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Influence of fertilizer levels on yield and NUE by rice in an Inceptisol

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Abstract
The experiment conducted at farmer field at Sonwahi village Ambikapur entitled "Influence of fertilizer levels on yield and NUE by rice in an Inceptisol" during kharif 2021. Field experiment was laid down in randomized block design using rice cultivar MTU 1156 as test crop, allocated randomly five fertilizer treatments T_1(control), T_2(50% RDF), T_3(100% RDF), T_4(150% RDF), T_5(100% RDF +5 t ha^{-1}) with five replications. The yield attributing parameters *viz*. plant height, effective $tiller^{-1}$ were found highest with applied level of 150% RDF. The highest grain and straw yield (61.80 q ha^{-1} and 75.45 q ha^{-1}) were found with applied RDF level at 150% was at par with 100% RDF + 5 t ha^{-1} FYM (60.48 q ha^{-1} and 74.33 q ha^{-1}). Maximum nitrogen, phosphorus, potassium uptake (100.11, 21.52, 165.97 kg ha^{-1}) of applied fertilizer i.e. 150% RDF. The nitrogen and phosphorus use efficiency were recorded with applied 50% RDF (40.40% and 18.15%). The highest potassium use efficiency was obtained at level of applied 50% RDF. The overall finding showed that use of 150% RDF at par with 100% RDF + 5 t ha^{-1} FYM increased the growth and yield attributes parameters of rice. Hence the farmers may apply 150% RDF doses for maximization of rice yield but may reduce N, P & K fertilizer doses with application of 5 t ha^{-1} FYM with 100% RDF for similar yield.

Keywords: Rice, fertilizer, nitrogen, phosphorus, potassium

Introduction
Fertilizer is one of the inputs which bring quantum jump in the yield and uptake of rice, to improve the production efficiency of rice and to synchronize the application of nutrients with the demand of the plant, it is necessary to apply required dose of inorganic fertilizer. NPK are the major important nutrients play a pivotal role for growth and metabolic process and ultimately for increasing the production and productivity of rice. Nutrient management is critical for profitable rice farming in Asia because fertilizers incur the second- highest input cost after labor. In Asia Farmer's mostly depend on chemical fertilizers, particularly N fertilizers, to boost rice yields. They also applied less amount of P and K fertilizers. Initially, there is a significant increase in yields by applying large amounts of fertilizers, but this has led to soil problems, declining crop yields, and global environmental issues.

Identifying the optimum dose of integrated nutrients however, required for maintaining the adequate supply of nutrient yield. Different recommendations on the rates of organic-inorganic fertilizer combination have been given for rice production in different parts of the world. Thus there is a need to develop and adopt environmentally friendly alternatives that can supplement or minimize the use of chemical fertilizers.

Rice is the staple and widely grown food crop for about 50% of the population that resides in Asia, where 90% of the world's rice is grown and consumed and also known as "National grain". India has the largest rice area in Asia, 43.77 million ha, accounting 29.4 percent of the global rice area with production of 121.46 mt. Indian rice productivity is still well below the world's average yield of 4.36 t ha^{-1}. Chhattisgarh is traditionally known as the rice bowl of India and occupies an area of .3.7 mha and recorded production of 8.34 mt with average productivity of 2.18 t ha^{-1} (Department of agriculture Raipur 2018-19). Advantages of combining organic and inorganic sources of nutrients in integrated nutrient management has been proved superior to the use of each component separately (Palaniappan and Annadurai 2007) [21]. The combined application of inorganic and organic fertilizers, usually termed integrated nutrient management, is widely recognized as a way of increasing yield and or improving productivity of the soil sustainably (Mahajan *et al*., 2008) [15].

