# Integrated nutrient management practices and its impact on growth, yield attributes, yield and nutrient uptake of 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 study the impact of Integrated nutrient management practices on growth, yield attributes, yield and nutrient uptake of rice. 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 (Plant height, number of tillers hill$^{-1}$, dry matter production Leaf Area Index**),** yield attributes, grain and straw yield of rice and NPK nutrient uptake. 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:** INM, green manure, green leaf 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 (IRCN, 2001), environmental pollution with adverse effects on human health, biotic and ecosystem.

Among the nutrient inputs, nitrogen ranks first to maximize output in agriculture (Sharma, 1995). 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 phytoregulators 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 integrated 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, with low soluble, low in available N, medium in available $P_2O_5$ and high in available $K_2O$.

The experiments were laid out in randomized block design with three replications. The treatment schedule comprised of $T_1$ - Control (No manures and fertilizer application), $T_2$ – 100% Recommended dose of fertilizer N (RDN), $T_3$ - 100% RDN + FYM @ 12.5 t $ha^{-1}$, $T_4$ - 75% RDN + 25% N through vermicompost (100% cow dung – Cd), $T_5$ – 75% RDN + 25% N through vermicompost (75% cow dung - Cd + 25% water hyacinth - Wh), $T_6$ - 75% RDN + 25% N through enriched poultry manure compost, $T_7$ - 75% RDN + 25% N through enriched coirpith compost, $T_8$ - 75% RDN + 25% N through *Sesbania aculeata*, $T_9$ - 75 % RDN + 25% N through *Crotalaria juncea*, $T_{10}$ - 75% RDN + 25% N through *Gliricidia sepium*, $T_{11}$ - 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.*, plant height, number of tillers $hill^{-1}$, dry matter production (DMP), and yield attributes *viz.*, number of productive tillers $hill^{-1}$, grain yield and straw yield were recorded. NPK nutrients uptake by the crop were also recorded.

**Result and Discussion**

Integrated nutrient management practices exerted marked influence on the plant height of rice. Among the treatments, application of 75% RDN through fertilizer + 25% N through vermicompost (75% cow dung – Cd + 25% water hyacinth - Wh) ($T_5$) recorded taller plants with the value of 108.7 cm during harvesting stage. The biochemical and biophysiological process might have been triggered by the vermicompost which was produced by using cow dung and water hyacinth (Lara Zirbes *et al.*, 2011). These factors could contribute favourably for enhanced plant height in the present investigation. This was statistically on par with application of 75% RDN + 25% N through vermicompost (100% cow dung – Cd) ($T_4$). This was followed by application of 75% RDN through fertilizer + 25% N through enriched poultry manure compost ($T_6$). The absolute control ($T_1$) registered shorter plants of 68.9 cm during harvesting stage.

Significant variation in number of tillers $m^{-2}$ and dry matter production were existed due to the integrated nutrient management practices. Among the treatments, application of 75% RDN through fertilizer + 25% N through vermicompost (75% cow dung – Cd + 25% water hyacinth – Wh) ($T_5$) recorded more number of tillers (444 $m^{-2}$) and higher DMP value of 12828 kg $ha^{-1}$ during 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 inturn to higher accumulation of dry matter. This is in the concurrence with the findings of Priyanka Anand (2010). It was found to be on par with the application of 75% RDN through fertilizer + 25% N through vermicompost (100 % Cd) ($T_4$). This was followed by the application of 75% RDN through fertilizer + 25% N through enriched poultry manure compost ($T_6$) at all the stages of crop growth. The treatment absolute control ($T_1$) produced minimum number of tillers $m^{-2}$ (218), lower DMP (12828 kg $ha^{-1}$) during harvesting stage of the crop.

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) ($T_5$). It was statistically on par with the application of 75% RDN through fertilizer + 25% N through vermicompost (100% Cd) ($T_4$). This was followed by application of 75% RDN through fertilizer + 25% N through enriched poultry manure compost ($T_6$). Absolute control ($T_1$) recorded the lower number of productive tillers $m^{-2}$ of 186.The same trend was followed in Leaf area index also.

Among the treatments, application of 75% RDN through fertilizer + 25% N through vermicompost (75% Cd + 25% Wh) ($T_5$) 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) ($T_4$) by registering a grain yield of 5890 kg $ha^{-1}$. Application of 75% RDN through fertilizer + 25% N through enriched poultry manure compost ($T_6$) was the next best treatment. The same trend was followed in straw yield and harvest index also. 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).

Higher NPK uptake by rice was observed under the application of 75 % RDN through fertilizer + 25 % N through vermicompost (75% Cd + 25% Wh) ($T_5$) with higher uptake of N (108.25 kg $ha^{-1}$), P (25.12 kg $ha^{-1}$) and K (138.42 kg $ha^{-1}$). However, it was statistically on par with the application 75% RDN through fertilizer + 25% N through vermicompost (100 % Cd) ($T_4$). Application of 75% RDN through fertilizer + 25% N through enriched poultry manure compost ($T_6$) was next in order. The supremacy of vermicompost lies in the fact that they could supply the nutrients in soluble form for a quite longer period by not allowing the entire soluble form into solution, to come in contact with soil and other inorganic constituents, thereby minimizing fixation and precipitation from the manures, the plant roots could compete very well with loss mechanisms and absorbed more nutrients. These results are corroborated with the findings of Avnish Chauhan and Joshi

(2010). Absolute control ($T_1$) recorded lower N uptake of 53.06 kg $ha^{-1}$, P uptake of 11.67 kg $ha^{-1}$ and K uptake of 64.19 kg $ha^{-1}$.

