International Journal of Plant & Soil Science

Volume 36, Issue 9, Page 946-951, 2024; Article no.IJPSS.124574
ISSN: 2320-7035

Effect of Integrated Nutrient Management on 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.

Article Information

DOI: https://doi.org/10.9734/ijpss/2024/v36i95045

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/124574

Original Research Article

Received: 25/07/2024
Accepted: 27/09/2024
Published: 30/09/2024

ABSTRACT

The present investigation was carried out during *kharif* season of 2022 and 2023 at Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.). The experiment consisted of fourteen different treatments in randomized block design replicated thrice. Soil of the experimental field was sandy loam in texture and slightly alkaline in reaction. The results showed that, on a pooled data basis, the highest grain yield (42.45 q/ha) was achieved with treatment T_8, which involved the application of 75 % NPK + FYM + Consortia + Nano

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Cite as: *Yadav, Praveen Kumar, Ravindra Kumar, Anil Kumar, Sanjeev Sharma, Munish Kumar, and Sanjeev Kumar. 2024. "Effect of Integrated Nutrient Management on Yield and Economics of Rice". International Journal of Plant & Soil Science 36 (9):946-51. https://doi.org/10.9734/ijpss/2024/v36i95045.*

Zinc. Similarly, higher straw yields of 69.23 q/ha and 67.00 q/ha were recorded during both years, with T_8 also yielding the maximum straw on a pooled basis, followed closely by T_{14}. Pooled data analysis revealed that T_8 achieved the highest grain and straw yields, along with the maximum Benefit-Cost (B: C) ratio of 3.42. The control (T_1) consistently recorded the lowest grain and straw yields across both years. The inclusion of FYM, Consortia, and Nano Zinc in INM treatments significantly improved yield performance and soil health, making T8 the most economically viable treatment.

Keywords: B: C ratio; consortia; economics; FYM; nano zinc; yield.

1. INTRODUCTION

"Rice (*Oryza sativa L.)* is the staple food to feed over half of the world's population. Use of inorganic fertilizers has several negative impacts on soil fertility. Presently; use of organic sources is slowly mushrooming up over the globe due to its scientifically proven beneficial effects. In India, rice is grown in about 47.05 million hectares with a production level of 135.54 million tones and the productivity is about 2781 kg/ha. There is an ample scope to increase the productivity of rice. To increase the productivity of rice, it is important to maintain the fertility and organic matter status of soil. Integrated fertilizer and organic manure nutrient management is one of the viable options for preserving soil quality with regard to crop productivity" (Bajpai et al*.,* 2006). Organic manures serve as the carbon and energy source for proliferation of microorganisms which may alter the activities of different enzymes. Incorporating organic manures into the soil not only influences the chemical and biological environment but also impacts nutrient availability for crop plants and microorganisms [1,2,3,4]. A promising approach is to develop effective fertilization strategies that can encourage agricultural sustainability by promoting soil microbial biomass and operation by integrating organic modifications with reduced chemical fertilizer (Mandal et al., 2007). The quality parameters of scented rice are improved by biofertilizers alone or in combination with organic manure (Dixit & Gupta, 2000; Quyen & Sharma, 2003). To supplement part of the nitrogen requirement with ecological and economic significance, blue green algae (BGA) and Azospirillum can be successfully used in wetland rice [5].

