

Impact of Integrated Nutrient Management on Soil Properties and Kala Namak Rice Yield in Central Uttar Pradesh

Abstract

Rice (*Oryza sativa*) is an enduring crop that can thrive in various types of soil and climates, making it a symbol of sustenance and often regarded as a miraculous gift from God. Kala Namak rice is cultivated in the tarai region of Siddharth Nagar districts of Eastern Uttar Pradesh. This rice variety is fragrant and typically commands a higher price for farmers compared to other kinds of rice. The soil physical properties i.e. bulk density, particle density and chemical properties i.e. pH, electric conductivity, organic carbon were recorded in study. The bulk density of different treatment found between 1.31 to 1.38 g cm⁻³ during first year and 1.31 to 1.39 g cm⁻³ during second year of study and particle density was found between 2.59 to 2.67 g cm⁻³ during first year and 2.59 to 2.66 g cm⁻³ during second year of study. The pH led between 8.16 to 8.03 in first year and 8.13 to 8.01 during second year, and an electrical conductivity (EC) led from 0.447 to 0.427 dSm⁻¹ and 0.457 to 0.417 dSm⁻¹ during first and second year of experiment. The treatment combination of 100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹) have best results in respect to soil physical and chemical properties. The highest yields of grain (28.40 q ha⁻¹ and 29.28 q ha⁻¹) and straw (52.50 q ha⁻¹ and 54.12 q ha⁻¹) were achieved in the first and second years, respectively. The treatment that resulted in the highest yields of grain and straw was 100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹) making it the best treatment. The next best treatment was 75 % RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹).

Key words: Rice, soil properties, yield, BGA, FYM.

1. Introduction

Rice (*Oryza sativa*) is an enduring crop that can thrive in various types of soil and climates, making it a symbol of sustenance and often regarded as a miraculous gift from God. Kala Namak rice is cultivated in the tarai region of Siddharth Nagar districts of Eastern Uttar Pradesh. This rice variety is fragrant and typically commands a higher price for farmers compared to other kinds of rice. The Uttar Pradesh Government is actively promoting Kala Namak rice as part of its One District One Product (ODOP) initiative. To support this, a project worth Rs. 12.00 Cr. has been approved for the promotion of Kala

Comment [AS1]:

Comment [AS2]:

Comment [AS3]: Arial, Bold, 11 font, left aligned, caps

Comment [AS4]: Please give proper keywords Put four to eight keywords} (Arial, inclined, 10 font, justified

Comment [AS5]: Arial, Bold, 11 font, left aligned, caps

Namak rice, scheduled for implementation in 2022. The Agricultural and Processed Food Products Export Development Authority (APEDA) has implemented several measures to encourage the cultivation and export of Kala Namak rice. These include training programs for farmers and stakeholders, promoting agricultural exports, organizing the 'Kala Namak Mahotsav' festival, and facilitating coordination between Farmer Producers Organizations (FPOs), exporters, and farmers. The Indian Council of Agricultural Research (ICAR) and its research institutes, namely the Indian Institute of Rice Research (IIRR) in Hyderabad, the National Rice Research Institute (NRRRI) in Cuttack, and the Indian Agricultural Research Institute (IARI) in New Delhi are collaborating with the Government of Uttar Pradesh to conduct research and development on Kala Namak rice. The global area of rice is 162.05 mha and production is 755.47 Mt with the 46.61 q ha⁻¹ productivity during (FAO, 2020), whereas India accounts 43.79 mha area with production 116.42 Mt and productivity 26.55 qha⁻¹(DAC&FW, 2019). In Uttar Pradesh, 5.75 million ha and production 15.54 million tonnes with 27.04 q ha⁻¹ productivity (DAC&FW, 2019). The Kanpur region in Uttar Pradesh is a prominent area for rice growing, covering a vast expanse of land. The composition of soil in Kanpur consists of 82% silt, 16% clay, and 2% sand, as reported by (Naiket *et al.*, 2022). The issue of global warming has prompted significant worry regarding current approaches in nutrient management. The crop primarily derives nutrients from the soil; nevertheless, achieving a high yield in crop production necessitates an increased nutrient supply. India's soils are predominantly lacking in organic carbon content, hence farmers primarily rely on fertilizers to fulfill their nitrogen requirements. Effectively managing nitrogen to enhance crop yield while maintaining soil productivity and environmental sustainability poses a significant challenge. Atmospheric nitrogen deposition mostly happens when sulfur dioxide and ammonia are released into the air through volatilization from soil that has been fed with inorganic nitrogen and manure (Ussiri and Lal, 2018). Zinc is crucial in the process of glucose metabolism, the detoxification of superoxide radicals, and providing plants with resistance against illnesses. Due to its association with enzymes, a lack of Zn in plants can result in many diseases. Furthermore, due to its limited mobility within plants, the deficient symptoms of Zn typically manifest in the actively growing young tissues. The issue of zinc shortage has garnered significant attention in India due to the fact that over half of the soils in the

