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Effects of nutrient management on yield and yield attributes of high yielding rice (*Oryza sativa* L.) varieties of Chhattisgarh

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Abstract
Field Experiment was conducted at instructional cum Research Farm of Rajmohini Devi College of Agriculture and Research Station, Ambikapur (C.G.) during *kharif* season of 2016-17 to study the effects of nutrient management on yield and yield attributes of high yielding rice (*Oryza sativa* L.) varieties. The experiment was laid out in a split plot design with three replications. The treatments consisted of four nutrient management practices *viz.* M_1-RDF (100: 60: 40 kg N:P_2O_5:K_2O ha^{-1}), M_2-150% RDF, M_3-RDF (N– LCC) (Basal application of 30% N and full P_2O_5+ K_2O and top dressing of Nitrogen as per LCC) and M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield(214: 42: 111 kg N:P_2O_5:K_2O ha^{-1}) as main plots and five rice varieties *viz.* Rajeshwari, Durgeshwari, Maheshwari, Karma masuri and Indira Aerobic-1 as sub plots. Among the nutrient management, highest yield attributes were recorded under treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg N:P_2O_5:K_2O ha^{-1}) which was superior over other rest of the nutrient management practices. Among the varieties, longest panicle (24.56 cm) was measured in variety Indira aerobic-1, highest number of grains panicle^{-1} (151.74) and number of filled grains panicle^{-1} (126.66) was recorded with Karma masuri, highest number of panicle (367.00 m^{-2}), test weight (31.27 g), grain yield (60.83 q ha^{-1}), straw yield (117.96 q ha^{-1}) and harvest index (34.17%) was recorded with variety Maheshwari.

Keywords: Rice varieties yield and yield attributes

Introduction
Rice is a member of the grass family (Gramineae). It is a major cereal crop which used as a source of main food for more than 85% population in the world and 90% in Asia but lacking, imbalanced, inappropriate or excessive use of nutrients in agricultural systems is a major cause for low crop yields in parts of developing country. In world, rice occupies an area of 162.31 million hectare and production of 494.31 million metric tonnes with average productivity of 4.55 metric tonnes ha^{-1}, (Foreign Agricultural Service/USDA Office of Global Analysis, 2017-18) [1]. India ranks first in area followed by China and Bangladesh. In India, rice occupies an area of 431.94 lakh hectares and production of 110.15 million tonnes with average productivity of 2550 kg ha^{-1}, (Anonymous, 2016) [2]. Chhattisgarh state is popularly known as **"Rice bowl of India"** because maximum area is covered under rice during *Kharif* season and contribute major share in national rice production. In Chhattisgarh, it occupies an area of around 3.82 million hectares and production of 6.09 million tonnes with productivity of 1597 kg ha^{-1}, (Anonymous 2016) [2].

Nitrogen, phosphorus and potassium are essential inputs and their deficiency is major constraint in the successful cultivation of rice. In recent years, it is noticed that for increasing the yield of rice, a major constraint is unbalanced used of nutrients. Hence, there is need for application of these nutrients in balance quantity for attaining optimum growth, development and enhancing the yield of rice. To realize the maximum possible benefits of rice crop and to obtain higher yield, it is essential to adopt recommended package of agronomic practices for successful cultivation of rice. Improved high yielding rice varieties contribute one of the major components of modern rice production technology (Prasad, 2004) [3].

The optimum use of N can be achieved by matching N supply with crop demand. A simple and quick method for estimating plant N demand is LCC *i.e.* Leaf Colour Chart and SPAD (chlorophyll meter) readings which can estimate leaf chlorophyll content in a non-destructive manner, thereby providing an indirect assessment of leaf N status. LCC is easy to use and is an inexpensive diagnostic tool for monitoring the relative greenness of a rice leaf as an indicator for the plant N status and can be used as an alternative to chlorophyll meter. It offers substantial opportunities to farmers for detection of time and amount of N to be applied (on demand) for efficient N use and high rice yield. Thus LCC becomes useful in avoiding under or above fertilization besides maintaining the appropriate time. Use of LCC for N management has consistently increased grain yield and profit in comparison to the farmers' fertilizer practice.

The soil test crop response (STCR) approach for targeted yield is unique in indicating both soil test based fertilizer dose and the level of yield that can be achieved with good management practices. In order to sustain the yield and reduce the cost of fertilizers and in turn cost of cultivation, the STCR approach is very important (Saxena *et al.*, 2008; Chatterjee *et al.*, 2010) [4-5].

