

Original Research Article

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STCR- Based Manure and Fertilizers Application Effect on Performance of Rice and Chemical Properties of Vertisol

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ABSTRACT

An experiment was conducted at soil science research farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, to study the effect of STCR-based manure and fertilizers application on growth and yield of rice, and changes in chemical properties of soil. Experiment was carried out during kharif season of 2016. Experiment was laid out in Randomized Block Design, consisting of four replications and six treatments viz., T₁: Absolute control, T₂: GRD, T₃: Targeted yield 50 qha⁻¹, T₄: Targeted yield 60 qha⁻¹, T₅: Targeted yield 50 qha⁻¹ with 5 t FYM ha⁻¹ and T₆: Targeted yield 60 qha⁻¹ with 5 t FYM ha⁻¹. The result revealed that rice growth parameters and grain yield was significantly affected due to fertilizers and manure application and recorded highest yield in treatment T₆ (5725 kg ha⁻¹) which was significantly superior to control. The chemical properties viz available nitrogen, phosphorus and potassium were found significantly higher as compared to control. Hence, it can be concluded that integrated use of NPK fertilizer with FYM based on STCR approach not only gave higher rice yield but also improve and sustain the soil fertility.

Keywords

STCR- Based
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Introduction

Rice (*Oryza sativa* L.) is the staple food of millions of people and provides about 700 calories/day/person for about 3000 million people living mostly in developing countries (Singh *et al.*, 2017). It is the grain that has shaped the cultures, diets and economics of billions of people in the world (Farooq *et al.*, 2009). Paddy is a staple food crop in south,

south-east and east-Asia where about 90% of world's paddy is grown and consumed. The country need to exaggerate its food grain production to 450 million tons (mt) at the end of the year 2050 to maintain its food security, this means country need to add 166 mt to its current production level of 284 mt (MoAFW, 2018). In India rice alone contributes about 43 percent into the countries food grain basket. This proclaims the addition of rice in meeting

food requirements of the starving mouth of country. Yield of rice depends on several factors like genotype, edaphic, climatic and management. Imbalanced fertilization of major nutrients is one of the reasons for lower production of rice in India (Reddy and Ahmed, 2000). Fertilizer is one of the most important and expensive inputs in agriculture and the application of correct amount of fertilizer is primary prerequisite for farm profitability and environmental safety (Kimetu *et al.*, 2004).

In India, fertilizers are generally applied to crops on the basis of generalized state level fertilizer recommendations, though the nutrient requirement of crops vary from place to place even for the same crop, as the fertility is highly variable chemical property of the soils. Fertilization of crops based on generalized recommendation leads to under fertilization or over fertilization, results in lower productivity, profitability along with environmental pollution.

Among the various scientific methods of fertilizer recommendation, which incorporate soil test values, nutrient requirement of the crop, contribution of nutrients from soil, manures, fertilizers and fixing yield-targets is only the Soil Test Crop Response (STCR) approach (Regar and Singh, 2014). Fertilizer recommendation based on yield target was first initiated by Troug (1960), which later modified by Ramamoorthy *et al.*, (1967) to suit the Indian condition. It provides a scientific basis for balanced fertilisation and balance between applied nutrients and soil available nutrients (Ramamoorthy and Velayutham, 2011). Soil test based application of plant nutrient helps to understand higher comeback ratio and benefit: cost ratio as the nutrients are applied in proportion to the amount of the deficiency of a particular nutrient and the correction of the nutrients imbalance in soil helps to harness the

synergistic effects of balanced fertilization (Rao and Srivastava, 2000). The present investigation aimed to study the relationship between the nutrient supplied by the soil and added fertilizers, their uptake and yield of paddy and to develop a guideline for judicious application of fertilizer for maximum production of paddy.