country have a low concentration of accessible zinc (Shukla *et al.*, 2014). They enhance the physico-chemical properties of the soil by augmenting its carbon, nitrogen, and accessible phosphorus content. Phosphorus (P) is the second most crucial mineral fertilizer for crop productivity, behind nitrogen. It constitutes 0.2% of the dry weight of plants.

2. Materials and methods

2.1 Experimentalsite

The experiment was conducted during *khariif season* of 2022 and 2023 at Student's Instructional Farm (S.I.F), C.S.A. University of Agriculture and Technology, Kanpur Nagar (U.P.). The field was well leveled and irrigated by tube well. The farm is situated at main campus of the university in the west northern part of Kanpur city under sub-tropical zone in 5th agro-climatic zone (central plain zone).

2.2 Treatments detail

T_1 = Control, T_2 = 100% RDF(N:P: K) : (120:60:60) kg, T_3 = 100% RDF + 5 ton ha⁻¹ FYM, T_4 = 75% RDF + 5 ton ha⁻¹, T_5 = 50 % RDF + 5 ton ha⁻¹, T_6 = 100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹), T_7 = 75% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹), T_8 = 50% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹), T_9 = 100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹), T_{10} = 75 % RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹), T_{11} = 50 % RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹).

2.3 Physico-Chemical properties of soil before and after the sowing of the crop

2.3.1 Bulk density

Bulk density of soil samples was determined using Pycnometer. The bulk density are the weight of the soil solids per unit volume of total soil. It is expressed in g/cm³ (Chopra and Kanwar 1991).

2.3.2 Particle density

Soil particle density are the ratio of mass (oven dry wt.) of the soil particles to the soil solid (not pore space). It is expressed in g/cm³ (Chopra and Kanwar 1991).

2.3.3 Organic carbon (g kg⁻¹)

Organic carbon was determined by Walkley and Black's rapid titration method as described by Walkley & Black (1934).

2.3.4 pH

pH was measured in 1:2.5 soil water suspension by Electric digital pH meter by Jackson (1973).

Comment [AS6]: Arial, normal, 10 font, justified

Comment [AS7]: Detailed instruction about this section is given below. After reading these instructions, please delete this paragraph and begin typing your text here. If you are using copy-paste option then select 'match destination formatting' in paste option OR use 'paste special' option and select 'unformatted Unicode text' option

Comment [AS8]: Make a table and give proper justification

Comment [AS9]: Sub-subheading (Arial, bold, 10 font, left aligned, underlined)-third level heading.

2.3.5 Electrical Conductivity (dSm^{-1})

Electrical conductivity was determined by conductivity meter in the same soil-water suspension in which pH was measured as described by Jackson (1973).

Table: 1 Physico-Chemical properties of soil before and after the sowing of the crop

S. No.	Soil characters	Value		Method employed
		2022	2023	
1.	pH (1:2.5 soil water suspension)	8.10	8.13	Glass electrode pH meter (Jackson, 1973)
2.	EC (dSm^{-1}) (1:2.5 soil water suspension)	0.45	0.46	Conductivity bridge (Jackson, 1973)
3	Bulk density (Mgm^3)	1.34	1.36	Coresampler method (Chopra & Kanwar, 1991)
4	Particle density (Mgm^3)	2.68	2.74	Graduated cylinder method (Chopra & Kanwar, 1991)
5.	Organic carbon (gkg^{-1})	3.5	3.4	Chromic acid digestion (Walkley and Black, 1934)

2.4 Statistical analysis

The observations recorded during the course of investigation were tabulated and analyzed statistically to draw a valid conclusion by using the procedure as given by Fisher and Yates (1949).

