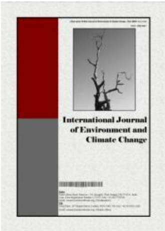

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Growth, Grain Yield and Soil Nutrient Status of *Kharif* Rice (*Oryza sativa* L.) as Influenced by Integrated Nutrient Management in Lower Gangetic Plains

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *the Kharif* season of 2019 at Instructional Farm, BCKV, Jaguli, Nadia (West Bengal) to study the Growth, yield, and soil nutrient status of *Kharif* rice (O*ryza sativa* L.) as influenced by integrated nutrient management under lower Gangetic plains in a Randomized Block Design (RBD) having three replications. Outcomes revealed that rice plots fertilized with NPK@125% of RDF(100:50:50 kg/ha) + FYM@ 5 t/ha +vermicompost @2.0 t/ha recorded the highest plant height, elongation rate dry matter accumulation, crop growth rate and no. of tillers per hill. The maximum grain (5.25 t/ha) and straw yield (5.84 t/ha) as well as soil nutrient status after harvest of *Kharif* rice was recorded with NPK@125% of RDF (100:50:50 kg/ha)+FYM@ 5 t/ha+ Vermicompost @2.0 t/ha followed by NPK@ 80:40:40 kg/ha + $ZnSO_4$@25 kg/ha which is 53.72% higher over control.

Keywords: Kharif rice; integrated nutrient management; soil nutrient status; yield.

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1. 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 a 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 [1]. Rice (*Oryza sativa* L.) is a leading food grain crop accounting for 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 167.1million hectares, India produced 116.42 m t in 44.5 m ha (rainy season: 102.13 m t from 39.27 m ha) [2,3]. Rice production in Chhattisgarh, the total area of production was reported to be about 3.87 million hectares with production accounting to be 11.63 million tonnes and a productivity of 3.0 t ha^{-1} [4]. Nitrogen is one of the important elements in plants owing to its major part in chlorophyll production, which is essential for the photosynthesis process and part of different enzymatic proteins that catalyze and regulate plant development processes [5]. 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, transfer, etc [6]. 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 [7]. 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 nitrogen metabolism helps in cell wall development, respiration, photosynthesis, chlorophyll formation, and enzyme activity [8]. 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 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 manuring can be explained as the pruning and collecting of leaves and twigs from various trees, herbs, and shrubs that provide essential plant nutrients to the soil and is capable of supplying the required plant nutrients with preserving very good soil health [9-11]. Therefore, the present investigation was laid out to judge the growth, yield attributes, and grain yield of Rice cv. IET 25701(Bidhan Suruchi) is influenced by integrated nutrient management under lower Gangetic plains.

2. MATERIALS AND METHODS

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}, P_2O_5 28.35 kg ha^{-1} and K_2O 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.*T_1-Control (No fertilizer),T_2-NPK@80:40:40kg/ha(RDF),T_3-NPK@80:40:40kg/ha+leaf manure (subabul) @2.5t/ha,T_4NPK@80:40:40kg/ha+Vermicompost @2t/ha, T_5-NPK @ 80:40:40 kg /ha+FYM@ 5 t/ha, T_6-NPK @ 80:40:40 kg/ha+$ZnSO_4$@25 kg /ha,T_7-NPK@125% of RDF, T_8-NPK@125% of RDF+FYM@5t/ha+Vermicompost@2t/ha.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 season 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 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 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 20cmX10cm spacing and 3seedlings/hill without damaging the seedlings. The depth of transplanting was 2.5-3 cm. One deep ploughing with a tractor followed by two ploughings with a 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 borders rows on each side and the net plot was accounted for the seed yield of the crop. Then, the harvested crop was left for two days in the field to make the sun dry. The produce was then threshed and seeds were separately collected for each plot manually [12,13]. 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, and a rectangular bit of 10 cm length and 1cm 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 plotted 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 analyzed statistically by OPSTAT (online statistical analysis tool).

