

Growth, grain yield and soil nutrient status of *kharif* rice (*Oryza sativa* L.) as influenced by integrated nutrient management in lower gangetic plains

ABSTARCT

A field experiment was conducted during *kharif* season, 2019 at Instructional Farm, BCKV, Jaguli, Nadia (West Bengal) to study “Growth, yield and soil nutrient status of *kharif* rice (*Oryzasativa*L.) as influenced by integrated nutrient management in lower gangetic plains” in a Randomized Block Design (RBD) having three replications. Outcomes revealed that rice plot fertilized with 125% NPK of RDF + FYM @ 5 t ha⁻¹ along with Vermicompost @ 2.0 t ha⁻¹ recorded the highest plant height, elongation rate, dry matter accumulation, crop growth rate, no. of tillers per hill. The maximum grain (5.25 tha⁻¹) and straw yield (5.84 t ha⁻¹) as well as soil nutrient status after harvest of *kharif* rice was recorded with 125% NPK of RDF + FYM @ 5 t ha⁻¹ + Vermicompost @ 2.0 t ha⁻¹ followed by NPK @ 80:40:40 kg ha⁻¹ + ZnSO₄ @ 25 kg ha⁻¹ which is 53.72% higher over control.

Keywords: *Khari* frice, integrated nutrient management, soil nutrient status and yield

INTRODUCTION:

Integrated nutrient management (INM) is the judicious use of all possible nutrient sources to meet the plant nutrient requirement at an optimum level to sustain the desired crop productivity on long-term basis for increasing the available plant nutrients and improving the physico-chemical and biological properties of soil through maximizing nutrient use efficiency and boosting the soil health (Jana *et al.*, 2020). Rice (*Oryza sativa* L.) is a leading food grain crop accounting half of the world's population and provides dietary energy and protein up to 2.5 billion people in the world predicted that around 50-60% improvement in rice production will be necessary to fulfill demand from population growth by 2025. India comes second to China in terms of area and production among the world's major rice producing nations. Out of 782 million tonnes of global rice production from 167.1 million hectares, India produced 116.42 m t in 44.5 m ha (rainy season: 102.13 m t from 39.27 m ha) (FAO, 2020; GOI 2020). Rice production in Chhattisgarh, the total area of production was reported to about 3.87 million hectares with production accounting to be 11.63 million tonnes and a productivity of 3.0 t ha⁻¹ (Anonymous, 2021). Nitrogen is one of the important elements in plant owing to its major part in chlorophyll

production, which is essential for the photosynthesis process and a part of different enzymatic proteins that catalyze and regulate plant development processes (Sarkar *et al.*, 2021). Phosphorus is an essential macronutrient that stimulates root, nodule, fruit and grain development as well as aids in vital metabolic functions like photosynthesis, carbon partition, sugar transport, energy storage and transfer etc (Mitra *et al.*, 2018). Potassium is important for the activation of several enzymes promoting sugar transport and regulating cell osmotic pressure involved in the stomatal regulation and maintaining the ion balance in the cytoplasm (Hu *et al.*, 2016a). Zinc is closely related to the inhibition of RNA synthesis and is directly or indirectly involved in the activation of several enzymatic systems closely involved in the nitrogen metabolism helps in cell wall development, respiration, photosynthesis, chlorophyll formation and enzyme activity (Monda *et al.*, 2020). Application of vermicompost and farm yard manure influences the physical, chemical and biological properties of soil helps in improving water holding capacity as well as efficiency of the microbial growth and activity by providing vitamins and growth hormones supplies all major nutrients (N, P, K, Ca, Mg, S) necessary for plant growth as well as micronutrients (Fe, Mn, Cu and Zn) which have a direct role on plant growth leads to better agriculture production. Green leaf manure can be explained as the pruning and collecting of leaves and twigs from various trees, herbs and shrubs provides essential plant nutrients to the soil is capable of supplying the required plant nutrients with preserving very good soil health. Therefore, the present investigation was laid out to judge growth, yield attributes, grain yield of Rice cv. IET 25701 (Bidhan Suruchi) influenced by integrated nutrient management under lower Gangetic plains.