3. Result and Discussion

3.1 Physico-Chemical Properties of Soil

3.1.1 Bulk density

The perusal of data pertaining to bulk density in Table 1. It is clearly revealed from the Table that there was no significant difference in the values of bulk density after each harvest of rice due to different treatments applied in Kalanamak rice. Though, the bulk density was decreased from initial status due to different treatments applied in Kalanamak rice crop. It ranged between 1.38 to 1.31 g cm^{-3} in first year and 1.39 to 1.31 g cm^{-3} in second year. The maximum bulk density was recorded with the treatment of T₉ (100% RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1}) followed by T₁₀ (75 % RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1}) and T₁₁ (50 % RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1}). Reported that by method of Chopra & Kanwar, 1991

3.1.2 Particle density

Comment [AS10]: Subheading Subheading (Arial, bold, 11 font, left aligned) - second level heading

The perusal of data pertaining to particle density in Table 1. It is clearly revealed from the Table that there was no-significant difference in the values of particle density after each harvest of rice due to different treatments applied in Kalanamak rice. Though, the particle density was decreased from initial status due to different treatments applied in Kalanamak rice crop. It ranged between 2.59 to 2.67 g cm⁻³ in first year and 2.59 to 2.67 g cm⁻³ in second year. The maximum bulk density was recorded with the treatment of T₉ (100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹) followed by T₁₀ (75 % RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹) and T₁₁ (50 % RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹). Reported that by method of Chopra & Kanwar, 1991.

3.1.3 Organic carbon

The data related to the organic carbon presented in the table 2, and The study was conducted to see whether there was any effect of different treatments and possible addition of organic carbon due to crop residues, therefrom. The organic carbon value was slightly higher during second year as compared that of first year. There were small but significant differences in organic carbon (plot wise) during both the years and also in pooled analysis. Remarkably all the treatments had higher organic carbon than that of control. It varied from 3.5 to 4.4 g kg⁻¹ in first year and from 3.4 to 4.2 g kg⁻¹ during second year. The maximum organic carbon i.e. (4.4 and 4.2 g kg⁻¹) during both year recorded in treatment T₉ (100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹) during first and second year respectively. Reported that by method of Walkley and Black, 1934)

3.1.4 Soil pH

The perusal data related to the pH of soil presented in the table 2. It clearly revealed that there was no-significant difference in the values of pH after each harvest of Kalanamak rice due to different treatments applied. The pH tended to decrease over control due to various treatments. EC varied from 8.16 to 8.03 in first year and from 8.13 to 8.01 during second year. The maximum reduction in soil pH was recorded with the treatment of T₉ (100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹) followed by T₁₀ [75 % RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹)]. Reported by Jackson, 1973

3.1.5 Electrical conductivity (dSm⁻¹)

The perusal data related to the EC of soil presented in the table 3. It clearly revealed that there was no-significant difference in the values of EC after each harvest of Kalanamak

rice due to different treatments applied. The EC tended to decrease over control due to various treatments. EC varied from 0.447 to 0.427 dSm⁻¹ in first year and 0.457 to 0.417 dSm⁻¹ during second year. The maximum reduction in soil EC was recorded with the treatment of T₉ (100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹)) followed by T₁₀ [75 % RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹)]. Reported by Jackson, 1973

3.2 Yield

3.2.5 Grain yield (q/ha)

The data of grain yield presented in the table 4. The grain yield ranges between 14.23 to 28.40 q ha⁻¹ and 15.39 to 29.28 q ha⁻¹ during first year and second year of experiment, respectively. The maximum grain yield i.e. 28.40 q ha⁻¹ and 29.28 q ha⁻¹ were recorded in the treatment T₉ [100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹)] during both year of experimentation, respectively which is at par with all the treatments and followed by 27.18 q ha⁻¹ during first and 28.50 q ha⁻¹ during second year recorded from the treatment T₁₀ [75 % RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹)]. The minimum grain yield i.e. 14.23 q ha⁻¹ during first year and 15.39 q ha⁻¹ during second year were recorded in the control treatment followed by the (17.33 q ha⁻¹ and 18.27 q ha⁻¹) grain yield during both year in the treatment T₂ (100% RDF). Similar result also reported that **Kumar et al. (2007)**, **Bhowmick et al. (2011)**, **Sangeeta et al. (2013)** and **Sharma et al. (2019)**.

