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Evaluating the effect of integrated nutrient management in transplanted rice (*Oryza sativa* L.)

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Abstract

The goal of this Kuruvai season (June - September, 2023) field trial was to assess how integrated nutrient management (INM) influences the performance of the ADT 43 rice variety under transplanted conditions. The trial, conducted at the Annamalai University Experimental Farm, Annamalai Nagar, employed a randomized block design with nine treatments in triplicate. The treatments comprised of T₁ - Control (no NPK); T₂ - 75% RDF+ FYM @ 12.5 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₃ - 75% RDF + Vermicompost @ 5 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₄ - 75% RDF + Green leaf manure @ 6.25 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₅ - 75% RDF + Pressmud @ 6 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₆ - 50% RDF + FYM @ 12.5 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₇ - 50% RDF + Vermicompost @ 5 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₈ - 50% RDF + Green Leaf manure @ 6.25 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₉ - 50% RDF + Pressmud @ 6 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering. From these a major influence on the development and harvest of transplanted rice was observed.

Keywords: Vermicompost, Green leaf manure, Pressmud, Panchagavya

Introduction

Rice (*Oryza sativa* L.) stands as the world's most critical cereal crop for human nutrition. It serves as the staple diet for over half of the global population and is especially vital in Southeast Asia (Jehangir *et al.*, 2022) [5]. Given the massive and growing population in this region, rice is expected to remain the dominant food source there for the foreseeable future. More than 40% of food grains produces in India are rice and 70% of rural residents are directly employed by this crop. The productivity of India's rice cultivation stands at 4.32 tonnes per hectare; this efficiency results in a national harvest of 137.00 million tonnes grown on 47.60 million hectares of land (USDA, 2024) [21]. The world wide projected demand of rice in 2050 is expected to be around 584 million tonnes.

Excessive agrochemical input had led to soil degradation, which has put the ecosystem in a precarious position. Nevertheless, these natural habitats are thought as an external economies. When farming methods use only chemical fertilizers for long durations, the soil is prone to deteriorating. Since these fertilizers neither build up soil fertility nor aid in improving the soil's physical and biological characteristics, they become a liability. These leads to the poor growth in agriculture.

In comparison to maintaining soil health, organic manures increase crop output by enhancing the soil characteristics. Furthermore, utilizing inorganic fertilizers is enhanced by the presence of organic manures. In addition to providing nutrients, organic fertilizer also offers micronutrients, that alters the physical behavior of the soil, and boosts the effectiveness of nutrients that are applied. It is known that applying vermicompost increased the prolonged availability of nutrients, improved the physical properties and also biological activity in the soil (Rajkhowa *et al.*, 2017) [14]. Because vermicompost stimulates soil microbial development and activity, plant nutrients are subsequently mineralized, and soil fertility and quality are increased, it is regarded as a desirable management practice in any agricultural production system. Application of farmyard manure primarily improved the nutritional status in plants. A second contributing

factor is the plant system's enhanced efficiency in taking up and moving nutrients. This improvement is linked to stronger root activity, which is itself a result of farmyard manure effectively preserving the soil health (Rekha *et al.*, 2018) ^[16]. As a locally-sourced product, Panchagavya is a leaf-applied fertilizer created by Tamil Nadu's organic cultivation community. It is broadly adopted for use on crops. Comprising a mix of five bovine products, Panchagavya is thought to influence life forms beneficially. The elements sourced from the cow are said to conduct cosmic power. Introducing this power to a living system helps correct imbalances, ultimately harmonizing the fundamental building blocks necessary for revitalized growth. (Sayi *et al.*, 2018) ^[18].

Therefore, an integrated strategy that combines manure and chemical fertilizer to supply nutrients is crucial, particularly in cropping systems that rely on rice. Furthermore, compared to the recommended dose of fertilizer applied, a significant improvement in rice grain quantity and quality has been reported under using integrated agro products. With aforementioned information in mind, the experiment sought to determine economics under rice yield. The study was designed to measure the results of integrated nutrient management on plant development and yield parameters.