Farm yard manure (FYM) is the most commonly used organic manure in most countries of the world. The application of farmyard manure improves soil structure, enhances nutrient exchange, and maintains soil health, making it highly beneficial for Integrated Nutrient Management (INM) or organic farming. FYM is a heterogeneous composted organic material consisting of dung, crop residue, and household sweeping in various stages of decomposition. It also had effect on residual phosphorus and potassium in soil [6-8]. FYM is rich in nutrients and contains 0.5 % Nitrogen, 0.2 % Phosphorus and 0.5 % Potassium. Application of FYM improves soil fertility and soil physical properties like soil structure, aeration, water holding capacity etc. Generally, the enzyme activities in the soil are closely related to the organic matter content and strongly influenced by the hydrothermal regimes [9,10,11]. Enzyme catalyzes all biochemical reactions and are an integral part of nutrient cycling in soil and these are sensitive indicators of soil ecological stress or other environmental changes. The main microbial enzymes involved in the mineralization of soil organic matter are cellulases, dehydrogenases, acid and alkaline phosphatase activity, proteases; nitrogen fertilization is the most important management strategy for the improvement of agricultural crops (Dotaniya et al*.,* 2019).

2. MATERIALS AND METHODS

Two successive field experiments were conducted during kharif 2022 and 2023 at the Crop Research Centre of Chandra Shekhar Azad University of Agriculture and technology Kanpur, Uttar Pradesh. Soil of the experimental field was sandy loam in texture and slightly alkaline in reaction. The experiment consisted fourteenth (14) treatments of INM based like that's Control (T_1) , 100 % N P K (T_2), 75 % NPK + FYM @ 5 ton/ha (T_3), 75 % NPK + NPK Consortia (T_4), 75 % NPK + FYM @ 5 ton /ha + Consortia (T_5), 75 % NPK + FYM @ 5 ton/ha + Nano zinc (T_6), 75 % NPK + Consortia + Nano zinc (T_7), 75 % NPK + FYM @ 5 ton/ha + Consortia + Nano zinc (T_8), 50 % NPK + FYM @ 5 ton/ha (T_9), 50 % NPK + Consortia (T_{10}), 50% NPK + FYM @ 5 ton/ha + Consortia (T_{11}), 50 % NPK + FYM @ 5 ton/ha + Nano zinc (T_{12}), 50 % NPK + Consortia + nano zinc (T_{13}), 50 % NPK + FYM @ 5 ton/ha + Consortia + Nano zinc (T_{14}) were applied in randomized block design with three replications. The recommended doses of phosphorus (P) and potassium (K) were applied in all treatments, except for the control. Rice variety (Pusa Basmati-1509) was transplanted in plant geometry (Row to row spacing 20 cm and plant to plant spacing 10 cm) on 16 July during 2022 and 2023. Recommended dose of fertilizer i.e. 120 kg N and 60 kg P and 40 kg / ha was applied through Urea, DAP and MOP with the FYM Consortia and Nano zinc. Whole of nitrogen, phosphorus and potassium and FYM was applied at planting while root of paddy nursery dipped in Consortia and transplanted in field. Nano zinc spray at 30, 60 DAT. After threshing each plot (3.2×3= 9.6 m^2) individually, the grains were cleaned, and their weight was recorded in kg/plot. This yield was then converted to a per-hectare basis. The observations collected during the study were organized into tables and analyzed statistically to reach valid conclusions.

2.1 Observation Recorded

2.1.1 Grain yield (q ha^{-1})

After cleaning and drying the grains, the grain yield was recorded in kg per plot. The moisture percentage in 100 g samples drawn from each treatment was determined with the help of moisture meter and grain yield per plot was adjusted to 14 per cent moisture. The yield of net plot, thus converted into q ha^{-1}.

2.1.2 Straw yield (q ha^{-1})

The straw yield of each net plot will be worked out by deducting the grain yield from the biological yield of each plot. Finally, the straw yield will be computed on hectare basis and expressed in q ha^{-1}.

2.1.3 Economics of treatments

The cost of cultivation was calculated by taking into account the cost of seed, fertilizer, herbicide and the hiring charges of labour and machines for land preparation, irrigation, fertilizer application, plant protection, harvesting and threshing and the time required per hectare to complete an individual field operation. Cost of irrigation was calculated by multiplying time (h) required to irrigate a particular plot, consumption of diesel by the pump (1 h^{-1}) and cost of diesel. Gross income is the minimum support price offered by the Government of India for rice. Net income was calculated as the difference between gross income and total cost.

