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Impact of fertilizers and Manure on growth, yield, nutrient uptake by rice and soil properties in a Vertisol under STCR approach

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ABSTRACT
Experiment was conducted at the Research Field of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur during kharif season of 2015 under AICRP on STCR to evaluate the impact of NPK integrated with FYM under STCR approach on performance of rice and change in properties of a Vertisol. Application of 147, 117 and 64 kg N, P_2O_5 and K_2O along with 5 t FYM ha^{-1} was produced significantly highest dry matter of leaves (0.97, 3.73, 7.19 and 7.45 g $hill^{-1}$), stem (1.39, 11.27, 13.55 and 15.35 g $hill^{-1}$) and roots (0.75, 1.77, 2.25 and 2.57 g $hill^{-1}$) at 30, 60 and 90 DAS and at harvest, respectively over control and GRD. Significantly higher yields of grain (5.75 t ha^{-1}), straw (7.57 t ha^{-1}) and total N, P and K uptake by rice (114.97, 20.91 and 131.21 kg ha^{-1}) were obtained with the higher doses of NPK along with FYM as compared to those obtained under control. Application of NPK integrated with FYM (T_6) was significantly improved in EC, organic carbon, available N, P and K contents in post harvest surface and sub-surface soils over control and fertilizers alone. Soil test based integrated nutrient management maximises dry matter accumulation, yields, NPK uptake by rice and improved soil fertility in a Vertisol.
***Key words**: Dry matter partitioning, integrated nutrient management, nutrient uptake, rice yield, soil properties, STCR approach*

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INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most staple food crop of millions people in south, south-east and east Asia where about 90% of world's is grown and consumed. It fulfils 43 per cent of total calories requirement of more than 70 per cent of the Indian population and contributes 45% to the total food grain production in India [26]. To meet the food demand of increasing population and to maintain self-sufficiency, the country need to exaggerate its food grain production to 450 million tonnes (mt) at end of the year 2050 to maintains its food security, this means country need to add 166 mt to its current production level of 284 mt [23]. In India, it occupies nearly 44.38 million hectares areas with production of 106.60 million tonnes and productivity of 2421 kg ha^{-1}. In Madhya Pradesh, it is being grown in an area of 2.02 million hectares with production of 3.58 million tonnes and productivity of 1768 kg ha^{-1} [1].

Imbalanced and continuous fertilization with major nutrients under intensive agriculture subvert the soil ecology, disrupt environment, degrade soil fertility and consequently show harmful effects on human health along with contaminating ground water [13]. It is also declining in productivity of rice in India caused by imbalance nutrient application [30].

Fertilizer is one of the precious and expensive inputs in agriculture and the application of correct amount of fertilizer is primary prerequisite for farm profitability and environmental safety [15]. Fertilization of crops based on generalized recommendation leads to under fertilization or over fertilization, results in lower productivity, profitability along environmental pollution. It is also play an important role in influencing the quality of crops and it is fact that the soil health deteriorates due to continuous use of chemical fertilizers [32]. Under these circumstances, the need of the day is to sustain agriculture without harming the delicate balance of soil ecology, soil fertility as well as unlocking the mystery of biota influencing plant growth by integration of fertilizers and organic manure [6]. Integration of inorganic nutrients with and without organic manure and their management have shown promising results not only in sustaining the productivity but have also proved to be effective in maintaining soil health and enhancing nutrient use efficiency [41].

Among the various scientific methods of fertilizer recommendation, first initiated by Troug [42] based on yield target, which later modified by [27]. Soil test based nutrient management approach has been found most effective to develop recommendations for potential productivity of crops and maintaining soil health. It provides a scientific basis for balanced fertilization and balance between applied nutrients and soil available nutrients [28]. Use of STCR-INM based fertilizer adjustment equations has been could be very useful for prescribing fertilizer doses to rice grown in rice-wheat sequence to achieve desired productivity and improving soil health [35]. The supplementary and complementary use of inorganic fertilizers and organic manure under STCR approach augment the efficiency of both the substances to sustain soil productivity. In light of above facts, present investigation was conducted to monitor the impact of integrated application of inorganic fertilizers with and without organic manure on growth, yield, nutrient uptake by rice and soil properties in a Vertisol under STCR approach.

