Performance of rice (*Oryza sativa* L.) cultivars under nutrient management practices in eastern plateau and hills zone of India~~.~~

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Abstract

Rice (*Oryza sativa* L.) is the staple food for nearly half of the world's population, and its continued increased production to meet the enhanced demand due to ever-increasing population faces many challenges towards food security. In India rice is cultivated in an area of 43.66 million hectares with a production 118.87 million tonnes and productivity of 2722 kg ha^{-1}. Rice is the major nutrient draining crop, there will be huge deficit in the soil nutrients in rice cultivated land. To stabilize the food and nutrient security and maintain soil fertility, there is need to integrate nutrient management through organic and inorganic sources that can help in maximization of yield as well as the sustainability in production system. Cultivation of high yielding varieties with high levels of fertilizer, specially, nitrogen have been the major factor of increased rice production in recent days, but overuse of chemical fertilizer has created environmental pollution through greenhouse gas emission, depletion of ozone layer, over exploitation of water resources which leads to global concern. Integrated Nutrient Management (INM) involving organic and inorganic sources of nutrient are very important in rice production. Many of our problems on declining productivity can be traced to improper and inefficient use of nutrients. Improper way of nutrient management has resulted in the nutrient imbalances in the soil with nutrients in excess while other nutrients depleted. With this backdrop, a field experiment entitled **"**Performance of rice (*Oryza sativa* L.) cultivars under nutrient management practices in eastern plateau and hills zone of India**"** was conducted at Chatabar farm, Faculty of Agricultural Science, Siksha 'O' Anusandhan University during *kharif* season of 2022 on sandy loam soil (medium land) to determine the effect of rice cultivars and nutrient management practices on growth parameters, yield attributes, yield, nitrogen uptake and comparative economics. The recommended dose of fertilizer applied was 80:40:40 kg ha^{-1} N, P_2O_5, K_2O respectively. Three varieties and four nutrient management are treated in split plot design with plot size of 4m × 3m. The treatments comprised of three varieties, V_1: CR Dhan – 206, V_2: CR Dhan 210 and V_3: CR Dhan 602 were laid out in main plot and four nutrient management comprised of N_1: 100% Recommended dose of nitrogen (RDN) through fertilizer, N_2: 50% RDN through fertilizer + 50% RDN through FYM, N_3: 50% RDN through fertilizer + 50% RDN through azolla and N_4: 50% RDN through FYM + 50% RDN through azolla are tested in subplot with three replications~~replicate thrice~~. The experimental result from this experiment indicated that CR Dhan 206 cultivate with 100% RDN through fertilizer produced maximum plant height, number of filled grain per panicle, panicle length, yield (grain and straw), harvest index, nitrogen uptake by grain and straw, net return and return per rupees investment. In case of nutrient management, application of 100% RDN through fertilizer and 50% RDN through fertilizer + 50% RDN through azolla are being at per with each other and significantly provided maximum grain yield, straw yield, nitrogen uptake, net return and return per rupees investment.

Key words: Rice, varieties, RDN, FYM, azolla, yield and economics.

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Introduction

Rice (*Oryza sativa*) is one of the important staple food grain crop in the world. It is a high calories food which contains about 75% starch, 6-7% protein, 2-2.5% fat, 0.8% cellulose and 5-9% ash. In Asia, more than two billion people are getting 60-70% of their energy requirement from rice and its derived products (Tomar *et al*., 2018). In India, it is cultivated in an area of 43.66 million hectares with a production of 118.87 million tonnes and productivity of 2722 kg ha^{-1} (AD and FW 2019-20). Increasing population in Asia demanding higher quantity of rice grain in recent days. More yield and profitability motivated the farmers to switch over to the high yielding varieties cultivation from traditional low yielded old varieties to feed the increasing population. So, it is needed~~s~~ to boost the rice production with ~~through~~ high yielding varieties because the ~~as~~ conventional varieties are still showing low productivity (why? Put reference). High yielding varieties uptake more nutrient compared to traditional varieties and deplete soil fertility (Reference Needed). The primary concept of integrated nutrient management is to maintain and adjust~~ing~~ long term soil fertility as well as supplying optimum quantity of nutrients to ~~the~~ plants through integration of all possible plant nutrient sources to sustain productivity of crop and soil. Azolla is a symbiont, anabaena, which have ability to fix atmospheric nitrogen has been used for a century in the rice ecosystem to increase rice production and maintain soil fertility (Reference required). After decomposition, its organic nitrogen mineralized quickly and released as ammonia form, becomes available as a nitrogen fixing biofertilizer for the growing rice crop. During the recent times, higher requirement of rice production as well as maintain soil fertility can be fulfilled by cultivation of recently developed high yielding rice varieties with integrated approach of nutrient management. Keeping these views in mind, a field experiment entitled "Performance of rice (*Oryza sativa* L.) cultivars under nutrient management practices in eastern plateau and hills zone of India" was conducted to know the ability of rice cultivars and nutrient management on yield attributes and yield, nitrogen uptake and economics of rice cultivation.

