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Response of traditional rice varieties to organic nutrient management practices under aerobic system

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Abstract
Traditional rice production is becoming popular among farmers due to its moisture stress tolerance and consumers' preference. To increase the yield and improve the quality of traditional rice in a rainfed situation, a balanced supply of essential nutrients is essential. A field experiment was conducted during summer 2021in a split-plot design replicated thrice to study the effect of organic and inorganic nutrient sources on the growth and yield of traditional rice varieties under furrow irrigated raised bed (FIRB) system of rice cultivation. The treatment consists of different organic manures with stage specific microorganisms and inorganic fertilizers on different traditional rice varieties. Nutrient management practices (main plot) comprises of M_1- basal application of enriched FYM @ 0.75 t ha^{-1} with stage specific microorganism, M_2- basal application of vermicompost @ 5 t ha^{-1} with stage specific microorganisms, M_3- basal application of composted coirpith @ 5 t ha^{-1} with stage specific microorganism, and M_4- application of 100% RDF (150:50:50 kg NPK/ha). Traditional rice varieties (sub plot) includes V_1-Seeraga samba, V_2-Mappillai samba, V_3-Sivappukavuni, V_4-Chinnar, V_5-Kullakar, V_6-Chithirakar. Stage-specific microorganisms were applied *viz*., stage 1-seed treatment with Azotobacter, Phosphobacteria and *Bacillus subtilis* (125ml ha^{-1}), stage 2- vegetative stage - soil application of Azospirillum and Phosphobacteria @ 500ml ha^{-1}, stage 3-flowering - soil application of K bacteria @ 500ml ha^{-1}, stage 4-PPFM spray twice during flowering and 15 days after flowering @ 500 ml ha^{-1}. Mappillai samba produced a greater growth attributes and grain yield of 3019.67 kg ha^{-1} among the traditional rice varieties tested. Application of 150:50:50 kg NPK ha^{-1}registered the highest grain (3042.0 kg ha^{-1}) and straw yield (7402.4 kg ha^{-1}). Application of 150:50:50 kg NPK ha^{-1} was found to be ideal nutreient management practice as it has enhanced the growth, physiological parameters and yield of traditional varities under FIRB system.

Keywords: Aerobic rice, organic and inorganic nutrients, traditional rice varieties, stage specific micro organism

Introduction
Rice (*Oryza sativa* L.) is the necessary food crop for the majority of the people in Asia, predominantly in South India. Traditional rice has a lot of medicinal properties and it will helps to stay energetic and young. Red rice is mainly helping to restore tumors in the body. Traditional rice varieties contains thiamine, riboflavin, calcium, vitamin D, high fiber, and glutamic acid. Some of the traditional varieties contain anthocyanin which is mainly used for antioxidative, anti-inflammatory and anti-carcinogenic. It contains less fat, low sugar, no gluten and also the presence of oryzanol- helps to block the cholesterol in the body. And hence traditional rice varieties are ideal food for diabetics and blood pressure patients. The use of improved rice varieties exhausted soil fertility more rapidly than traditional rice. Organic manures are the rich source of microflora and it contains enzymes, growth hormones, and also it will increases the Physio-chemical and biological properties of the soil. Inorganic fertilizers increases the growth and yield of rice combined with biofertilizers like azospirillum and phosphobacteria. Traditional rice cultivation is being done in some pockets of Tamil Nadu with minimum nutrient support. There is no specific nutrient recommendation for traditional rice varieties. There is awareness among the consumers as traditional rice are having high nutrient and medicinal properties; and the demand is increasing. Hence, this study will pave the way for increasing the productivity and profitability of traditional rice cultivation.

Materials and Methods
Field experiment was conducted at Dryland Agricultural Research Station (DARS), TNAU, Chettinad, Sivagangai district of Tamil Nadu during summer 2021 to study the effect of

organic and inorganic nutrient sources on the growth and yield of traditional rice varieties under aerobic rice production (FIRB) system. The experimental site is located at 10˚10'N latitude and 78˚47' E longitude at an elevation of 126 m above Mean Sea Level. The farm is situated in Southern Agro climatic Zone of the Tamil Nadu. Mean annual rainfall of the location is 894.4 mm, out of which, 338 mm is distributed during South West Monsoon (SWM), 416.5 mm during North East Monsoon (NEM), 38.8 mm during winter and 101.1 mm during summer seasons. The average maximum and minimum temperatures during cropping period were 28.8 ˚C, and 25.67 ˚C. The total rainfall received during the cropping period was 107.6 mm with a mean relative humidity of 81.26 percent.