MATERIAL AND METHODS

Field study was under taken in on-going research programme of AICRP on STCR, JNKVV, Jabalpur, Madhya Pradesh during *kharif* season of 2015 with rice (var. Kranti) as the test crop to evaluate the impact of inorganic fertilizers integrated with and without organic manure on growth, yield, nutrient uptake by rice and soil properties in a Vertisol under STCR approach. The experiment was conducted at the Research Field of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur situated in the south-eastern part of the Madhya Pradesh at 23^0 13' N latitude, 79^0 57' E longitudes and at an altitude of 393 meter above mean sea level. The experimental soil was medium black belongs to Kheri series of fine montmorillonitic, hypothermic family of *Typic Haplustert*. The initial physico-chemical properties of pre-experimental surface (0-15 cm) and subsurface (15-30 cm) soils having pH (7.67 and 7.65), EC (0.30 and 0.26 dS m^{-1}), organic carbon (5.51 and 5.45 g kg^{-1}), available nitrogen (239.45 and 217.63 kg ha^{-1}), available phosphorus (19.57 and 17.39 kg ha^{-1}) and available potassium (345.21 and 320.57 kg ha^{-1}). The experiment consisted of six treatments based on soil test values and targeted yield of rice replicated four times in a randomized block design *viz.*, T_1: Absolute control; T_2: GRD (120:60:40 kg N, P_2O_5 and K_2O ha^{-1}); T_3: Targeted yield 50 q ha^{-1} (105:82:43 kg N, P_2O_5 and K_2O ha^{-1}); T_4: Targeted yield 60 q ha^{-1} (147:117:64 kg N, P_2O_5 and K_2O ha^{-1}); T_5: Targeted yield 50 q + FYM 5 t ha^{-1} (105:82:43 kg N, P_2O_5 and K_2O ha^{-1}) and T_6: Targeted yield 60 q + FYM 5 t ha^{-1} (147:117:64 kg N, P_2O_5 and K_2O ha^{-1}). The doses of fertilizer were calculated based on soil test values, targeted yield and developed fertilizer prescription equations for rice. The sowing of seed of rice was done at a spacing of 25 × 10 cm in 5 m x 5 m plot size. The calculated amount of FYM as per the treatments was applied to soil and mixed thoroughly in well-prepared plots one month before sowing. Total N, P and K contents of the FYM were 0.61, 0.56 and 0.73%, respectively. As per the treatments specification half dose of nitrogen and entire doses of phosphorus and potassium were applied as basal in the form of urea, single super phosphate and muriate of potash, respectively. The remaining nitrogen was applied in two equal splits at 25 and 55 days after sowing (DAS), respectively.

The observations on dry matter partitioning of leaves, stem and roots $hill^{-1}$ at different days (30, 60, 90) after sowing and at harvest was recorded from five tagged rice plants which were selected randomly from net plot area. Grain and straw yields of rice were recorded after harvest of net plot. The nitrogen content in grain and straw samples were digested in

H_2SO_4 and determined by Micro-Kjeldahl method as described by AOAC [1]. Samples were digested in di-acid (HNO_3:$HClO_4$, 9:4 v/v) and phosphorus and potassium were determined by Vanado Molybdate yellow colour method and Flame-Photometric method [5]. Plant uptake of nitrogen, phosphorus and potassium were computed by multiplying the yield with the respective nutrient content. The composite surface (0-15 cm) and subsurface (15-30 cm) soil samples before the start of the experiment and each plot of the experimental field after harvest of rice crop were taken. The soil samples were air-dried, ground to pass through a 2 mm sieve and were analysed for pH, EC, organic carbon, available N, P and K by following standard procedures. Soil pH and EC were determined by preparing 1:2.5 soil water suspensions and measured by glass electrode pH meter and digital electrical conductivity meter [12]. Organic carbon content in soil was determined by using potassium dichromate rapid titration method [46]. Available nitrogen was determined by alkaline potassium permanganate method evolved by Subbiah and Asija [39]. Available phosphorus was extracted with 0.5 M $NaHCO_3$ (pH 8.5) and colour developed by ascorbic acid [25] and available potassium was extracted with neutral normal ammonium acetate and estimated by using Flame photometer [12]. Data pertaining to each character of the rice crop were tabulated and analysed statistically by applying the standard technique. Analysis of variance for randomized block design was work out and the significance of treatments were tested to draw valid conclusions as described by Gomez and Gomez [10].