Materials and Methods

The research was performed as a field trial between June and September of 2023 at the Agronomy Department's Experimental Farm within Annamalai University, located in Annamalai Nagar, Cuddalore District, Tamil Nadu (11°24' N, 79°44' E, and +5.79 m MSL). The experiment was structured using a Randomized Block Design (RBD), consisting of nine different treatments that were repeated three times. The listed treatments consists of T₁ - Control (no NPK); T₂ - 75% RDF+ FYM @ 12.5 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₃ - 75% RDF + Vermicompost @ 5 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₄ - 75% RDF + Green leaf manure @ 6.25 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₅ - 75% RDF + Pressmud @ 6 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₆ - 50% RDF + FYM @ 12.5 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₇ - 50% RDF + Vermicompost @ 5 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₈ - 50% RDF + Green Leaf manure @ 6.25t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering; T₉ - 50% RDF + Pressmud @ 6 t ha⁻¹ + 3% Panchagavya foliar spray @ AT, PI & 50% flowering. The research utilized the ADT 43 rice variety, which is known for its short maturity period, planted at a density of 60 kilograms per hectare. Organic manures of FYM, pressmud, vermicompost and Green leaf manure were applied as a basal in the field. The quantitative measurements corresponding to growth and output characteristics underwent calculation. And also the nutrient uptake by plants were also analyzed. The standard for plant height was established as the distance from the plant's base to the apex of the uppermost leaf when the crop was harvested. The average height for five sample plants was calculated and recorded in centimeters. Tiller concentration can be estimated by placing quadrats randomly within each of the plots. Then the total number of tillers that present within each quadrats will be counted. Using the equation suggested by Palanisamy and Gomez (1974) ^[13], the crop's LAI at flowering, ensuring the process did not require removing any leaves.

$$LAI = \frac{K (L \times W)(\text{Number of leaves hill}^{-1})}{\text{Area occupied by the plant}}$$

Where,

K = Adjustment factor (0.75)

L = Leaf length (cm) W = Leaf width (cm)

To assess root length and volume, whole rice plants were uprooted before observation at flowering stage. The roots were gently washed to remove soil particles, and Individual root length was recorded by taking measurements that spanned from the bottom of the plant stem to the end of the root. and recorded in centimeters. The method, that based on the water displacement principle, uses the difference between the initial and final water volume in a volumetric cylinder to calculate the volume of the root. and it's recorded in cubic centimeters (cm³). To ensure accurate measurements, the moisture was removed from the samples in a sequence, beginning with ambient drying followed by heat-forced desiccation in an oven for 48 hours with temperature of 65 °C ± 5 °C. The average dry weight of the collected plant specimens recorded. Dry matter production was measured per plot and it is expressed in kilograms per hectare (kg ha⁻¹). In each net plot of the field a quadrat of 0.25 m² size was placed at four places and the total number of productive tillers were estimated. For the purpose of counting the filled grains panicle⁻¹, the panicles were selected at random. Grains were categorized as either well-filled or chaffy using a manual test—pressing them with fingers—and the counts for each category were then noted individually. Thousands of filled grains can be estimated by gathering the weight of the entire grain yield from every plot at a moisture level of 14 per cent and expressed in g. For estimating total N, P and K, the plant specimens, which had been dried in an oven for dry matter analysis, were first chopped and then milled using a Willey mill. The resulting dry matter production, along with the nutrient concentrations obtained (expressed as percentages), was used to calculate the nutrient uptake.

The various growth parameters observed during the study were analyzed statistically using the methods outlined by Gomez and Gomez (1984) ^[2]. The 'F' test determined if treatments varied significantly, using a 5% error margin (P=0.05). The Critical Difference (CD) provided the threshold for significance, while 'NS' denoted non-significant findings.

Results and Discussion

Growth and yield attributes

The study revealed a notable difference in both the quantitative and qualitative attributes assessed across different nutrient management strategies (Table 1). Among all treatments, the application of 75% RDF + vermicompost @ 5 t ha⁻¹ + 3% panchagavya foliar spray @ AT, PI and 50% flowering (T₃) emerged as the optimal practice. This treatment led to the maximum recorded vertical growth (101.54 centimetre), tiller concentration per square metre (424), root length (26.27 centimetre), root volume (28.07 cubic centimetre), LAI (6.24), and DMP aa (12648 kg ha⁻¹). The more immediate in addition to higher availability of essential nutrients contains some type of phytohormones during crop development phase, which boosted crop physiological and metabolic activity and allowed for greater nutrient absorption and photosynthesis, leading to increase in plant height, tiller production, and leaf area index. The foliar spray of panchagavya which contains growth

enzymes such as GA 3-oxidase and GA 2- oxidase triggered responses within the plant and favored rapid cell division and multiplication. It also enhances the growth regulators within the cells. Consequently, these growth regulators promoted essential growth and development in the plant system. These evidence concur with earlier work from Medhi *et al.* (2022) ^[13], Kumar *et al.* (2024) ^[11], Ranjit (2018) ^[16], Kumar *et al.* (2017) ^[9], Upadhyay *et al.* (2022) ^[21] and Sarkar *et al.* (2023) ^[18].

