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Effect of Organic NPK Granules and Inorganic Fertilizers on Growth, Yield and Economics of Rice

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Authors' contributions

This work was carried out in collaboration among all authors.All authors read and approved the final manuscript.

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ABSTRACT

Modern intensive agriculture, which sparked the "Green Revolution" in the early 1970s, degraded the environment, which decreased productivity and had other negative impacts on the environment and public health. In order to improve the health of the agricultural environment, organic farming, which primarily forgoes the use of chemicals in agriculture, depends on a comprehensive production and management system. The multitude of microorganisms in the soil under this holistic management method ensures that the soil is alive, active, and productive by keeping it biologically

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active. It is a reality that plants can and do absorb huge amounts of big organic molecules, such as vitamins, chelated minerals, hormones, and other substances that are advantageous to them, refuting the claim that plants only ever take up nutrients in inorganic form. To investigate further, a field experiment was conducted at the Experimental Farm, Department of Agronomy, Annamalai University, Annamalai Nagar, Cuddalore District of Tamil Nadu from June to September 2023 to study the effect of combined application of graded levels of inorganic fertilizers along with organic NPK granules on growth, yield and economics of rice. The experiment was laid out in randomized block design with seven treatments, comprised of different levels of inorganic fertilizers and organic NPK granules. Among the treatments evaluated, application of 70% NPK through inorganic fertilizers and 30% NPK through organic NPK granules registered higher growth, yield attributes and yield of rice. However the net income and benefit cost ratio was observed under application of 100% NPK through inorganic fertilizers which was comparable with application of 70% NPK through inorganic fertilizers and 30% NPK through organic granules. Therefore it can be concluded that combined application of 70% NPK through inorganic fertilizers and 30% NPK through organic granules is an environmental safe and economically viable nutrient management practice for getting higher yield and income from rice and it can be recommended to the rice growers.

Keywords: Economics; inorganic fertilizers; organic NPK granules; rice; yield.

1. INTRODUCTION

Rice is one of the most important food crops and more than half of the world's population depends on rice for their daily calories. It is cultivated over an area of 160.59 million hectares in 114 countries, producing 742.54 million tonnes of rice annually with an average yield of 4.62 t ha^{-1} (USDA, 2022). In Asia and the Pacific, rice is the primary staple food and supplies 21% of dietary energy per more than 90% of the Asian consumes rice Depar *et al*., [1]. Rice is a significant component of Indian agriculture [2,3,4,5]. The tagline "rice is life" is the most fitting for India because this crop is essential to the country's food security and provides a living for millions of people. Most Indian farmers get their living on the paddy crop. India is the country that produces the most rice, with an area under cultivation of 46.37 million hectares, generating an estimated 130.29 million tonnes of rice annually, with a productivity of 2.8 t ha^{1} (MAFW, 2022). In Tamilnadu, Rice is grown on 2.21 million hectares with an average productivity of roughly 3.66 t ha^{1} and a production of 8.07 million tonnes [6].

About 14.29 Mt of India's total rice production is derived from dry-season (rabi) rice, with the remainder coming from wet-season (kharif) rice. Deteriorating soil health, inadequate fertilizer application, a lack of suitable rice types, pest infestation, and frequent floods and droughts are the contributing factors to the decline in rice yields [7]. Among these, a lack of macronutrients and micronutrients has an impact on rice productivity and growth. In India, after green revolution, rice cultivation is mainly depends on inorganic fertilizers. Continues use of inorganic fertilizers larger quantity in the same field year after years affects soil health and crop productivity. Hence there is a shift for organic farming. However organic farming yields somewhat lesser produces when compare to use of inorganic fertilizers and it not enough to meet out the demand of the growing population. Moreover, the availability organic sources are limited for crop production. Therefore, alternate organic sources of nutrients are needed. To solve all the above issues, integrated uses of organic and inorganic fertilizers are more imperative.

The recommended approach for creating a long-lasting integrated plant nutrient system (IPNS) is integrated nutrient management, or INM. The INM is a practice that sustains soil fertility and productivity because it increases the availability of both native and applied soil nutrients during the crop-growing season, synchronizing the plants' time and space-dependent nutrient demands with the availability of nutrients from the labile soil and applied nutrient pools. It also improves and maintains the soil's chemical, biological, and physical health and stops the deterioration of the soil, water, and environment by encouraging carbon sequestration and reducing the amount of fertilizer nutrients that would otherwise leak into water bodies and the atmosphere.