RESULTS AND DISCUSSION

Dry matter partitioning

An appropriate distribution of biomass in different plant parts is an important aspect, which ultimately determines the yield. Data on dry matter partitioning of plant parts (leaves, stem and roots) hill^{-1} was affected significantly by different treatments of NPK nutrients integrated with and without FYM based on soil test values at different days of crop growth of rice (30, 60, 90 DAS and at harvest). It was observed that lucid improvement in dry matter partitioning hill^{-1} was recorded with each successive increment of NPK levels with FYM at all the crop stages except at harvest, which was decreased gradually (Table 1). Application of 147:117:64 kg N, P_2O_5 and K_2O integrated with FYM 5 t ha^{-1} (T_6) was produced significantly increased with highest dry matter of leaves (0.97, 3.73, 7.19 and 7.45 g hill^{-1}), stem (1.39, 11.27, 13.55 and 15.35 g hill^{-1}) and roots (0.75, 1.77, 2.25 and 2.57 g hill^{-1}) over rest the treatments except T_4 and T_5 at all the stages with respect to dry matter of leaves and stem, T_4 at 30, 60 and 90 DAS with respect to dry matter of roots hill^{-1}, respectively. However, the minimum values of dry matter partitioning of leaves, stem and roots hill^{-1} were obtained in control at all the stages of rice crop, respectively. The progressive increase in dry matter production is the cumulative effect of all the growth characters with increasing NPK levels incorporated with FYM might be due to increased plant height, leaf area and leaf area index which are indicator of higher chlorophyll per unit area improving accumulation and transport of nutrients which in turn resulted in higher dry matter accumulation of plants. The findings are in accordance with the results on dry matter performance was reported by Naing Oo *et al.* [24], Samsul *et al.* [31], Srivastava *et al.* [38] and Khidrapure *et al.* [16]. Similarly Vidya *et al.* [43] have also reported that application of poultry manure @ 1.5 t ha^{-1} + 100% RDF recorded significantly higher total dry matter in comparison to other treatments including control.

Grain and straw yields

An examination of the data revealed that each increment of NPK levels caused significant variation in grain and straw yields of rice. Higher yield response in comparison to NPK was recorded with NPK nutrients along with FYM. Application of higher doses of NPK nutrients along with FYM recorded significantly highest yield response followed by higher doses of NPK nutrients (Table 2). Maximum grain (5.75 t ha^{-1}) and straw (7.57 t ha^{-1}) yields of rice were obtained in the treatment receiving 147:117:64 kg N, P_2O_5 and K_2O along with FYM 5 t ha^{-1} (T_6) over rest of the treatments except T_4 and T_5, which was being statistically at par with treatment T_6 whereas, minimum grain (2.82 t ha^{-1}) and straw (4.37 t ha^{-1}) yields were registered under control. Higher targeted yield of 60 q ha^{-1} with FYM 5 t ha^{-1} (T_6) could not be achieved and deviated by ± 4.12 % negatively, whereas the targeted yield of 50 q ha^{-1} along with FYM 5 t ha^{-1} (T_5) was obtained comfortably. Similar was the trend observed in case of straw. The findings are in accordance with the results on yield performance was reported by Kumar *et al.* [17], Mahmud *et al.* [20] and Senthilvalavan and Ravichandran [33]. Further, Chesti *et al.* [8] also found significantly higher grain yield of 5.36 t ha^{-1} with the application of 100% NPK + 10 t FYM ha^{-1} as compared to the grain yield of 4.96 t ha^{-1} with the 100% NPK alone. Benefits accruing from the integrated use of NPK nutrients with FYM might be attributed to better supply of nutrients through incorporation of organic manures along with conductive physical environment leading to better root activity and higher nutrient absorption, which resulted in better plant growth and superior yield attributes responsible for high yield [41]. The improvement in yield under higher level of nutrients might be due to higher absorption of nutrients responsible for increased photosynthetic accumulation and high biomass production which resulted in greater yield. Better crop due to synergistic effect all these factors helped in increasing photosynthetic rate and more photosynthates mobilization, which in term perhaps increased the movement of photosynthates from source to sink. Thus, finally resulted in increasing the yield and yield component.