The beneficial effect of organic manures on soil properties in addition to nutrition of rice through supply of major nutrients is obvious. Desirable quantity of nutrients drawn from a sustainable source and applied at an appropriate time favourably influences the nutrient uptake, growth and yield of hybrid rice (Ghodake *et al*. 2008; Kumar & Yadav 2009; Subha Lakshmi *et al*. 2014) [9, 13, 30]

Nutrient use efficiency (NUE) is an important concept critically in evaluating crop production systems. It is greatly influenced by fertilizer management as well as by soil- and plant-water management. The main role of NUE is to increase the overall performance of cropping systems by providing economically optimum nourishment to the crop while minimizing nutrient losses from the field, supporting agricultural system sustainability through contributions to soil fertility or other soil quality components. Increasing nutrient use efficiency (NUE) is critical in order to achieve expected production while using as little fertilizer as possible. As the nutrient use efficiency for N, P, and K decreased with the increase of applied levels of fertilizers. (Fageria *et al.* 2016) [8]. The use of the proper fertilizer in the right amount is one of the most important management strategies for maximizing crop productivity and fertilizer efficiencies. Crop productivity and quality are dependent on better availability of essential crop nutrients. Global food security in the rice-consuming countries of the world will have to produce 50% more rice with improved quality to meet consumers' demand by 2025.Use of organic and inorganic sources in combinations for balanced crop nutrition for realization the maximum yield of rice with quality of the product is essentially needed.

Materials and Method

The experimental site is situated in village Sonwahi under agro- climatic zone of northern hill of Chhattisgarh at about 10 km away from the Ambikapur city, district Surguja (Chhattisgarh) and located between of 23.12º 8' N latitude and of 83º 18' E longtitute with an altitude of 613.07 m above mean sea level. The general climate of this region is sub humid, it receives a annual rainfall of 1130 to 1250 mm, out of which above 88% is received during the rainy season. Field experiment was laid down in randomized block design using rice cultivar MTU 1156 as test crop, allocated randomly five fertilizer treatments T_1(control), T_2(50% RDF), T_3(100% RDF), T_4(150% RDF), T_5(100% RDF +5 t ha^{-1}) with five replications. The sources of fertilizer applied in the form of urea, single superphosphate and muriate of potash, respectively. Initial soil samples were collected from each plot and analyzed for pH, Ec, organic C, available N (Subbiah and Asija 1956) [29], available P (Bray and Kurtz, 1945) [5], available K (Jackson, 1973) [12], available micronutrients (Fe, Mn, Zn, Cu). The plant samples from each plot were analyzed for N (modified Kjeldahl's method), P (di-acid digestion and vanadomolybdate method) and K content (Flame photometer). The respective percent content of different nutrients was multiplied by the corresponding dry matter yield to estimate the nutrient uptake.

Results and Discussion

Effect of fertilizer levels on yield and yield attributes

The plant height of rice recorded was significantly influenced at 90 DAT by different levels of applied fertilizers. The maximum plant height was recorded with applied 150% RDF (T_4) 103.83 cm which was found at par with T_5 -100% RDF +5 t/ha^{-1} FYM (103.45) and lowest was observed under control (90.72). Mohanty *et al*, 2013 [20] observed same results with chemical fertilizer along with FYM application as compared to other treatment combinations. Similar result was found by Apon *et al.* (2018) [2], Ram *et al.* (2020) [22], Mahmud AJ *et al.* (2016) [16]. The result showed that the number of effective tiller $hill^{-1}$ of rice significantly increased with increase in NPK levels, 150% RDF (T_4) has significantly higher effective tiller $hill^{-1}$ i.e. 8.71 which was found at par with applied 100% RDF + 5 t ha^{-1} FYM (T_5) and the lowest effective tiller were recorded at control (T_1) i.e. 5.53 and the similar result was found by Reddy *et al* (2017) [23] who supported that significant increase in 150% NPK over control may be due to increased NPK levels resulted in greater availability of nutrient from the soil. The results in conformity with the findings of Singh *et al.* (2013), Nayak *et al.* (2007), Rout *et al.* (2007). The result showed non-significant variation with different applied fertilizer levels. However, the highest test weight of rice was recorded under 100% RDF+5 t ha^{-1} FYM (T_5) i.e. 31.50g which was at par with 150% RDF(T_4), i.e. 31.38g, and the lowest found in control 30.76 g. Similar result was observed by Reddy *et al.* (2017) [23]. The data showed a significant increase in grain and straw yield of rice with different fertilizer levels. The highest grain yield was recorded under applied treatment 150% RDF (T_4) 61.80 q ha^{-1} as compared to other treatment100% RDF,50% RDF but at par from 100% RDF + 5 t ha^{-1} FYM (T_5) 60.48 q ha^{-1} and the lowest grain yield was recorded at control 25.54 q ha^{-1} (T1). The straw yield was highest at 150% RDF (T_4) 75.45 q ha^{-1} which is at par with 100% RDF + 5 t ha^{-1} (T_5) and the lowest was recorded at control(T_1) 31.12 q ha^{-1}. This might be due to increased in growth of plants and also due to continuous and synchronize supply, of nutrients throughout the growth stage of rice. This similar finding was reported by Yadav *et al*. (2021) [32] and Behera *et al.* (2020).

