

Increasing the crop growth rate and productivity enhancement by nutrient management practices in rice (*Oryza sativa* L.)

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Abstract

Field investigations were carried out at the Experimental farm, Department of Agronomy, Annamalai University, Annamalainagar, to increase the crop growth rate and enhancing the productivity of rice by imposing nutrient management practices. The experiments were laid out in randomized block design with three replications. Integrated application of 75% recommended dose of N through fertilizer and 25% N through various organic manures (FYM, cow dung based vermicompost, cow dung and water hyacinth based vermicompost, enriched poultry manure compost, enriched coirpith compost, green manures and green leaf manures) with recommended dose of P and K were evaluated with farmers' practice and absolute control. Among the different combinations, application of 75% RDN through fertilizer + 25% N through vermicompost (75% Cd + 25% Wh) had strikingly impressive effect on growth attributes (dry matter production, Leaf Area Index, crop growth rate), yield attributes (productive tiller m^{-2} , filled grains panicle $^{-1}$, fertility percentage), grain and straw yield of rice. This treatment was statistically on par with the application of 75% RDN through fertilizer + 25% N through vermicompost (100% Cd). Vermicompost prepared from cow dung as well as cow dung and water hyacinth were on par with each other in recording higher values. The integration of organic and inorganic forms of N excelled over the absolute control treatment.

Key words: crop growth rate, INM, green manure, vermicompost, water hyacinth.

Introduction

Rice is the most important staple food for more than half of the world's population, including regions with high population density and rapid growth. Among the rice growing countries, India has the largest area (44 million hectares) and it is the second largest producer (131 million tonnes) of rice next to China (197 million tonnes). The rice productivity in India is 3.37 t ha $^{-1}$ while the world average is 4.25 t ha $^{-1}$ (IRRI, 2011). At the current population growth rate (1.5 %), the rice requirement of India by the year 2025 would be around 125 million tonnes (Kumar *et al.*, 2009). To meet the food requirement of the growing population, India has to increase its rice productivity by three per cent per annum (Gulab Singh Yadav *et al.*, 2009). In Tamil Nadu, it is cultivated in an area of 17.89 lakh hectares with the production and productivity of 50.40 lakh tonnes and 2.82 t ha $^{-1}$, respectively. Rice often surprises us with phenomenal adjustments to its environment perhaps that is the reason why it has become one of the world's prime food crops.

Highly intensified chemical agriculture with repeated application of fertilizers, insecticides, fungicides and herbicides has resulted in environmental pollution, soil degradation, depletion of fertility and decline in productivity. Though synthetic fertilizers have contributed more for enhancing agricultural production, their extensive use for longer period have contributed equally or more negatively in erosion of soil fertility and decline in productivity level, environmental pollution with adverse effects on human health, biotic and ecosystem.

Among the nutrient inputs, nitrogen ranks first to maximize output in agriculture. Nitrogen is the key to any fertilizer management programme and it is the mean by which yield potential of modern rice genotypes can be achieved. Recent response studies indicated the use of more than 150 kg nitrogen ha⁻¹ than to the older ones of around 120 - 150 kg nitrogen ha⁻¹. The low N recovery, increased pollution and enhanced cost of production resulted in renewed interest in organic manuring to partially substitute the fertilizer N and to achieve sustainable productivity.

Research evidences proved beyond doubt that the complementary use of organic and inorganic sources of plant nutrients can sustain the optimum crop yields and improve the soil health. Farm yard manure (FYM) is the most commonly used organic manure. It supplies macro and micronutrients apart from improving physical conditions of the soil (Sengar *et al.*, 2000). In the recent years, vermicompost has been identified as one of the major gears to convert the biodegradable organic material into resourceful manure. It is rich in available nitrogen, phosphorus, potassium, calcium, vitamins, natural phyto regulators and microflora in balanced form that help in re-establishment of the natural fertility of the soil (Banik and Ranjita Bejbaruah, 2004). Water hyacinth, an aquatic and most problematic weed can be effectively utilized for the production of vermicompost (Sudhakar, 2000) when mixed with cow dung upto 25 per cent on dry weight basis (Renuka *et al.*, 2007).