Nutrient uptake

Application of increasing NPK levels with and without FYM based on soil test values and targeted yield of rice recorded significantly higher uptake nitrogen, phosphorus and potassium by grain, straw and biological produce of rice over that of control (Table 2). Application of NPK nutrients integrated with FYM significantly higher nitrogen, phosphorus and potassium uptake in comparison to NPK only. The highest uptake of nitrogen, phosphorus and potassium by grain (63.84, 13.55 and 15.73 kg ha^{-1}), straw (51.13, 7.36 and 115.48 kg ha^{-1}) and total uptake (114.97, 20.91 and 131.21 kg ha^{-1}) were recorded with the incorporation of 147:117:64 kg $N:P_2O_5:K_2O$ + 5 t FYM ha^{-1} (T_6) over rest the treatments except T_4 and T_5 with respect to nitrogen and phosphorus uptake by grain, straw and total uptake and T_4 with respect to potassium uptake by grain, straw and total uptake, which was being statistically at par with T_6. However, the nitrogen, phosphorus and potassium uptake by grain, straw and total uptake under treatment T_1 having control had significantly lower as compared to other treatments. Use of FYM under T_6 significantly enhanced the total uptake of N, P and K by biological produce of rice to an extent of 32, 34 and 26%, respectively over that of NPK only having GRD (T_2). The increase in uptake of nutrients in the organic manure treated plots may be due to extra amount of nutrients supplied by these organics providing conductive physical environment facilitating better root growth and absorption of nutrients from the native as well as applied sources which ultimately favoured the highest nutrient uptake [4]. It also might be due to the fact that the balanced use of various plant nutrient sources results in proper absorption, translocation and assimilation of nutrients, ultimately increasing the dry matter accumulation and nutrient contents of crop. These results are in agreement with those reported by Singh *et al.* [35], Vidyavathi *et al.* [44], Mitra and Mandal [22], Chesti *et al.* [7] and Senthilvalavan and Ravichandran [33]. Earlier, Chesti *et al.* [7] observed that the significantly higher total NPK uptake by rice (96.3, 20.4 and 109.5 kg ha^{-1}, respectively) with the application of 100% NPK + 10 t FYM ha^{-1} as compared to the total NPK uptake (86.5,18.1 and 96.8 kg ha^{-1}, respectively) with the 100% NPK alone.

Soil properties

Soil pH

A perusal of data in Table 3 showed that application of NPK nutrients with and without FYM based on soil test values and targeted yield of rice resulted in non-significant changes in soil pH after harvest of rice at 0-15 and 15-30 cm soil depth. Data clearly indicated that increasing levels of nutrients with and without organic manure decreased soil pH as compared to without fertilizers at both the soil depths. It was also evident from the data that soil pH at both the soil depths under different treatments varied from 7.61-7.66 and 7.62-7.65, respectively against the initial soil pH values of 7.67 and 7.65. The results showed that numerically maximum values of soil pH (7.66 and 7.65) were recorded in control, whereas addition of inorganic nutrients along with FYM having 147:117:64 kg N, P_2O_5 and K_2O + FYM 5 t ha^{-1} (T_6) slightly reduced the soil pH in both the soil depths. No significant change in soil pH due to treatments at both the soil depths was observed might be due to higher buffering capacity of Vertisol. Continuous application of manure and fertilizers indicated that the possibility of alteration in pH being relatively high when fertilizers were used alone than conjoint use of fertilizer with organic manure. Similar results are also reported by Swarup and Yaduvanshi [40], Raut and Mahapatra [39], Dwivedi *et al.* [9] and Habtamu [11].

Electrical Conductivity

Data on electrical conductivity (EC) of surface and sub-surface soils after harvest of rice varied significantly due to different treatments. It is evident from the data on EC at both the soil depths was varied from 0.227-0.283 dS m^{-1} and 0.205-0.247 dS m^{-1}, respectively (Table 3). It was also observed that EC of sub-surface soil was lower than the surface soil and significantly higher values of EC (0.283 and 0.247 dS m^{-1}) were obtained under T_6, which was statistically at par with T_5, while minimum values of EC (0.227 and 0.205 dS m^{-1}) were obtained under control at both the soil depths, respectively. The EC almost slightly higher if balanced fertilizers were used along with FYM might be due to stabilizing effects of FYM. It was also observed that the FYM might have accelerated the dissolution of sparingly soluble salts thereby increasing the electrical conductivity of soil. In contrast Bahadur *et al.* [3] reported that the application of organic manures along with inorganic fertilizers was more effective to decrease the EC of soil as compare to without organic manures application under rice-wheat cropping sequence.

