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

Abstract

The experiment was conducted during *kharif 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 experiment was laid out in Randomized Block Design with eleven treatments each replicated thrice. 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 (Blue Green Algae), FYM (Farm Yard Manure)

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 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 (NRRI) 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 **(Naik*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 fulfil 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 *kharif 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 5^{th} agro-climatic zone (central plain zone).

List 1: Details of treatments

S.No.		Treatment	Treatment Combination
1.		**T_1**	Control
2.		**T_2**	100% RDF(N:P: K) : (120:60:60) kg
3.		**T_3**	100%RDF + 5 ton ha^{-1} FYM
4.		**T_4**	75% RDF + 5 ton ha^{-1}
5.		**T_5**	50 % RDF + 5 ton ha^{-1}
6.		**T_6**	100% RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1})
7.		**T_7**	75% RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1})
8.		**T_8**	50% RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1})
9.		**T_9**	100% RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1})
10.		**T_{10}**	75 % RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1})
11.		**T_{11}**	50 % RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1})

2.2Physico-Chemicalpropertiesofsoilbefore and afterthesowingofthecrop

2.2.1 Bulk density

Bulk density of soil samples was determined using Pycnometer. The bulk density are the weightof the soil solids per unit volume of total soil. It is expressed in g/cm^3**(Chopra and Kanwar1991).**

2.2.2 Particle density

Soil particle density are the ratio of mass (oven dry wt.) of the soil particles to the soil solid (notporespace).It is expressed in g/cm^3(ChopraandKanwar 1991).

2.2.3 Organic carbon (g kg^{-1})

OrganiccarbonwasdeterminedbyWalkleyandBlack'srapidtitrationmethodasdescribedbyWalkley&Black (1934).

2.2.4 pH

pH was measured in1:2.5 soil watersuspension byElectricdigital pH meter byJackson (1973).

2.2.5 Electrical Conductivity (dSm^{-1})

Electricalconductivity wasdeterminedbyconductivitymeterinthesamesoil-watersuspensionin which pHwas measured as described byJackson (1973).

Table: 1 Physico-Chemicalpropertiesofsoilbefore and afterthesowingofthecrop

S. No.	Soilcharacters	Value		Methodemployed
		2022	2023	
1.	pH (1:2.5soil watersuspension)	8.10	8.13	GlasselectrodepHmeter(Jackson,1973)
2.	EC (dsm^{-1}) (1:2.5soil watersuspension)	0.45	0.46	Conductivitybridge(Jackson,1973)
3	Bulk density(Mgm^3)	1.34	1.36	Coresamplermethod(Chopra&Kanwar, 1991)
4	Particle density(Mgm^3)	2.68	2.74	Graduated cylinder method (Chopra&Kanwar, 1991)
5.	Organiccarbon(gkg^{-1})	3.5	3.4	Chromicaciddigestion(WalkleyandBlack, 1934)

2.3Statisticalanalysis

The observations recorded during the course of investigation were tabulated andanalyzed statistically to draw a valid conclusion by using the procedure at 5 % level of significance. (FisherandYates,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 clearlyrevealed from the Table that there was no-significant difference in the values of bulk density after eachharvestofriceduetodifferenttreatmentsappliedin Kalanamak rice.Though,thebulk densitywasdecreasedfrominitial status due to different treatments applied in kalanamak rice crop. It ranged between 1.38 to 1.31 g cm^{-3} infirst year and 1.39 to 1.31 g cm^{-3} in second year. The highest bulk density was recorded withthe treatment of T_9 (100% RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1}) followedbyT_{10} (75 % RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1})and T_{11} (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

The perusal of data pertaining to particle density in Table 1. It is clearlyrevealed from the Table that there was no-significant difference in the values of particle density after eachharvestofriceduetodifferenttreatmentsappliedin Kalanamak rice.Though,theparticle densitywasdecreasedfrominitial status due to different treatments applied in kalanamak rice crop. It ranged between 2.59 to 2.67 g cm^{-3} infirst year and 2.59 to 2.67 g cm^{-3} in second year. The highest bulk density was recorded withthe treatment of T_9 (100% RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1}) followedbyT_{10} (75 % RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1})and T_{11} (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 3, 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 highestorganic carbon i.e. (4.4 and 4.2 g kg^{-1}) during both year recorded in treatment T_9 (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 WalkleyandBlack, 1934)

3.1.4 Soil pH

The persual data related to the pH ofsoil presented in the table 3. 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 highest reduction in soil pH was recorded with the treatment of T_9 (100% RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1}) followed by T_{10} [75 % RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1})].Similar finding was also reported by **Umri *et al.*, (2022)**

3.1.5 Electrical conductivity (dSm^{-1})

The perusal data related to the EC o soil presented in the table 4. 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 0.427dSm^{-1} in first year and 0.457 to 0.417 dSm^{-1} during second year. The highest reduction in soil EC was recorded with the treatment of T_9 (100% RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1}) followed by T_{10} [75 % RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1})].Similar findings was also reported by **Patra*et al.*,(2020)**

3.2.5 Grain yield (q/ha)

The data of grain yield presented in the table 5. 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 highest grain yield i.e. 28.40 q ha^{-1} and 29.28 q ha^{-1} were recorded in the treatment T_9 [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 T_{10} [75 % RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1})]. The lowest 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 T_2 (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 5. 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 highest straw yield i.e. 52.50 q ha^{-1} and 54.12 q ha^{-1} were recorded in the treatment T_9 [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 T_{10} [75 % RDF + 5 ton ha^{-1} FYM + Zn (5 kg ha^{-1}) + BGA (10 kg ha^{-1})]. The lowest 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 T_1.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 T_9 [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}).

Table-2: Effect of Integrated Nutrient Management on bulk density and particle density on Kalanamak rice

Treatment Symbol	TreatmentCombination	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.- 3: Effect of Integrated Nutrient Management on organic carbon and electrical conductivity on Kalanamak rice

Treatment Symbol	TreatmentCombination	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.:4- Effect of Integrated nutrient management on Electrical conductivity

reatmentSymbol	TreatmentCombination	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.- 5.: 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

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