Materials and methods

The field experiment was carried out at instructional cum Research Farm of Rajmohini Devi College of Agriculture and Research Station, Ambikapur, Surguja (C.G.) during *Kharif* season of 2016-17. The soil of experimental field was '*Inceptisols*' which is locally known as '*Chawar*'. The soil was slightly acidic (pH 5.9) in nature with medium soil organic carbon, low nitrogen, medium phosphorus and medium potash. The experiment was laid out in a split plot design with three replications. The treatment consisted of four nutrient management practices *viz.* M_1-RDF (100: 60: 40 kg $N:P_2O_5:K_2O$ ha^{-1}), M_2-150% RDF, M_3-RDF (N– LCC) (Basal application of 30% N and full $P_2O_5 + K_2O$ and top dressing of Nitrogen as per LCC) and M_4 (Soil test based recommended dose for 7.0 t ha^{-1} grain yield) as main plots and five rice varieties *viz.* Rajeshwari, Durgeshwari, Maheshwari, Karma masuri and Indira Aerobic-1 as sub plots. The yield and yield attributes of five rice varieties are as follows.

Number of panicle (m^{-2})

A number of panicle bearing tillers were counted from five places in each plot from quadrate of $1m^{-2}$ areas and the average was worked out by dividing the summation by five.

Length of panicle (cm)

The length of panicle was taken from 5 panicles selected randomly from harvested produce. It was measured from the neck node to the tip of the last spikelet. After this, the average length of panicle was determined.

Number of grains panicle^{-1}

The five panicles of the tagged plants were threshed and total numbers of grains were counted and mean value of respective character was calculated.

Number of filled grains panicle^{-1}

The number of filled grains panicle^{-1} was counted separately from the five panicles of tagged plants in each plot.

Test weight (1000 seed weight, g)

A random grain samples were taken from the produce of each net plot. Out of the samples, 1000 grains were counted from each net plot and same were dried in oven at 60°C to constant weight, thereafter, weight so obtained was noted as 1000 seed weight (test weight).

Grain yield (q ha^{-1})

The grain yield from net plot of each treatment including 5 sample hills was weighed and expressed as q ha^{-1}.

Straw yield (q ha^{-1})

This was calculated by deducting the grain yield from bundle weight and expressed as q ha^{-1}.

Harvest index (%)

The harvest index was calculated by dividing the grain yield with biological yield (grain + straw yield) and multiplied by 100. The harvest index was calculated by the following the formula and expressed in percent.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (Grain yield)}}{\text{Biological yield (Grain yield + Straw yield)}} \times 100$$

Results and discussion

Number of panicle (m^{-2})

The data on number of panicle (m^{-2}) are presented in Table 1. It is evident that different nutrient management practices have their significant response on the number of panicle (m^{-2}). Significantly the highest number of panicle (357.67 m^{-2}) was recorded in treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg N: P_2O_5: K_2O ha^{-1}) and it was at par with treatment M_2-150% RDF. Whereas, lowest number of panicle (342.33 m^{-2}) was recorded under M_1-RDF (100: 60: 40 kg N: P_2O_5: K_2O ha^{-1}).

Among different varieties, significantly higher number of panicle (367.00 m^{-2}) was recorded in V_3-Maheshwari as compared to other rice varieties. Whereas, the lowest number of panicle (333.92 m^{-2}) was recorded under V_4–Karma masuri. This was mainly due to higher photosynthetic efficiency and net assimilation, which helped in increasing the overall growth of the plant, (Patel, 2011) [6].

Length of panicle (cm)

The data are presented in Table 1. Among various nutrient management practices, non significant result was obtained with respect to length of panicle (cm). Among the rice varieties, significantly longest panicle (24.56 cm) was measured in variety Indira Aerobic-1 and found at par with V_4- Karma masuri. Whereas, the lowest length of panicle (20.71 cm) was recorded under V_2–Durgeshwari. Almost similar result also reported by Patel (2011) [6].

Number of grains panicle^{-1}

It is evident from the data given in the Table 1 that number of grains panicle^{-1} significantly affected due to different nutrient management practices as well as rice varieties. Among different nutrient management practices, highest number of grains panicle^{-1} (152.19) was recorded under treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg N: P_2O_5: K_2O ha^{-1}) which was at par with treatment M_2-150% RDF. Whereas, the lowest number of grains panicle^{-1} was recorded in M_1-RDF (100: 60: 40 kg N: P_2O_5: K_2O ha^{-1}).

Among the rice varieties, highest number of grains panicle^{-1} (151.74) was recorded in V_4- Karma masuri which was at par with V_5– Indira Aerobic-1 and V_3–Maheshwari. Whereas, the lowest number of grains panicle^{-1} (141.08) was recorded under V_2–Durgeshwari. Karma masuri rice variety responded very well among the different nutrient management practices, thus maximum number of grains panicle^{-1} was observed. Similar result also reported by Singh (2012) [7].