Organic carbon

Data on organic carbon (OC) revealed that significantly increased in OC content under different treatments of application of inorganic fertilizers along with organic manure and the values ranged from 5.21 to 5.47 g kg^{-1} at 0-15 cm and 5.23 to 5.40 g kg^{-1} at 15-30 cm soil depth, respectively. It is clearly showed that organic carbon content of soil increased with NPK levels with and without FYM as compared to without inorganic fertilizers and it was also observed that OC content in surface soil was higher than the sub-surface soil (Table 3). Further it was also observed that OC content in surface soil was higher than the sub-surface soil. Maximum OC contents (5.47 and 5.40 g kg^{-1}) were obtained under T_6 (147:117:64 kg $N:P_2O_5:K_2O$ + 5 t FYM ha^{-1}) over rest of the treatments, while minimum OC contents (5.21 and 5.47 g kg^{-1}) were registered under control at both the soil depths, respectively. The improvement of OC content might be due to organic manures, which is a storehouse of nutrients and contributes to improved soil fertility. It was also farmyard manure increased organic carbon content by adding organic matter directly and also by improving crop yield, resulting in increased left over of root and plant biomass in the soil. The findings are in good agreement to those reported by Kumar and Singh [19], Walia *et al.* [45], Thakur *et al.* [41], Kalhapure *et al.* [14] and Habtamu [11]. Earlier, Chesti *et al.* [7] reported that three years of conjoint use of 10 t FYM ha^{-1} with 100% NPK significantly improved the organic carbon content over the chemical fertilizers alone.

Available N, P and K

A perusal of data on available N, P and K contents in soil after harvest of rice crop at 0-15 cm and 15-30 cm soil depth as affected significantly by different treatments of inorganic nutrients with and without organic manure based on soil test values and targeted yield of rice. It is evident from the data that residual available N, P and K contents in surface soil were comparatively higher than the sub-surface soil and a declining trend from its initial level Table 3). The maximum decline was in control, and the magnitude of decline decreased with decreasing levels of NPK application without FYM. However, there were significant build-up with maximum of available N, P and K (227.55, 25.75 and 309.15 kg ha^{-1}) at 0-15 cm and (211.27, 21.47 and 295.83 kg ha^{-1}) at 15-30 cm soils receiving 147:117:64 kg N, P_2O_5 and K_2O along with 5 t FYM ha^{-1} (T_6) as compared to the rest of the treatments, while minimum values were registered under control at both the soil depths. The increase in available nutrients might be attributed to the incorporation of nutrients with organic manure brought about increased availability of nutrient in soil solution exceeding the demand of crop plant at any given stage is often subjected to either fixation by soil colloid or conversion in to unavailable form. The FYM treated plot may be ascribed to higher availability of NPK and also other nutrients, higher occurrence of different beneficial microorganisms, producing growth promoting hormones, antibiotics, enzymes etc., which improved soil health. Similar results were reported by Singh *et al.* [36], Kumar *et al.* [18], Naing Oo *et al.* [24], Walia *et al.* [45], Kalhapure *et al.* [14], Sharma and Subehia [34], Habtamu [11] and Mishra *et al.* [21]. These results are in line with findings of Vidyavathi *et al.* [44] who also observed that integrated application of manure and fertilizer resulted in significantly higher available N, P and K than chemical fertilizer alone.

Table 1: Impact of fertilizers and manure based on soil test values and targeted yield on dry matter partitioning of rice.

Treatments	Dry matter partitioning hill^{-1} (g)											
	30 DAS			60 DAS			90 DAS			At harvest		
	Leaves	Stem	Roots	Leaves	Stem	Roots	Leaves	Stem	Roots	Leaves	Stem	Roots
T_1: Control	0.71	0.89	0.44	2.53	6.97	1.03	4.31	8.11	1.15	4.77	8.97	1.43
T_2: GRD (120:60:40 kg $N:P_2O_5:K_2O$ ha^{-1})	0.77	1.03	0.51	2.91	8.39	1.25	5.53	9.73	1.56	5.83	11.13	1.77
T_3: T.Y. 50 q ha^{-1} (105:82:43 kg $N:P_2O_5:K_2O$ ha^{-1})	0.81	1.15	0.61	3.15	9.33	1.39	5.99	10.71	1.73	6.25	12.37	1.95
T_4: T.Y. 60 q ha^{-1} (147:117:64 kg $N:P_2O_5:K_2O$ ha^{-1})	0.93	1.27	0.69	3.51	10.83	1.65	6.95	12.53	2.05	7.29	14.31	2.25
T_5: T.Y. 50 q + 5 t FYM ha^{-1} (105:82:43 kg $N:P_2O_5:K_2O$ ha^{-1})	0.87	1.23	0.65	3.37	10.31	1.51	6.63	11.73	1.87	6.87	13.83	2.13
T_6: T.Y. 60 q + 5 t FYM ha^{-1} (147:117:64 kg $N:P_2O_5:K_2O$ ha^{-1})	0.97	1.39	0.75	3.73	11.27	1.77	7.19	13.55	2.25	7.45	15.35	2.57
SE m ±	0.04	0.05	0.03	0.12	0.37	0.06	0.25	0.44	0.08	0.27	0.51	0.09
CD *(p=0.05)*	0.11	0.16	0.08	0.37	1.13	0.18	0.77	1.37	0.23	0.83	1.56	0.28

Table 2: Impact of fertilizers and manure based on soil test values and targeted yield on yield and nutrient uptake by rice.