Materials and methods

A field experiment entitled "~~p~~Performance of rice (*Oryza sativa* L.) cultivars under nutrient management practices in eastern plateau and hills zone of India", was conducted at the Agricultural Research Station, Brinjhagiri, Chatabar of Faculty of Agricultural Sciences, Siksha O Anusandhan (Deemed to be University), Bhubaneswar (Odisha) during *kharif* season of 2022. The experimental field enjoyed medium land situation and contained sandy loam soil with

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Commented [S6]: Font size and colour slightly acidic in reaction (pH = 5.78). The available nitrogen, phosphorous and potassium content of soil before cultivation was 256 kg/ha, 20.29 kg/ha and 194.16 kg/ha respectively. This region has a hot and dry tropical climate. During the experimentation, highest maximum temperature was recorded in the standard week of 31st (34.5˚C) followed by 36th (34.3˚C) and lowest temperature 20.3˚C was observed in 44rd standard week. A good amount of rainfall(1112mm) occurred during experimentation (27th to 44th meteorological week) (Figure 1). Three high yielding varieties and four nutrient management are treated in split plot design with plot size of 4m × 3m. The treatments comprised of three varieties, V_1: CR Dhan – 206, V_2: CR Dhan 210 and V_3: CR Dhan 602 were laid out in main plot and four nutrient management comprised of N_1: 100% Recommended dose of nitrogen (RDN) through fertilizer, N_2: 50% RDN through fertilizer + 50% RDN through FYM, N_3: 50% RDN through fertilizer + 50% RDN through azolla and N_4: 50% RDN through FYM + 50% RDN through azolla are tested in subplot with three replication~~replicate thrices~~.

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Result and discussion:

Growth parameters

At maturity, irrespective of different nutrient management, CR Dhan 210 (V_2) produced tallest plant (123.88 cm) whereas, shortest plant observed in CR Dhan 602 (V_3) (112.43 cm). Full RDN (100%) through fertilizer (N_1) attained tallest plant (125.60 cm) followed by 50% RDN through fertilizer + 50% RDN through azolla (N_3) (119.83 cm) whereas, smallest plant recorded at 100 DAT (114.97 cm) on 50% RDN through FYM + 50% RDN through Azolla (N_4) at maturity (Table 2). There is no significant difference among the treatment combination on plant height. Nitrogen application from inorganic source has increased~~ing~~ plant height faster than inorganic and organic combination because of the faster availability and the same result has found by Malik *et al*., (2003).

Yield parameters

Among three rice varieties, the highest number of effective tillers (panicles) per hill was obtained from CR Dhan 206 (V_1) (9.03) and lowest number of effective tillers per hill was obtained from CR Dhan 602 (V_3) (8.53). The length of panicle and panicle weight was found highest in CR Dhan 206 (V_1) (24.60 cm and 2.37g respectively) and lowest length of panicle received from CR Dhan 602 (V_3) (23.20 cm). In case of nutrient management study, 100% RDN through fertilizer (N_1) application produced maximum number of effective tillers per hill (9.17), highest panicle length (24.90 cm) and panicle weight (2.44 g). 50% RDN through fertilizer + 50% RDN through azolla (N_3) gave the second highest effective number of tillers per hill (8.93) and length of panicle (24.60 cm). While the lowest number of effective tillers/hill and panicle length was found from 50% RDN through FYM + 50% RDN through azolla (N_4) i.e. 8.3 and 23.8 cm respectively (Table 2). The maximum number of effective tillers per hill, length of panicle and panicle weight was obtained from 100% RDN through fertilizer, due to the availability of nutrient in a simple form that plant can uptake easily and rapidly and it is similar to the findings of Gohani (2014) and Apon *et al*., 2018. 50 % RDN through fertilizer +50 % RDN through azolla gave the statistically at paer values of the yield attributing characters. This result also found similar trend by the research of Hussain *et al*., 2012 and Naing, 2010.