The data revealed that the application of 75% RDF + vermicompost @ 5 t ha⁻¹ + 3% panchagavya foliar spray @ AT, PI and 50% flowering (T₃) was the most effective treatment. This treatment resulted in the highest no of productive tillers m⁻² (382), no of filled grains panicle⁻¹ (104.9) and thousand grain weight (15.4 g) at harvest (Table 2). The combined application of the organic and inorganic manure surpassed the control in enhancing productive tillers, grains per panicle, spikelet fertility and panicle weight. This improvement is attributed to the greater and balanced nutrient availability throughout the crop growth period. Similar to the findings of Kashedul *et al.* (2015) ^[8] Vermicompost serves a dual purpose by enhancing the rhizosphere's physical conditions and ensuring a steady nutrient supply to crops. It adds organic matter, beneficial microorganisms, and plant growth-promoting substances to the soil, while inorganic fertilizers supplement essential nutrients. This combined effect creates a more favorable soil environment, improving nutrient availability and uptake in rice plants, which leads to enhanced photosynthetic activity and nutrient transport. The improved nutrient absorption supports stronger vegetative growth and stimulates the synthesis of plant growth-enhancing compounds. Consistent application of vermicompost ensures a reliable source of easily absorbable nutrients, thereby increasing photosynthesis, enzyme activity, energy production, carbohydrate and fat metabolism and overall plant respiration—collectively contributing to better plant health and productivity. Applying a foliar spray of panchagavya, a bio-enhancer rich in macro and micro nutrients, creates an environment conducive to crop growth and development, ultimately leading to higher yields. The consistent provision of nitrogen from panchagavya throughout the crop's lifecycle promotes optimal photosynthesis.

Furthermore, the combined use of panchagavya and vermicompost enhances the microbial activity in the soil, which in turn boosts crop yields. These findings align with those of Senthamizhkumaran *et al.* (2021) ^[20] and Kumar *et al.* (2023) ^[10]

Nutrient uptake

Integrated nutrient management significantly influenced rice plants nutrient uptake (nitrogen, phosphorus, potassium). The treatment combining the application of 75% RDF + vermicompost @ 5 t ha⁻¹ + 3% panchagavya foliar spray @ AT, PI and 50% flowering (T₃) demonstrated the highest nutrient uptake (Table 3). This treatment resulted in the highest uptake of N (146.84 kg ha⁻¹), P (50.72 kg ha⁻¹) and K (135.64 kg ha⁻¹). Increase in the plant height is estimated by enhanced plant height, leaf area, photosynthetic activity, root development, and dry matter production in which facilitated greater nutrient uptake. The overall nutrient uptake by the crop is determined by the combined effect of nutrient concentration and the crop's dry matter accumulation. INM strategies enhanced nutrient utilization efficiency, which led to greater NPK assimilation in the rice plants. This increased absorption is probably a result of the higher nutrient availability provided by both the native soil pool and the supplementary organic manure (Kamaleshwaran and Elayaraja, 2021) ^[7]. The elevated rate of nutrient absorption is partly driven by organic compounds that leach from the vermicompost. These compounds act as solubilizing agents, freeing up nutrients from complex structures during decomposition. This process simultaneously diminishes the soil's nutrient-binding capacity while promoting the release of essential elements. Moreover, carbon dioxide, a byproduct of organic matter decomposition, was instrumental in mobilizing phosphorus. The synergistic application of manures and fertilizers, supplemented by a panchagavya spray, proved most effective, primarily because vermicompost offers a rich source of readily available potassium and releases all its nutrients at a significantly higher and more sustained rate. Observation that validate the results reported by Choudhary *et al.* (2017) ^[1], Hoque *et al.* (2022) ^[4], Masni and Wasli (2019) ^[12] and Jana *et al.* (2020) ^[5].