Treatments	Yield (t ha^{-1})		Nutrient uptake (kg ha^{-1})								
			Nitrogen			Phosphorus			Potassium		
	Grain	Straw	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1: Control	2.82	4.37	29.72	25.45	55.17	5.81	3.17	8.98	7.65	63.87	71.52
T_2: GRD (120:60:40 kg $N:P_2O_5:K_2O$ ha^{-1})	4.19	5.83	43.87	34.11	77.98	8.97	4.90	13.87	10.93	85.61	96.54
T_3: T.Y. 50 q ha^{-1} (105:82:43 kg $N:P_2O_5:K_2O$ ha^{-1})	4.78	6.51	51.25	40.86	92.11	10.51	5.73	16.24	12.37	93.56	105.93
T_4: T.Y. 60 q ha^{-1} (147:117:64 kg $N:P_2O_5:K_2O$ ha^{-1})	5.35	7.13	58.86	47.49	106.35	12.65	6.87	19.52	14.61	105.35	119.96
T_5: T.Y. 50 q + 5 t FYM ha^{-1} (105:82:43 kg $N:P_2O_5:K_2O$ ha^{-1})	5.20	6.99	57.13	45.74	102.87	12.13	6.63	18.76	13.95	101.73	115.68
T_6: T.Y. 60 q + 5 t FYM ha^{-1} (147:117:64 kg $N:P_2O_5:K_2O$ ha^{-1})	5.75	7.57	63.84	51.13	114.97	13.55	7.36	20.91	15.73	115.48	131.21
SE m ±	0.23	0.32	2.25	1.77	4.13	0.47	0.25	0.71	0.53	4.19	4.85
CD *(p=0.05)*	0.69	0.99	6.93	5.45	12.72	1.45	0.77	2.19	1.63	12.91	14.94

Table 3: Impact of fertilizers and manure based on soil test values and targeted yield on properties of the post-harvest soil.

Treatments	pH (1:2.5)		EC (dS m^{-1})		OC (g kg^{-1})		Available nutrients (kg ha^{-1})					
							Nitrogen		Phosphorus		Potassium	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1: Control	7.66	7.65	0.227	0.205	5.21	5.23	165.33	171.98	10.81	11.35	251.27	247.65
T_2: GRD (120:60:40 kg $N:P_2O_5:K_2O$ ha^{-1})	7.65	7.64	0.243	0.217	5.35	5.33	199.41	193.43	17.93	16.77	283.41	271.43
T_3: T.Y. 50 q ha^{-1} (105:82:43 kg $N:P_2O_5:K_2O$ ha^{-1})	7.64	7.64	0.251	0.224	5.31	5.29	193.27	189.31	19.27	17.24	277.55	266.51
T_4: T.Y. 60 q ha^{-1} (147:117:64 kg $N:P_2O_5:K_2O$ ha^{-1})	7.63	7.63	0.267	0.235	5.41	5.34	212.67	201.53	22.73	19.35	295.30	283.47
T_5: T.Y. 50 q + 5 t FYM ha^{-1} (105:82:43 kg $N:P_2O_5:K_2O$ ha^{-1})	7.63	7.63	0.259	0.231	5.39	5.31	205.19	198.15	21.87	18.93	293.37	279.35
T_6: T.Y. 60 q + 5 t FYM ha^{-1} (147:117:64 kg $N:P_2O_5:K_2O$ ha^{-1})	7.61	7.62	0.283	0.247	5.47	5.40	227.55	211.27	25.75	21.47	309.15	295.83
SE m ±	0.091	0.087	0.006	0.005	0.078	0.051	4.95	4.61	0.45	0.39	7.52	7.11
CD *(p=0.05)*	NS	NS	0.018	0.015	0.241	0.156	15.24	14.20	1.37	1.19	23.17	21.90

CONCLUSIONS

The results of present study revealed that the application of higher doses of inorganic nutrients integrated with manure based on soil test values and targeted yield of rice was the best combination because of brought about an increase in growth, yield, nutrient uptake and soil fertility over control and NPK alone.

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