3. RESULTS AND DISCUSSION

3.1 Grain Yield

The data presented in Table 1 indicate that all treatments significantly increased grain yield compared to the control. The highest grain yields, 40.13 q ha^{-1} in the first year and 43.12 q ha^{-1} in the second year, were recorded with treatment T8 (75% NPK + Consortia + FYM @ 5 tons/ha + Nano Zinc). The control plot (T_1) produced the lowest yields, with 18.29 q ha^{-1} in the first year and 20.66 q ha^{-1} in the second year. On a pooled data basis, the maximum grain yield was 41.62 q ha^{-1}, followed by 39.85 q ha^{-1} in T_{14} (50% NPK + Consortia + FYM @ 5 tons/ha + Nano Zinc), with the lowest yield of 18.98 q ha^{-1} recorded in the control with application of FYM, Consortia, and Nano zinc obtained 52 % more yield as compared to only NPK application. The addition of farmyard manure (FYM) improves soil structure, moisture retention, and microbial activity, which in turn supports better root growth and nutrient uptake. Nano Zinc, a micronutrient, helps in improving enzymatic functions and photosynthesis, leading to more efficient plant metabolism and higher grain yield. Similar findings were reported by Sangeeta et al. (2020), Sravan et al. (2020) and Singh et al., [12].

3.2 Straw Yield

The data in Table 1 show that straw yield was significantly affected by nutrient applications in both years of the study. In the first year, straw yield ranged from 41.84 to 73.41 q ha^{-1}, while in the second year it varied from 44.15 to 79.11 q ha^{-1}. The highest straw yield was recorded in T_8 (75 % NPK + Consortia + FYM @ 5 tons/ha + Nano Zinc), with 73.41 q ha^{-1} in the first year and 79.11 q ha^{-1} in the second year, followed by T_{14} (50% NPK + Consortia + FYM @ 5 tons/ha + Nano Zinc). The control plot produced the lowest straw yields, 41.84 q ha^{-1} in 2022 and 44.15 q ha^{-1} in 2023. Based on pooled data, the maximum straw yield was 76.26 q ha^{-1} in T_8, while the minimum was 43.00 q ha^{-1} in the control. The lower yields in the control plot emphasize the importance of balanced nutrient management, as the absence of these supplemental inputs limits plant growth and biomass production. Similar findings were reported by Shahni et al. [13], Kumar et al., [14] and Ruan et al., [15].

Table 1. Effect of integrated nutrient management on yield of rice

Treatment Symbol	Treatment Combination	Grain yield (q/ha)			Straw yield (q/ha)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T_1	Control (Absolute)	18.92	20.66	19.79	41.84	44.15	43.00
T_2	100% NPK	23.64	26.60	25.12	49.55	53.81	51.68
T_3	75% NPK + FYM @ 5 ton/ha	27.31	30.74	29.02	54.24	58.92	56.58
T_4	75% NPK + NPK Consortia	28.46	32.04	30.25	55.37	60.14	57.76
T_5	75% NPK + FYM @ 5 ton /ha + Consortia	32.44	36.55	34.49	59.90	65.08	62.49
T_6	75% NPK + FYM @ 5 ton/ha + Nano zinc	33.76	38.05	35.90	61.10	66.37	63.74
T_7	75% NPK + Consortia + Nano zinc	35.68	40.46	38.07	62.59	68.38	65.49
T_8	75% NPK + FYM @ 5 ton/ha + Consortia + Nano zinc	40.13	43.12	41.62	71.41	77.11	74.26
T_9	50% NPK + FYM @ 5 ton/ha	24.49	27.55	26.02	50.71	55.08	52.90
T_{10}	50% NPK + Consortia	25.95	29.20	27.58	52.63	57.16	54.89
T_{11}	50% NPK + FYM @ 5 ton/ha + Consortia	29.67	33.42	31.55	56.57	61.45	59.01
T_{12}	50% NPK + FYM @ 5 ton/ha + Nano zinc	31.35	35.32	33.33	58.56	63.61	61.08
T_{13}	50% NPK + Consortia + nano zinc	34.90	39.34	37.12	62.45	67.84	65.15
T_{14}	50% NPK + FYM @ 5 ton/ha + Consortia + Nano zinc	38.34	41.36	39.85	67.66	73.48	70.57
	SEM(+/-)	**1.12**	**1.30**	**0.86**	**1.30**	**1.40**	**0.96**
	C.D.at 5% of level	**3.25**	**3.77**	**2.43**	**3.79**	**4.08**	**2.72**

