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Research Article

Significance of Integrated Nutrient Management Practices on Growth and Yield Certain Traditional Rice Varieties

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Abstract

Background and Objective: Being a modern food habit world, the global population tries to take back their health by way of consuming traditional rice varieties which possess a lot of nutritional assets, traits of disease and pest resistance and certain specific traits of tolerance to stress conditions. But the area of its cultivation is quite less due to its low yielding potential. Developing an ideal nutrient schedule using inorganic and organic sources helps to improve their productivity and to evaluate the significance of INM practices on the growth and yield of traditional rice varieties this study was conducted. **Materials and Methods:** The experiment was conducted during the Navarai season in 2018 at an experimental farm, Faculty of Agriculture, Annamalai University, India. The experiment was laid on a split-plot design with four traditional varieties in main plots four INM practices and control in the subplots. **Results:** It was found that the traditional rice variety Karungkuruva proved its superiority in growth and yield attributes and yield over other tested varieties. Application of 125% RDF+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer registered the maximum values of growth attributes except for yield which was realized with 100% RDF+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer combination in all the traditional rice varieties. **Conclusion:** The study identified that the INM practice of applying 100% RDF+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer can be beneficial for increasing the yield of traditional rice varieties significantly.

Key words: Growth, INM, karungkuruva, nutritional assets, *Sesbania*, traditional rice, yield

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Rice plays an important role in Indian agriculture, occupying up to 44 million hectares with the cultivation of modern rice cultivars. Globally rice occupies an area of 162.19 million hectares with a production of 498.4 million metric tonnes and a productivity of 4.59 metric tonnes per hectare. In India, it is grown over an area of 43.50 million hectares with a total production of 115.00 million metric tonnes with a productivity of 3.97 metric tonnes per hectare¹. But in case of traditional rice cultivation occupied less area in both India and the world. Though India had been rich with such a wide range of landraces, only a few varieties are now used in cultivation. Research on National Bureau Plant Genetic Resource collections indicates that about 2,000 local landraces are available and they form about 60 per cent of all rice sown on a small scale by the marginal farmers. In recent years various threats and pressures are endangering the unique traditional rice varieties. Several varieties are on the verge of extinction². Many of them might be drought-tolerant, flood-tolerant and amenable to ill-drained and lowland cultivation. A large number of varieties possess the traits of disease and pest resistance. The most significant characteristics are noticed that many traditional varieties possess their medicinal and nutritional traits³. Similarly, the research on the traditional rice varieties of Tamil Nadu revealed some significant findings on the ability of native varieties to withstand many adverse conditions and they possess antioxidant properties with higher zinc and iron content than white rice^{4,5}. DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging activity is higher in red rice than in black and white rice⁶. Karungkuruvaai has been found to have the property of curing Filariasis (commonly called "elephant's foot"), a disease spread by mosquitoes.

The use of chemical fertilizers and organic manure has both positive and negative effects on plant growth and the soil. Every crop cycle, a huge amount of chemical fertilizers are applied to achieve maximum yield in rice to meet the demand. Due to the indiscriminate and injudicious use of chemical fertilizers, pesticides and aberrant weather conditions, the production and productivity of rice in India are facing more sustainability issues. The use of chemical fertilizers alone couldn't fulfil the nutrient thrust and health of the soil in a long run. The use of chemical fertilizers unanimously without the addition of organic manures may create problems such as environmental pollution, destruction of soil biota that supports the crop production, the depletion of soil organic carbon and mineral nutrients, groundwater contamination, soil acidification or basification⁷. However, the application of

organic manure has multiple benefits due to the balanced supply of nutrients. Immobilization and decomposition of harmful elements, soil structure stability and root development and increased soil water availability. Especially Green manures are playing a vital role in improving soil fertility by increasing soil organic matter, available nitrogen and reducing nutrient losses through leaching and soil erosion⁸. Bio-fertilizers are the source of microbial inoculants, which have proven results in enhancing NUE. Among that Azospirillum has beneficial effects on both plant growth and yield of rice and is of great agronomic importance. Azospirillum can utilize atmospheric nitrogen and contribute towards the balance root environment through the protection against pathogens and equilibrate nutrient flow in the soil. It reflects an increase in the crop yield by 15-20%.