MATERIALS AND METHOD:

An experiment was laid out during the kharif season of 2019 at Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal to study crop growth and yield of rice (*Oryza sativa* L.) as influenced by integrated nutrient management in the lower gangetic plains. The farm is located at 22°93'N latitude and 88°53'E longitude with an altitude of 9.75 m above mean sea level with average precipitation during the experimental period is around 1450 mm. The soil of experimental site was neutral in reaction (pH 6.7) with soil organic carbon 0.52%, available N 202.45 kg ha⁻¹, P₂O₅ 28.35 kg ha⁻¹ and K₂O 196.50 kg ha⁻¹ which managed in a Randomized Block Design (RBD) having three replications with 4.0mX3.0m plot size with eight different treatment combinations *i.e.* T₁- Control (No fertilizer), T₂-NPK @ 80:40:40 kg ha⁻¹(RDF), T₃-NPK @ 80:40:40 kg ha⁻¹ + leaf manure (subabul) @ 2.5 t ha⁻¹, T₄-NPK @

80:40:40 kg ha⁻¹ + Vermicompost @ 2 t ha⁻¹, T₅- NPK @ 80:40:40 kg ha⁻¹ + FYM @ 5 t ha⁻¹, T₆- NPK @ 80:40:40 kg ha⁻¹ + ZnSO₄ @ 25 kg ha⁻¹, T₇- NPK @ 125% of RDF, T₈-125% NPK (RDF) + FYM @ 5 t ha⁻¹ + Vermicompost @ 2 t ha⁻¹. Rice cv. IET-25701 (Bidhan Suruchi) is cultivated predominantly in West Bengal, Odisha, Uttar Pradesh and Assam generally recommended for both kharif and boro season with an average yield of 56 q/ha and 62.4 q/ha respectively of 110–114 days maturity which is moderately resistant to bacterial leaf blight, leaf blast, stem borer and brown plant hopper, non-lodging, non-shattering variety. Meteorological data pertaining to the cropping seasons revealed that maximum temperature ranged between 23.35°C to 33.92°C and minimum temperature prevailed between 9.98°C to 18.06°C. The maximum and minimum relative humidity fluctuated between 94.08 to 97.23% and 44.65 to 59.56%, respectively. Nitrogen, phosphorus and potassium at 80, 40 and 40 kg ha⁻¹ as urea, single super phosphate and muriate of potash respectively with green leaf manure, Farmyard manure, and vermicompost were given as per the schedule to control weeds one hand weeding was done before the first top dressing and another hand weeding was done before the next top dressing. The seedlings were transplanted in a row at 20cm X 10cm spacing and 3 seedlings/hill without damaging the seedlings. The depth of transplanting was 2.5–3 cm.

One deep-ploughing with tractor followed by two ploughings with power tiller and subsequent leveling with a ladder was done to make the soil in friable condition. Harvesting operation was done manually leaving the two border rows on each side and the net plot was accounted for seed yield of the crop. Then, the harvested crop was left for two days in the field to make sun drying. The produce was then threshed and seeds were separately collected for each plot manually. After proper cleaning and drying, seeds and straw of each net plot were weighed and yield was recorded. At different stages, the height was taken by measuring the distance by scale from the ground level to the top of the highest leaf by stretching the leaf of the plant. Ten samples of green leaf lamina from two hills of each plot were separated, a rectangular bit of 10 cm length and 1 cm width were cut from the leaves. Leaf area index (LAI) is the area of leaf surface per unit area on the land surface, can be calculated for each treatment and plot at different growth stages. Observations were recorded on growth parameters viz. plant height, elongation rate, dry matter accumulation, crop growth rate, tillers per hill and yield attributes viz. panicle length, panicle weight, filled grains, grain yield, straw yield as well as harvest index. All the data were analysed statistically by OPSTAT (online statistical analysis tool).