3. RESULTS AND DISCUSSION

3.1 Crop Growth Characters

The crop growth in terms of plant height of Kharif rice cultivated with different nutrient management practices was found significant (Table 1). Among different nutrient management practices, NPK @125%ofRDF(100:50:50kg/ha)+FYM@5t/ha+Vermicompost @ 2t/ha 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 the 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 [14]. Plant elongation rate (cm/day) of transplanted *Kharif* rice varied significantly with the variety of different nutrients management practices in new alluvial soils of lower Indo-Gangetic Plains of West Bengal [15,16]. However, the elongation rate of plants with different treatments varied from 0.83 to 1.24cm/day at 45-60 DAT. Among different treatments applied, NPK @80:40:40 kg/ha+leaf manure@2.5t/ha achieved the highest elongation rate (1.24cm) which is followed by NPK@125% ofRDF(100:50:50kg/ha+FYM@5t/ha)+vermicompost@2t/ha obtaining value of 1.18 cm. Dry matter accumulation increased with the increasing duration of the crop (Table 1). However, significantly highest dry matter accumulation (762.00g/m^2) observed at harvest was recorded with application NPK@125%ofRDF(100:50:50kg/ha)+FYM@5t/ha+ vermicompost@ 2t/ha. This value is followed by NPK@125% of RDF (100:50:50 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 an associated adequate quantity of chemical N fertilizers may manufacture higher dry matter yield than those of conventional inorganic N fertilizers treatments [17,18]. The Crop growth rate of Kharif rice varied from 3.11 to 10.89 gm^{-2}day^{-1}with different nutrient management practices from 60 DAT-harvest. The application of the dose of NPK (@ 125% of RDF(100:50:50 kg/ha)+FYM@5t/ ha+ Vermicompost @2.0t/ha recorded the highest CGR depicting a value of (10.89g/m^2/day), which is followed by NPK @ 125% of RDF(100:50:50 kg/ha) obtaining the value of 10.23 g/m^{2}day while the lowest CGR value was found under the treatment control plot (3.11 g/m^2/day). Data pertaining to tiller numbers in Kharif rice indicated that at 60 DAT the rice plant showed significant variation in tiller number under different nutrient management practices. However, the application of NPK @125% of RDF(100:50:50kg/ha)+FYM@5t/ha+vermicompost @2t/ha recorded a 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. [19] and reported that productive tillers per hill were increased by the application of FYM along with different macro and micronutrients applications. The root length of Kharif rice at 60 DAT varied significantly with different nutrient management practices (Table 1). Significantly, the highest root length at 60 DAT (28.2 cm) was found with NPK@125% of RDF+FYM@5t/ha+Vermicompost@2t/haover the remaining treatments which was followed by NPK @ 80:40:40 kg/ha+Vermicompost @2 t/ha 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 characteristics that may be attributed to mineralization of FYM or through solubilization of nutrients from native sources during the process of decomposition [20].

3.2 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 NPK @125%ofRDF(100:50:50kg/ha)+FYM@5t/ha+Vermicompost @ 2t/ha which was statistically at par with NPK@125% RDF(100:50:50kg/ha).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 NPK@125%ofRDF(100:50:50 kg/ha)+FYM@5t/ha+Vermicompost @ 2t/ha^{-1} which was followed by NPK @ 80:40:40 kg/ ha+ $ZnSO_4$ @ 25 kg/ ha. The lowest value of effective tillers/m (191) was obtained from control. The filled grain/panicle of transplanted Kharif rice was significantly influenced by integrated nutrient management practices (Table 2). However, the number of filled grains $panicle^{-1}$ recording the best value inNPK@125% of RDF(100:50:50 kg/ha)+FYM @ 5t/ha +Vermicompost@2t/ha was significantly superior (123.33).The lowest number of filled grain/panicles was recorded in the control plot (83.66). A similar kind of association was revealed by Patel et al. [21] and Rao et al. [22] for the number of filled grains per panicle. The same trend was followed in terms of grain, straw yield as well as 1000-seed weight obtaining the best value of 5.25 kg/ha, 5.84 kg/ha and 20.17 gm at NPK@125% of RDF(100:50:50 kg/ha)+FYM@5t/ha+vermicompost@2t/ha. This values are statistically at par with NPK @ 80:40:40 kg/ha^-+ $ZnSO_4$@ 25 kg/ha. Acharya et al. [23] 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 [24] observed that straw yields were favorably influenced by the combined application of inorganic fertilizers and organic manures. Organic nutrients like Farmyard manure and vermicompost might have supplied the essential minerals and worked as a catalyst for efficient use of applied nutrients for increasing the yield attributes Ramkrishna et al. [25] and Sowmya et al. [26].