Effect on nutrient uptake & their use efficiency by rice

The result reveals that nitrogen uptake of rice increased significantly with levels of applied different fertilizer levels over control shows significant result on N uptake by rice influenced by different fertilizer levels. The highest N uptake in grain (72.47 kg ha^{-1}), straw (27.64 kg ha^{-1}) and total nitrogen uptake (100.11 kg ha^{-1}) was recorded under 150% RDF (T_4) which was found at par with treatment 100% RDF +5 t ha^{-1} FYM (T_5) and the lowest was recorded under treatment control(T_1). Similar result were found by Reddy *et al* (2017) [23] where nitrogen uptake was highest at 150% RDF followed by 100% RDF + 5 t ha^{-1} FYM and lowest in control. The continuous application of fertilizer with organic manure resulted in higher nitrogen uptake in rice crop (Sathish *et al*., 2011) [26] and similar finding was reported by Sahu *et al.* (2020) [25], Apon *et al.* (2018) [2]. The data shows that phosphorus uptake in both grain and straw of rice was significantly influenced by different treatments. The total phosphorus uptake varied from 7.84 to 21.52 kg ha^{-1}. The highest grain uptake of phosphorus was recorded in 150% RDF(T_4) 17.40 kg ha^{-1} followed by 100% RDF +5 t ha^{-1} FYM (T_5) 16.08 kg ha^{-1} and lowest was recorded at control (T_1) 6.44 kg ha^{-1}, the highest straw uptake of phosphorus was found in 100% RDF +5t $^{-1}$ FYM (T_5) 4.14 kg ha^{-1} which is at par with 150% RDF (T_4) 4.12 kg ha^{-1} and lowest at control (T_1) 1.41 kg ha^{-1} and the total phosphorus was highest at 150% RDF(T_4) 21.52 kg ha^{-1} followed by 100% RDF +5 t ha^{-1} FYM (T_5)

20.23 kg ha^{-1} and lowest in control(T_1) 7.84 kg ha^{-1}. The total phosphorus uptake increases with increase in phosphorus levels explained by Mehendi *et al.* (2009). The result revealed that the K uptake of both grain and straw of rice was significantly influenced by various fertilizer levels. The K uptake varies from (60.65 to 165.97 kg ha^{-1}). The highest uptake of grain and was observed in 150% RDF (T_4) followed by 100% RDF +5t $^{-1}$ FYM (T_5) and lowest in control, the highest straw uptake was found at 150% RDF followed by 100% RDF +5 t ha^{-1}and lowest at control(T_1) and the total potassium uptake was highest at 150% RDF (T_4) 165.97 kg ha^{-1} RDF followed by 100% RDF +5t $^{-1}$ FYM (T_5) 165.65 kg ha$^{-1.}$ This might be due to increase in fertilizer level results in increase in potassium uptake. The data showed that with increasing fertilizer levels from control to 50% RDF the efficiency increases and further increase in fertilizer levels reduces the nitrogen use efficiency. The maximum nitrogen use efficiency was recorded in T_2 - 50% RDF (43.40%) and lowest was recorded in T_4-150% RDF (33.21%) followed by T_5 -100% RDF+5 t ha^{-1} FYM (39.58%). Sharma *et al*. (2022) [27] Metwall *et al.* (2011) [19], Eagle *et al*. 2001 [7] and Zaidi *et al.* (2007) [32] reported that there is a decrease in nitrogen use efficiency at higher level of fertilizer.