3.2.6 Straw yield (q/ha)

The data of straw yield presented in the table 4. The straw yield ranges between 33.32 to 52.50 q ha⁻¹ during first year and 35.17 to 54.12 q ha⁻¹ during second year of study. The maximum straw yield i.e. 52.50 q ha⁻¹ and 54.12 q ha⁻¹ were recorded in the treatment T₉ [100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹)] during both year of experimentation, respectively which is significant over all the treatments and followed by 50.28 q ha⁻¹ and 52.27 q ha⁻¹ during first and second year recorded from the treatment T₁₀ [75 % RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹)]. The minimum straw yield i.e. 33.32 q ha⁻¹ during first year and 35.17 q ha⁻¹ during second year were recorded in the control treatment T₁. Similar result also reported that **Sharma et al. (2014)** and **Thulasi et al. (2016)**.

Conclusion

The soil physiochemical properties viz., pH, electric conductivity, organic carbon, bulk density, particle density changes due to application of FYM, BGA, NPK, Zn and increase the yield of Kala Namak rice in Central zone of Uttar Pradesh. From the present finding, the highest yields of grain (28.40 q ha^{-1} and 29.28 q ha^{-1}) and straw (52.50 q ha^{-1} and 54.12 q ha^{-1}) were recorded in treatment T₉ [100% RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹)] under field conditions during 2021-22 and 2022-23. The next best treatment was 75 % RDF + 5 ton ha⁻¹ FYM + Zn (5 kg ha⁻¹) + BGA (10 kg ha⁻¹).

Comment [AS11]: briefly state the major findings of the study

Comment [AS12]: A brief acknowledgement section given after the conclusion section just before the references.

Comment [AS13]: Authors may use the following wordings for this section

Comment [AS14]: Declaration of competing interest

UNDER PEER REVIEW

Table-1: Effect of Integrated Nutrient Management on bulk density and particle density on Kalanamak rice

Treatment Symbol	Treatment Combination	Bulk density (g cm ⁻³)			Particle density (g cm ⁻³)		
		2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T1	Control	1.31	1.31	1.31	2.59	2.59	2.59
T2	100% RDF	1.33	1.32	1.32	2.60	2.61	2.60
T3	100%RDF + 5 ton ha ⁻¹ FYM	1.35	1.337	1.34	2.61	2.63	2.62
T4	75% RDF + 5 ton ha ⁻¹ FYM	1.34	1.34	1.34	2.60	2.63	2.62
T5	50% RDF + 5 ton ha ⁻¹ FYM	1.34	1.33	1.33	2.61	2.62	2.61
T6	100% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	1.37	1.36	1.36	2.64	2.64	2.64
T7	75% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	1.36	1.35	1.35	2.63	2.64	2.63
T8	50% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	1.35	1.35	1.35	2.63	2.64	2.63
T9	100% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	1.38	1.39	1.38	2.67	2.67	2.67
T10	75 % RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	1.38	1.37	1.37	2.67	2.66	2.66
T11	50 % RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	1.36	1.36	1.36	2.65	2.65	2.65
	S.E.(m)(±)	0.024	0.017	0.011	0.040	0.037	0.027
	C.D.(p = 0.05)	NS	NS	NS	NS	NS	NS

Table No.- 2: Effect of Integrated Nutrient Management on organic carbon and electrical conductivity on Kalanamak rice

