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Evaluation of different organic manure of rice productivity and soil chemical indicator in a *vertisol*

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Abstract
The study conducted Research cum Instructional Farm IGKV, Nutrients play a crucial role in maximizing crop productivity and their supply is predominantly met through chemical fertilizers such as urea, DAP and muriate of potash. However, the current challenges in the availability and escalating cost of these fertilizers necessitate exploring alternative nutrient sources. In this context, a field experiment was conducted during *kharif* 2024-25 at the Research-cum-Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh), to evaluate the potential of different organic manures as substitutes for chemical fertilizers in sustaining crop productivity and improving soil fertility under rice cultivation. The experiment was laid out in a Randomized Block Design comprising seven treatments with four replications. The treatments included: T_1-Control, T_2-100% RDF (100:60:40 kg N:P:K ha^{-1}), T_3-100% FYM (24t ha^{-1}), T_4-100% Vermicompost (10t ha^{-1}), T_5-100% Poultry manure (10t ha^{-1}), T_6-100% Kitchen waste compost (10 t ha^{-1}) and T_7-100% Cow dung (24 t ha^{-1}).

The results of one season indicated that the application of 100% RDF (T_2) was most effective in enhancing growth, yield attributes, yield, nutrient uptake, nutrient use efficiencies and economic returns. The treatment T_2 recorded the highest total tillers hill^{-1} (9.6), effective tillers hill^{-1} (6.5), grains panicle^{-1} (127), panicle length (23.55 cm), panicle weight (4.50 g), grain yield (61.62 q ha^{-1}), straw yield (78.12 q ha^{-1}), harvest index (44.11%) and yield increase over control (189%). The maximum test weight (18.48 g) was observed in T_7 (Cow dung). Nutrient uptake was also significantly higher under T_2, with N, P and K uptake values of 105.04, 18.46 and 163.00 kg ha^{-1}, respectively. Similarly, the highest partial factor productivity, agronomic efficiency and recovery efficiency for N, P and K were observed under T_2.

Regarding soil properties, organic manure treatments showed positive effects on soil health. Treatments with poultry manure (T_5), cow dung (T_7), FYM (T_3) and vermicompost (T_4) maintained favorable soil pH (7.20), EC (0.33 dS m^{-1}) and organic carbon (0.60%). Available N (212.00 kg ha^{-1}), P (18.95 kg ha^{-1}) and K (440.21 kg ha^{-1}) were highest under T_6, T_2 and T_3, respectively. Micronutrient availability was also enhanced under organic manures, with Fe (12.36 ppm) and Mn (7.36 ppm) highest in T_4, Cu (1.38 ppm) in T_5 and Zn (0.65 ppm) in T_3. Correlation analysis revealed that available N was the most critical factor influencing rice yield. The highest benefit-cost ratio (2.93) was recorded in T_2, followed by T_3 (2.77). Overall, the study concluded that while 100% organic manure applications could not match the yield levels obtained with RDF, they played a significant role in sustaining and improving soil nutrient status.

Keywords: Organic manure, rice productivity, vertisol, soil chemical properties, nutrient availability, soil fertility, soil organic carbon, nitrogen, phosphorus and potassium

Introduction

- Soil, is a fundamental natural resource supporting a variety of ecosystem functions and services to the benefit of the mankind.
- However, the current production process to fulfil the food requirement of ever-increasing population, it has been the tremendous pressure on soil ecosystem health to increase the productivity per unit area under indiscriminate use of fertilizer
- In such scenario there is a need to evaluate different sources of organic manure that can replace excess use of chemical fertilizer to maximize productivity and sustain soil health with respect to soil nutrient status and factor productivity.

Materials and Methods

The present investigation entitled "Evaluation of different organic manures on rice productivity and soil chemical indicator in a *Vertisol*" was conducted at STCR field-Instruction cum research farm, College of Agriculture, IGKV, Raipur, (C.G.) during the year 2024-25. The experiment was carried out to study the yield attributes, yield of rice, nutrient uptake, balance factor, productivity, soil chemical indicators and relationship between crop yield and soil chemical indicators as influence by different organic manures. The details of experimental techniques, materials used and methods adopted for treatment evaluation during the course of investigation.