Nowadays, there is an increased demand for quality-based rice and rice products, which could lead to farmers producing these traditional varieties again and, thereby, checking the trend of landraces from getting extinct. These varieties are generally produced low and stable yields even under unfavourable conditions. Although the increasing demand for traditional rice grain production has to be achieved with the aid of integration of organic and inorganic fertilizer to maintain sustainability in its production. Therefore the present study was planned to achieve a highly productive and remunerative traditional rice crop with suitable, sustainable integrated nutrient management practices which are lacking presently.

MATERIALS AND METHODS

Study area: The field experiment was conducted at the Annamalai University, Experimental farm, Annamalai Nagar, during the Navarai season of 2018, to identify the effect of Integrated nutrient management on the yield of traditional rice varieties. The experimental farm is geographically situated at 11°24'N and latitude 79°44'E longitude at an altitude of +5.79 m above mean sea level.

Experimentation: The soil of the experimental field was Clay loam in nature with the pH and EC of 8.0 and 0.38 dS m⁻¹, respectively. The available NPK status of the soil was low, medium and high (219.4, 20.2 and 280.7 kg ha⁻¹, respectively). The experiment was laid out in a split-plot design and replicated thrice. For experimental purpose four short duration traditional rice varieties namely, M₁-Aruvuthangkuruvaai (70 days), M₂-Poongar (90 days), M₃-Kullakar (110 days) and M₄-Karungkuruvaai (115 days) were

chosen as main plots and nutrient schedule of S_1 - Control, S_2 -100% RDF, S_3 -75% RDF+Green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S_4 -100% RDF+Green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S_5 -125% RDF+Green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum) as subplots. The experimental main field was puddled to a satisfactory colloidal condition and after levelling, the plots were laid out. The seedlings were transplanted in the main field at 18 (days after sowing) (Aruvatham kuruvai and Poongar) and 24 DAS (Kullakar and Karungkuruva) Gap filling was carried out within 10 days after transplanting to maintain a uniform plant population in all individual plots. The green manure was applied 15 days before transplanting as per the treatment schedule.

The fertilizers were applied to the experimental field as per the recommended manurial schedule of 50:25:25 kg N, P₂O₅ and K₂O ha⁻¹. Urea (46% N), Di Ammonium phosphate (46% P₂O₅ and 18% N) and Muriate of potash (60% K₂O) fertilizers. The entire dose of phosphorus and potassium were applied basally. A half dose of nitrogen was applied basally and the remaining half doses of nitrogen were applied 25 days after transplanting (active tillering stage). For weed control, hand weeding was done twice at 30 DAT. Need-based plant protection measures were taken to control pests and diseases. Five plants in each plot were selected at random in border rows and tagged. These plants were used for recording all biometric observations at different stages of crop growth and yield of rice varieties.

Statistical analysis: The experimental data were statistically analyzed as suggested by⁹ and the significant differences

between the means were tested against the critical difference at a 5% probability level.

RESULTS AND DISCUSSION

Growth attributes: The nutrition through inorganic and different sources of organic amendments showed a positive influence on different growth attributes of traditional rice varieties. Among the traditional rice varieties, M_4 (Karungkuruva) registered higher growth attributes (plant height, number of tillers and DMP). Concerning plant height, M_4 (Karungkuruva) recorded significantly maximum plant 98.21 and 126.7 cm at flowering and harvest stage, respectively. It was followed by M_3 (Kullakar) (Table 1). The same trend was registered in other growth attributes like the number of tillers⁻¹ (Table 2), DMP (Table 3). The higher values of growth attributes might be because higher doses of nutrients resulted in higher availability of nutrients in the soil for plant nourishment and further, an organic source with slow-release and continuous availability of nutrients enhanced the cell division, elongation as well as various metabolic processes which ultimately increased the growth attributes. Similar findings have also been reported¹⁰.