The result on phosphorus use efficiency on rice with different fertilizer level is showed that the Phosphorus use efficiency was found highest in 50% RDF (T_2) 18.15% and lowest was recorded in 150% RDF (T_4) 15.19% followed by 100% RDF +5t $^{-1}$ FYM (T_5) 17.08%. Decrease in Phosphorus use efficiency is reported at higher levels of fertilizer reported by Shabnam *et al*. (2016), Rasul *et al.* (2016), ZHU *et al.* (2016).The Potassium use efficiency was highest in 50% RDF (T_2) 204.85% and lowest was recorded under 150% RDF (T_4) 175.54% followed by 100% RDF+5 t ha^{-1} FYM (T_5) 161.54%. Decrease in Potassium use efficiency is reported at higher levels of fertilizer reported by Sharma *et al*. (2022) [27], Mesele *et al*. (2019) [18].

Table 1: Effect of fertilizer levels on yield and yield attributes (plant height (cm), effective tillers hill^{-1}, test weight 1000 seeds, Grain and straw yield

Treatments	Plant height (cm)	Number of effective tiller hill^{-1} (cm)	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Control	90.72	90.72	30.76	25.54	31.12
50%RDF	94.46	94.46	31.05	41.40	51.69
100%RDF	100.22	100.22	31.08	52.18	61.41
150%RDF	103.83	103.83	31.38	61.80	75.45
100%RDF+5t/ha FYM	103.45	103.45	31.50	60.48	74.33
S.Em±	0.718	0.718	0.19	1.92	1.73
CD (p=0.05)	2.15	2.15	NS	5.76	5.21

Table 2: Effect on fertilizer levels on Nitrogen uptake (kg ha^{-1}), Phosphorus uptake (kg ha^{-1}) and Potassium uptake (kg ha^{-1}) by rice

Treatments	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Control	29.35	11.00	40.34	6.44	1.41	7.84	7.78	52.87	60.65
50%RDF	47.78	18.60	66.38	10.92	2.37	13.29	12.74	88.88	101.62
100%RDF	60.32	22.34	82.66	14.42	3.01	17.43	19.86	111.81	131.67
150%RDF	72.47	27.64	100.11	17.40	4.12	21.52	25.16	140.81	165.97
100%RDF+5t/ha FYM	70.51	27.22	97.73	16.08	4.14	20.23	26.01	139.64	165.65
S.Em±	2.35	0.84	3.03	0.72	0.26	0.88	1.765	6.320	7.280
CD (p=0.05)	7.06	2.54	9.09	2.17	0.78	2.64	5.29	18.94	21.82

Table 3: Effect on fertilizer levels on Nitrogen use efficiency (%), Phosphorus use efficiency (%) and Potassium use efficiency (%)by rice

Treatments	Nitrogen use efficiency (%)	Phosphorus use efficiency (%)	Potassium use efficiency (%)
Control	0.00	0.00	0.00
50%RDF	43.40	18.15	204.85
100%RDF	35.26	15.98	177.56
150%RDF	33.21	15.19	175.54
100%RDF+5t/ha FYM	39.58	17.08	161.54
S.Em±	2.94	1.48	17.26
CD (p=0.05)	8.83	4.43	51.75

Conclusions

The yield attributes *viz*. plant height (cm), effective tiller hill^{-1}, was significantly improved with applied fertilizer levels over control and maximum were found with 150%RDF which was at par with 100% RDF+5 t ha^{-1} FYM and similarly the grain and straw yield was found highest at 150%RDF at par with 100% RDF+5 t ha^{-1} FYM over control. Among different levels of applied fertilizer the highest total N, P & K uptake was found with 150%RDF treatment followed by 100%RDF +5t ha^{-1} FYM. The highest nitrogen and phosphorus use efficiency was recorded at 50%RDF and the lowest found in 150%RDF which was at par with 100% RDF+5 t ha^{-1} FYM treatment. The highest potassium use efficiency was found at 50% RDF and lowest with applied 100% RDF +5 t ha^{-1} treatment at par with applied 150% RDF.

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