Materials and Methods

This study was under taken in an ongoing AICRP on STCR project, JNKVV, Jabalpur (M.P.). The present investigation was carried out in *Kharif* season in 2016 with the test crop rice (Kranti variety) at the soil science research farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, situated in the South-Eastern part of the Madhya Pradesh at 23° 13' North latitude, 79° 57' East longitudes and at an elevation of 393 meter above mean sea level. The soil of the experimental site was Vertisol (medium black) belongs to Kheri series of fine montmorillonitic hyperthermic family of *Typic Haplusterts*. The initial physico-chemical properties of pre-experimental surface (0-15 cm) soil were presented in Table 1.

The experiment was laid out in randomized block design (RBD) with four replications consisting of 6 treatments combinations *viz*: T₁: Absolute control; T₂: General recommended dose (120:60:40 kg N, P₂O₅ and K₂O ha⁻¹); T₃: Targeted yield 50 q ha⁻¹ (115:90:49 kg N, P₂O₅ and K₂O ha⁻¹); T₄: Targeted yield 60 q ha⁻¹ (157:125:70 kg N, P₂O₅ and K₂O ha⁻¹); T₅: Targeted yield 50 q + 5 t FYM ha⁻¹ (115:90:49 kg N, P₂O₅ and K₂O ha⁻¹); T₆: Targeted yield 60 q + 5 t FYM ha⁻¹ (157:125:70 kg N, P₂O₅ and K₂O ha⁻¹).

Fertilizer prescription equations for rice developed under AICRP on STCR, Jabalpur, given below, are used for the calculation of the doses of fertilizer and manure.

$$\begin{aligned} \text{FN} &= 4.25 \text{ T} - 0.45 \text{ SN} \\ \text{FP}_2\text{O}_5 &= 3.55 \text{ T} - 4.89 \text{ SP} \\ \text{FK}_2\text{O} &= 2.10 \text{ T} - 0.18 \text{ SK} \end{aligned}$$

Where, FN, FP₂O₅ and FK₂O are fertilizer N, P₂O₅ and K₂O in kg ha⁻¹, respectively; T= targeted grain yield in q ha⁻¹, SN, SP and SK are soil available N, P and K in kg ha⁻¹ respectively.

Data collection

Plant height at different crop growth stages (30, 60, 90 DAS and at harvest) was recorded from five tagged rice plants which were selected randomly from net plot area. Plant height is taken from the base of the plant to the tip of the top most leaf with the help of measuring scale and the average is expressed in cm., while the number of tillers also counted in the same plants and average values are expressed at their respective crop growth stages. After harvesting, panicles are grouped into bundles according to the imposed treatments, allowed to dry in the field till it obtained constant weight. The threshing of panicles from different treatments was done manually followed by recording the grain and straw yield (kg ha⁻¹). Soil samples has been collected from the experimental plots for soil nutrient analysis.

Statistical analysis

The data pertaining to each character of the rice crop were tabulated and analyzed statistically by applying the standard technique. Analysis of variance for randomized block design was worked out and the significance of treatments were tested to draw valid conclusions as described by Gomez and Gomez (1984). The differences of treatments mean were tested by 'F' test of significance on the basis of null hypothesis. Critical differences were worked out at 5 percent level of probability where 'F' test was significant. If the variance ratios (F-test) were found significant at 5% level of significance,

the standard error of mean (SEm) and critical differences (CD) were calculated accordingly.

Results and Discussion

Plant height

Data revealed that there was marked significant difference in plant height at various treatments at all the stages except 30 DAS where it did not differ significantly (Table 2). The maximum plant height (*viz.*, 30.95, 59.17, 76.61 and 76.33 cm at 30 DAS, 60 DAS, 90 DAS and at harvest, respectively) were recorded in treatment T₆ where highest NPK levels integrated with FYM (157:125:70 kg N: P₂O₅: K₂O + 5 t FYM ha⁻¹) were applied, while it was found minimum under control at all the stages. The progressive increase in plant height might be due to the fact that the demand of NPK levels with FYM have been sufficient for the formation of chlorophyll and nucleic acids which are responsible for growth and development (Srivastava *et al.*, 2013). The findings are in accordance with the results reported by, Challa Venureddy (2014) and Mahmud *et al.*, (2016).