RESULTS AND DISCUSSION:

Crop growth characters:

The crop growth in terms of plant height of kharifrice cultivated with different nutrient management practices was found significant (Table 1). Among different nutrient management practices, 125% NPK (RDF *i.e.* 80:40:40 kg/ha) + FYM @ 5 t ha⁻¹ + Vermicompost @ 2 t ha⁻¹ recorded significantly higher plant height at 60 DAT (108.16 cm) over the other treatments which is statistically at par 125% NPK (RDF *i.e.* 80:40:40) obtaining value of 107.43 cm. The lowest plant height (82.93 cm) was obtained from control (No fertilizer). The increased plant height due to organic source of nutrients along with chemical applications, which might have boosted the metabolic and physiological activity of the plant assimilating more amounts of nutrients which ultimately increased the plant height (Nishi *et al.* 2019). Plant elongation rate (cm day⁻¹) of transplanted *Kharifrice* varied significantly with the variation of different nutrient management practices in new alluvial soil of lower Indo-Gangetic Plains of West Bengal. However, the elongation rate of plants with different treatments varied from 0.83 to 1.24 cm day⁻¹ at 45-60 DAT. Among different treatments applied, NPK @ 80:40:40 kg/ha + leaf manure @ 2.5 t/ha achieved the highest elongation rate (1.24 cm) which is followed by 125% NPK @ 80:40:40 kg/ha + FYM (5 t ha⁻¹) + vermicompost @ 2 t ha⁻¹ obtaining value of 1.18 cm. Dry matter accumulation increased with increasing duration of crop (Table 1). However, significantly highest dry matter accumulation (762.00 g m⁻²) observed at harvest was recorded with application 125% NPK (RDF *i.e.* 80:40:40 kg/ha) + FYM @ 5 t ha⁻¹ + vermicompost @ 2 t ha⁻¹. This value is followed by 125% NPK (RDF *i.e.* 80:40:40 kg/ha) was recorded value of 745.70 g m⁻². The lowest value (386.33 g m⁻²) of dry matter accumulation was recorded at control. Few studies have shown that, organic manures with associate adequate quantity of chemical N fertilizers may manufacture higher dry matter yield than those of conventional inorganic N fertilizers treatments (Singh *et al.*, 1994 and Chung *et al.*, 2000). The Crop growth rate of kharif rice was varied from 3.11 to 10.89 g m⁻² day⁻¹ with different nutrient management practices from 60 DAT-harvest. The application of the dose of 125% NPK (@ 100:50:50 kg/ha) + FYM @ 5 t ha⁻¹ + Vermicompost @ 2.0 t/ha recorded the highest CGR depicting a value of (10.89 g m⁻² day⁻¹), which is followed by NPK @ 125% of RDF obtaining value of 10.23 g m⁻² day⁻¹ while the lowest CGR value was found under the treatment control plot (3.11 g m⁻² day⁻¹). Data pertaining to tiller numbers in kharifrice indicated that at 60 DAT the rice plants showed

significant variation in tiller number under different nutrient management practices. However application of 125%NPK(100:50:50)+ FYM 5t/ha +vermicompost 2t ha⁻¹recorded significantly higher number of tillers per hill (12.06) over the others, whereas the lowest value(6.10)was obtained from control.Mirza *et al.* (2005) and they reported that productive tillers per hill were increased by the application of FYM along with different macro and micro nutrients application.The root length of kharifrice at 60 DAT varied significantly with different nutrient management practices (Table 1). Significantly, highest root length at 60 DAT (28.2 cm) were found with 125% NPK (RDF) +FYM 5 t ha⁻¹ + Vermicompost 2 t ha⁻¹ over the remaining treatments which was followed by NPK @ 80:40:40 kg ha⁻¹+ Vermicompost 2 t ha⁻¹ and this value was statistically at par with other treatments. The lowest value (19.3) was obtained at control (No fertilizer).These findings are in close agreement with those of The increase in crop growth characters may be attributed to mineralization of FYM or through soubilization of nutrients from native source during the process of decomposition (Ghasa *et al.* 2015).

