod Districts of Kerala State which is rich in estuaries and wetlands. The farming system consists of one rice crop in the monsoon season alternated by a fish crop in the summer. Rice farming is carried out in a purely natural way in *kaippad* relying on the monsoon and sea tides. Single crop of rice is cultivated on mounds in a low to medium saline phase of the production cycle during June-October [4]. The soil type of *kaippad* area is saline hydromorphic [6]. The rich microflora in the soil helps in the rapid degradation of the biomass carried to the *kaippad* region by rivulets and water currents [7]. Traditional cultivars namely *Kuthiru*, *Kuttusan*, *Orkazhama*, *Chovvarian* and *Orthadian* tolerant too low to medium salinity are cultivated in various *kaippad* fields in Kerala. The high yielding saline resistant *pokkali* varieties do not perform well in *kaippad* saline tracts. This may be due to the difference in the physicochemical properties of the soils. The soil pH throughout the depth of soil profiles of *kaippad* is slightly acidic, whereas that of *pokkali* is slightly alkaline [4, 7].

2. Materials and Methods

The study was carried out on participatory mode in farmers' fields at Ezhome and Keezhara regions in Kannur District of Kerala so as to assess the comparative performance of the cultivars used by the farmers. One typical farming unit each of the five cultivars raised by the farmers was selected for the present study and straight from land preparation to harvest all the steps were designed and monitored by the investigators. The experiment was carried out in the first crop season of 2009-10. Data on the agronomic characters of ten plants each selected from three plots at random in the case of each cultivar were recorded and analyzed statistically for mean, range and coefficient of variation (CV). Analysis of variance was carried out to test the significance of variations, F value was calculated in the case of each character and significance of variations in the case of each character between cultivars was found out with reference to standard F table [8]. Critical difference (CD) was calculated for each character so as to compare the performance of each character Overall performance of the five rice cultivars was analyzed based on performance indices calculated for each agronomic character and the cumulative performance index derived from them as suggested by Amaravenmathy and Srinivasan [9] using the formula:

$$\text{Performance index} = \frac{\text{Accession mean of the character}}{\text{Grand mean}}$$

However in the case of total duration and plant height, the following formula has been used since short duration and low plant height are the desirable forms of the character:

$$\text{Performance index} = \frac{\text{Grand mean of the character}}{\text{Accession mean}}.$$

3. Results and Discussion

Comparative performance of five native rice cultivars in the farmers' field of the study area was analyzed statistically (Table 1). Six growth characters including total duration, tiller number at harvest, Number of ear bearing tillers (EBT number), EBT%, and number of leaves per tiller at the time of harvest and plant height were studied for the comparative analysis of the cultivars (Table 2). Total duration was the minimum in *Orthadian* and the maximum in *Orkazhama*. Mean tiller number at harvest was the minimum in *Orthadian* with an average of 6.93 and it was the maximum in *Kuthiru* (8.97). Number of ear bearing tillers (EBT) varied from 4-13 in the different cultivars studied. *Orthadian* with 6.43 EBT on the average showed the minimum and *Kuthiru* with 8.47 EBT showed the maximum. EBT% was more than 90% in all the cultivars studied except in *Chovvarian* which showed an EBT% of 87.99. It was the maximum in *Orkazhama* with an average of 95.87%. Number of leaves per tiller was the maximum in *Chovvarian* and minimum in *Orthadian*. Plant height was the minimum in *Kuttusan* with an average of 138.03 cm and the maximum in *Chovvarian* with 150.40 cm as average. All the seven growth characters studied showed significant variation between cultivars except plant height.

The study has shown that all the rice cultivars traditionally used in this area are tall in nature. Generally, semi dwarf and dwarf varieties of rice are considered to be superior in terms of harvest index. But, since this farming area is flooded up to one meter or more in the monsoon season which is the rice farming season also, semi dwarf or dwarf varieties of rice could not be grown here and the only way out is selection of good performing tall genotypes from the farming area. Moreover, since the farming area represents a unique geographical location with very peculiar climatic situations, development of best performing varieties utilizing the existing traditional gene pool is the only feasible and recommendable method for the maintenance of its uniqueness.

Seven yield characters were also compared in terms of mean values. Panicle length among the cultivars was the minimum in *Orthadian* and the maximum in *Orkazhama*. Mean number of spikelets per panicle was the minimum in *Orthadian* (80.23) and the maximum in *Kuttusan* (145.47). In the case of seeds per panicle the minimum value of 65.67 was shown by *Orthadian* and the maximum of 113.13 by *Kuttusan*. The lowest panicle density (3.49) was shown by *Orthadian* and the highest by *Kuttusan* (5.58). Hundred grain weights were the lowest in *Kuttusan* (1.03 g) and the highest in *Orthadian* (3.53 g). Fertility percentage was the lowest in *Kuthiru* (71%) and the highest in *Chovvarian* (88%) and yield per plant was the lowest in *Orthadian* (15 g) and the highest in *Kuthiru* (28.27 g). All the seven yield characters showed significant variation between cultivars.

Study of overall performance of five rice cultivars was attempted based on performance index and cumulative performance index. The study revealed that the cultivar *Kuthiru* ranked first based on the cumulative performance index calculated on the basis of thirteen characters including six growth characters and seven yield characters (Table 2). The cultivars *Kuttusan* and *Orkazhama* ranked second and third. The study on the comparative performance of the five native cultivars listed above *in situ* showed that *Kuthiru* was the most promising cultivar when compared to others. Selection and further improvement programmes using these cultivars will give rise to promising rice varieties suited for the needs of this special rice ecosystem.