Treatment Symbol	Treatment Combination	Organic carbon (g kg ⁻¹)			pH		
		2023	2022	Pooled	2022	2023	Pooled
T1	Control	3.40	3.50	3.45	8.16	8.13	8.15
T2	100% RDF	3.50	3.70	3.60	8.13	8.12	8.12
T3	100% RDF + 5 ton ha ⁻¹ FYM	3.80	3.90	3.85	8.09	8.07	8.08
T4	75% RDF + 5 ton ha ⁻¹ FYM	3.70	3.80	3.75	8.10	8.08	8.09
T5	50% RDF + 5 ton ha ⁻¹ FYM	3.60	3.80	3.70	8.12	8.10	8.11
T6	100% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	4.00	4.10	4.05	8.07	8.04	8.05
T7	75% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	3.90	3.99	3.95	8.07	8.05	8.06
T8	50% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	3.80	4.00	3.90	8.09	8.06	8.07
T9	100% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	4.20	4.40	4.30	8.03	8.01	8.02
T10	75 % RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	4.10	4.30	4.19	8.04	8.02	8.02
T11	50 % RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	4.00	4.20	4.10	8.06	8.03	8.04
	S.E.(m)(±)	0.062	0.054	0.038	0.094	0.114	0.073
	C.D.(p = 0.05)	0.185	0.161	0.113	NS	NS	NS

Table No.:3- Effect of Integrated nutrient management on Electrical conductivity

Treatment Symbol	Treatment Combination	Electrical conductivity (dSm ⁻¹)		
		2022	2023	Pooled
T ₁	Control	0.447	0.457	0.453
T ₂	100% RDF	0.487	0.493	0.493
T ₃	100% RDF + 5 ton ha ⁻¹ FYM	0.470	0.457	0.463
T ₄	75% RDF + 5 ton ha ⁻¹ FYM	0.473	0.470	0.470
T ₅	50% RDF + 5 ton ha ⁻¹ FYM	0.483	0.477	0.480
T ₆	100% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	0.450	0.447	0.450
T ₇	75% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	0.463	0.450	0.457
T ₈	50% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	0.457	0.463	0.457
T ₉	100% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	0.427	0.417	0.423
T ₀	75 % RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	0.443	0.433	0.433
T ₁₁	50 % RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	0.447	0.440	0.443
	S.E.(m)(±)	0.007	0.009	0.006
	C.D.(p = 0.05)	0.022	0.026	0.019

Table No.- 4.: Effect of Integrated nutrient management on Grain yield (q/ha)and Straw yield (q/ha)

Treatment Symbol	TreatmentCombination	Grain yield (q/ha)			Straw yield (q/ha)		
		2022	2023	Pooled	2022	2023	Pooled
T ₁	Control	14.23	15.39	14.81	33.32	35.17	34.25
T ₂	100% RDF	17.33	18.27	17.80	35.47	37.80	36.63
T ₃	100%RDF + 5 ton ha ⁻¹ FYM	22.08	22.78	22.43	41.49	43.20	42.35
T ₄	75% RDF + 5 ton ha ⁻¹ FYM	20.82	21.00	20.91	39.86	41.53	40.69
T ₅	50% RDF + 5 ton ha ⁻¹ FYM	19.36	20.15	19.75	37.67	39.20	38.43
T ₆	100% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	25.00	26.06	25.53	47.33	49.47	48.40
T ₇	75% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	24.30	25.29	24.79	45.19	47.45	46.32
T ₈	50% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹)	23.17	24.60	23.88	43.61	45.59	44.60
T ₉	100% RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	28.40	29.28	28.84	52.50	54.12	53.31
T ₁₀	75 % RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	27.18	28.50	27.84	50.28	52.27	51.28
T ₁₁	50 % RDF + 5 ton ha ⁻¹ FYM + Zn (5 kg ha ⁻¹) + BGA (10 kg ha ⁻¹)	26.32	27.44	26.88	48.33	50.30	49.31
	S.E.(m)(±)	0.327	0.409	0.240	0.571	0.583	0.409
	C.D.(p = 0.05)	0.971	1.215	0.714	1.697	1.732	1.214

Reference

Comment [AS15]: Hilly M, Adams ML, Nelson SC. A study of digit fusion in the mouse embryo. *Clin Exp Allergy*. 2002;32(4):489-98.

Please correct reference

Awang, A. Jalloh, M.B. Kuan, P.S. Itoh, K. Mitsui, T. and Alidin, M.D. (2016). Effect of Adding Appropriate Mixture of NPK and Chicken Manure on Growth and Yield of TR-9 Paddy Variety on Beach Ridges Interspersed with Swales (BRIS) Soil. *Bulletin of Faculty of Agriculture, Niigata University*, **68**:43-48

Azad, B.S. and Lehria, S.K. (2001). Yield maximization of rice through integrated nutrient management under irrigated condition. *Annals of Agriculture Research*, **22**(4):471-475.