Poultry manure contains considerable amount of plant nutrients which has to be used as manure after composting. Enrichment of poultry wastes with phosphatic fertilizers and biofertilizers can increase its nutrient content and availability. Use of green manures, a rich source of nitrogen helps to keep soil quality and fertility enhancement as a whole meeting a part of nutrient need of crops. The pre-season green manuring and its in-situ incorporation had improved growth and productivity of succeeding cereals, particularly rice. Therefore, the present investigation was planned to develop a remunerative, productive and sustainable nutrient management for rice crop.

Materials and Methods

Field experiments were conducted at the Experimental Farm, Department of Agronomy, Annamalai University, Annamalainagar to ascertain the effect of integrated nutrient management practices on growth, yield and nutrient uptake of rice. The experimental site is situated at 11°24' N latitude and 79°44' E longitude with an altitude of +5.79 m above mean sea level in the southern part of India and 15 km away from the Bay of Bengal coast. The weather at Annamalainagar is moderately warm with hot summer months. The initial analysis of the experimental soil revealed that heavy clay with neutral in reaction, low in available N, medium in available P₂O₅ and high in available K₂O.

The experiments were laid out in randomized block design with three replications. The treatment schedule comprised of T₁ - Control (No manures and fertilizer application), T₂ - 100% Recommended dose of fertilizer N (RDN), T₃ - 100% RDN + FYM @ 12.5 t ha⁻¹, T₄ - 75% RDN + 25% N through vermicompost (100% cow dung - Cd), T₅ - 75% RDN + 25% N through vermicompost (75% cow dung - Cd + 25% water hyacinth - Wh), T₆ - 75% RDN + 25% N through enriched poultry manure compost, T₇ - 75% RDN + 25% N through enriched coirpith compost, T₈ - 75% RDN + 25% N through *Sesbania aculeata*, T₉ - 75% RDN + 25% N through *Crotalaria juncea*, T₁₀ - 75% RDN + 25% N through *Gliricidia sepium*, T₁₁ - 75% RDN + 25% N through *Pongamia glabra*.

The organic manures viz., FYM, vermicompost, enriched poultry manure compost, enriched coirpith compost, green manures and green leaf manures and inorganic fertilizers viz., urea, super phosphate and muriate of potash were used in the experiments. Green manure *in situ* with *Sesbania aculeata* and *Crotalaria juncea* as well as green leaf manures *Gliricidia sepium* and *Pongamia glabra* were incorporated one week before transplanting of rice in the respective treatments. Recommended agronomic management practices were followed as per the guidelines given by the Department of Agriculture, Government of Tamil Nadu. The growth attributes viz., dry matter production (DMP), leaf area index (LAI), crop growth rate (CGR) and yield attributes (productive tiller m⁻², filled grains panicle⁻¹, fertility percentage), grain yield and straw yield were recorded. Harvest index for the crop was also worked out.

Result and Discussion

Growth attributes of rice were greatly influenced by integrated nutrient management practices (Table 1). There was also a steady increase in DMP with advancement of age, attaining its peak at harvest in all the treatments. Application of 75 % RDN through fertilizer + 25 % N through vermicompost (75 % Cd + 25 % Wh) (T₅) recorded significantly higher DMP of 12584 kg ha⁻¹ during harvesting stage and it was on par with the application of 75 % RDN through fertilizer + 25 % N through vermicompost (100 % Cd) (T₄). This was followed by application of 75 % RDN through fertilizer + 25 % N through enriched poultry manure compost (T₆). Lower dry matter production of 5835 kg ha⁻¹ was associated with the treatment absolute control (T₁) at harvesting stage. The higher dry matter recorded with the application of water hyacinth based vermicompost might be ascribed to steady and slow release of both native and applied nutrients which might have enabled the leaf area duration to extend, thereby providing an opportunity for plants to increase the photosynthetic rate which in turn to higher accumulation of dry matter. This is in the concurrence with the findings of Priyanka Anand (2010). It also contained high proportion of humic substances (*i.e.*, humic acids, fulvic acids and humin) which provided numerous sites for chemical reaction; microbial components known to enhance plant growth and disease suppression through the activities of bacteria (*Bacillus*), yeasts (*Sporobolomyces* and *Cryptococcus*) and fungi (*Trichoderma*) as well as chemical antagonists such as phenols and amino acids. This is consistent with the findings of Nagavalemma *et al.* (2004).