Table 1: Details of Experiment

Crop	:	Rice (*Oryza sativa* L.)
Variety	:	Chhattisgarh Dhan 1919
Season	:	Kharif 2024-25
Soil type	:	Vertisol
Design	:	Randomized Block Design (RBD)
Replications	:	04
Treatments	:	07
Plot size	:	6m x 5m=30m^2
Total no. of plots	:	28
Spacing (Row to Row)	:	20 cm
RDF (N: P2O5:K2O)	:	120:60:40 kg ha^{-1}
Date of transplanting	:	06 August, 2024
Date of harvesting	:	21 November, 2024

Table 2: Details of treatment used in the present study

Notations used	Treatments
T_1	Control
T_2	RDF (100:60:40 kg ha^{-1})
T_3	100% FYM (24 tha^{-1})
T_4	100% Vermicompost (10 t ha^{-1})
T_5	100% Poultry manure (10 t ha^{-1})
T_6	100% Kitchen waste (10 t ha^{-1})
T_7	100% Cow dung (24 t ha^{-1})

***RDF:** Recommended Dose of Fertilizer (120:60:40 kg ha^{-1}), (N: P_2O_5:K_2O)

Table 3: Nutrient status of organic manure used in the study

S. No	Organic manure	Available N (%)	Available P (%)	Available K (%)	pH	EC
1	Vermicompost	1.30	0.80	0.80	7.06	1.00
2	Cow dung	0.50	0.20	0.20	6.95	0.20
3	Kitchen waste	1.20	1.5	1.20	8.11	1.03
4	Poultry	1.20	0.80	0.80	6.64	1.78
5	FYM	0.50	0.30	0.60	6.63	0.89

Table 4: Amount of nutrient applied by different organic manure based on nutrient status

	Organic manure	Applied N (kg ha^{-1})	Applied P (kg ha^{-1})	Applied K (kg ha^{-1})
1	Vermicompost	130	80	80
2	Cow dung	120	48	48
3	Kitchen waste	120	150	120
4	Poultry	120	80	80
5	FYM	120	72	144

Results and Discussions

Yield attributes

Results revealed that both organic manures and the recommended dose of fertilizer (RDF) significantly influenced the total tillers per hill and effective tillers per hill of rice compared to the control. Among the treatments, the maximum total tillers (9.6) and effective tillers (6.5) per hill were recorded under T_2 (RDF), while the minimum values (5.4 and 3.5, respectively) were observed in T_1 (Control). The superior performance of RDF may be attributed to its ability to provide a balanced and readily available supply of essential macro and micro-nutrients, which are critical for key physiological processes in rice. RDF also improves soil physical and chemical properties, enhancing nutrient availability and overall soil fertility.

The comparatively lower performance of organic manures in tiller production may be due to the slow mineralization of organic manures applied to soil, resulting in a delayed and reduced nutrient release, which is insufficient to meet the crop's immediate requirements. These findings are in agreement with the reports of Biswal *et al.* (2021) [2], Dhaliwal *et al.* (2023) [4] and Baghel *et al.* (2024) [1] in rice.

Table 5: Effect of different organic manure and RDF on Total tillers and effective tillers of Rice

Notation	Treatments	Effective tillers hills^{-1}	Total tiller hills^{-1}
T_1	Control	5.4^c	3.5^c
T_2	100% RDF	9.6^a	6.5^a
T_3	100% FYM	7.2^b	5.3^b
T_4	100% Vermicompost	7.6^b	5.7^b
T_5	100% Poultry manure	7.2^b	5.2^b
T_6	100% Kitchen waste	7.3^b	5.5^b
T_7	100% Cow dung	7.2^b	5.3^b
	SE(m) ±	0.33	0.17
	C.D. at 5%	0.69	0.52

Note: The superscript letters signifies that the treatment means with similar letters are *at par* at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD-value comparison of treatment means