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Among the three varieties, CR Dhan 206 (V_1) showed the significantly highest number of filled grains per panicle (104.33) and the lowest number of filled grains per panicle obtained from CR Dhan 602 (V_3) (94.83). While coming to the nutrient management, 100% RDN through fertilizer (N_1) gave the highest values of number of filled grain per panicle (109.44) followed by 50% RDN through fertilizer + 50% RDN through azolla (N_3) 106.56 (Table 2). This might be due to the continuous availability of readily available nutrient throughout the growing period.

Yield:

Among the three varieties, CR Dhan 206 (V_1) produced the highest grain yield (4.22 t ha^{-1}) and lowest grain yield received from CR Dhan 602 (V_3) (4.07 t ha^{-1}). From the nutrient management practices, 100% RDN through fertilizer (N_1) gave the highest grain yield (4.79 t ha^{-1}) followed by 50% RDN through fertilizer + 50% RDN through azolla (4.36 t ha^{-1}) and the lowest grain yield is from 50% RDN through FYM + 50% RDN through azolla (N_4) (3.57 t ha^{-1}). There is significant difference of grain yield among the treatment combination (variety and nutrient management practices) are presented in Table 3 and found the highest yield is from the treatment V_1N_1 (4.99 t ha^{-1}) and lowest from V_2N_4 (3.39 t ha^{-1}). While coming to straw yield and harvest index, in terms of varieties CR Dhan 206 (V_1) is having the highest values of straw yield (5.73 t ha^{-1}). In terms of nutrient management, the straw yield and harvest index found highest for 100% RDN through fertilizer (N_1) (6.20 t ha^{-1} and 0.44 respectively) followed by 50% RDN through fertilizer + 50% RDN through azolla (N_3) (5.83 t ha^{-1} and 0.43 respectively) but the lowest straw yield and harvest index is obtained from 50% RDN through FYM + 50% RDN through azolla (N_4) (4.85 t ha^{-1} and 0.42 respectively). This result was found similar to the findings of Singh *et al*., 1998.

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Nutrient uptake by crop

Nitrogen uptake by grain and straw found highest by CR Dhan 602 (V_3) (50.53 kg ha^{-1} and 44.82 kg ha^{-1} respectively) and uptake is lowest by grain and straw observed by CR Dhan 210 (V_2) (47.57 kg ha^{-1} and 40.78 kg ha^{-1} respectively). From nutrient management, highest uptake of nitrogen by grain and straw obtained by the application of 100% RDN through fertilizer (N_1) (54.36 kg ha^{-1} and 44.37 kg ha^{-1}) followed by 50% RDN through fertilizer + 50% RDN through azolla (N_3) (50.55 kg ha^{-1} and 43.33 kg ha^{-1}). The significantly lowest uptake of nitrogen by grain and straw is obtained by 50% RDN through FYM + 50% RDN through azolla (N_4) (45.17 kg ha^{-1} and 42.05 kg ha^{-1}respectively) (Table 3).

Cost of cultivation

The cost of cultivation, gross return, net return and return per rupees invested will be vary according to different varieties and nutrient management practices (Table 4). Cost of cultivation calculated highest for the treatment V_3N_2 (RsS/- 71718) followed by V_1N_2 and V_2N_2 (Rs/- 71518 each) and the lowest cost of cultivation is for V_1N_3 and V_2N_3 (RSs/- 66518 each). Gross return is highest for V_1N_1 (Rs/- 108931.7) followed by V_2N_1 (Rs/- 105438.9) and lowest for V_2N_4 (Rs/- 74003.7). Coming to Net return, it is highest for V_1N_1 (Rs/- 41261.7) followed by V_2N_1 (Rs/- 38642.1) and lowest for V_2N_4 (Rs/- 4637.7).