Table 1: Influence of INM Strategies on the Vegetative Growth of Transplanted Rice

Treatments	Plant height (cm)	No of tillers m ⁻²	Root Depth (cm)	Root mass (cc)	LAI	DMP (kg ha ⁻¹)
T ₁ - Control (no NPK)	78.94	262	18.06	16.92	3.07	5198
T ₂ - 75% RDF+ FYM @ 12.5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	94.85	384	23.38	24.59	5.14	10796
T ₃ - 75% RDF+ Vermicompost @ 5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	101.54	424	26.27	28.07	6.24	12648
T ₄ -75% RDF+ Green leaf manure @ 6.25 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	97.10	397	24.33	25.76	5.51	11453
T ₅ - 75% RDF+ Presmud @ 6 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	99.29	411	25.29	26.92	5.87	12042
T ₆ - 50% RDF+ FYM @ 12.5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	85.77	328	19.14	19.97	3.66	9057
T ₇ - 50% RDF+ Vermicompost @ 5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	92.56	370	22.39	23.44	4.77	10662
T ₈ - 50% RDF+ Green leaf manure @ 6.25 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	88.09	328	20.43	21.13	4.03	9471
T ₉ - 50% RDF+ Pressmud @ 6 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	90.38	355	21.42	22.29	4.39	10032
S.ED	0.78	5.59	0.42	0.53	0.14	151.23
CD (P=0.05)	2.13	12	0.93	1.14	0.35	312.00

Table 2: Influence of INM on the Yield Characteristics of Transplanted Rice.

Treatments	No of productive tillers m ⁻²	No of filled grains panicle ⁻¹	Thousand grain weight (g)
T ₁ - Control (no NPK)	296	85.26	15.16
T ₂ - 75% RDF+ FYM @ 12.5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	346	97.92	15.36
T ₃ - 75% RDF+ Vermicompost @ 5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	382	104.98	15.42
T ₄ - 75% RDF+ Green leaf manure @ 6.25 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	357	100.27	15.38
T ₅ -75% RDF+ Presmud @ 6 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	370	102.63	15.40
T ₆ - 50% RDF+ FYM @ 12.5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	321	88.34	15.27
T ₇ -50% RDF+ Vermicompost @ 5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	333	95.54	15.34
T ₈ - 50% RDF+ Green leaf manure @ 6.25 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	308	90.73	15.29
T ₉ - 50% RDF+ Pressmud @ 6 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	320	93.15	15.32
S.ED	4.12	1.08	0.02
CD (P=0.05)	8.00	2.30	NS

Table 3: The Influence of INM Practices on Nutrient Uptake by Transplanted Rice.

Treatments	Plant nutrient uptake (kg ha ⁻¹)		
	N	P	K
T ₁ - Control (no NPK)	126.43	39.97	108.25
T ₂ - 75% RDF+ FYM @ 12.5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	140.99	47.73	126.41
T ₃ - 75% RDF+ Vermicompost @ 5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	146.84	50.72	135.64
T ₄ - 75% RDF+ Green leaf manure @ 6.25 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	142.67	48.75	129.47
T ₅ - 75% RDF+ Presmud @ 6 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	144.64	49.73	132.55
T ₆ - 50% RDF+ FYM @ 12.5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	130.24	42.86	114.11
T ₇ - 50% RDF+ Vermicompost @ 5 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	138.10	46.52	123.36
T ₈ - 50% RDF+ Green leaf manure @ 6.25 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	132.60	43.96	117.18
T ₉ - 50% RDF+ Pressmud @ 6 t ha ⁻¹ + 3% Panchagavya foliar spray @ AT, PI and 50% flowering	135.47	45.21	120.27
S.ED	0.79	0.45	1.42
CD (P=0.05)	1.61	0.97	3.02

Conclusion

The simultaneous and coordinated application of recommended doses of chemical fertilizers (RDF), earthworm-produced organic manure (vermicompost), and a leaf-surface application of the traditional fermented bio-enhancer (Panchagavya) demonstrated superior performance in rice plant the comprehensive T₃ treatment successfully met the nutritional requirements of rice plants, fostering vigorous growth and development. This balanced delivery of crucial elements that present in vermicompost which includes N, P, K, Mg and Ca optimized photosynthesis, tillering, and grain filling. Consequently, the plants exhibited greater height, tiller count, panicle length, and grain weight, culminating in higher yields. Furthermore, this method enhanced soil health. It supports more efficient nutrient flow through the ecosystem by building up soil organic matter, leading to a better physical arrangement of soil particles and a higher capacity for nutrient storage. This greater efficiency in nutrient uptake by the rice plants diminished the necessity for liberal fertilizer use and curtailed nutrient leaching. Thoughtful mix of natural and synthetic resources are highly endorsed in lowland rice farming as a powerful strategy for improving both yield and economic returns.

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