Among the subplot treatments, S_5 (125% RDF+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer (Azospirillum), registered significantly maximum plant height of 96.50 and 124.16 cm at flowering and harvest stage, respectively. It was followed by S_4 (100% RDF+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment (Azospirillum). The same trend was followed in other growth attributes (i.e., no. of tillers hill⁻¹, DMP) recorded (Table 2-3). This may be due to the combined application of NPK along with green manure incorporation and bio-fertilizer seed treatment. Nitrogen causes vegetative

Table 1: Effect of INM practices on plant height of traditional rice varieties

Main/sub	Plant height (cm)									
	Flowering stage					Harvest stage				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	70.0	72.7	76.0	85.8	76.1	99.0	102.0	104.0	110.1	103.7
S_2	73.6	74.8	86.0	94.9	82.3	102.0	103.3	110.5	120.0	108.9
S_3	77.7	86.9	95.0	101.3	90.2	105.0	111.0	122.0	131.5	117.5
S_4	82.2	90.8	97.1	103.0	93.3	106.5	114.0	126.0	134.0	120.1
S_5	85.1	94.3	100.7	106.0	96.5	109.7	118.0	131.0	138.0	124.2
Mean	77.7	83.9	90.9	98.2		104.5	110.6	118.7	126.7	
	Main	Sub	M at S	S at M		Main	Sub	M at S	S at M	
S.Em	1.09	0.96	2.03	1.91		1.20	1.14	2.37	2.28	
CD (0.05)	2.74	1.96	4.42	4.16		3.00	2.33	5.11	4.92	

Main plots: M_1 : Aruvathangkuruvai, M_2 : Poongar, M_3 : Kullakar, M_4 : Karungkuruva, Subplots: S_1 : Control, S_2 : 100% RDF, S_3 : 75% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S_4 : 100% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S_5 : 125% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S.Em: Standard error of mean and CD: Critical difference

Table 2: Effect of INM practices on several tillers hill⁻¹ of traditional rice varieties

Main/sub	Number of tillers hill ⁻¹									
	Flowering stage					Harvest stage				
	M ₁	M ₂	M ₃	M ₄	Mean	M ₁	M ₂	M ₃	M ₄	Mean
S ₁	8.0	9.5	11.0	14.7	10.8	7.5	8.5	9.6	13.1	9.7
S ₂	10.0	10.1	16.0	19.1	13.8	8.6	9.5	13.6	17.5	12.3
S ₃	12.5	17.0	19.5	22.7	17.9	11.0	14.3	17.6	20.5	15.9
S ₄	13.0	18.0	20.5	24.0	18.9	12.0	15.3	18.3	22.5	17.0
S ₅	14.5	19.0	22.0	26.0	20.4	12.8	16.5	19.0	24.3	18.1
Mean	11.6	14.7	17.8	21.3		10.4	12.8	15.6	19.6	
	Main	Sub	M at S	S at M		Main	Sub	M at S	S at M	
S.Em	0.19	0.18	0.38	0.37		0.20	0.14	0.32	0.28	
CD (0.05)	0.48	0.37	0.82	0.79		0.50	0.28	0.71	0.61	

Main plots: M₁: Aruvuthangkuruva, M₂: Poongar, M₃: Kullakar, M₄: Karungkuruva, Subplots: S₁: Control, S₂: 100% RDF, S₃: 75% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S₄: 100% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S₅: 125% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S.Em: Standard error of mean and CD: Critical difference

Table 3: Effect of INM practices on dry matter production (DMP) and number of productive tillers of traditional rice varieties

Main/sub	DMP kg ha ⁻¹					No of productive tillers hill ⁻¹				
	M ₁	M ₂	M ₃	M ₄	Mean	M ₁	M ₂	M ₃	M ₄	Mean
	M ₁	M ₂	M ₃	M ₄	Mean	M ₁	M ₂	M ₃	M ₄	Mean
S ₁	2720.6	3480.7	4231.7	5430.0	3965.7	164.7	177.0	189.3	237.3	192.1
S ₂	3608.0	4160.0	5442.0	7043.0	5063.3	178.7	186.2	242.3	284.3	222.9
S ₃	4271.7	5501.3	7150.0	7881.0	6201.0	208.3	255.0	290.0	329.3	270.7
S ₄	5223.3	5996.7	7530.0	9005.0	6938.9	236.3	283.0	318.0	374.7	303.0
S ₅	5315.3	6320.0	7936.0	9165.0	7184.1	220.0	275.7	306.6	353.3	288.9
Mean	4227.8	5091.7	6457.9	7704.9		201.6	235.4	269.3	315.8	
	Main	Sub	M at S	S at M		Main	Sub	M at S	S at M	
S.Em	81.5	97.9	193.3	195.9		3.1	3.5	6.9	6.9	
CD (0.05)	293.3	200.5	410.9	416.6		7.7	7.1	14.8	14.9	