Conclusion:

Based on the result from above experiment it can be concluded that growing CR Dhan 206 with 100% RDN through fertilizer produced maximum grain yield (4.99 ton/ha), harvest index (0.43), net return (Rs 41261/-) and benefit cost ratio (1.60) and can be recommended to the farmer.

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Table 1: Physiochemical properties of soil.

Properties	Value
Soil texture	Sandy loam
pH	5.78
Electrical conductivity (dS m^{-1})	6.7

Organic carbon (%)	0.41
Available nitrogen (kg ha^{-1})	256
Available phosphorus (kg ha^{-1})	20.29
Available potassium (kg ha^{-1})	194.16

Table 2: Effect of varieties and nitrogen management on plant height (cm), no. of panicles/hill, no. of grains/panicle, panicle length (cm) and panicle weight (g).

Treatment	Plant height (cm)	No. of panicles/hill	No. of filled grains/panicle	Panicle length (cm)	Panicle weight (g)
V_1 (CR Dhan 206)	120.50	9.03	104.33	24.6	2.37
V_2 (CR Dhan 210)	123.88	8.77	100.58	24.5	2.21
V_3 (CR Dhan 602)	112.43	8.53	94.83	23.2	1.99
SEm ±	**1.95**	**0.19**	**2.16**	**0.52**	**0.09**
CD (p = 0.05)	**7.67**	**0.73**	**8.46**	**2.06**	**0.37**
N_1 (100% RDN through Fertilizer)	125.60	9.17	109.44	24.9	2.44
N_2 (50% RDN through Fertilizer + 50% RDN through FYM)	115.33	8.62	95.67	24.2	2.06
N_3 (50% RDN through Fertilizer + 50% RDN through Azolla)	119.83	8.93	106.56	24.6	2.40
N_4 (50% RDN through FYM +50% RDN through Azolla)	114.97	8.37	88.00	23.8	1.86
SEm ±	**1.07**	**0.23**	**3.02**	**0.23**	**0.08**
CD (p = 0.05)	**4.19**	**0.92**	**11.85**	**0.92**	**0.32**

Table 3: Effect of varieties and nitrogen management on grain yield(t/ha), straw yield(t/ha), harvest index and nitrogen uptake(kg/ha).

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index	Nitrogen uptake (kg/ha)	
				By grain	By straw
V_1 (CR Dhan 206)	4.22	5.73	0.42	48.57	43.36
V_2 (CR Dhan 210)	4.12	5.45	0.43	47.57	40.78
V_3 (CR Dhan 602)	4.07	5.48	0.43	50.53	44.82
SEm ±	**0.03**	**0.14**	**0.01**	**1.28**	**3.85**
CD (p = 0.05)	**0.12**	**0.53**	**0.02**	**5.01**	**15.12**
N_1 (100% RDN through Fertilizer)	4.79	6.20	0.44	54.36	44.37
N_2 (50% RDN through Fertilizer + 50% RDN through FYM)	3.83	5.33	0.42	45.47	42.22

N_3 (50% RDN through Fertilizer + 50% RDN through Azolla)	4.36	5.83	0.43	50.55	43.33
N_4 (50% RDN through FYM +50% RDN through Azolla)	3.57	4.85	0.42	45.17	42.04
SEm ±	**0.15**	**0.05**	**0.00**	**1.98**	**1.46**
CD (p = 0.05)	**0.53**	**0.19**	**0.01**	**7.48**	**5.74**

Table 4: Effect of varieties and nitrogen management on cost of cultivation (Rs/-), gross return (Rs/-), net return (Rs/-) and return per rupees investment.