The experiment was laid out in a Split Plot Design with three main and four sub plots which were replicated thrice. The main plot consisted of four nutrient sources *viz*., M_1 - enriched FYM application @ 0.75 t ha^{-1} with stage specific microorganism, M_2-vermicompost application @ 5 t ha^{-1} with stage specific microorganisms, M_3- composted coirpith application @ 5 t ha^{-1} with stage specific microorganism, and M_4- application of 100% RDF (150:50:50 kg NPK/ha). Stage-specific microorganisms tried were; seed treatment with azotobacter, Phosphobacteria and *Bacillus subtilis* @125ml ha^{-1} (stage I), soil application of azospirillum and Phosphobacteria @ 500 ml ha^{-1},at vegetative stage (II), soil application of K bacteria @ 500 ml ha^{-1}at flowering stage (III), PPFM Spray twice during flowering stage @ 500 ml ha^{-1}stage (IV). Sub plot consisted of six traditional rice varieties namely Seeraga samba (V_1), Mappillai samba (V_2), Sivappukavuni (V_3), Chinnar(V_4), Kullakar (V_5) and Chithirakar (V_6). The raised beds (FIRB) were formed at 120 x 90/30 cm after thorough land preparation. Seeds were hand dibbled on the raised beds (90 cm) at 20 x10 cm spacing by which five rows were accommodated on each bed. Need based irrigation were given only with furrows. Periodical biometric observations were taken with tagged plants. The crop was harvested at different dates based on their physiological maturity. The plots were harvested manually with sickle and threshed, cleaned and grain weight was recorded separately and expressed in kg ha^{-1}. The straw from each net plot was sun-dried, weighed and straw yield was expressed in kg ha^{-1}.

Results and Discussion

Growth attributes

Plant height

The plant height observed among the traditional rice varieties differed significantly and nutrient application had a significant influence on the plant height of traditional rice varieties (Table 1). Gradually plant height increased from tillering to panicle initiation. Among the traditional rice varieties, the maximum plant height (93.17 cm) was recorded in chithirakar (V_6) at active tillering stage. During panicle initiation stage, the higher plant height (103.79 cm) was observed in mappillai samba (V_2). Regarding nutrient application 100% RDF -150:50:50 kg NPK/ha (M_4) recorded higher plant height of 87.5 and 99.8 cm at active tillering and panicle initiation stages. With regard to interaction, higer plant hight was recorded with seeraga samba (V_1) which received 100% RDF 150:50:50 kg NPK/ha (M_4V_1) at active tillering stage (107.5 cm). At panicle initiation stage, the higher plant height (133.2 cm) was recorded in mappillai samba (V_2) which received 100% RDF-150:50:50 kg NPK/ha (M_4V_2). The fact that greater nutrition promotes favourable benefits such as quicker photosynthesis, absorption, cell division, and vegetative development may account for the increase in plant height. These results are consistent with finding of Dutta and Chauhan's (2010) [3]. The disparities in plant height among the varieties could be related to genetic variances (Khatun 2001 and Das *et al.* 2012) [1].

Table 1: Effect of nutrient application on plant height of traditional rice varieties

	Plant height (cm) Active tillering					Plant height (cm) Panicle initiation				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
V_1	64.50	62.17	65.83	107.50	75.00	82.83	72.00	71.50	97.83	81.04
V_2	90.50	83.33	91.50	94.17	89.88	103.83	84.50	93.67	133.17	103.79
V_3	54.83	46.33	45.67	58.33	51.29	81.83	50.83	60.50	81.83	68.75
V_4	49.00	49.17	47.67	56.17	50.50	67.67	66.00	63.17	69.17	66.50
V_5	83.83	72.50	78.67	102.00	84.25	109.67	99.33	95.83	109.00	103.46
V_6	89.00	89.83	87.00	106.83	93.17	97.50	90.17	97.00	108.33	98.25
Mean	71.94	67.22	69.39	87.50	74.01	90.56	77.14	80.28	99.89	86.97
	M	S	M X S	S X M		M	S	M X S	S X M	
SEd	0.820	2.805	5.610	5.187		0.615	2.071	3.830	4.142	
CD(p=0.05)	2.007	5.669	10.483	11.339		1.505	4.185	7.742	8.370	