Development and utilization of hybrids and other high yielding varieties in such highly important and unique geographical hamlets of localized crop evolution will lead to the loss and displacement of the unique plant gene pools of such areas and it will result in irrecoverable erosion and extinction of such genotypes.

Table 1. Growth and yield characters of the cultivars studied for comparative performance

Characters	Cultivars						
	Kuthiru	*Kuttusan*	*Orkazhama*	*Chovvarian*	*Orthadian*	CD @5%	CD @1%
Growth characters							
1.Total duration (days)							
Range	121-136	124-155	114-146	121-139	121-136	3.32	4.73
Mean	128.23±0.13	134.43±0.09	135.53±0.87	128.73±0.28	127.50±0.49		
CV	0.38	0.28	2.50	0.86	1.50		
2.Tiller numbers at harvest							
Range	5-14	5-14	6-10	4-12	5-9	0.91	1.29
Mean	8.97 ±0.18	8.50±0.13	8.57±0.08	7.73±0.13	6.93±0.10		
CV	7.59	6.11	3.75	6.38	5.83		
3.EBT number							
Range	5-13	5-13	5-10	4-10	5-9	0.90	1.27
Mean	8.47±0.13	8.00±0.16	8.23±0.12	6.77±0.10	6.43±0.12		
CV	5.94	7.81	5.61	5.59	7.18		
4.EBT%							
Range	81.82-100	83.33-100	77.78-100	62.5-100	71.43-100	4.44	14.08
Mean	94.76±0.87	94.11±0.62	95.87±0.51	87.99±0.36	92.96±0.68		
CV	3.56	2.56	2.04	1.59	2.82		
5.No. of leaves per tiller at harvest							
Range	3-7	3-7	3-8	3-12	3-7	0.82	1.17
Mean	4.87±0.08	4.97±0.04	5.40±0.13	6.60±0.19	4.70±0.09		
CV	6.28	3.08	9.26	10.93	7.67		
6.Plant height (cm)							
Range	107-171	105-167	105-172	125-178	107-165	NS	NS
Mean	146.10±1.25	138.03±3.01	141.77±1.77	150.40±1.50	140.57±1.08		
CV	3.32	8.44	4.83	3.86	2.99		
Yield characters							
7.Panicle length (cm)							
Range	21-31.5	20.5-31	22.5-30.5	18-28.6	16.5-28	1.65	2.34
Mean	26.75±0.23	25.89±0.17	26.88±0.08	24.60±0.35	22.73±0.25		
CV	3.35	2.59	1.15	5.44	4.28		
8.Spikelets per panicle							
Range	102-188	81-192	66-153	59-136	41-117	14.94	21.25
Mean	136.73±2.38	145.47±2.09	120.67±1.76	99.73±2.48	80.23±1.79		
CV	6.71	5.56	5.66	9.63	8.62		
9.Seeds per panicle							
Range	55-134	70-161	53-126	30-117	28-99	11.40	16.22
Mean	97.77±0.84	113.13±2.65	90.23±0.50	88.40±1.69	65.67±1.51		
CV	3.36	9.06	2.17	7.41	8.89		
10.Panicle density							
Range	3.40-7.24	3.95-7.09	2.59-5.88	3.00-5.55	2.48-4.25	0.53	0.75
Mean	5.17±0.12	5.58±0.05	4.49±0.08	4.02±0.06	3.49±0.05		
CV	8.91	3.13	6.53	6.22	5.15		
11.Hundred grain weight (g)							
Range	2.94-3.89	1.93-2.68	2.63-3.67	2.11-4.33	3.09-4.04	0.13	0.18
Mean	3.43±0.01	2.35±0.02	2.98±0.02	3.41±0.02	3.53±0.02		
CV	1.27	3.75	2.71	1.76	1.89		
12.Fertility percentage							
Range	44-90	65-93	52- 90	51-98	63-94	4.45	6.33
Mean	71±0.66	78±1.00	76±0.48	88±0.53	81±0.25		
CV	3.56	4.95	2.44	2.34	1.20		
13.Yield per plant (g)							
Range	13.44-45.92	10.64-34.36	8.80-34.55	5.06-32.16	5.62-27.75	3.27	4.66
Mean	28.27±0.43	21.37±0.52	22.32±0.39	20.37±0.42	15.00±0.55		
CV	5.89	9.38	6.78	7.99	14.15		

Table 2. Performance index of the cultivars studied

Characters	Cultivars				
	Kuthiru	*Kuttusan*	*Orkazhama*	*Chovvarian*	*Orthadian*
1. Total duration	1.04	0.91	0.93	1.07	1.13
2. Tiller number at harvest	0.94	0.95	0.73	0.49	0.75
3. EBT number	0.96	0.97	0.75	0.42	0.73
4. EBT%	1.04	1.04	1.04	0.86	0.97
5. Plant height	0.87	0.85	0.81	1.01	0.99
6. Panicle length	1.14	1.12	1.06	0.84	0.91
7. Spikelets per panicle	1.20	1.36	0.93	0.50	0.46
8. Seeds per panicle	1.19	1.32	0.85	0.48	0.42
9. Panicle density	1.08	1.23	0.89	0.61	0.51
10. Hundred grain weight	1.13	0.79	0.93	1.15	1.21
11. Fertility percentage	1.01	0.99	0.91	0.94	0.97
12. Yield per plant	1.21	0.99	0.57	0.22	0.36
Overall performance index	12.82	12.51	10.41	8.59	9.41
Rank	I	II	III	V	IV

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