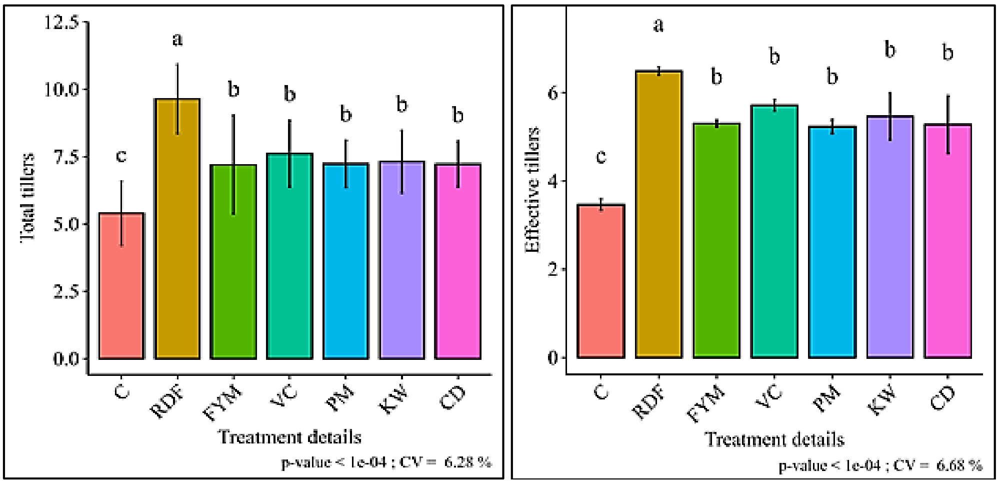
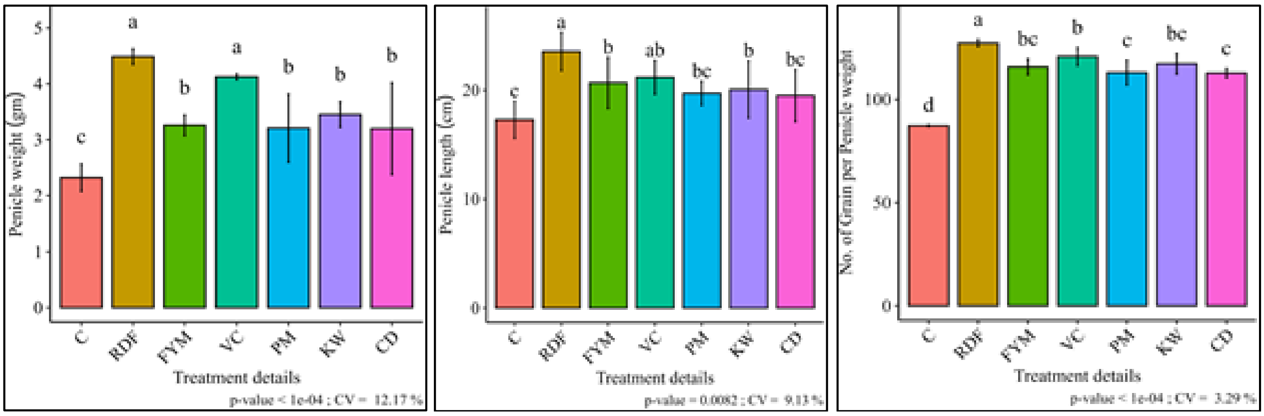


Table 6: Effect of different organic and RDF application on number of grains, panicle length, panicle weight and test weight of rice

Notations	Treatments	No of grains per panicle	Panicle length	Panicle weight	Test weight (g)
T_1	Control	87^{d}	17.28^{c}	2.32^{c}	18.22
T_2	100% RDF	127^{a}	23.55^{a}	4.50^{a}	18.36
T_3	100% FYM	116^{bc}	20.67^{b}	3.30^{b}	18.29
T_4	100% Vermicompost	121^{b}	21.17^{ab}	4.12^{a}	18.32
T_5	100% Poultry manure	113^{c}	19.71^{bc}	3.21^{b}	18.40
T_6	100% Kitchen waste	117^{bc}	20.06^{b}	3.45^{b}	18.45
T_7	100% Cow dung	112^{c}	19.50^{bc}	2.32^{c}	18.48
		SE(m) ±	1.86 1.31	0.30	0.10
		C.D. at 5%	5.54 2.75	0.62	NS

Note: The superscript letters signifies that the treatment means with similar letters are *at par* at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD-value comparison of treatment means.