Number of tillers per plant

STCR-based application of fertilizers and manure leads to the statistically significant variation in number of tillers plant⁻¹ at all growth stages (Table 2). It is evident from the data that number of tillers were increased with increasing levels of NPK with FYM. At early growth stage (30 DAS), the treatment T₆ (157:125:70 kg N: P₂O₅: K₂O + 5 t FYM ha⁻¹) brought significantly maximum number of tillers (2.85) over control. Whereas, minimum number of tillers were recorded (1.97) in treatment T₁ (control). At 60 DAS the significantly maximum number of tillers (7.75) were recorded in treatment T₆ (157:125:70 kg N: P₂O₅: K₂O + 5 t ha⁻¹FYM) which were statistically at par with rest of

treatment except control. However, the minimum number of tillers (4.13) was recorded in treatment T₁. At 90 DAS, the maximum number of tillers (8.67) were recorded in treatment T₆ (157:125:70 kg N: P₂O₅: K₂O +5 t ha⁻¹FYM) which was significant over rest of the treatments except T₃, T₄ and T₅. The minimum number of tillers (4.65) was recorded in treatment T₁ (control). At harvest, the number of tillers slightly decreases. The maximum number of tillers (8.51) were also recorded in T₆ (T.Y.6 t ha⁻¹ + 5 t ha⁻¹ FYM) which was significant over all the treatments but at par with T₄ and T₅ whereas, the minimum number of tillers (4.19) were recorded in treatment T₁, followed by T₂ (7.51), respectively. The increment in number of tillers with NPK and FYM can be attributed to soil conditions with more availability and uptake of nutrients, water and growth promoting substances to promote more tillers. Similar findings have been also reported by Srivastava *et al.*, (2013), Tabar *et al.*, (2012) and Mahmud *et al.*, (2016).

Grain yield

Grain yield of rice was significantly

influenced by different level of fertilizers and manure application based on STCR approach. Maximum grain yield viz. 5725, 5213, 5371, 4819 and 4237 kg ha⁻¹ was recorded with treatment T₆, T₅, T₄, T₃ and T₂ respectively.

However, Treatment T₆, T₅ and T₄ are at par and were significantly different from T₁, T₂ and T₃. Minimum grain yield of 2781 kg ha⁻¹ was found under control. Higher yield in T₆ and T₅ might be due to the integrated application of NPK fertilizers and FYM, which enhance the nutrient availability throughout the growing season (Table 3). Similar findings were also reported by Subehia and Sepehya (2012), Gautam *et al.*, (2013), Kumar *et al.*, (2014) and Mahmud *et al.*, (2016).

Chemical properties

The residual available nitrogen content at both the stages under different treatments varied from 181.45 to 253.39 and 153.21 to 211.67 kg ha⁻¹ at 60 DAS and at harvest soil, respectively, against the initial values of 217.83 kg ha⁻¹ (Table 3).

Table.1 Initial Chemical properties of experimental soil at 0-15 cm depth

Particulars	Method employed	
	0-15 cm	Method
Soil pH (pH _w 1:2.5 at 25 °C)	7.57	Glass electrode pH meter (Jakson, 1973)
Electrical Conductivity (dS m ⁻¹ at 25 °C)	0.321	Electrical conductivity meter (Jakson, 1973)
Organic Carbon (g kg ⁻¹)	5.41	Potassium dichromate rapid titration method (Walkley and Black, 1934)
Available Nitrogen (kg ha ⁻¹)	217.83	Alkaline permanganate method (Subbiah and Asija, 1956)
Available Phosphorus (kg ha ⁻¹)	21.45	Soil extracted with 0.5 M NaHCO ₃ and colour development by ascorbic acid (Watanabe and Olsen s, 1965)
Available Potassium (kg ha ⁻¹)	311.57	Neutral normal ammonium acetate method by using Flame photometer (Hanway and Heidel, 1952)

