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Evaluation of Traditional Varieties of Rice (*Oryza sativa* L.) for Yield under Organic Production System

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ABSTRACT

Background: Organic farming seems to be one of the best options to offer healthier food and environment in the present situation. However, non availability of promising varieties is a major constraint which inevitably makes us to shift towards traditional varieties. Rice being the major crop grown and consumed in Tamil Nadu, an attempt was made to study the yield potential of different traditional varieties of rice under organic cultivation.

Methods: The experiment was conducted during *rabi* season of 2020-2021 at wetland farms of Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in RBD with twelve varieties replicated thrice under SRI method. The treatments consisted of twelve traditional varieties *viz*., Athur Kichili samba, Garudan samba, Illuppaipoo samba, Milagu samba, Poonkar, Sorna masuri, Thooya malli samba, Thanga samba, Kuzhiadichan, Kullakar, Anaikomban and Thulasi vasa samba.

Result: The investigation revealed that significantly higher plant height, number of productive tillers, panicle weight, panicle length, fertility percentage were observed in Kuzhiadichan and Anaikomban which eventually led to higher grain and straw yield. The aforementioned varieties have also fetched higher net returns of Rs. 96,476 ha^{-1} and Rs. 73,893 ha^{-1}, respectively indicating their suitability under organic production system.

Key words: Economics, Organic farming, Rice, SRI, Traditional varieties, Yield.

INTRODUCTION

An ecological aim for the present era is encouraging an evergreen revolution focusing upon organic farming for health and environmental protection. 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 protectors (Bueren *et al*., 2002). As the environment under organic farming management is primarily different from chemical, it needs specific varieties that are adaptive (Kokare *et al*., 2014; Hazra *et al*., 2018; Palanog *et al.,* 2019) and can perform well with greater yield stability than improved varieties. Further, most of the current varieties are highly fertilizer responsive and requires higher amount of water. Evaluation of suitability of traditional rice varieties under organic farming is important to recommend them for adoption under organic farming.

Rice is the leading crop produced and consumed on a large scale in the state of Tamil Nadu, India. The acreage under rice cultivation constitutes about one-third of the total area under the crops in the whole state. Rice productivity in the state is high (3,809 kg ha^{-1}) as compared to the national productivity of about 2,705 kg ha^{-1} (Annual Report on Agriculture, 2020-21). Traditional rice varieties have an enhancing potential in a wide range of neutraceutical and functional foods. Besides, they are hardy and sturdy against nature's vagaries and pathological and entomological threats reducing the cost of cultivation to farmers. Moreover, traditional varieties outperform high yielding varieties under low input, drought and water logging conditions (Mohammed and Subbalakshmi, 2017). Hence, keeping in view of above information, an attempt was made to evaluate selected traditional rice varieties of Tamil Nadu for their suitability under organic production system.

