International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2020; 8(1): 1020-1024

Received: 24-11-2019
Accepted: 27-12-2019

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

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DOI: https://doi.org/10.22271/chemi.2020.v8.i1m.8381

Abstract
The present investigation entitled "Effects of different nutrient management on growth attributes and yield of high yielding rice (*Oryza sativa* L.) varieties of Chhattisgarh" was conducted in northern hilly zone of Chhattisgarh at Rajmohini Devi College of Agriculture and Research Station, Ambikapur C.G. during *kharif* 2016-17. The study was comprised four treatments of nutrient management practices *viz.* M_1-RDF (100: 60: 40 kg NPK ha^{-1}), M_2-150% RDF, M_3-RDF (N– LCC) (Basal application of 30% N and full P+K 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 NPK ha^{-1}) as main plots and five rice varieties *viz.* Rajeshwari, Durgeshwari, Maheshwari, Karma masuri and Indira Aerobic-1 as sub plots. The present study revealed that the maximum value of plant population (m^{-2}), plant height (cm), number of leaves hill^{-1}, number of tillers hill^{-1}, dry matter accumulation (g hill^{-1}) and crop growth rate (g day^{-1} hill^{-1}) were recorded under treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg NPK ha^{-1}) which was superior over other rest of the nutrient management practices. The application of treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg NPK ha^{-1}) with variety Maheshwari produced maximum growth attributes and grain yield (60.83 q ha^{-1}).

Keywords: rice varieties, growth attributes and yield

Introduction
The rice plant is a member of Poaceae family. It is a most important nutritional staple food crop for more than 60 percent of the world people. 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). 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, 2016-17) [2]. Chhattisgarh is popularly known as "Rice bowl of India". 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) [1].

Nitrogen is a 'key' element among essential nutrients and plays vital role in growth as well as development of the plants by virtue of being an integral part of chlorophyll, protein and nucleic acids and deficiency of this element in plant body leads stunted growth, appearance of light green pale yellow colour on the older leaves starting from tips towards the base of the leaf blade. Nitrogen management in rice field is different from other crops because of the continuous sub-emergence of the field results aerobic to anaerobic condition of the root zone. During these process losses of nitrogen take place through leaching and denitrification. Amongst various essential plant nutrients the nitrogen, phosphorus and potassium play a pivotal role for growth and metabolic process in rice plant. NPK is the base nutrients for increasing production and productivity of rice.

Synchronization of fertilizer N application to rice with crop demand following need-based fertilizer N management practices is another approach that can produce potential yields, reduce N losses and improve N use efficiency (Singh *et al.* 2010) [9]. The need-based use of nitrogen avoids excessive use of fertilizer N, minimize insect-pest incidence and thus also provides economic benefits to the farmers. Since varied N management practices result in differences in leaf area index, biomass, leaf chlorophyll and tissue N concentration, it should be possible to evaluate plant N status using spectral properties of leaves or crop canopy. The need-based application of fertilizer N involves the use of gadgets such as Green Seeker optical sensor, Chlorophyll meter (SPAD meter) and leaf colour chart (LCC). The LCC being a simple and farmer's friendly gadget can be used even by illiterate farmers to decide time of fertilizer N applications. It has shown potential to produce high yield with improved N use efficiency in transplanted rice (Singh *et al*. 2007) [8].

Maintaining the soil quality at desirable level is very complex issue due to involvement of climatic, soil, plant and human factors and their interactions. The recommendation of plant nutrients is equally important in sustaining soil fertility and productivity. Prescribing fertilizer dose needs due consideration for improving soil quality. Among different methods of formulating fertilizer recommendations the concept of soil test crop response correlation (STCR) has been quantitative, precise and meaningful (Truog 1960 and Ramamoorthy *et al*. 1967) [11, 7] which consider the soil test values for the targeted yields (Karem *et al*., 2014) [5].

Materials and Methods

The field experiment was conducted during *Kharif*, 2017 at Research farm of Rajmohini Devi College of Agriculture and Research Station, Ambikapur, Surguja (C.G.). Geographically, Ambikapur is situated in the north of Chhattisgarh and lies between $23^0$10' N latitude and $83^0$15' E longitude having an altitude of 623 meter above mean sea level. It is the head quarter of district Surguja of Chhattisgarh. 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 in fertility having 0.19% soil organic carbon, low N (175.60 kg ha^{-1}), medium P (19.71 kg ha^{-1}) and medium K (313.6 kg ha^{-1}).

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 NPK ha^{-1}), M_2-150% RDF, M_3-RDF (N– LCC) (Basal application of 30% N and full P+K 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 fertilizers were applied as per the treatments. The N, P and K were applied through Urea, Single super phosphate and Muriate of potash. The whole amount of P and K were applied at the time of transplanting as a basal dose. Whereas, N was applied as a top dressing in three equal splits i.e. 1^{st} 10 DAT, 2^{nd} 30 DAT and 3^{rd} 60 DAT in all treatment *viz.* M_1, M_2 and M_4 except M_3. In case of treatment M_3, 30% of N was applied at the time of transplanting as a basal dose and remaining 70% N was applied based on leaf colour chart.