Table.2 Effect of STCR- based manures and fertilizers recommendation on plant height, number of tillers and yield of rice

Treatment	Plant height (cm)				Number of tillers/plant				Grain yield kg/ha
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	
T ₁	28.81	44.68	51.43	50.57	1.97	4.13	4.65	4.19	2781
T ₂	29.13	51.71	65.57	64.93	2.43	6.81	7.53	7.15	4237
T ₃	29.43	53.79	68.31	67.75	2.59	7.13	7.98	7.69	4819
T ₄	30.19	57.33	73.13	72.73	2.77	7.57	8.46	8.27	5371
T ₅	29.87	55.85	71.55	71.11	2.69	7.33	8.21	7.95	5213
T ₆	30.95	59.17	76.61	76.33	2.85	7.75	8.67	8.51	5725
SEm ±	1.05	1.72	2.07	1.95	0.10	0.22	0.25	0.24	219
CD (<i>p</i> =0.05)	NS	5.29	6.39	NS	0.31	0.69	0.77	0.73	675

Table.3 Effect of different treatments on available major nutrient content in soil

Treatments	Available Nitrogen (kg ha ⁻¹)		Available Phosphorus (kg ha ⁻¹)		Available Potassium (kg ha ⁻¹)	
	60 DAS	At Harvest	60 DAS	At harvest	60 DAS	At Harvest
T ₁ :	181.45	153.21	15.73	11.27	257.53	223.67
T ₂	225.63	187.65	22.37	18.45	273.97	257.43
T ₃	231.27	181.43	23.91	20.71	278.65	251.35
T ₄	243.51	199.77	26.43	23.69	285.39	265.59
T ₅	239.83	193.59	27.85	25.17	289.41	267.23
T ₆	253.39	211.67	30.17	27.53	297.25	279.31
SE m ±	5.37	4.83	0.75	0.55	6.97	6.41
CD (<i>p</i> =0.05)	16.53	14.87	2.31	1.69	21.47	19.73

The lowest residual N in control (T₁) shows that N was depleted in the soil and crop used the indigenous soil nitrogen which claims the depletion of soil fertility, in contrast to this, residual N content at harvest in soil in T₆ was at par with that of initial N level. Thus, it can be supposed that T₆ was more beneficial for improving and sustaining the soil fertility. Higher residual nutrient in T₆ might be due to the incorporation of fertilizers with organic manure brought about increased availability of nutrient in soil solution exceeding the demand of crop plant. Similar results were also reported by Subehia (2012) and Habtamu (2015). Similarly, the increasing levels of N-P-K with and without FYM caused significant

improvement in available phosphorus at 60 DAS and at harvest of rice crop. It is clearly evident from the data that application of N-P-K nutrients integrated with FYM significantly increased the content of available P at both the stages over without inorganic nutrients. The maximum available phosphorus was found in T₆ (30.17 and 27.53 kg ha⁻¹ at 60 DAS and at harvest, respectively) and minimum observed in T₁ (15.73 and 11.27 kg ha⁻¹ at 60 DAS and at harvest, respectively). Garg and Milkha (2010) reported the increasing levels of P application continuously either alone or with organic manure improved the available P status. While potassium is not a fundamental element

of plant but it is mandatory in huge quantity almost equal to N. It may be seen from the data that the available potassium content increased with the application of NPK fertilizers with and without integration of FYM as compared to control. The data of available potassium as influenced by various treatments at both the stages indicated that the status of available potassium was higher in all the treatments over control, it varied from 257.53 kg ha⁻¹ to 297.25 kg ha⁻¹ at 60 DAS and 223.67 kg ha⁻¹ to 279.31 kg ha⁻¹ at harvest soil. Results were in accordance with that of Laxminarayana (2006). It is evident from the above data that STCR based fertilizer and manures application not only increase the growth and yield of rice but also improved and sustained the soil fertility.

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