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MATERIALS AND METHODS

Field experiment was conducted during *rabi* season of 2020-2021 at wetland farms of Tamil Nadu Agricultural University, Coimbatore. The experimental site is located in the western agro climatic zone of Tamil Nadu at 11°N latitude, 77°E longitude and at an altitude of 426.72 m above mean sea level. The soil of the experimental field was clay loam, moderately drained grouped under *Vertic Ustochrept* (belonging to Noyyal series) taxonomical classification. It was low in available N, medium in available P and high in available K. The experiment was laid out in a randomized block design (RBD) with twelve traditional varieties as treatments which were replicated thrice. The varieties *viz*., V_1: Athur Kichili samba, V_2: Garudan samba, V_3: Illuppaipoo samba, V_4: Milagu samba, V_5: Poonkar, V_6: Sorna masuri, V_7: Thooya malli samba, V_8: Thanga samba, V_9: Kuzhiadichan, V_{10}: Kullakar, V_{11}: Anaikomban, V_{12}: Thulasi vasa samba were selected based on crop duration and to identify potential varieties suitable for growing in organic conditions under prevailing agro-climatic conditions. Seeds of the rice varieties were treated with *Bacillus subtilis* @ 10 g kg^{-1} of seeds, *Azosprillum* and *Phosphobacteria* @ 30 g kg^{-1} of seeds before sowing. Then seeds were soaked in water for 24 hours and incubated for another 12 hours for inducing sprouting. The sprouted seeds were broadcasted in a well prepared raised bed nursery which was enriched with well decomposed farm yard manure @ 1.25 kg m^{-2}, neem cake @ 50 g m^{-2} and *Trichoderma viridie* @ 4 g m^{-2}. Seeds of dhaincha (*Sesbania rostrata*) @ 25 kg ha^{-1} were sown in the main field and the biomass was incorporated as *in situ* at 45 days after sowing (DAS). Neem cake @ 250 kg ha^{-1} and gypsum @ 500 kg ha^{-1} were applied just before last ploughing. The treatment plots were formed and fourteen days old rice seedlings were transplanted in the main field at a spacing of 25 cm x 25 cm @ one seedling per hill. Before transplanting, seedling root dip treatment was given with *Azospirillum* (1 kg ha^{-1}) + *Phosphobacteria* (1 kg ha^{-1}) in 40 litres of water for 15-30 minutes. After accounting N contribution through the incorporation of dhaincha, the remaining nutrient requirement was meet out from organic amendments *viz.,* vermicompost @ 1000 kg ha^{-1} each at active tillering, panicle initiation and heading stages and foliar application of *Panchagavya* @ 3% twice at 30 and 45 days after transplanting (DAT) as growth promoters. Alternate wetting and drying was maintained throughout the cropping period. One weeding with cono weeder at 20 DAT, followed by hand weeding at 30 and 60 DAT was carried out. Neem Seed Kernel Extract (5%), *Beauveria bassiana* (2%) and *Bacillus subtilis* @ 4 ml $litre^{-1}$ were used to manage pests and diseases. For observations, twelve hills per plot were tagged and all the growth and yield parameters were recorded only from the earmarked hills. The economics of the system was worked out considering the prevailing cost of inputs and price of output. All the results were then subjected to statistical analysis for drawing conclusion using analysis of variance (ANOVA) procedure (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

Plant height greatly influences the yield of rice ecotypes particularly *indica* ecotypes (Li *et al*., 2019). It is strongly correlated with life span, seed mass and time to maturity and is a major determinant of a species ability to compete for light (Moles *et al*., 2009). In this study, the highest plant height at harvest (135.6 cm) was recorded in Kuzhiadichan (V_9). However, it was on par with Anaikomban (V_{11}), Garudan samba (V_2) and Kullakar (V_{10}). The traditional rice variety Poonkar (V_5) had produced the shortest plant height at harvest of 108.6 cm (Fig 1). The difference in plant height among the varieties may be due to the varietal character. Dissecting the genetic architecture of different varieties will give insights regarding the molecular basis of phenotype from the cellular to the whole organism level.

Productive tillers

The number of productive tillers per meter square contributes materially towards the final grain yield. It was reported that the maximum number of productive tillers per meter square (269) was observed in traditional rice variety Kuzhiadichan (V_9) which was significantly higher than other varieties except Anaikomban(V_{11}), Kullakar (V_{10}), Illuppaipoo samba (V_3), Thooya malli samba (V_7) and Athur Kichili samba (V_1) which were statistically on par. Minimum number of productive tillers (113) was recorded in Poonkar (V_5) (Fig 1). Genotypic variation in tillering pattern was also reported by Shahidullah *et al*. (2009); Efendi *et al*. (2015); Kumari and Shanmugam (2020).

Panicle length

The highest panicle length of 26.9 cm was recorded in Anaikomban (V_{11}) which was superior to all other varieties (Fig 2). It was followed by Kuzhiadichan (V_9), Poonkar (V_5), Illuppaipoo samba (V_3) and Thulasi vasa samba (V_{12}). Shortest panicle length of 21.2 cm was observed in