Main plots: M₁: Aruvuthangkuruva, M₂: Poongar, M₃: Kullakar, M₄: Karungkuruva, Subplots: S₁: Control, S₂: 100% RDF, S₃: 75% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S₄: 100% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S₅: 125% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S.Em: Standard error of mean and CD: Critical difference

growth though it increases plant height. The incorporation of green manuring can deliver a considerable amount of nitrogen and increase the LAI of crops¹¹. Increasing leaf area index leads to a more light interception which subsequently produces higher dry matter production. Seed treatment with Azospirillum might have a positive influence on the growth attributes due to the secretion of plant growth-promoting hormones, signal molecules, nitrogen fixation and absorption of nutrients from the soil and thereby stimulates the metabolism of photosynthesis than the untreated plots. This result was in line with the findings of^{12,13}.

The interaction effect between main and subplots was significant. The treatment combination of M₄, S₅ (Karungkuruva along with 125% Recommended dose of NPK+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment) registered the higher values of growth attributes. This might be attributed because higher doses of nutrients resulted in increased the availability of nutrients in the soil for plant nourishment and further the combination of organic

sources facilitated the slow and continuous availability of nutrients enhanced cell division, elongation as well as various metabolic processes which increased plant growth attributes, as discussed earlier. Similar findings were also reported by¹⁴.

Yield attributes and yield: The higher values of the number of productive tillers m⁻² (Table 3) were registered in the main plot treatment, M₄ (Karungkuruva). Among the main plot treatments, concerning the number of productive tillers, M₄ (Karungkuruva) recorded a significantly higher number (315.8). It was followed by M₃ (Kullakar). The variations in yield attributing characters among the varieties were obtained due to their genetic makeup of rice cultivar and better utilization capacity of available nutrients than other varieties. Similar findings of yield attributes were reported¹⁵. Concerning subplot treatments, a higher number of productive tillers (303.0) was observed under S₄ (100% Recommended dose of NPK+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment). It might be due to the combined application of

Table 4: Effect of INM practices on grain and straw yield of traditional rice varieties

Main/sub	Grain yield kg ha ⁻¹					Straw yield kg ha ⁻¹				
	M ₁	M ₂	M ₃	M ₄	Mean	M ₁	M ₂	M ₃	M ₄	Mean
S ₁	900	1249	1458	2100	1427	1925	2554	2943	3563	2746
S ₂	1259	1453	2104	2809	1906	2578	2933	3566	4386	3366
S ₃	1463	2133	2850	3355	2450	2945	3587	4413	4813	3939
S ₄	2060	2473	3316	4016	2966	3500	3833	4763	5249	4336
S ₅	1900	2463	3200	3864	2856	3560	4053	4808	5406	4456
Mean	1516	1954	2585	3229		2901	3392	4098	4683	
	Main	Sub	M at S	S at M		Main	Sub	M at S	S at M	
S.Em	42.46	52.19	102.56	104.38		45.09	48.89	98.39	97.78	
CD (0.05)	105.91	106.79	217.75	221.60		112.47	100.04	210.60	209.29	

Main plots: M₁: Aruvuthangkuruva, M₂: Poongar, M₃: Kullakar, M₄: Karungkuruva, Subplots: S₁: Control, S₂: 100% RDF, S₃: 75% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S₄: 100% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S₅: 125% RDF+green manure (*Sesbania aculeata* at 6.25 t ha⁻¹)+seed treatment with bio-fertilizer (Azospirillum), S.Em: Standard error of mean and CD: Critical difference

organic manures and inorganic fertilizers that can uplift the panicle formation and panicle growth. The increased values of productive tillers with the application of manures especially by the use of green manures may be improved the soil structure, enhance the nutrient exchange, effective utilization of nutrients and increase yield and yield attributes. Present study results are in line with the findings of the previous studies¹⁶. The number of productive tillers m⁻² was high under subplot treatment S₄ (100% Recommended dose of NPK+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment) than S₅, it was due to only the judicious requirement and use of organic manures and inorganic fertilizer enabled rice plant to assimilate sufficient photosynthesis resulting in increased productive tillers and filled grains in panicle, it was evidenced earlier by reports¹⁷. Excessive application of fertilizers leads to a reduction in grain filling percentage¹⁸.