M_1- Enriched FYM @ 0.75 t ha^{-1} + stage specific microorganism; M_2- vermicompost @ 5 t ha^{-1} + stage specific microorganism; M_3- Composted coirpith @ 5 t ha^{-1} + stage specific microorganism; M_4- 100% RDF 150:50:50 kg NPK/ha; V_1-Seeraga samba; V_2-Mappillai samba; V_3-Sivappukavuni; V_4-Chinnar; V_5-Kullakar; V_6-Chithirakar.

Tiller production

The maximum number of tillers $hill^{-1}$ was observed in sivappukavuni (V_3) during active tillering (31.2) and panicle initiation (26.9) stages (table 2). About nutrient management, application of 100% RDF-150:50:50 kg NPK/ha (M_4) recorded higher no of tillers $hill^{-1}$ at active tillering (29.58) and panicle initiation stages (27.72). With regard interaction, the maximum number of tillers (38.5 $hill^{-1}$) was recorded in sivappukavuni (V_3) at active tillering stage which received 100% RDF-150:50:50 kg NPK/ha (M_4V_3). At panicle initiation stage the maximum number of tillers $hill^{-1}$ (35.67) was recorded in mappillai samnba which received 100% RDF-150:50:50 kg NPK/ha (M_4V_2). This could be related to the fact that a well balanced diet increases the number of tillers (Dutta and Chauhan, 2010 and Singh *et al*. 2011) [3, 7]. Tillering ability plays a vital role in determining rice grain yield. Too few tillers result in fewer panicles, but excessive tillers enhance high tiller mortality, small panicle, poor grain filling and sequent reduction in grain yield (Peng *et al*., 1996) [5]. Number of tillers $hill^{-1}$ differed due to varietal variations (Ramasamy *et al*., 1987) [6].

Table 2: Effect of nutrient application on tiller production of traditional rice varieties

	No of tillers hill^{-1} Active tillering					No of tillers hill^{-1} Panicle initiation				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
V_1	20.83	15.33	21.33	23.33	20.21	18.00	17.33	20.17	27.50	20.75
V_2	19.67	16.67	23.17	28.83	22.08	17.17	22.83	25.83	35.67	25.38
V_3	32.67	24.67	28.83	38.50	31.17	20.00	27.67	25.17	34.67	26.88
V_4	17.33	19.67	19.17	31.17	21.83	14.83	18.17	19.33	19.00	17.83
V_5	16.00	21.83	16.83	23.33	19.50	21.83	22.83	20.00	28.33	23.25
V_6	17.67	15.17	20.00	32.33	21.29	14.50	23.67	27.83	21.17	21.79
Mean	20.69	18.89	21.56	29.58	22.68	17.72	22.08	23.06	27.72	22.65
	M	S	M X S	S X M		M	S	M X S	S X M	
SEd	1.819	1.639	3.502	3.279		1.629	1.513	3.207	3.027	
CD (p=0.05)	4.452	3.313	7.079	6.626		3.986	3.058	6.482	6.117	

M_1- Enriched FYM @ 0.75 t ha^{-1} + stage specific microorganism; M_2- vermicompost @ 5 t ha^{-1} + stage specific microorganism; M_3- Composted coirpith @ 5 t ha^{-1} + stage specific microorganism; M_4- 100% RDF 150:50:50 kg NPK/ha; V_1-Seeraga samba; V_2-Mappillai samba; V_3-Sivappukavuni; V_4-Chinnar; V_5-Kullakar; V_6-Chithirakar

SPAD N value

Among the traditional rice varieties, a higher SPAD N value (41.00) was recorded in Kullakar (V_5) at active tillering stage whereas at panicle initiation stage higher SPAD N value (38.32) was recorded in Chinnar (V_4). With regard to nutrient management, application 100% RDF 150:50:50 kg NPK/ha (M_4) recorded the maximum SPAD N value was recorded at active tillering (39.90) and panicle initiation (37.24) stages. When we compare the interaction, the maximum SPAD N value (43.82) was recorded in chinnar (V_4) at active tillering stage which received 100% RDF 150:50:50 kg NPK/ha (M_4V_4), In panicle initiation stage higher SPAD N value (50.47) was recorded with seeraga samba (V_1) which received 100% RDF 150:50:50 kg NPK/ha (M_4V_1). This may be due to the maintenance of leaf chlorophyll at a threshold level throughout the crop growth stages (Yuan Z *et al.* 2016) [8].