Among the treatments, application of 75% RDN through fertilizer + 25% N through vermicompost (75% Cd + 25% Wh) (T₅) recorded higher LAI of 6.74 at flowering stage. It was on par with application of 75% RDN through fertilizer + 25% N through vermicompost (100% Cd) (T₄). Application of 75% RDN through fertilizer + 25% N through enriched poultry manure compost (T₆) was next in order. The minimum LAI of 1.75 at flowering stage was observed under absolute control (T₁).

Nutrient management practices exerted significant influence on crop growth rate (CGR). The crop growth rate found to increase from active tillering - panicle initiation, panicle initiation - flowering phase with a decline at flowering - harvesting phase. Application of 75% RDN through fertilizer + 25% N through vermicompost (75% Cd + 25% Wh) (T₅) recorded higher CGR of 8.47, 16.18 and 10.35 g m⁻² day⁻¹ at active tillering - panicle initiation, panicle initiation - flowering and flowering - harvesting phases, respectively. However, it was statistically comparable with the application of 75% RDN through fertilizer + 25% N through vermicompost (100% Cd) (T₄). Application of 75% RDN through fertilizer + 25% N through enriched poultry manure compost (T₆) was next in merit. Lower CGR values of 5.82, 6.36 and 3.76 g m⁻² day⁻¹ during active tillering - panicle initiation, panicle initiation - flowering and flowering - harvesting phases were observed under absolute control (T₁).

A significant difference in productive tillers m⁻² was recorded at harvest stage as a result of integrated nutrient management practices. Higher panicle number of 324 was registered under the application of 75 % RDN through fertilizer + 25 % N through vermicompost (75% Cd + 25% Wh) (T₅). It was statistically on par with the application of 75% RDN through fertilizer + 25% N through vermicompost (100% Cd) (T₄). This was followed by application of 75% RDN through fertilizer + 25% N through enriched poultry manure compost (T₆). Absolute control (T₁) recorded the lower number of productive tillers m⁻² of 186. The same trend was followed for the other yield attributes filled grains panicle⁻¹ and fertility percentage.

Among the treatments, application of 75% RDN through fertilizer + 25% N through vermicompost (75% Cd + 25% Wh) (T₅) recorded higher grain yield of 6154 kg ha⁻¹ and it was found to be on par with the application of 75% RDN through fertilizer + 25% N through vermicompost (100% Cd) (T₄) by registering a grain yield of 5890 kg ha⁻¹. Application of 75% RDN through fertilizer + 25% N through enriched poultry manure compost (T₆) was the next best treatment. Higher straw yield of 6680 kg ha⁻¹ was recorded under the treatment 75% RDN through fertilizer + 25% N through vermicompost (75% Cd + 25% Wh) (T₅). The same treatment recorded higher harvest index of the crop. This might be due to the fact that vermicompost offered a balanced nutritional release pattern to plants, provided nutrients such as available N, soluble K, exchangeable Ca, Mg and P that could be taken readily by plants (Parthasarathi *et al.*, 2008), efficient translocation of assimilates to the sink and greater soil microbial diversity and activity which resulted in higher grain and straw yield (Arancon *et al.*, 2006). Lower grain yield, straw yield and harvest index were recorded under the treatment Absolute control (T₁).

Conclusion

From the results of the field experiments, it can be concluded that integrated nutrient management practice with 75 % RDN through fertilizer + 25% N through vermicompost (75% Cd + 25% Wh) applied to rice was found to be an agronomically sound, ecologically safe and economically viable practice for augmenting higher productivity for the tail end area of Cauvery Deltaic Zone of Tamil Nadu.