Number of filled grains panicle^{-1}

On perusal of data presented in Table 1, it is evident that filled grains panicle^{-1} varied significantly due to different nutrient management as well as rice varieties. Among different nutrient management practices, highest number of filled grains panicle^{-1} (128.33) was recorded in treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg N: P_2O_5: K_2O ha^{-1}) and found at par with treatment M_2-150% RDF and M_3- RDF (N- LCC) (Basal application of 30% N and full P_2O_5 + K_2O and top dressing of nitrogen as per LCC). Whereas, the lowest number of filled grains panicle^{-1} (116.73) was recorded under M_1-RDF (100: 60: 40 kg N: P_2O_5: K_2O ha^{-1}).

Among the rice varieties, highest number of filled grains panicle^{-1} (126.66) was recorded under V_4-Karma masuri which was at par with V_5–Indira Aerobic-1 and V_3–Maheshwari. Whereas, the lowest number of filled grains panicle^{-1} (119.58) was recorded under V_2–Durgeshwari.

Test weight (1000 seed weight, g)

The data on test weight in Table 1, clearly shows that it was did not significantly influenced due to different nutrient management. Among different nutrient management, higher test weight was recorded with M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg N: P_2O_5: K_2O ha^{-1}) followed by M_2-150% RDF and M_3- RDF (N – LCC) (Basal application of 30% N and full P+K and top dressing of nitrogen as per LCC). The lowest test weight was recorded under M_1-RDF (100: 60: 40 kg N: P_2O_5: K_2O ha^{-1}).

Among the rice varieties, V_3–Maheshwari recorded significantly higher test weight (31.27 g) as compared to other rice varieties. Whereas, the lowest test weight (17.40 g) was recorded under V_4–Karma massuri. Among the varieties, variation in test weight of different rice varieties due to their own genetic character, thus maximum value of test weight observed in variety Maheshwari.

Grain yield (q ha^{-1})

Data on grain yield are presented in Table 2. It was significantly influenced due to the different nutrient management as well as rice varieties. Among the different nutrient management, application of treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg N: P_2O_5: K_2O ha^{-1}) produced significantly higher grain yield (59.13 q ha^{-1}) and found at par with M_2- 150% RDF. Whereas, the lowest grain yield (55.53 q ha^{-1}) was recorded under M_1-RDF (100: 60: 40 kg N: P_2O_5: K_2O ha^{-1}).

Among the varieties, V_3–Maheshwari produced the significantly higher grain yield (60.83 q ha^{-1}) and found at par V_1–Rajeshwari (58.83 q ha^{-1}). Whereas, the lowest grain yield was recorded under V_4–Karma masuri (54.42 q ha^{-1}). Growth and yield attributing characters as well as genetic behavior were responsible for higher grain yield of Maheshwari rice as compared to other varieties. Almost similar result also reported by Singh (2012) [7] and Chand *et al*. (2016) [8].

The nutrient management practices and varieties (M X V) did not interact significantly (Table 3). However, all the varieties produced the maximum grain yield when fertilized with soil test based recommended dose of 214: 42: 111 kg N: P_2O_5: K_2O ha^{-1} (M_4) gave highest grain yield showed non-significant difference in grain yield (q ha^{-1}). Among all the treatment combinations, rice cv. Maheshwri fertilized with 214: 42: 111 kg N: P_2O_5: K_2O ha^{-1} (V_3M_4) recorded the maximum grain yield of 63.33 q ha^{-1} being super over other treatment combinations.

Straw yield (q ha^{-1})

The straw yield of rice was not significantly affected due to different nutrient management practices but it was significantly affected due to rice varieties (Table 2). Among the varieties, significantly highest straw yield was recorded with V_3–Maheshwari (117.96 q ha^{-1}). Whereas, the lowest straw yield was recorded under V_4-Karma masuri (107.09 q ha^{-1}). This might be due to lesser partitioning of dry matter in to grains. It is also reflected from the higher number of unfilled grains panicle^{-1} and lowest harvest index which contributed to higher straw yield, Sahu (2014) [9].

Harvest Index (%)

Harvest index is the ratio of economic yield with biological yield. The results revealed that it was not influenced significantly due to the different nutrient management practices but vary significantly with different rice varieties (Table 2). Among different nutrient management, application of treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg N: P_2O_5: K_2O ha^{-1}) registered higher harvest index (34.03%) followed by M_2-150% RDF and M_3- RDF (N – LCC) (Basal application of 30% N and full P_2O_5 + K_2O and top dressing of nitrogen as per LCC) with 33.88% and 33.83% respectively. The lowest value of harvest index was obtained with M_1- RDF (100: 60: 40 kg N: P_2O_5: K_2O ha^{-1}).