Organic NPK granules are newly developed organic sources of nutrients which contains adequate amount of major nutrients. It releases minerals that are beneficial to the plant, stimulates soil life and also provides a good amount of macronutrients. It increases the minerals' high availability and duration of activity. Using organic NPK granules has two primary benefits: it raises the resilience to pests and diseases and increases the amount of organic carbon in the soil, which improves plant growth, quality, and production. Higher leaching losses are seen and nutrients are supplied more quickly using inorganic fertilizers. Conversely, leaching losses are significantly reduced and nutrients are supplied throughout time by the organic NPK granules. Sustained nutrition delivery improves nutrient utilization efficiency and promotes healthier growth and development. Keeping the above facts in mind, the present investigation was programmed to study effect of organic NPK granules and inorganic fertilizers on productivity and profitability of low land rice.

2. MATERIALS AND METHODS

A field experiment was carried out during *Kuruvai* season (June – September) of 2023 at Annamalai University, Experimental Farm, Cuddalore District in Tamil Nadu to study the combined effect of organic NPK granules and inorganic fertilizers on the productivity and profitability of lowland rice. The experimental field area comes under the North Eastern Agro-Climatic Zone of Tamil Nadu. The experimental farm is geographically located at 11.38º North latitude and 79.72º east longitude with an altitude of + 5.79 m above MSL. The climate of the experimental site is moderately hot. The maximum temperature ranged from 28.2ºC to 40.1ºC with a mean of 34.15ºC, the minimum temperature ranged from 16.8ºC to 25.6ºC with a mean of 21.2ºC and the relative humidity ranged from 77 to 96 per cent. The mean annual rainfall was 1500 mm with a distribution of 80% during the North – East monsoon, 15% during the South – West monsoon, and the remaining 5% as summer showers. 19 days throughout the cropping period saw a total of 327.6 mm of rainfall. The mean daily sunshine of 4.8 hrs day^{-1} was also recorded during the cropping period. The soil is low in available nitrogen (200 kg ha^{-1}), medium in available phosphorus (21 kg ha^{-1}), and high in available potassium (228 kg ha^{-1}).

The experiment was laid put in randomized block design with seven treatments and three replications. The treatments comprised of T_1 – No NPK, T_2 – 100% NPK through inorganic fertilizers, T_3 –100% NPK through organic NPK granules, T_4 – 100% NPK through organic N rich, P rich and K rich Granules, T_5 –70% NPK through inorganic fertilizers and 30% NPK through organic granules, T_6 –30% NPK through inorganic fertilizers and 70% NPK through organic granules, T_7 – 50% NPK through inorganic fertilizers and 50% NPK through organic granules. Short duration rice variety of ADT 43 was chosen for this study. The recommended seed rate of 60 kg ha^{-1}and fertilizer schedule of 120:40:40 kg NPK ha^{-1} was used in this experiment. Organic granules such as Organic NPK granules (5:5:5), N rich (7-1-1), P rich (0.5-15-1), and K rich (0.5-0.5-15) were obtained as a gift samples from Privi Life Sciences Pvt. Ltd. Navi Mumbai. The quantitative assessment of growth, yield parameters and yield were recorded at respective stages of crop growth.

Plant height was measured from ground level to the tip of the top most leaf at tillering, flowering and at harvest from the five randomly selected plants. The average was worked out and expressed in cm. The number of tillers hill^{-1} was recorded by counting the tillers at active tillering stage (DAT) and expressed as number of tillers hill^{-1}. The plants were selected randomly for measuring root length. The entire rice plant was uprooted before observation and roots were washed. The root length was measured from the base of the plant to the root tip individually at tillering and flowering stages and expressed in cm. Root volume was found out by immersing the roots into a measuring cylinder containing a known volume of water. By measuring the increase in the water column, root volume was assessed at tillering and flowering stages of the crop and expressed in cm^3. Plant samples from experimental plots were collected randomly at active tillering, flowering and harvest stages. The collected samples were first air dried and then oven dried at 80ºC $\pm 5^0$ C for 72 hours till a constant weight obtained and the weight was recorded. The mean dry weight was expressed in kg ha^{-1}.