Table 2. Effect of integrated nutrient management on economics of rice

S. No	Treatment Symbol	Treatment Combination	Total cost of cultivation (₹)	Gross Return (₹/ha)	Net Return (₹/ha)	B:C
1	T_1	Control (Absolute)	34312	87760	53448	1.56
2	T_2	100% NPK	39883	126320	86437	2.17
3	T_3	75% NPK + FYM @ 5 ton/ha	45982	144370	98388	2.14
4	T_4	75% NPK + NPK Consortia	38916	149880	110964	2.85
5	T_5	75% NPK + FYM @ 5 ton /ha + Consortia	46416	169205	122789	2.65
6	T_6	75% NPK + FYM @ 5 ton/ha + Nano zinc	49982	175470	125488	2.51
7	T_7	75% NPK + Consortia + Nano zinc	42916	185025	142109	3.31
8	T_8	75% NPK + FYM @ 5 ton/ha + Consortia + Nano zinc	50416	222650	172234	3.42
9	T_9	50% NPK + FYM @ 5 ton/ha	44606	130530	85924	1.93
10	T_{10}	50% NPK + Consortia	37540	137765	100225	2.67
11	T_{11}	50% NPK + FYM @ 5 ton/ha + Consortia	45040	155705	110665	2.46
12	T_{12}	50% NPK + FYM @ 5 ton/ha + Nano zinc	48606	163860	115254	2.37
13	T_{13}	50% NPK + Consortia + nano zinc	41540	181055	139515	3.36
14	T_{14}	50% NPK + FYM @ 5 ton/ha + Consortia + Nano zinc	51540	202685	151145	2.93

3.3 Economics

The economic analysis of any experimental research is crucial for identifying the most beneficial treatment combination from both the perspective of soil health and the farmer's profitability. While treatments with higher chemical fertilizer usage may result in the highest net returns and lower cultivation costs compared to those incorporating organic sources, such treatments cannot be recommended from a soil health perspective. The maximum cost of cultivation was incurred under T14 and T8, amounting to Rs. 50,416.00 and Rs. 51,560.00 during 2022 and 2023, respectively. The highest gross return was achieved with the application of 75 % NPK + FYM @ 5 tons/ha + Consortia + Nano Zinc. Net returns were highest under T_8 in both 2022 and 2023. Although T14 did not provide higher returns during these years, it is more beneficial for soil health due to the inclusion of FYM (organic source), Consortia biofertilizer, and Nano Zinc, which enhance the soil's physical, chemical, and biological properties. The benefit-cost (B:C) ratio was found to be the highest under T_8 (3.42) on a pooled data basis, owing to its comparatively lower cost of cultivation, while the lowest ratios were observed under T_1 (1.45 and 1.67) during 2022 and 2023. Similar findings were reported by Imade et al. [16] and Sharma et al. [17].

4. CONCLUSION

To achieve maximum yield of rice grain and straw yield during Kharif season, an integrated nutrient management system of application of 75 % NPK + FYM @ 5 ton/ha + Consortia + Nano zinc seems better one since grain and straw yield in these treatment was maximum and also maximum b:c ratio found which is more profitable compare to other.

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 this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/124574