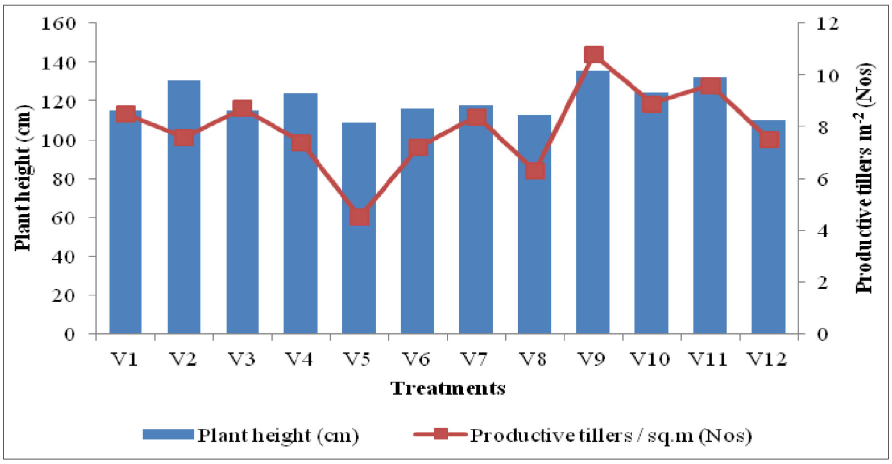

Fig 1: Plant height and productive tillers of traditional rice varieties grown organically.

traditional variety Garudan samba (V_2). Panicle length is less influenced by the environment (Raisheed *et al.,* 2002). Hence, variation in panicle length might be due to genetic makeup of the varieties. The results are in accordance with the findings of Idris and Matin (1990); Irfan *et al*. (2005); Shrestha *et al*. (2021).

Panicle weight

With regard to panicle weight, Kuzhiadichan (V_9) registered the highest panicle weight of 3.85 g which was significantly greater than other varieties except Poonkar (V_5). It was followed by Thanga samba (V_8), Anaikomban (V_{11}), Sorna masuri (V_6) and Kullakar (V_{10}). Lesser panicle weight of 2.58 g was noted in traditional variety Illuppaipoo samba (V_3) (Fig 2). Panicle weight is the measure of crop's photosynthetic performance and partitioning efficiency. The variety which stores large amount of carbohydrates and proteins in the source during vegetative stage and better partitioning from source to sink during ripening stage produces grains with higher weight and optimum number of grains per panicle which in turn results in higher panicle weight as in the variety Kuzhiadichan (V_9).

Filled grains

Grain number per panicle is the function of panicle length and grain density. Among the varieties evaluated, the number of filled grains per panicle was maximum (157.20) in rice variety Milagu samba (V_4) however, it was statistically comparable with Anaikomban (V_{11}) followed by Sorna masuri (V_6) Thulasi vasa samba (V_{12}) and Kuzhiadichan (V_9). Significantly lesser number of filled grains per panicle was noted in Thanga samba (V_8) (Fig 3). Palanog *et al*. (2019) stated that number of spikelets per panicle was one of the most variable traits evaluated under organic management practices. Raisheed *et al.* (2002) noted that the correlation of panicle length with number of grains per panicle at genotypic level was negative and significant while at phenotypic levels was positive and non-significant.

Thousand grain weight

Thousand grain weight is a stable varietal character, as it is regulated by several genes (Lee *et al*., 2015). Mean values of thousand grain weight obtained in this study showed significant differences suggesting the existence of variation among the varieties (Fig 2). The highest 1000 grain weight of 27.80 g and 26.65 g were recorded in Kuzhiadichan (V_9) and Poonkar (V_5), respectively. This can be hypothesized to higher N uptake from soil, maintaining more reduced nitrogen, chlorophyll content and higher nitrate reductase and carboxylase enzyme activities, which would contribute to the accumulation of additional photosynthates during grain-filling period. Nature of these plants was categorized as stay-green cultivars in maize by Wilman *et al* 1987. Lowest 1000 grain weight of 14.50 g was recorded in rice variety Thulasi vasa samba (V_{12}). Jat *et al*. (2019) reported that remobilization of N from vegetative tissues to grains after flowering, delayed leaf senescence and prolonged grain filling period produced heavier grains in maize cultivars. Kastura and Nakaide (2011) observed that the rice varieties with greater sink capacity and source activity per plant could produce heavier grain weight under aerobic conditions.

Fertility percentage

Fertility percentage or filled spikelets is affected by number of factors such as weather, soil, nutrient availability and incidence of diseases and insects. Kuzhiadichan (V_9) obtained higher fertility percentage of 89.46 percent because of lesser number of unfilled grains (15.13), which was followed by Anaikomban (86.16%) and Kullakar (81.59%). The lower fertility percentage of 63.87 and 66.19 was recorded in Thulasi vasa samba (V_{12}) and Thanga samba (V_8), respectively (Fig 3). Palanog *et al.* (2019) observed variation in spikelet fertility across genotypes and across management practices. Kumari and Shanmugam (2020) observed varied fertility percentage across varieties under organic production system.