As per the data presented in Table 6, different organic manure and RDF treatments significantly influenced the number of grains per panicle, panicle length, panicle weight and test weight of rice. The maximum values for grains per panicle, panicle length, panicle weight and test weight (127, 23.55 cm, 4.50 g and 18.48 g) were recorded under T_2 (Recommended Dose of Fertilizer, RDF) and T_7 (100% Cow Dung), whereas the minimum values (87, 17.28 cm, 2.32 g and 18.22 g) were observed in T_1 (Control, no fertilizer or organic amendment).

Table 7: Effect of different organic and RDF application on grain yield, straw yield, harvest index and magnitude changes in yield of Rice

Notations	Treatments	Grain yield (q ha-1)	Straw yield (q ha-1)	Harvest index (%)	Magnitude changes in yield
T_1	Control	21.33^{d}	28.35^{c}	42.77^{a}	-
T_2	100% RDF	61.62^{a}	78.12^{a}	44.11^{a}	189
T_3	100% FYM	55.57^{bc}	68.16^{b}	42.56^{a}	137
T_4	100% Vermicompost	51.32^{b}	29.10^{b}	42.62^{a}	141
T_5	100% Poultry manure	47.28^{c}	66.94^{b}	41.35^{a}	122
T_6	100% Kitchen waste	49.25^{bc}	67.81^{b}	42.08^{a}	131
T_7	100% Cow dung	49.25^{bc}	66.32^{b}	42.63^{a}	131
	SE(m) ±	1.90	1.37	1.42	-
	C.D. at 5%	5.65	4.07	4.20	-

Note: The superscript letters signifies that the treatment means with similar letters are *at par* at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD-value comparison of treatment means.

The superior performance of RDF can be attributed to the balanced and readily available supply of macro and micro-nutrients, which promotes longer panicles, higher grain formation, greater panicle weight and improved test weight. In contrast, the relatively lower performance of organic manure treatments is likely due to the slow mineralization of organic materials, resulting in a delayed nutrient release that may not fully meet the crop's nutrient demand during critical stages of panicle initiation and grain development. These findings are in agreement with Jothi *et al.* (2021) [5], and Moe *et al.* (2023) [7] in rice.

The observed superiority of RDF in enhancing rice productivity can be attributed to the balanced and readily available supply of essential nutrients, which supports optimal vegetative growth, efficient photosynthesis and assimilate translocation to developing grains. Adequate nutrient availability during critical growth stages ensures a higher number of panicles, better grain filling and improved partitioning of assimilate, reflected in an enhanced harvest index. In contrast, the relatively moderate performance of organic manures is primarily due to the slow mineralization of nutrients. The gradual release of nitrogen, phosphorus and potassium from organic sources often does not coincide with the crop's peak nutrient demand during tillering, panicle initiation and grain filling. Additionally, variability in nutrient content and the higher carbon-to-nitrogen ratio in some organic amendments can temporarily immobilize nutrients, limiting their immediate availability to the plant. Despite this, organic manures play a crucial role in improving soil structure, enhancing microbial activity and maintaining long-term soil fertility, which contributes to sustainable productivity over time.

These findings highlight the importance of synchronizing nutrient supply with crop demand. While RDF ensures rapid nutrient availability and immediate yield benefits, organic manures may offer the dual advantage of high productivity and soil sustainability. The study aligns with previous research indicating that balanced fertilization enhances growth and yield attributes more effectively than sole organic amendments, while organic manures support long term soil health and fertility (Paul *et al.*, 2013; Sangeetha *et al.*, 2013; Pawar *et al.*, 2017; Sathiyabama *et al.*, 2021) [8, 10, 9, 11].