Among all rice varieties, higher value of harvest index was recorded under V_3–Maheshwari (34.17%) as compared to all other varieties. Whereas, the lowest value of harvest index was recorded under V_4-Karma masuri (33.69%). Almost similar result also reported by Sahu *et al*. (2013) [10].

Table 1: Effect of different nutrient management on number of panicle (m^{-2}), length of panicle (cm), number of grains panicle^{-1}, number of filled grains panicle^{-1} and test weight of different rice varieties

Treatments	No. of panicle (m^{-2})	Length of panicle (cm)	No. of grains panicle^{-1}	No. of filled grain panicle^{-1}	Test weight (g)
Main Plot: Nutrient management (04)					
M_1- RDF (100: 60: 40 kg N:P_2O_5:K_2O ha^{-1})	342.33	21.75	140.20	116.73	25.52
M_2- 150% RDF	349.40	22.57	147.80	124.27	25.56
M_3- RDF (N – LCC) (Basal application of 30% N and full P_2O_5 + K_2O and top dressing of nitrogen as per LCC)	345.33	22.13	146.25	123.25	25.54
M_4- Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214:42:111 kg N:P_2O_5:K_2O ha^{-1})	357.67	22.75	152.19	128.33	25.58
SEm±	3.30	0.23	1.67	1.58	0.08
CD (5%)	11.41	NS	5.76	5.46	NS
Sub Plot: Varieties (05)					
V_1– Rajeshwari	356.08	20.89	142.53	120.87	30.56
V_2– Durgeshwari	347.42	20.71	141.08	119.58	26.37
V_3– Maheshwari	367.00	23.12	148.48	123.48	31.27
V_4– Karma Masuri	333.92	22.23	151.74	126.66	17.40
V_5– Indira Aerobic-1	339.00	24.56	149.22	125.13	22.15
SEm±	3.17	0.24	2.14	1.94	0.07

CD (5%)		9.12	0.70	6.16	5.58	0.19
Interaction (M X V)	SEm±	5.48	0.42	3.70	3.36	0.12
	CD (5%)	NS	NS	NS	NS	NS

*RDF= Recommended Dose of Fertilizers, *LCC= Leaf Colour Chart

Table 2: Effect of different nutrient management on grain yield (q ha^{-1}), straw yield (q ha^{-1}) and harvest index (%) of rice varieties

Treatments		Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Main Plot: Nutrient management (04)				
M_1- RDF (100: 60: 40 kg N:P_2O_5:K_2O ha^{-1})		55.53	110.81	33.70
M_2- 150% RDF		57.80	112.41	33.88
M_3- RDF (N – LCC) (Basal application of 30% N and full P_2O_5 + K_2O and top dressing of nitrogen as per LCC)		56.67	111.48	33.83
M_4- Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214:42:111 kg N:P_2O_5:K_2O ha^{-1})		59.13	113.35	34.03
SEm±		0.53	0.60	0.11
CD (5%)		1.82	NS	NS
Sub Plot: Varieties (05)				
V_1– Rajeshwari		58.83	114.93	33.86
V_2– Durgeshwari		57.00	111.59	33.80
V_3– Maheshwari		60.83	117.96	34.17
V_4– Karma Masuri		54.42	107.09	33.69
V_5– Indira Aerobic-1		55.33	108.49	33.77
SEm±		0.72	0.86	0.10
CD (5%)		2.09	2.48	0.27
Interaction (M X V)	SEm±	1.26	1.49	0.17
	CD (5%)	NS	NS	NS

Table 3: Effect of nutrient management and varieties on grain yield (q ha^{-1}) of different rice varieties

Nutrient management (M)	Varieties (V)					Mean
	Rajeshwari (V_1)	**Durgeshwari (V_2)**	**Maheshwari (V_3)**	**Karma masuri (V_4)**	**Indira Aerobic-1**	
M_1	56.67	54.67	58.33	53.33	54.67	55.53
M_2	59.00	58.67	61.00	55.33	55.00	57.80
M_3	58.33	55.33	60.67	54.00	55.00	56.67
M_4	61.33	59.33	63.33	55.00	56.66	59.13
Mean	58.83	57.00	60.83	54.42	55.33	

	Nutrient management (M)	Varieties (V)	Interaction (M X V)
SEm±	0.53	0.72	1.26
CD (5%)	1.82	2.09	NS

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