Treatment	Cost of Cultivation (Rs/-)	Gross Return (Rs/-)	Net Return (Rs/-)	Return per rupee investment
V_1N_1 (CR Dhan 206) (100% RDN through Fertilizer)	67670	108931	41261	1.60
V_1N_2 (CR Dhan 206) (50% RDN through Fertilizer + 50% RDN through FYM)	71518	84918	13400	1.18
V_1N_3 (CR Dhan 206) (50% RDN through Fertilizer + 50% RDN through Azolla)	66518	94305	27787	1.41
V_1N_4 (CR Dhan 206) (50% RDN through FYM + 50% RDN through Azolla)	69366	80334	10968	1.15
V_2N_1 (CR Dhan 210) (100% RDN through Fertilizer)	67670	106312	38642	1.57
V_2N_2 (CR Dhan 210) (50% RDN through Fertilizer+ 50% RDN through FYM)	71518	80989	9471	1.13
V_2N_3 (CR Dhan 210) (50% RDN through Fertilizer + 50% RDN through Azolla)	66518	98016	31498	1.47
V_2N_4 (CR Dhan 210) (50% RDN through FYM + 50% RDN through Azolla)	69366	74003	4637	1.06
V_3N_1 (CR Dhan 602) (100% RDN through Fertilizer)	67870	105438	37568	1.55
V_3N_2 (CR Dhan 602) (50% RDN through Fertilizer+ 50% RDN through FYM)	71718	91904	20186	1.28
V_3N_3 (CR Dhan 602) (50% RDN through Fertilizer + 50% RDN through Azolla)	66718	100199	33481	1.50

V_3N_4 (CR Dhan 602) (50% RDN through FYM + 50% RDN through Azolla)	69566	86665	17099	1.24
SEm (+)	55.7	69.8	49.9	
CD (p = 0.05)	219	275	192	

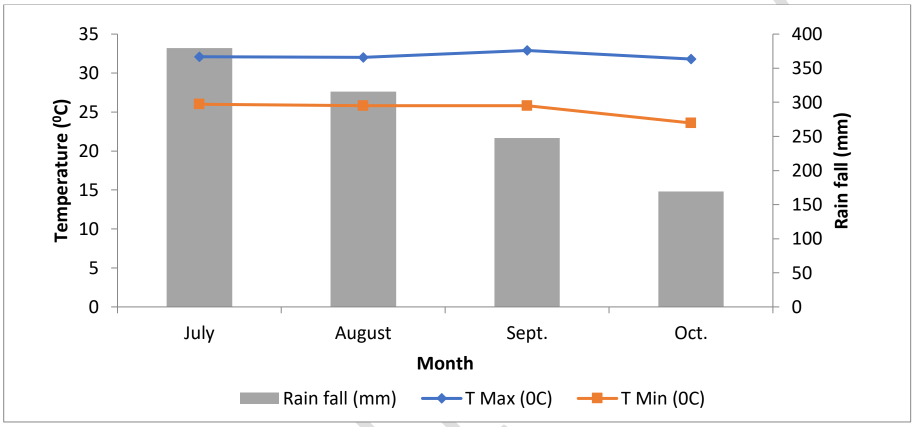

Fig. 1 Temperature and rain fall during the experimental period.

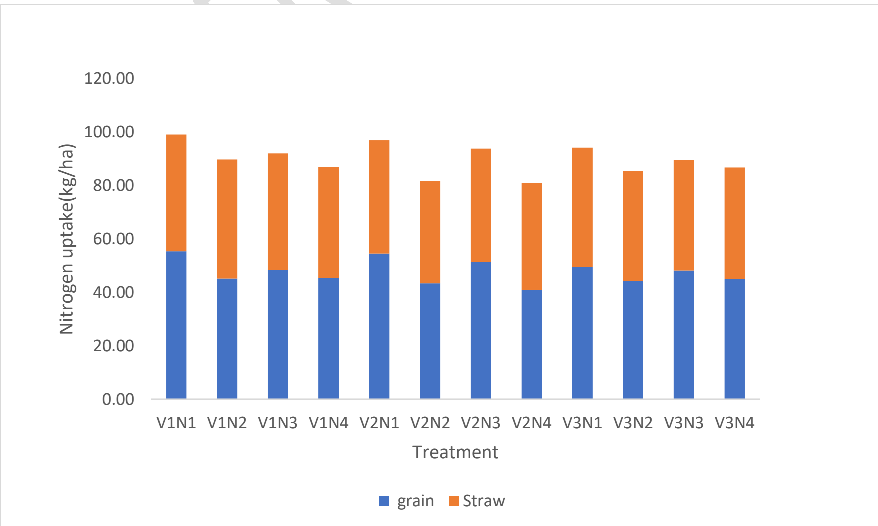

Fig. 2 Effect of variety and nutrient management on nitrogen uptake (kg/ha) by grain and straw of *kharif* rice.