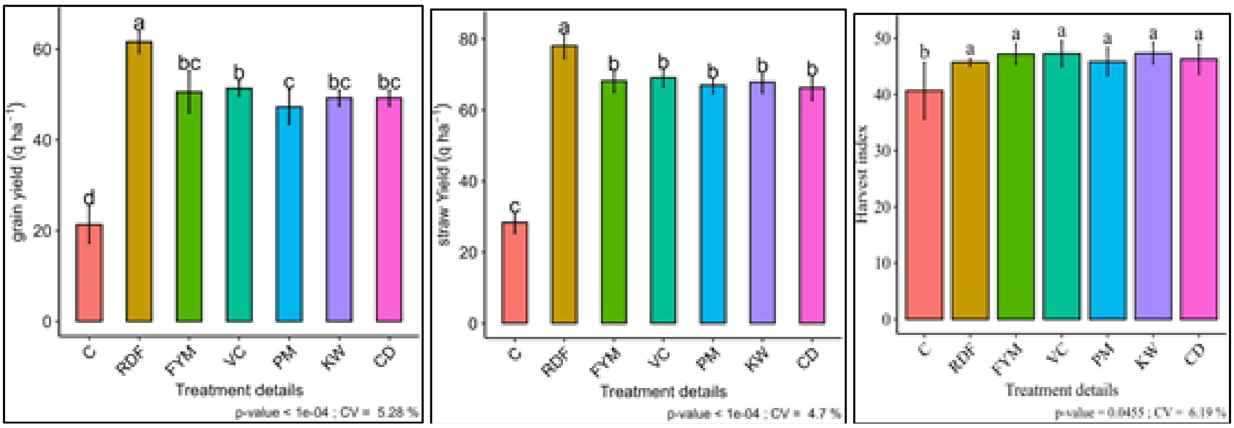
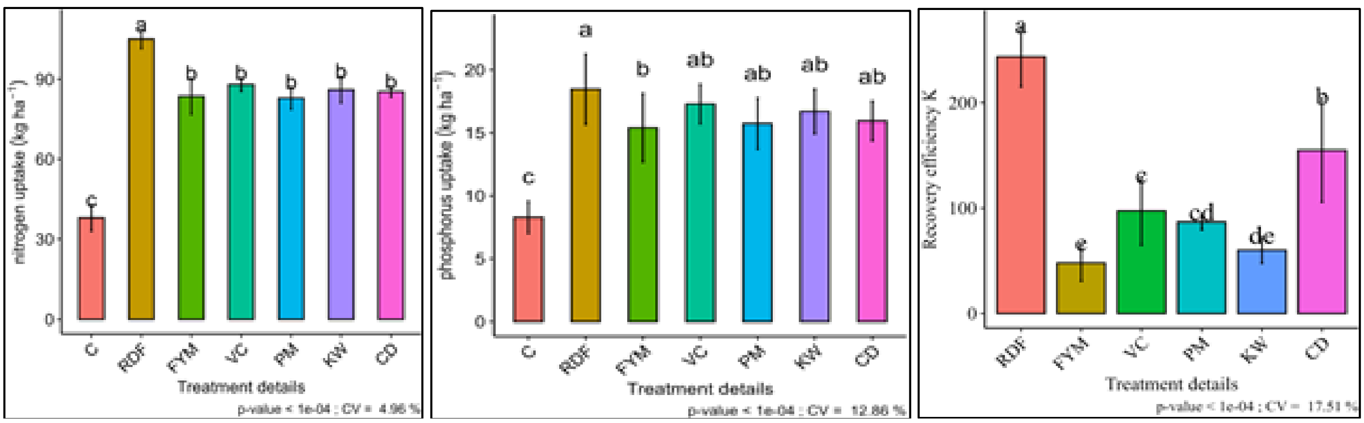


Table 8: Effect of different organic manure and RDF on N P K uptake of Rice

Notations	Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
T_1	Control	38.02^c	8.27^c	65^c
T_2	100% RDF	105.04^a	18.46^a	163^a
T_3	100% FYM	83.61^b	15.40^b	135^b
T_4	100% Vermicompost	88.01^b	17.29^{ab}	143^{ab}
T_5	100% Poultry manure	82.90^b	15.72^{ab}	135^b
T_6	100% Kitchen waste	86.05^b	16.69^{ab}	137^b
T_7	100% Cow dung	85.30^b	15.92^{ab}	140^b
	SE(m) ±	2.35	0.97	6.28
	C.D. at 5%	6.99	2.88	18.64

Note: The superscript letters signifies that the treatment means with similar letters are *at par* at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD-value comparison of treatment means.