Table 3: Effect of nutrient application on SPAD N value of traditional rice varieties

	SPAD N value active tillering					SPAD N value panicle initiation				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
V_1	35.45	40.80	38.38	39.73	38.59	26.82	28.60	27.17	50.47	33.26
V_2	35.27	32.68	36.78	36.15	35.22	30.30	27.28	26.48	35.47	29.88
V_3	34.73	37.90	37.27	39.77	37.42	29.43	28.73	30.62	31.92	30.18
V_4	39.70	40.40	34.50	43.82	39.60	40.37	37.23	33.78	41.88	38.32
V_5	37.18	41.10	42.27	43.45	41.00	17.60	21.27	37.13	34.83	27.71
V_6	35.80	36.92	38.85	36.47	37.01	22.35	26.20	32.77	28.90	27.55
Mean	36.36	38.30	38.01	39.90	38.14	27.81	28.22	31.33	37.24	31.15
	M	S	M X S	S X M		M	S	M X S	S X M	
SEd	0.993	0.742	1.679	1.483		2.578	1.974	4.431	3.948	
CD (p=0.05)	2.430	1.499	3.394	2.997		6.308	3.990	8.956	7.980	

M_1- Enriched FYM @ 0.75 t ha^{-1} + stage specific microorganism;M_2- vermicompost @ 5 t ha^{-1} + stage specific microorganism; M_3- Composted coirpith @ 5 t ha^{-1} + stage specific microorganism; M_4- 100% RDF 150:50:50 kg NPK/ha;V_1-Seeraga samba;V_2-Mappillai samba;V_3-Sivappukavuni;V_4-Chinnar;V_5-Kullakar;V_6-Chithirakar.

Dry matter production (g/plant)

The data on DMP recorded at active tillering and panicle initiation stage is given in table 4. Among the traditional rice varieties, the maximum DMP was recorded in mappillai samba (V_2) during active tillering stage (38.94 g/plant) and panicle initiation stage (50.17 g/plant). With regard to nutrient application, 100% RDF 150:50:50 kg NPK/ha (M_4) recorded the maximum DMP of 39.88 and 51.12 g/plant at active tillering and panicle initiation stage respectively. With regard to interaction, higher DMP was recorded in Sivappu Kavuni during active tillering (54.00 g/plant) and panicle initiation (65.23 g/plant) stages which received 100% RDF 150:50:50 kg NPK/ha (M_4V_3). Crop photosynthetic activity and dry matter production increased when sufficient nutrients are available (Goverdhan *et al.,* 2017) [3]. The increase in DMP might be due to looser soil which facilitates more access to water and nutrients which resulted in the better establishment of plant with the production of higher number of tillers. The higher tiller production resulted in the production of the higher leaf which leads to improvement in leaf area and photosynthetic rate in raised bed system which ultimately leads to higher DMP.

Table 4: Effect of nutrient application on DMP of traditional rice varieties

	DMP (g/plant) active tillering					DMP (g/plant)panicle initiation				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
V_1	25.50	29.75	15.25	34.75	26.31	36.73	40.98	26.48	45.98	37.55
V_2	36.20	48.30	34.25	37.00	38.94	47.43	59.53	45.48	48.23	50.17
V_3	42.35	18.75	17.00	54.00	33.03	53.58	29.98	28.23	65.23	44.26
V_4	25.00	21.75	27.00	20.75	23.63	36.23	32.98	38.23	31.98	34.86
V_5	26.25	23.00	18.75	47.00	28.75	37.48	34.23	29.98	58.23	39.98
V_6	29.25	31.75	27.50	45.80	33.58	40.48	42.98	38.73	57.03	44.81
Mean	30.76	28.88	23.29	39.88	30.70	41.99	40.12	34.53	51.12	41.94