Leaf area index (LAI) of rice at tillering and flowering was worked out without removing the leaves by using the following formula as proposed by Palaniswamy and Gomez (1974)

$$\mathrm{LAI} = \frac{\mathrm{L} \times \mathrm{W} \times \mathrm{K} \times \text{Number of leaves hill}^{-1}}{\text{Spacing (cm}^2)}$$

Where,

L = Maximum length of 3rd leaf blade from the top (cm)

W = Maximum width of the same leaf (cm)
K = Adjustment factor (0.75)

Plot-specific crops were bundled and sun-dried individually. After the grain was washed, each plot was threshed. To get a consistent weight for the final yield measurement, the cleaned grain was sun-dried one more time. The related plot yield was increased by the grain production from pre-tagged hills. The ultimate grain yield was computed and reported in kg/ha, or kilograms per hectare. Every plot's straw was sun-dried to a consistent weight. The related plot yield was increased by the straw from the five labeled hills. The ultimate yield of straw was computed and reported in kg/ha, or kilograms per hectare.

Gross income was calculated using grain and straw yield of rice based on prevailing market price and expressed in rupees ha^{-1}. Net income was calculated by deducting the cost of cultivation from gross income as given below and expressed in rupees ha^{-1}. The BCR was calculated treatment wise by dividing the gross income by total cost of cultivation.The different growth and yield components observed during the course of the investigation were analyzed statistically as per the procedure suggested by Gomez and Gomez (1984). Whenever the results were found significant ('F' test), the critical difference (CD) were arrived at a 5% probability level (P=0.05). Treatment differences that are not significant were denoted by 'NS'.

3. RESULTS AND DISCUSSION

Application of organic NPK granules and inorganic fertilizers significantly influenced the growth, yield and economics of lowland rice. Among the various treatments tried, application of 70% NPK through inorganic fertilizers and 30% NPK through organic granules gave significantly highest plant height (105.4 cm), number of tillers $hill^{-1}$ (17.96), root length (25.47 cm), root volume (26.54 cc), leaf area index (7.65) and dry matter production (11520 $kgha^{-1}$) of rice (Table 1). Increased plant height might be due to the application of mineral fertilizers along with organic manures increased larger concentration of nutrients in the cell – sap which promotes rapid cell division, a differentiation that performed better nutrient mobilization which resulted in maximum stem elongation, faster growth and the cumulative effect of photosynthesis due to increased availability of nutrients that led to increased plant height, number of tiller m^{-2} and dry matter production [8]. The nutrients N, P and K makes the soil more fertile because nitrogen has benefits for plants, namely stimulating the growth of leaves and tillers, as well as the formation of roots. Similar results were also obtained by Sutardi *et al*. [9]. Organic manures have a complex structure which had undergone chemical and enzymatic degradation in lowland soils which became a hormone that together enhanced the root respiration, formation, development and its proliferation [10]. The combination of organic and inorganic fertilizers may facilitate its greater availability and increased uptake of macro and micro nutrients and active participation in carbohydrate assimilation, photosynthesis, and starch formation, translocation of protein and sugar and source to sink activity ended in increased leaf area. This was followed by the application of 50% NPK through synthetic fertilizers and50%NPKthrough organic granules and recorded the values of higher plant height (102.71 cm), number of tillers $hill^{-1}$(17.24), root length (24.28 cm), root volume (25.35 cc), leaf area index (7.31) and dry matter production (11195 kg ha^{-1}) of rice. This was comparable with the application of 100% NPK through synthetic fertilizers. The least values on growth attributes were recorded in absolute control (No NPK).

Regarding grain and straw, addition of 70% NPK through inorganic fertilizers and 30% NPK through organic NPK granules recorded the highest grain yield of 5382 $kgha^{-1}$which was 19.10%, 22.33 % and 51.7 per cent higher over T_3, T_4 and control (Table 2). Similarly, the same treatment recorded the higher straw yield of 8657 kg/ha which was 8.13%, 22.51%, 24.64% and 45.70 per cent higher over T_2, T_3, T_4 and control. This was followed by application of 50% NPK through synthetic fertilizers and50%NPKthrough organic granules which was on par with application of 100% NPK through synthetic fertilizers, which was on par with application of 100% NPK through synthetic fertilizers. The least grain and straw yield was recorded with no NPK treatment. Increase in grain straw yield at 70% NPK through inorganic fertilizers and 30% NPK through organic granules might be due to the fact that adequate levels of nitrogen, phosphorus and potassium in organic NPK granules might have improved respiration, energy transfer, cell division, efficient physiological and metabolic processes resulting in luxuriant vegetative and reproductive growth. The synergistic effect of micronutrients on root development, vegetative and reproductive growth positively impacted the dry matter of the crops. A balanced NPK

Table 1. Effect of organic NPK granules and inorganic fertilizers on growth attributes of rice (*Oryza sativa* L.)