Yield attributes and grain yield

Panicle length of rice varied from 20.26 to 23.48 cm with a variation of 17.04% over control. The maximum panicle length (23.48cm) was achieved with the combined application 125%NPK(100:50:50)+FYM @ 5tha⁻¹+Vermicompost @ 2tha⁻¹which was statistically at par with NPK@125% RDF. The lowest value in panicle length (20.26 cm) was observed by the control treatment. Effective tillers m⁻²(326)was found significant obtaining best result 125%NPK(100:50:50)+FYM @ 5tha⁻¹+Vermicompost @ 2tha⁻¹ which was followed by NPK @ 80:40:40 kg ha⁻¹+ ZnSO₄ @ 25 kg ha⁻¹. The lowest value of effective tillers m⁻² (191) was obtained from control.Filled grainpanicle⁻¹of transplanted Kharif rice was significantly influenced by integrated nutrientmanagementpractices(Table 2). However, the number of filled grainspanicle⁻¹recording best value in 125% RDF+FYM @ 5t/ha +Vermicompost@2t/hawas significantly superior (123.33).The lowest number of filled grain/panicle was recorded in the control plot (83.66). Similar kind of association was revealed by Patel *et al.* (2014) and Rao *et al.* (2014) for number of filled grains per panicle.The same trend was followed in terms of grain ,straw yield as well as 1000-seed weight obtaining best value of 5.25 kg/ha, 5.84 kg/ha and 20.17 gm at 125%RDF+ FYM5t/ha+vermicompost@ 2t/ha. This values are statistically at par with NPK @ 80:40:40 kg ha⁻¹+ ZnSO₄ @ 25 kg ha⁻¹. Acharya *et al.* (1998) pointed out that the application of N, P, and K fertilizer along with FYM increased the growth attributes, yield components and grain yield of rice

compared with that of N, P and K through fertilizer alone. Balasubramanian and Wahab (2012) observed that straw yields were favorably influenced by combined application of inorganic fertilizers and organic manures. Organic nutrients like Farmyard manure and vermicompost might have supplied the essential minerals and worked as catalyst for efficient use of applied nutrients for increasing the yield attributes Ramkrishna *et al.*, 2007 and Sowmya *et al.*, 2011.

Soil nutrient status after harvest

After the harvest of Kharif rice, available soil nitrogen, phosphorus, and potassium varied significantly with different nutrient management practices (Table 3). The available nitrogen was more ($279.30 \text{ kg ha}^{-1}$) in the plot fertilized with higher dose of 125% RDF + FYM @ 5 t ha^{-1} along with vermicompost @ 2 t ha^{-1} . The lowest available nitrogen ($161.30 \text{ kg ha}^{-1}$) was recorded in the control plot because the plant utilized the native soil nutrient. The highest available phosphorus (42.63 kg ha^{-1}) recorded in the application of a higher dose of nutrient *i.e.* 125% RDF + FYM (5 t ha^{-1}) + Vermicompost (2.0 t ha^{-1}) followed by the NPK @ 125% RDF and lowest available phosphorus recorded in the control plot. The highest available potassium was obtained from the higher dose of 125% RDF + FYM (5 t ha^{-1}) along with Vermicompost (2.0 t ha^{-1}) fertilized plot ($235.03 \text{ kg ha}^{-1}$) the lowest data was obtained in control plot where no fertilizer was applied.

Conclusion

Conclusively, integrated nutrient management was found to be superior for enhancing growth and yield of rice cv. IET-25701 (Bidhan Suruchi). Among the different combination given, application of 125% NPK (80:40:40 kg ha^{-1}) + FYM @ 5 t ha^{-1} along with Vermicompost @ 2.0 t ha^{-1} recorded the highest grain yield (5.25 t ha^{-1}) was found more beneficial in terms of growth parameters and yield attributes of rice along with available nutrient status after harvest in lower Gangetic alluvial soil of West Bengal.

Table1:Growth characters of *kharif* rice as influenced by different nutrient management practices

Treatment	Plant height(cm) at 60 DAT	Elongation rate(cm/day) at45-60 DAT	Drymatter accumulation (g/m ²) at harvest	Crop growth rate (g/m ² /day) at60-Harvest	Tillers/hill at 60 DAT	Root length (cm) 60 DAT
T ₁	82.93	0.83	386.33	3.11	6.10	19.3
T ₂	95.46	0.92	699.10	8.48	9.19	23.6
T ₃	103.10	1.24	712.43	9.45	9.30	25.4
T ₄	102.83	1.01	722.90	9.29	9.56	25.6
T ₅	102.76	1.11	725.06	10.11	9.43	25.3
T ₆	104.80	1.03	734.80	9.32	11.53	22.5
T ₇	107.43	0.94	745.70	10.23	11.18	23.2
T ₈	108.16	1.18	762.00	10.89	12.06	28.2
SEm (±)	0.67	0.04	4.93	1.25	0.12	0.92
CD at 5%	2.06	0.13	15.10	3.82	0.38	2.87