3.3 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 kg/ha) in the plot fertilized with higher dose of NPK@125% of RDF(100:50:50 kg/ha)+ FYM @ 5t/ha+vermicompost@2t/ha. The lowest available nitrogen (161.30 kg/ha) was recorded in the control plot because the plant utilized the native soil nutrient. The highest available phosphorus (42.63 kg/ha) recorded in the application of a higher dose of nutrient *i.e*. NPK@125%RDF(100:50:50)+FYM(5t/ha)+Vermi compost (2.0t/ha) followed by the NPK @125%RDF(100:50:50) and lowest available phosphorus recorded in the control plot. The highest available potassium was obtained from the higher dose of NPK@125%RDF(100:50: 50 kg/ha)+FYM@(5t/ha)+Vermicompost@2.0t/ha fertilized plot (235.03 kg/ha) the lowest data was obtained in the control plot where no fertilizer was applied.

Table 1. Growth characters of *kharif* rice as influenced by integrated nutrient management practices

Treatment	Plant height (cm) at 60 DAT	Elongation rate (cm/day) at 45-60 DAT	Dry matter accumulation (g/m^2) at harvest	Crop growth rate (g/m^2/day) at 60-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

[T_1-Control (Nofertilizer),T_2-NPK@80:40:40kg/ha(RDF),T_3-NPK@80:40:40kg/ha+leaf manure (subabul)@2.5t/ha,T_4-NPK@80:40:40 kg/ha+Vermicompost @ 2 t/ha, T_5-NPK @ 80:40:40 kg/ha+ FYM@5 t/ha, T_6-NPK @ 80:40:40 kg /ha+$ZnSO_4$@25 kg/ha,T_7-NPK@125% of RDF, T_8- NPK@125% of RDF +FYM@ 5 t/ha +Vermicompost@ 2 t/ha]

Table 2. Yield attributes and grain yield of *kharif* rice as influenced by integrated 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

[T_1-Control (Nofertilizer),T_2-NPK@80:40:40kg/ha (RDF),T_3-NPK@80:40:40kg/ha+ leaf manure(subabul)@ 2.5 t /ha ,T_4-NPK @ 80:40:40 kg/ha+ Vermicompost @ 2 t/ha, T_5-NPK @ 80:40:40 kg /ha+ FYM@ 5 t/ ha, T_6-NPK @ 80:40:40 kg /ha+$ZnSO_4$@25 kg/ha,T_7-NPK@125% of RDF, T_8-NPK@125% of RDF+FYM@5 t/ha+Vermicompost @2 t/ha]

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

Treatment	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available soil K_2O (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

[T_1-Control (No fertilizer), T_2-NPK@80:40:40kg/ha (RDF), T_3-NPK@80:40:40kg/ha+leaf manure(subabul) 2.5 t /ha, T_4-NPK @ 80:40:40 kg/ha+Vermicompost@2t/ha, T_5-NPK @ 80:40:40 kg/ha+FYM @5 t/ ha, T_6-NPK @ 80:40:40 kg/ha+$ZnSO_4$@25kg/ha, T_7-NPK@125%ofRDF, T_8-NPK@125%ofRDF+FYM@ 5 t/ha +Vermicompost@ 2 t/ha]