Results and Discussion

Plant population (m^{-2})

The data pertaining to plant population (m^{-2}) are presented in Table 1. Since the rice varieties grown under transplanted condition and seedlings of rice properly placed in experimental field, the plant population was not influenced significantly due to the different nutrient management as well as different rice varieties, over entire crop growth period (30 DAT).

Plant height (cm)

Data on the plant height of rice at 30, 60, 90 DAT and at harvest are presented in Table 1. Data revealed the average plant height increased progressively with advancement of the crop stage. Plant height varied significantly at 30, 60, 90 DAT at harvest.

Among different nutrient management practices, treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg NPK ha^{-1}) recorded significantly higher plant height at 30, 60, 90 DAT and at harvest of crop growth, which was at par with M_2-150 % RDF at 30, 60 and 90 DAT. Whereas, lowest plant height was recorded under M_1- RDF (100: 60: 40 kg NPK ha^{-1}) compared to other nutrient management options. Plant height significantly influenced by different rice varieties. The significantly higher plant height was recorded under V_3–Maheshwari at 30, 60, 90 DAT and at harvest stage of crop and which was statistically at par with V_1-Rajeshwari at all growth stages of crop. Whereas, lowest plant height was recorded under V_4-Karma masuri at all growth stages of crop. The differences in plant height of various rice cultivars depends upon their genetic ability as well as varying response to nutrient management practices which might have led to variation in plant height (Choudhary *et al.*, 2010) [4].

Number of leaves $hill^{-1}$

The data pertaining to number of leaves $hill^{-1}$ are presented in Table 2. The data revealed that the number of leaves $hill^{-1}$ was increased with increasing plant age at 30 and 60 DAT and then gradually slowed down thereafter. Among the different nutrient management practices, number of leaves $hill^{-1}$ was found significant at 30, 60 DAT and at harvest. The significantly higher number of leaves $hill^{-1}$ was recorded under treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg NPK ha^{-1}) at 30 DAT and at harvest stage of crop and 60 DAT which was found at par with M_2-150 % RDF. Whereas, lowest number of leaves $hill^{-1}$ at all the stages was recorded under M1-RDF (100: 60: 40 kg NPK ha^{-1}). Higher number of leaves $hill^{-1}$ in respective treatments except M_1-RDF might be due to supply of nutrients under these treatments which were sufficient to meet the demand of the crop and thereby increased the number of leaves.

All the five varieties showed significant result at 30, 60 DAT and at harvest. V_3-Maheshwari recorded significantly higher number of leaves $hill^{-1}$ at all growth stages of crop as compared to other rice varieties. Whereas, lowest number of leaves $hill^{-1}$ at all growth stages were recorded under V_4–Karma masuri. The variability in number of leaves was might be due to the varietal characteristics (Patel, 2011) [6].

Number of tillers $hill^{-1}$

Data pertaining to number of tillers $hill^{-1}$ are presented in Table 2. The average number of tillers increased linearly with the crop age, reaching peak at 60 days after transplanting, but thereafter decreased towards maturity due to tiller mortality. Among different nutrient management practices, application of treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg NPK ha^{-1}) recorded significantly higher number of tillers $hill^{-1}$ at 30 and 60 DAT and which was at par with M_2-150% RDF at 30 and 60 DAT. Whereas, lowest number tillers $hill^{-1}$ was recorded under M_1-RDF (100: 60: 40 kg NPK ha^{-1}).

Among different varieties, V_3-Maheshwari recorded significantly higher number of tillers $hill^{-1}$ at 30 and 60 DAT of crop growth and which was at par with V_1-Rajeshwari at 30 and 60 DAT. Whereas, the lowest number of tillers $hill^{-1}$ was recorded under V_4–Karmamasuri. This indicates that nutrient supply was sufficient to meet the demand of crop growth and development, thus higher number of tillers hill^{-1} recorded with V_3-Maheshwari.

Dry matter accumulation (g hill^{-1})

The data pertaining to dry matter accumulation (g hill^{-1}) are presented in Table 3. Among the different nutrient management practices, the treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg NPK ha^{-1}) recorded significantly higher dry matter accumulation (g hill^{-1}) at 30, 60, 90 DAT and at harvest and which was at par with M_2-150 % RDF at 30, 60, 90 DAT and at harvest. Whereas, lowest dry matter accumulation (g plant^{-1}) was recorded under M_1-RDF (100: 60: 40 kg NPK ha^{-1}).

Among the varieties, V_3-Maheshwari recorded significantly higher dry matter accumulation (g hill^{-1}) at 30, 60, 90 DAT and at harvest as compared to other rice varieties at all growth stages of crop. Whereas, lowest dry matter accumulation (g hill^{-1}) was recorded under V_4–Karma masuri. The accumulation of crop biomass depends upon the formation of organs for nutrient absorption (root) and photosynthesis (leaf canopy). Important determinants of these organs as well as the photosynthetic rate are the availability of NPK and other essential nutrient elements. In tillering crops like rice, the number of tillers per unit area, the plant height and leaf size are the physical components influencing dry matter production during different time intervals. At early growth stages, the root and leaf development are small, therefore, dry matter accumulation is also small. But, during grand growth period, these organs are active and result in higher dry matter production due to accumulation of photosynthates. Consequently, with the increase in plant height and number of tillers with higher nutrient levels under different nutrient management practices, dry matter accumulation also increased at all the dates of observation. Dry matter accumulation increased with increase in crop age upto maturity Also, the differential growth behavior of various rice cultivars depends upon their genetic ability as well as varying response to nutrient management practices which might have led to variation in resultant growth parameters, as also reported by earlier studies (Choudhary *et al.*,2010) [4].