Treatments	Plant height (cm)	Number of tillershill^{-1}	Root length (cm)at flowering	Root volume (cm) at flowering	LAI at flowering	DMP (kg ha^{-1}) at harvest
T_1 – No NPK	89.97	13.98	20.70	19.56	5.77	9548
T_2 – 100% NPK through inorganic fertilizers	100.86	16.70	24.28	24.34	7.07	10898
T_3 –100% NPK through organic NPK granules	94.99	15.24	22.89	21.89	6.38	10215
T_4 – 100% NPK through organic N rich, P rich and K rich Granules	92.98	14.71	22.05	20.90	6.16	9920
T_5 –70% NPK through inorganic fertilizers and 30% NPK through organic granules	105.4	17.96	25.47	26.54	7.65	11520
T_6 –30% NPK through inorganic fertilizers and 70% NPK through organic granules	98.00	15.92	23.07	23.13	6.75	10564
T_7 – 50% NPK through inorganic fertilizers and 50% NPK through organic granules	102.71	17.24	24.28	25.35	7.31	11195
S.Ed	1.06	0.28	0.42	0.46	0.13	152.65
C.D (p=0.05)	2.32	0.61	1.14	1.14	0.29	310.00

Table 2. Effect of organic NPK granules and inorganic fertilizers on grain and straw yield of rice (*Oryza sativa* L.)

Treatments	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
T_1 – No NPK	2600	4700
T_2 – 100% NPK through inorganic fertilizers	4974	7953
T_3 –100% NPK through organic NPK granules	4354	6708
T_4 – 100% NPK through organic N rich, P rich and K rich Granules	4180	6524
T_5 –70% NPK through inorganic fertilizers and 30% NPK through organic granules	5382	8657
T_6 –30% NPK through inorganic fertilizers and 70% NPK through organic granules	4664	7395
T_7 – 50% NPK through inorganic fertilizers and 50% NPK through organic granules	5152	8273
S.Ed	88	137
C.D (p=0.05)	187	290

Table 3. Effect of organic NPK granules and inorganic fertilizers on economics of rice (*Oryza sativa* L.)

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	BCR
T_1 – No NPK	31,495	51,500	20,005	1.63
T_2 – 100% NPK through inorganic fertilizers	46,023	97,485	51,462	2.12
T_3 –100% NPK through organic NPK granules	82,920	85,080	2,160	1.02
T_4 – 100% NPK through organic N rich, P rich and K rich Granules	86,670	81,764	-4,906	0.94
T_5 –70% NPK through inorganic fertilizers and 30% NPK through organic granules	54,735	1,05,533	50,798	1.93
T_6 –30% NPK through inorganic fertilizers and 70% NPK through organic granules	76,012	91,347	15,335	1.20
T_7 – 50% NPK through inorganic fertilizers and 50% NPK through organic granules	62,255	1,01,009	38,754	1.62

fertilization boosted nutrient uptake in rice which might have stimulated more enzymes for carbohydrate and protein metabolism that caused a rise in the photosynthetic activity which in turn reflected in the reproductive growth [11]. Besides nutrient contribution from the soil for realizing better crop growth and development, physiological progressions like higher chlorophyll content, soluble protein, nitrate reductase activity thus enhancing the source-sink relationship and formation of yield attributes ultimately increasing the seed and straw yield in lowland rice [12]. Improved vegetative growth due to the application of organic NPK granules and inorganic fertilizers throughout the crop period helps in better translocation of the source to the reproductive sink which showed an increment in the yield attributing characters thus increasing the yield of the crop [11].

With respect to economics, Application of 100% synthetic fertilizers recorded the highest net income of Rs.51,462 ha^{-1} and benefit cost ratio of 2.12 (Table 3). The higher grain yield and higher market value of the produce enhanced the net income and BCR of rice [9 and 13]. However, this was comparable with application of 70% NPK through synthetic fertilizers and 30% NPK through organic NPK granules and recorded the net income of Rs.50,798 ha^{-1} and benefit cost ratio of 1.93 [14].

4. CONCLUSION

The experimental results showed that there was a marked variation in the growth and yield of rice due to application of organic NPK granules and graded levels of inorganic fertilizers. In light of the above-mentioned facts, it can be concluded that combined application of 70% NPK through synthetic fertilizers and 30% NPK through organic granules (T_5) was the optimal nutrient management strategy to enhance the productivity and profitability of rice and it can be recommended to the farming community, especially under lowland conditions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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