Grain yield

Maximum yield is predetermined by the potential of a variety under a similar environment (Yoshida, 1981). Statistical analysis revealed the presence of highly significant differences among the traditional rice varieties for grain yield under organic production system (Table 1). The variety

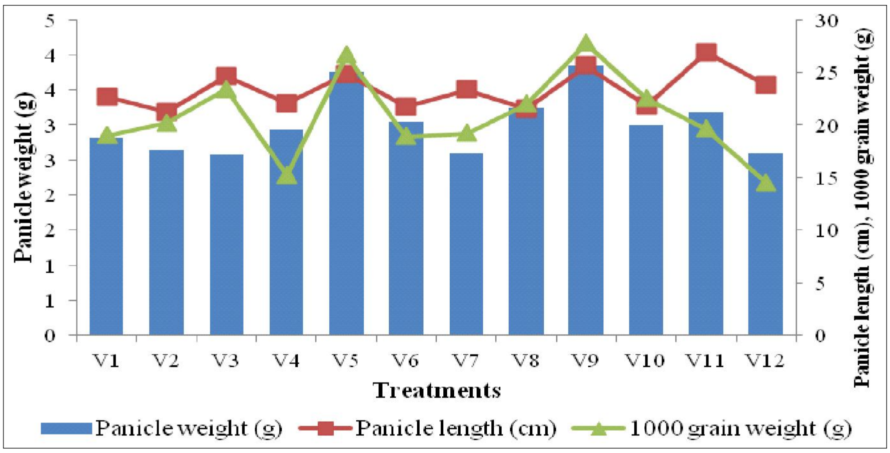

Fig 2: Panicle length, panicle weight and 1000 grain weight of traditional rice varieties grown organically.

Kuzhiadichan (V_9) out-yielded all the varieties by producing higher grain yield of 5611 kg ha^{-1} which was 17, 45, 61, 66, 77, 82, 87, 104, 115 and 120 per cent yield increase, respectively over Anaikomban (V_{11}), kullakar (V_{10}), Sorna masuri (V_6), Athur kichili samba (V_1), Illuppaipoo samba (V_3), Thooya malli samba (V_7), Milagu samba (V_4), Garudan samba (V_2), Thanga samba (V_8), Thulasi vasa samba (V_{12}) and Poonkar (V_5). It has been well documented that the yield was effectively contributed by the number of productive tillers, grains per panicle, thousand grain weight and spikelet fertility. In the present investigation the variety Kuzhiadichan (V_9) had performed better on above mentioned parameters. Singh *et al.* (2017) evaluated various rice varieties under organic farming and stated that the differences observed in yield of rice varieties can be attributed to the genetic character as well as their adaptation potential under low input organic conditions. Vignesh and Prakash (2019) revealed that the varieties Raja mannar, Pal kudaivazhai, Kuzhiadichan and Raja mudi performed well by recording better observations in biometric, biophysical, growth analysis and yield parameters. The results of this study are also in line with Srilatha *et al.* (2011); Jagadeeshwar *et al.* (2012) and Rao *et al.* (2013).

Straw yield

With respect to straw yield, Kuzhiadichan (V_9) recorded significantly higher straw yield of 8522 kg ha^{-1} which was statistically on par with Anaikomban (V_{11}), Garudan samba (V_2), Athur kichili samba (V_1) and Kullakar (V_{10}). Significantly lesser straw yield was recorded in Poonkar (V_5) with 4794 kg ha^{-1} (Table 1). Better utilization of light, carbon dioxide and nutrients available under organic production system had resulted in higher biomass production by different varieties. Vanaja *et al.* (2013) reported that the rice cultivar MK 157 had produced higher grain (4.9 t ha^{-1}) and straw yield (8.4 t ha^{-1}) under organic nutrient management. Raman and Prakash (2017) reported that the application of vermicompost and biofertilizers have led to higher yield in rice as compared to other organic sources.