Bhowmick M. K., Dhara M. C., Bag M. K., Adhikari B. and Kundu C. (2011). Integrated nutrient management for aromatic rice in West Bengal. *Short Communication Oryza* Vol. 48 No. 3, 2011 (276-277).

Chaudhary R.C., Mishra S.B., Yadav S.K. & Ali Jabir. (2012) Extinction to Distinction: Current Status of Kalanamak, the Heritage Rice of Eastern Uttar Pradesh and its likely Role in Farmers' Prosperity. *LMA Convention Journal* Vol. 8, No. 1, 2012, 7-14.

Department of Agriculture, Cooperation and Farmers Welfare (DAC&FW) undertook in 2019

Despande, H.H. and Devasenapathy, P. (2011). Effect of different organic sources of nutrients and green manure on growth and yield parameters of rice (*Oryza sativa* L.) grown under lowland condition. Agricultural Research Information Centre. *Crop Research (Hisar)*, **41**(1/3):1-5.

FAO, (2014). A regional rice strategy for sustainable food security in Asia and the rapid publication 2014/05.

Jackson, M.L. (1973) Soil chemical analysis. 2nd Edn., *Prentice Hall of India Pvt. Ltd.*, New Delhi, pp. 498.

Naik, S. P., Patra, N. R., & Malik, J. N. (2022). Cyclic behavior of late quaternary alluvial soil along Indo-Gangetic Plain: Northern India. *International Journal of Geo-Engineering*, 13, 1-20.

Sangeetha, S.P. Balakrishnan, A. and Devasenapathy, P.

(2013). Influence of Organic Manures on Yield and Quality of Rice (*Oryza sativa* L.) and Black gram (*Vigna mungo* L.) in Rice-Black gram Cropping Sequence. *American J. Plant Sciences*, 4:1151-1157.

Sharma, U. Subehia, S.K. Rana, S.S. Sharma, S.K. Negi, S.C. (2014). Soil sulphur fraction and their relationship with soil properties and rice (*Oryza sativa* L.) yield under long-term integrated nutrient management in an acid alfisol. Gaurav Society of Agricultural Research Information Centre. *Research on crops*, 15(4):738-745.

Shivay, Y. S., Prasanna, R., Mandi, S., Kanchan, A., Simranjit, K., Nayak, S., ... & Nain, L. (2022). Cyanobacterial inoculation enhances nutrient use efficiency and grain quality of basmati rice in the system of rice intensification. *ACS Agricultural Science & Technology*, 2(4), 742-753.

Shivay, Y. S., Prasanna, R., Mandi, S., Kanchan, A., Simranjit, K., Nayak, S., ... & Nain, L. (2022). Cyanobacterial inoculation enhances nutrient use efficiency and grain quality of basmati rice in the system of rice intensification. *ACS Agricultural Science & Technology*, 2(4), 742-753.

Shukla, A. K., Tiwari, P. K., & Prakash, C. (2014). Micronutrients deficiencies vis-a-vis food and nutritional security of India. *Indian J. Fert*, 10(12), 94-112.

Thulasi, V. Moossa, P.P. and Narayanankutty, M.C. (2016). Influence of long-term application of farm yard manure and in situ green manures on crop productivity and soil organic carbon under rice-rice system in a typical plustalf. *Advance Research J. Crop Improvement*, 7(1):111-115.

Ussiri, D. A., & Lal, R. (2018). Nitrogen cycling and dynamics in terrestrial ecosystems. *Soil and climate. CRC Press, Boca Raton*, 183-218.

Vitousek, P. M., Aber, J. D., Howarth, R. W., Likens, G. E., Matson, P. A., Schindler, D. W., Schlesinger, W. H., and Tilman, D. G. (1997). Human alteration of the global nitrogen cycle: Sources and consequences. *Ecol. Applic.* 7, 737-750

Walkey, A. and Black, I.A. (1934). An examination of Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science* 37, 29-38.

UNDER PEER REVIEW