Table 1. Effect of nutrient management practices on dry matter production, Leaf area index and crop growth rate of rice

Treatments	Dry matter production (kg ha ⁻¹)	Leaf Area Index (LAI)	Crop growth rate (CGR)		
			AT - PI	PI - F	F - H
T ₁ – Absolute control (No manures and fertilizer application)	5835	3.83	5.82	6.36	3.76
T ₂ – 100 % Recommended dose of fertilizer N (RDN)	8182	4.82	6.85	12.07	4.20
T ₃ – 100 % RDN + FYM @ 12.5 t ha ⁻¹	9998	5.63	7.60	13.99	6.45
T ₄ – 75 % RDN + 25 % N through VC (100 % Cd)	12210	6.59	8.30	16.10	9.62
T ₅ – 75 % RDN + 25 % N through VC (75 % Cd + 25 % Wh)	12584	6.74	8.47	16.18	10.35
T ₆ – 75 % RDN + 25 % N through EPMC	11382	6.20	7.92	15.40	8.42
T ₇ – 75 % RDN + 25 % N through ECC	10393	5.82	7.60	14.66	6.72
T ₈ – 75 % RDN + 25 % N through <i>Sesbania aculeata</i>	10337	5.74	7.64	14.59	6.71
T ₉ – 75 % RDN + 25 % N through <i>Crotalaria juncea</i>	10144	5.68	7.56	14.16	6.64
T ₁₀ – 75 % RDN + 25 % N through <i>Gliricidia sepium</i>	8843	5.21	7.23	12.86	4.82
T ₁₁ – 75 % RDN + 25 % N through <i>Pongamia glabra</i>	9105	5.25	7.28	13.23	5.05
S.Ed	278.60	0.170	0.142	0.341	0.189
CD (P = 0.05)	565.80	0.344	0.287	0.682	0.381

*VC – Vermicompost; Cd – Cow dung; Wh – Water hyacinth; EPMC – Enriched poultry manure compost; ECC – Enriched coirpith compost

Table 2. Effect of nutrient management practices on productive tiller m⁻², filled grains panicle⁻¹, fertility percentage, grain and straw yield of rice.

Treatments	Productive tiller m ⁻²	Filled grains panicle ⁻¹	Fertility percentage	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index
T ₁ – Absolute control (No manures and fertilizer application)	186	59.0	60.57	2180	3905	35.8 (36.78)
T ₂ – 100 % Recommended dose of fertilizer N (RDN)	223	78.5	70.47	3497	4935	41.5 (40.09)
T ₃ – 100 % RDN + FYM @ 12.5 t ha ⁻¹	269	85.5	73.14	4593	5655	44.8 (42.03)
T ₄ – 75 % RDN + 25 % N through VC (100 % Cd)	316	93.2	76.39	5890	6570	47.3 (43.43)
T ₅ – 75 % RDN + 25 % N through VC (75 % Cd + 25 % Wh)	324	94.5	76.89	6154	6680	48.0 (43.82)
T ₆ – 75 % RDN + 25 % N through EPMC	298	90.4	75.33	5414	6220	46.5 (43.02)
T ₇ – 75 % RDN + 25 % N through ECC	280	87.3	74.05	4883	5805	45.7 (42.53)
T ₈ – 75 % RDN + 25 % N through <i>Sesbania aculeata</i>	276	86.9	73.83	4792	5795	45.3 (42.28)
T ₉ – 75 % RDN + 25 % N through <i>Crotalaria juncea</i>	271	86.3	73.51	4670	5724	44.9 (42.07)
T ₁₀ – 75 % RDN + 25 % N through <i>Gliricidia sepium</i>	241	81.3	71.50	3908	5185	43.0 (40.98)
T ₁₁ – 75 % RDN + 25 % N through <i>Pongamia glabra</i>	249	82.6	71.95	4105	5250	43.9 (41.49)
S.Ed	7.12	1.26	0.36	135.6	167.7	1.8
CD (P = 0.05)	14.83	2.58	0.75	274.8	342.2	NS

*VC – Vermicompost; Cd – Cow dung; Wh – Water hyacinth; EPMC – Enriched poultry manure compost; ECC – Enriched coirpith compost

** The values in parenthesis are sine-arc transformed values

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