The findings of the present study indicate that nutrient management through different organic manures and RDF had a pronounced effect on the uptake of N, P and K by rice. The superior nutrient uptake observed under RDF (T_2) can be attributed to the balanced and readily available supply of essential macro-nutrients, which promotes vigorous vegetative growth, enhanced root development and improved nutrient absorption from the soil. The higher N, P and K uptake under RDF is also a result of better synchrony between nutrient availability and crop demand, ensuring that nutrients are accessible during critical growth stages such as tillering, panicle initiation and grain filling.

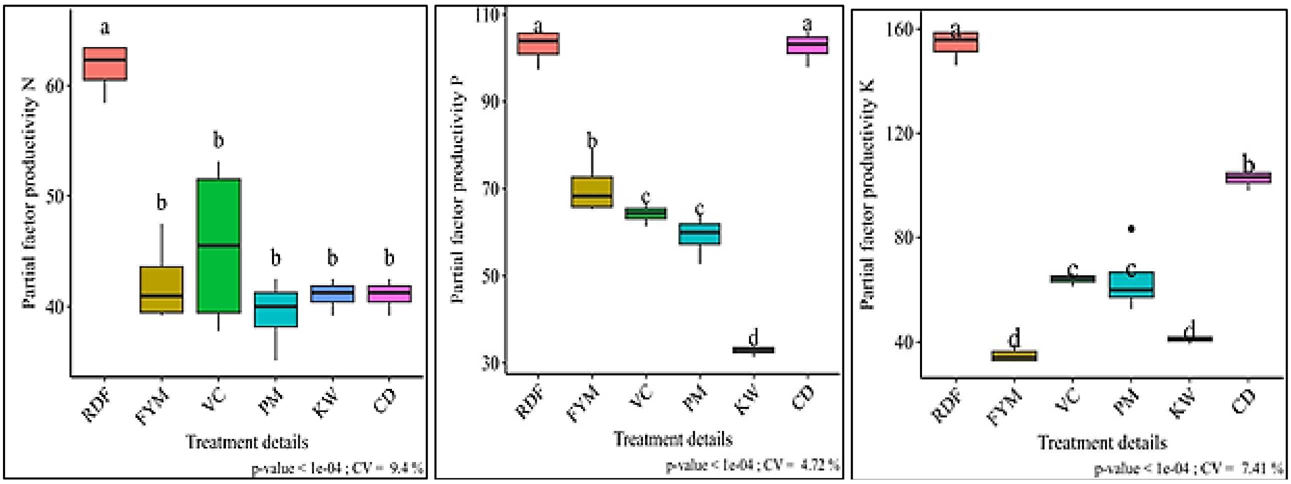
In contrast, the comparatively moderate nutrient uptake under organic manures is primarily due to the gradual mineralization of nutrients, which delays their availability to the crop. Nitrogen in organic amendments is released slowly through microbial decomposition, phosphorus may remain in less soluble forms and potassium release can be limited depending on the source and soil characteristics. As a result, nutrient availability during peak demand periods is sometimes insufficient, leading to moderate uptake levels compared to chemical fertilizers.

Furthermore, the higher nutrient uptake under RDF not only increases the concentration of N, P and K in plant tissues but also enhances overall biomass and grain production, thereby amplifying total nutrient accumulation. Organic manures, while slower in supplying nutrients, contribute to long-term soil fertility, organic carbon content and microbial activity, which are essential for sustainable crop production.

The observations are in agreement with earlier studies by Choudhary *et al.* (2009) [3], Biswal *et al.* (2021) [2] and Baghel *et al.* (2024) [1], which also reported that balanced fertilization improves nutrient uptake, growth and yield in rice.

Table 9: Nutrient factor productivity of NPK

Notations	Treatments	Partial factor productivity N	Partial factor productivity P	Partial factor productivity K
T_1	Control	61.62^a	8.27^c	65^c
T_2	100% RDF	61.62^a	102.70^a	154.06^a
T_3	100% FYM	42.14^b	70.24^b	35.15^d
T_4	100% Vermicompost	45.48^b	64.15^{bc}	64.15^c
T_5	100% Poultry manure	39.40^b	59.10^c	63.98^c
T_6	100% Kitchen waste	41.04^b	32.83^d	41.04^d
T_7	100% Cow dung	41.04^b	102.60^a	102.60^b
	SE(m) ±	4.76	4.50	4.50
	C.D. at 5%	10.71	11.55	14.85