Harvest index

Harvest index is an indicator of a crop's ability to grow during vegetative stage and its potential to remobilize assimilates from vegetative tissues to grains during the grain-filling period. In the present study, the harvest index ranged from 39.70%

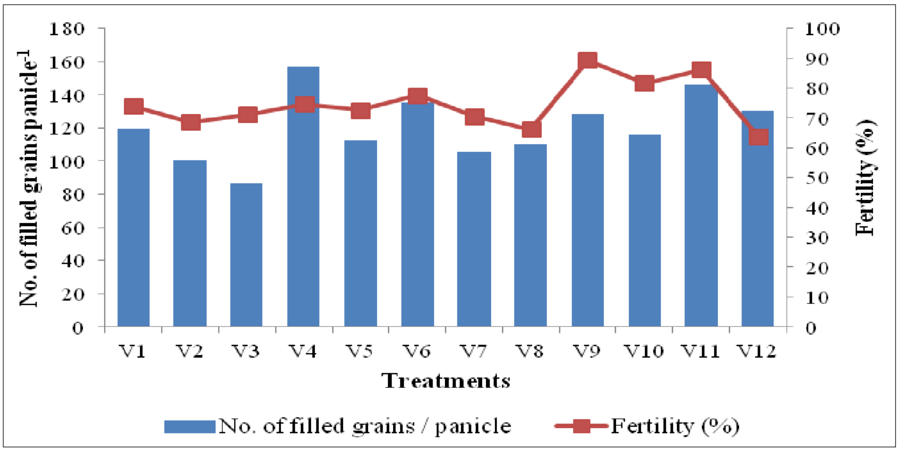

Fig 3: Filled grains and fertility percentage of traditional rice varieties grown organically.

Table 1: Yield (kg ha^{-1}) and economics (Rs. ha^{-1}) of traditional rice varieties grown organically.

Treatments	Grain yield	Straw yield	Cost of cultivation*	Net return*	B:C ratio*	Harvest Index (%)*
V_1 - Athur Kichili samba	3383	7256	65068	37655	1.58	31.8
V_2 - Garudan samba	2850	7572	65068	25113	1.39	27.3
V_3 - Illuppaipoo samba	3172	6367	65068	30155	1.46	33.3
V_4 - Milagu samba	2994	5711	65068	65738	2.01	34.4
V_5 - Poonkar	2556	4794	65068	25808	1.40	34.8
V_6 - Sorna masuri	3478	6117	65068	62169	1.96	36.2
V_7 - Thooya malli samba	3089	6500	65068	28405	1.44	32.2
V_8 - Thanga samba	2750	6078	65068	18877	1.29	31.2
V_9 - Kuzhiadichan	5611	8522	65068	94210	2.45	39.7
V_{10} - Kullakar	3867	7189	65068	49571	1.76	35.0
V_{11} - Anaikomban	4800	7600	65068	86238	2.33	38.7
V_{12} - Thulasi vasa samba	2606	5161	65068	12974	1.20	33.5
CD (P=0.05)	705	2005	-	-	-	-

*Data statistically not analyzed.

(Kuzhiadichan) to 27.35 % (Garudan samba) indicating wide difference among the varieties evaluated (Table 1).

Economics

Analyzing the economic performance of the varieties is important before recommending it for organic production. In this study, the cost of cultivation was same (Rs. 65,108 ha^{-1}) for all the varieties as it involved similar management practices. The highest net return of Rs. 96,476 ha^{-1} was recorded in Kuzhiadichan (V_9) with the highest B:C ratio of 2.48. It was followed by Anaikomban (V_{11}), Kullakar (V_{10}) and Athur Kichili samba (V_1) (Net return of Rs.73983, Rs.49531 and Rs.37615 per ha with B:C ratio of 2.13, 1.76 and 1.58, respectively). The variety Poonkar (V_5) registered the lowest net return of Rs.10,779 per ha with B:C ratio of 1.17 (Table 1). Under similar cost of production, the varieties producing higher yields will provide more returns and benefit per rupee invested. Rao *et al*. (2013) reported that rice variety RNR 2465 recorded higher gross returns, net returns and B:C ratio due to higher grain and straw yield. Hossain *et al*. (2008) noted that the benefit-cost ratio of rice variety Fakhre malakand was the highest (2.36) compared to all other varieties under organic cultivation.

CONCLUSION

Identifying organic responsive traditional varieties is pivotal as far as quality food production is concerned. Hence, the present study was undertaken with the objective of testing the traditional rice varieties for their suitability under organic cultivation especially for higher yield. Based on the results, it was concluded that the varieties Kuzhiadichan and Anaikomban were found to be high yielding and remunerative under organic farming conditions compared to all other varieties tested in the wetland farms of Tamil Nadu Agricultural University, Coimbatore during *rabi* 2020-2021.

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Conflict of interest: None.

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