The interaction effect between the main and subplot treatment was significant. The treatment combination of M₄, S₄ (Karungkuruva along with 100% Recommended dose of NPK+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment) registered the higher number of productive tillers. Better performance of combined use of organic manures with chemical fertilizers might have to a synergistic effect of inorganic fertilizer and organic manures, as well as the slow release of nutrients throughout the crop growth period, thus helping to form more photosynthates and translocating the same from source to sink and also the immediate release of N and improved soil physical properties might have enhanced the crop growth and in turn yield attributes of rice. Present study results are in corroboration with the findings of researchers¹⁹.

The yield potential of rice is determined by values of growth and yield attributes. Among the rice varieties, M₄ (Karungkuruva) recorded higher values in grain (3229 kg ha⁻¹)

and straw yield (4683 kg ha⁻¹) and it was followed by M₃ (Kullakar) (Table 4). This might be due to the production of more photosynthetic pigments and photosynthetic rate, which supply the assimilates from source to sink, which in turn increase the growth and yield attributes, which reflect on the higher yield. Among the subplot treatments grain yield was high in S₄ (100% Recommended dose of NPK+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment). Application of optimum dose of fertilizers might have increased vigour, photosynthetic accumulation and better translocation of photosynthates to the sink²⁰. Increased grain yield with increasing NPK levels only up to the optimum level has also been reported by several workers in the past^{21,22}.

Even though subplot treatment S₅ recorded higher growth attributes (plant height and number of tillers m⁻²), the straw yield recorded was high due to the higher uptake of nutrients with lower grain yield. Grain yield increased significantly with levels of nitrogen but a significant increase was recorded only up to 100% RDN further increase in fertilizer application failed to produce a significant effect on grain yield²³. Similar to the present experiment, traditional rice variety kalu Heenati attributed to severe lodging due to the higher plant height boosted by the excessive use of inorganic fertilizer and the yield reduction was also caused by the reduction of filled spikelet percentage was reported by scientists²⁴. Incorporation of green manure also has a significant effect on yield, which has endorsed a higher rate of N mineralization as a result of high cation exchange capacity, slow and steady release of N could make the soil more productive²⁵. Effect of Azospirillum, contribute to increased yields through better-colonized roots thus realising enhanced water and nutrient uptake and also benefited by biological N fixation.

The interaction effect between the main plot and subplots were significant. The increased yield can be ascribed to the effect of adequate availability of NPK in soil solution, may

cause an increase in root growth, thereby increasing the nutrient uptake of nutrients, higher yield due to combined application of inorganic fertilizer and organic manures, which attributed to sustained nutrient supply and also as a result of better utilization of applied nutrients through improved micro-environmental conditions, especially the activities of soil microorganisms involved in nutrient transformation and fixation^{26,27}. Saving traditional rice varieties need to be take more research duly as they are very nutritious and have medicinal values which can play a better role in human nutrition. Concerning the yield of these varieties usually low where implying better nutrient management practices like INM can improve the production rate in different environments. From the present study results, implementing certain INM practices, especially 100% application of a recommended dose of NPK+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment acted well in improving all four traditional varieties tested. However, the quality of these varieties beyond their genetic nature through nutrient management practices can not be promised when using only inorganic sources.

CONCLUSION

From the enlightening study, several parameters in traditional rice varieties, Karunkuruvai with the application of 125% RDF+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment come out with the maximum values of most of the growth attributes, (plant height, number of tillers, DMP), number of productive tillers. However, the yield was higher with 100% RDF+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment. Thus, the Integrated nutrient management practice of 100% RDF+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment can be recommended to the traditional rice-growing farmers which may benefit with yield and quality.

SIGNIFICANCE STATEMENT

The present study identified that the application of integrated nutrient management practice of applying 100 % RDF+*Sesbania aculeata* at 6.25 t ha⁻¹+bio-fertilizer seed treatment beneficial for increasing the yield of traditional rice varieties significantly. And the findings can help the researchers to uncover the importance of growing traditional rice varieties and save them not to becoming extinct. Further, the quality and yield of these traditional rice varieties can not be ignored due to their medicinal and values. Thus, this study

provides light on traditional landraces like karunkuruvai can help in our nutrition and improve the farmer's income possibly.

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