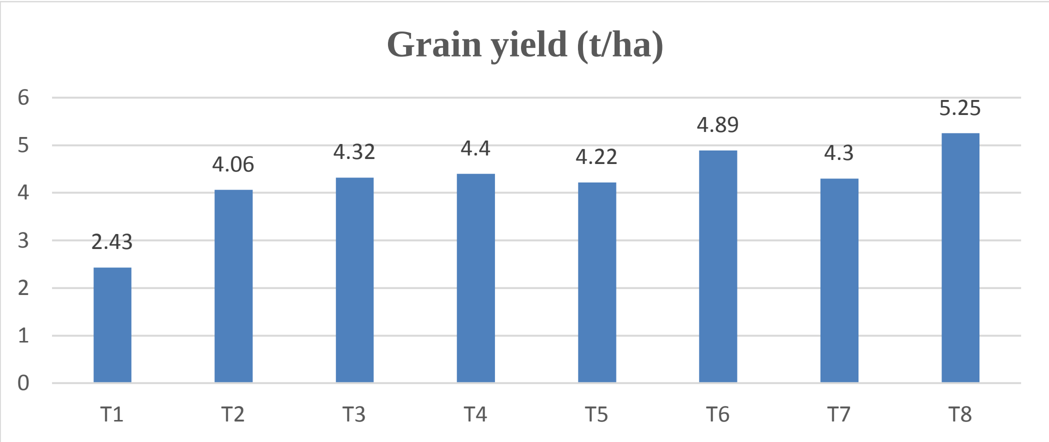

Fig. 1. Grain yield (t/ha) of rice grown with integrated nutrient management

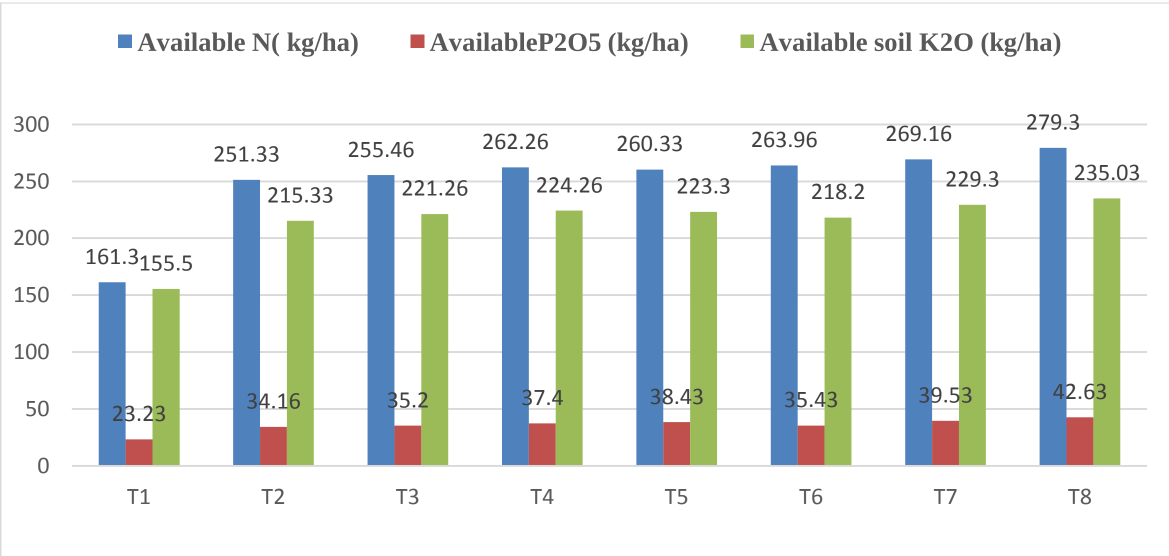

Fig. 2. Soil nutrient status (kg/ha) of rice grown with integrated nutrient management

4. CONCLUSION

Conclusively, integrated nutrient management was found to be superior for enhancing the growth and yield of rice cv. IET-25701(Bidhan Suruchi).Among the different combinations given, application of NPK @125% of RDF (100:50:50 kg/ha)+ FYM @ 5t/ha +Vermicompost@ 2.0 t/ha recorded the highest grain yield (5.25t/ha) 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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