**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.** Impact of integrated nutrient management on plant height, number of tillers hill$^{-1}$, dry matter production, Leaf area index at flowering stage and number of productive tillers hill$^{-1}$ of rice crop

| **Treatments** | **Plant height (cm)** | **Number of tillers hill$^{-1}$** | **Dry matter production (kg ha$^{-1}$)** | **Leaf Area Index (LAI))** | **Number of productive tillers hill$^{-1}$** |
|---|---|---|---|---|---|
| $T_1$ – Absolute control (No manures and fertilizer application) | 68.9 | 218 | 5835 | 3.83 | 189 |
| $T_2$ – 100 % Recommended dose of fertilizer N (RDN) | 78.8 | 268 | 8182 | 4.82 | 231 |
| $T_3$ – 100 % RDN + FYM @ 12.5 t ha$^{-1}$ | 91.6 | 343 | 9998 | 5.63 | 270 |
| $T_4$ – 75 % RDN + 25 % N through VC (100 % Cd) | 105.3 | 421 | 12210 | 6.59 | 318 |
| $T_5$ – 75 % RDN + 25 % N through VC (75 % Cd + 25 % Wh) | 108.7 | 444 | 12584 | 6.74 | 327 |
| $T_6$ – 75 % RDN + 25 % N through EPMC | 99.9 | 392 | 11382 | 6.20 | 299 |
| $T_7$ – 75 % RDN + 25 % N through ECC | 94.4 | 361 | 10393 | 5.82 | 280 |
| $T_8$ – 75 % RDN + 25 % N through *Sesbania aculeata* | 94.0 | 354 | 10337 | 5.74 | 278 |
| $T_9$ – 75 % RDN + 25 % N through *Crotalaria juncea* | 92.3 | 346 | 10144 | 5.68 | 275 |
| $T_{10}$ – 75 % RDN + 25 % N through *Gliricidia sepium* | 84.2 | 299 | 8843 | 5.21 | 245 |
| $T_{11}$ – 75 % RDN + 25 % N through *Pongamia glabra* | 86.5 | 311 | 9105 | 5.25 | 250 |
| **S.Ed** | 2.36 | 12.5 | 278.60 | 0.170 | 8.35 |
| **CD (P = 0.05)** | 4.89 | 27.5 | 565.80 | 0.344 | 17.64 |

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

**Table 2.** Impact of integrated nutrient management on grain yield, straw yield and NPK nutrient uptake of rice crop

| Treatments | Grain yield (kg ha$^{-1}$) | Straw yield (kg ha$^{-1}$) | Harvest index | Nutrient uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | | | | N | P | K |
| $T_1$ – Absolute control (No manures and fertilizer application) | 2180 | 3905 | 35.8 (36.78) | 53.06 | 11.67 | 64.19 |
| $T_2$ – 100 % Recommended dose of fertilizer N (RDN) | 3497 | 4935 | 41.5 (40.09) | 73.65 | 16.36 | 90.00 |
| $T_3$ – 100 % RDN + FYM @ 12.5 t ha$^{-1}$ | 4593 | 5655 | 44.8 (42.03) | 89.98 | 20.04 | 109.98 |
| $T_4$ – 75 % RDN + 25 % N through VC (100 % Cd) | 5890 | 6570 | 47.3 (43.43) | 106.82 | 24.42 | 134.31 |
| $T_5$ – 75 % RDN + 25 % N through VC (75 % Cd + 25 % Wh) | 6154 | 6680 | 48.0 (43.82) | 108.25 | 25.12 | 138.42 |
| $T_6$ – 75 % RDN + 25 % N through EPMC | 5414 | 6220 | 46.5 (43.02) | 100.44 | 22.76 | 125.20 |
| $T_7$ – 75 % RDN + 25 % N through ECC | 4883 | 5805 | 45.7 (42.53) | 93.54 | 20.78 | 114.32 |
| $T_8$ – 75 % RDN + 25 % N through *Sesbania aculeata* | 4792 | 5795 | 45.3 (42.28) | 93.03 | 20.67 | 113.71 |
| $T_9$ – 75 % RDN + 25 % N through *Crotalaria juncea* | 4670 | 5724 | 44.9 (42.07) | 91.25 | 20.29 | 111.58 |
| $T_{10}$ – 75 % RDN + 25 % N through *Gliricidia sepium* | 3908 | 5185 | 43.0 (40.98) | 79.59 | 17.69 | 97.27 |
| $T_{11}$ – 75 % RDN + 25 % N through *Pongamia glabra* | 4105 | 5250 | 43.9 (41.49) | 81.95 | 18.21 | 100.16 |
| **S.Ed** | 135.6 | 167.7 | 1.8 | 2.32 | 0.56 | 3.37 |
| **CD (P = 0.05)** | 274.8 | 342.2 | NS | 4.84 | 1.12 | 6.78 |

*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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