	M	S	M X S	S X M	M	S	M X S	S X M
S.Ed	3.007	2.549	5.542	5.099	3.007	2.549	5.542	5.099
CD (p=.05)	7.359	5.152	11.200	10.305	7.359	5.152	11.200	10.305

M_1- Enriched FYM @ 0.75 t ha^{-1} + stage specific microorganism; M_2- vermicompost @ 5 t ha^{-1} + stage specific microorganism; M_3- Composted coirpith @ 5 t ha^{-1} + stage specific microorganism; M_4- 100% RDF 150:50:50 kg NPK/ha; V_1-Seeraga samba; V_2-Mappillai samba; V_3-Sivappukavuni; V_4-Chinnar; V_5-Kullakar; V_6-Chithirakar.

Grain and straw yield

The grain and straw yield of traditional rice varieties were greatly influenced by the application of various manures and ferilizers.

Among the traditional rice varieties, the maximum grain (3019.7 kg/ha) and straw (8668.8 kg/ha) yield were recorded by Mappillai samba (V_2) whereas the lowest grain (2447 kg/ha) and straw yield (6308.4 kg/ha) were recorded in Chithirai Kar (V_6). With regard to nutrient management practices, the maximum grain (3042 kg/ha) and straw yield (7402.4 kg/ha) were registered under 100% RDF 150:50:50 kg NPK/ha (M_4). On the other hand, the lowest grain (2390.6 kg/ha) and straw yield (6906.3 kg/ha) were recorded with composted coir pith application @ 5 t ha^{-1} with stage specific microorganism (M_3). Application of 100% RDF 150:50:50 kg NPK/ha to mappillai samba (M_4V_2) excelled the other combinations by registering the highest grain (3475.3 kg/ha) and straw (8930.7 kg/ha) yield.

The yield differences among the traditional rice varieties might be due to increased tiller and DMP as well as yield attributing characters like a number of panicles m^{-2}, no of filled grains panicle^{-1} and test weight. An increase in yield could be related to improved photosynthate translocation from source to sink as a result of greater NPK uptake, which is responsible for quick and easy translocation (Kumar *et al*., 2000 and Singh *et al*., 2000) [4].

Table 5: Effect of nutrient application on grain and straw yield of traditional rice varieties

	Grain yield (kg/ha)					Straw yield (kg/ha)				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
V_1	2961	2697.33	2284.00	3123.33	2766.42	6900.33	6728.00	6573.67	7108.00	6827.50
V_2	3080.67	2948.00	2574.67	3475.33	3019.67	8681.67	8577.00	8486.00	8930.67	8668.83
V_3	2699.00	2497.67	2216.33	2965.00	2594.50	6553.00	6459.67	6337.33	6885.67	6558.92
V_4	2938.33	2755.00	2522.33	3093.00	2827.17	7338.67	7248.67	7131.33	7619.33	7334.50
V_5	2831.33	2728.33	2584.00	2911.67	2763.83	7042.33	6945.67	6836.00	7179.67	7000.92
V_6	2548.00	2394.00	2162.33	2683.67	2447.00	6346.67	6122.00	6073.67	6691.33	6308.42
Mean	2843.06	2670.06	2390.61	3042.00	2736.43	7143.78	7013.50	6906.33	7402.44	7116.51
	M	S	M X S	S X M		M	S	M X S	S X M	
SEd	12.065	26.144	49.234	52.288		6.720	9.197	18.086	18.393	
CD (p=0.05)	29.524	52.837	99.505	105.675		16.444	18.586	36.552	37.173	

M_1- Enriched FYM @ 0.75 t ha^{-1} + stage specific microorganism; M_2- vermicompost @ 5 t ha^{-1} + stage specific microorganism; M_3- Composted coirpith @ 5 t ha^{-1} + stage specific microorganism; M_4- 100% RDF 150:50:50 kg NPK/ha; V_1-Seeraga samba; V_2-Mappillai samba; V_3-Sivappukavuni; V_4-Chinnar; V_5-Kullakar; V_6-Chithirakar.

Conclusion

The present study results confirmed that inorganic nutrient management practices improved the growth and yield of traditional rice varieties. Among the variety, mappillai samba performed better under inorganic nutrient management. Therefore, application of 150:50:50 kg NPK ha^{-1} can be recommended for enhacing the productivity of traditional rice under rainfed condition.

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