[T₁- Control (No fertilizer), T₂-NPK @ 80:40:40 kg ha⁻¹(RDF), T₃-NPK @ 80:40:40 kg ha⁻¹ + leaf manure(subabul) 2.5 t ha⁻¹, T₄-NPK @ 80:40:40 kg ha⁻¹+ Vermicompost 2 t ha⁻¹, T₅- NPK @ 80:40:40 kg ha⁻¹+ FYM 5 t ha⁻¹, T₆- NPK @ 80:40:40 kg ha⁻¹+ ZnSO₄ @ 25 kg ha⁻¹, T₇-NPK @ 125% of RDF, T₈-125% NPK (RDF) +FYM 5 t ha⁻¹ + Vermicompost 2 t ha⁻¹]

Table 2: Yield attributes and grain yield of *kharif* rice as influenced by different nutrient management practices

Treatment	Panicle length (cm)	Effective tiller m ⁻²	Filled grains Panicle ⁻¹	1000-seed weight(g)	Grain yield (t/ha)	Straw yield (t/ha)
T ₁	20.26	191	83.66	18.42	2.43	4.45
T ₂	22.24	306	112.20	18.54	4.06	5.23
T ₃	22.37	310	114.66	18.73	4.32	5.33
T ₄	21.97	316	119.00	18.82	4.40	5.58
T ₅	22.07	311	116.00	18.65	4.22	5.47
T ₆	23.24	321	120.66	19.99	4.89	5.80
T ₇	22.62	314	115.33	19.32	4.30	5.29
T ₈	23.48	326	123.33	20.17	5.25	5.84
SEm (±)	0.33	2.88	4.58	0.02	0.27	0.16
CD at 5%	1.02	8.82	14.04	0.09	0.38	0.5

[T₁- Control (No fertilizer), T₂-NPK @ 80:40:40 kg ha⁻¹(RDF), T₃-NPK @ 80:40:40 kg ha⁻¹ + leaf manure(subabul) 2.5 t ha⁻¹, T₄-NPK @ 80:40:40 kg ha⁻¹+ Vermicompost 2 t ha⁻¹, T₅- NPK @ 80:40:40 kg ha⁻¹+ FYM 5 t ha⁻¹, T₆- NPK @ 80:40:40 kg ha⁻¹+ ZnSO₄ @ 25 kg ha⁻¹, T₇-NPK @ 125% of RDF, T₈- 125% NPK (RDF) +FYM 5 t ha⁻¹ + Vermicompost 2 t ha⁻¹]

Table 3: Soil nutrient status as influenced by integrated nutrient management practices of rice during *kharif* season

Treatment	Available N (kg/ha)	Available P ₂ O ₅ (kg/ha)	Available soil K ₂ O (kg/ha)
T ₁	161.30	23.23	155.50
T ₂	251.33	34.16	215.33
T ₃	255.46	35.20	221.26
T ₄	262.26	37.40	224.26
T ₅	260.33	38.43	223.30
T ₆	263.96	35.43	218.20
T ₇	269.16	39.53	229.30
T ₈	279.30	42.63	235.03
SEm (±)	2.38	0.65	0.81
CD at 5%	7.31	2.01	2.49
Initial	202.45	28.35	196.50

[T₁- Control (No fertilizer), T₂-NPK @ 80:40:40 kg ha⁻¹(RDF), T₃-NPK @ 80:40:40 kg ha⁻¹ + leaf manure(subabul) 2.5 t ha⁻¹, T₄-NPK @ 80:40:40 kg ha⁻¹+ Vermicompost 2 t ha⁻¹, T₅- NPK @ 80:40:40 kg ha⁻¹+ FYM 5 t ha⁻¹, T₆- NPK @ 80:40:40 kg ha⁻¹+ ZnSO₄ @ 25 kg ha⁻¹, T₇-NPK @ 125% of RDF, T₈- 125% NPK (RDF) +FYM 5 t ha⁻¹ + Vermicompost 2 t ha⁻¹]

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