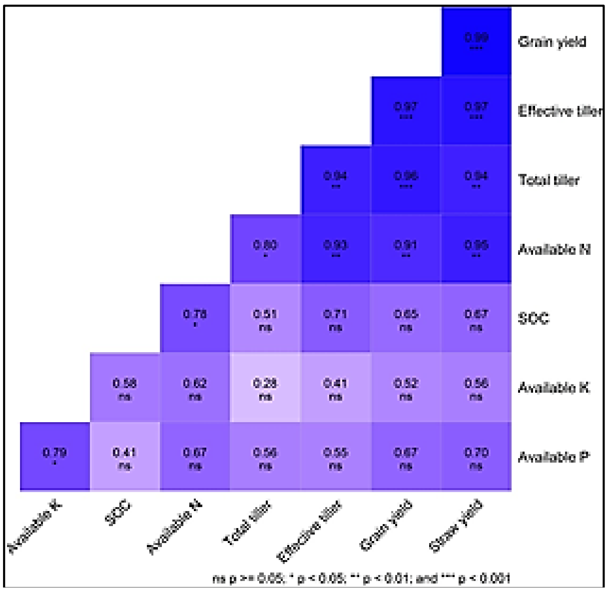
The differences in partial factor productivity among treatments can be attributed to variations in nutrient availability, release patterns and their synchronization with crop demand. Application of the recommended dose of fertilizers ensures readily available nutrients, promoting efficient uptake and higher nutrient use efficiency. However, higher fertilizer rates may sometimes result in diminishing returns, where additional nutrients contribute less to yield per unit applied.

In contrast, organic sources such as FYM, poultry manure and kitchen waste release nutrients more slowly, which can limit their immediate availability during critical crop growth stages. Nevertheless, these organic amendments enhance soil physical, chemical and biological properties, improving long-term nutrient cycling, microbial activity and overall soil fertility. Integrated nutrient management (INM), which combines organic and inorganic sources, can optimize nutrient supply, maintain agronomic efficiency and ensuring sustainable rice production.

To establish the relationship between crop yield and soil chemical indicators

The correlation analysis among soil fertility parameters, crop growth attributes and yield revealed several important relationships. Grain yield and straw yield exhibited very strong and highly significant positive correlations with effective tillers (r=0.97, p<0.001 for both) and total tillers (r=0.94-0.96, p<0.01 to 0.001), indicating that tiller production is a major determinant of rice productivity. Among the soil fertility parameters, available N showed the highest and most significant positive correlation with grain yield (r=0.95, p<0.01) and straw yield (r=0.91, p<0.01), as well as with total tillers and effective tillers. This clearly indicates that available N is the most critical soil factor governing yield performance under the present study, playing a key role in promoting vegetative growth, tiller formation and ultimately higher productivity.

Soil Organic Carbon (SOC) exhibited moderate but non-significant correlations with grain (r=0.67) and straw yield (r=0.70), indicating its supportive role in soil health over the long term rather than immediate yield response. Available P and K showed weak to moderate, non-significant correlations with growth and yield parameters. Overall, the results emphasize that tiller number and available nitrogen are the most influential factors affecting rice yield, while SOC, P and K contribute more indirectly to crop performance.



Conclusion

The present study concluded that the 100% application of different organic manure did not achieve rice yield as compared to RDF. However, they were effectively sustained the soil nutrient status.

- The nutrient uptake and factor productivity of N, P and K were maximized under RDF, while vermi-compost recorded the highest values among the organic treatments.
- Organic manures also played a crucial role in maintaining or improving the soil nutrient status (available N, P and K) compared to the initial levels, suggesting their potential to sustain soil fertility over time.
- Correlation analysis indicated that soil available nitrogen had the strongest positive relationship with rice yield, identifying it as a sensitive and reliable indicator of soil productivity in this system.
- In the present study organic manure applications achieved the good yield, however, it was significantly lower than 100% RDF, this may be because the study is based on one season experiments and the organic manure having potential of slow nutrient release capacity. It may be possible that the continuous field experiment up to at least 3 years may give more clear results about the impact of different organic manures.

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