Crop growth rate (g day^{-1} hill^{-1})

The data pertaining to crop growth rate are presented in Table 3. The data revealed that the crop growth rate (g day^{-1} hill^{-1}) differed significantly due to nutrient management and varieties. Among different nutrient management practices, application of treatment M_4-Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg NPK ha^{-1}) recorded higher crop growth rate (g day^{-1} hill^{-1}) at 30, 60, 90 DAT and at harvest as compared to other nutrient management practices. Whereas, lowest crop growth rate (g day^{-1} hill^{-1}) was recorded under M_1-RDF (100: 60: 40 kg NPK ha^{-1}).

Among the varieties, higher crop growth rate (g day^{-1} hill^{-1}) at 30, 60, 90 DAT and at harvest was noticed with V_3-Maheshwari and which was at par with V_1-Rajeshwari at all the growth stages of crop. Whereas, lowest crop growth rate (g day^{-1} hill^{-1}) was recorded under V_4–Karma masuri at 60, 90 DAT and at harvest and 30 DAT it was similar with V_5-Indira Aerobic-1.

Grain yield (q ha^{-1})

Data on grain yield are presented in Table 3. 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 NPK 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 NPK 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) [10] and Chand *et al.* (2016) [3].

Table 1: Effect of different nutrient management on plant population (m^{-2}) and plant height (cm) of different rice varieties

Treatments		Plant population (m^{-2}) 30 DAT	Plant height (cm)			
			30 DAT	60 DAT	90 DAT	At harvest
Main Plot: Nutrient management (04)						
M_1- RDF (100: 60: 40 kg NPK ha^{-1})		49.17	62.53	102.13	108.27	110.03
M_2- 150% RDF		49.27	64.42	103.04	109.43	111.78
M_3- RDF (N – LCC) (Basal application of 30% N and full P+K and top dressing of Nitrogen as per LCC)		49.20	63.04	102.48	108.52	110.27
M_4- Soil test based recommended dose for 7.0 t ha^{-1} grain yield (214: 42: 111 kg NPK ha^{-1})		49.33	64.57	104.59	111.90	114.60
SEm±		0.15	0.40	0.48	0.83	0.83
CD (5%)		NS	1.38	1.68	2.86	2.87
Sub Plot: Varieties (05)						
V_1– Rajeshwari		49.42	64.93	108.55	114.87	116.87
V_2– Durgeshwari		49.25	62.50	106.50	113.12	115.12
V_3– Maheshwari		49.50	67.50	110.53	116.92	118.89
V_4– Karma Masuri		48.88	61.39	84.03	91.18	92.78
V_5– Indira Aerobic-1		49.17	61.88	105.68	111.55	114.77
SEm±		0.29	1.23	0.73	1.05	1.03
CD (5%)		NS	3.53	2.11	3.03	2.96
Interaction (M X V)	SEm±	0.50	2.12	1.27	1.82	1.78
	CD (5%)	NS	NS	NS	NS	NS

Table 2: Effect of different nutrient management on number of leaves hill-1 and number of tillers hill-1 of different rice varieties

Treatments		No. of leaves hill-1			No. of tillers hill-1	
		30 DAT	60 DAT	At harvest	30 DAT	60 DAT
Main Plot: Nutrient management (04)						
M1- RDF (100: 60: 40 kg NPK ha-1.)		29.89	41.23	37.43	8.47	10.66
M2- 150% RDF		31.82	43.55	39.62	8.80	11.07
M3- RDF (N – LCC) (Basal application of 30% N and full P+K and top dressing of Nitrogen as per LCC)		31.03	42.03	38.56	8.77	10.97
M4- Soil test based recommended dose for 7.0 t ha-1 grain yield (214: 42: 111 kg NPK ha-1)		33.28	44.35	41.35	9.29	11.45
SEm±		0.42	0.32	0.39	0.15	0.13
CD (5%)		1.45	1.10	1.35	0.51	0.46
Sub Plot: Varieties (05)						
V1– Rajeshwari		32.11	43.11	40.11	8.77	11.10
V2– Durgeshwari		31.45	42.12	38.45	8.71	10.90
V3– Maheshwari		34.99	47.33	44.33	9.55	11.86
V4– Karma Masuri		28.67	40.17	36.17	8.48	10.59
V5– Indira Aerobic-1		30.31	41.23	37.14	8.67	10.75
SEm±		0.74	0.99	1.04	0.29	0.27
CD (5%)		2.13	2.86	3.00	0.83	0.78
Interaction (M X V)	SEm±	1.28	1.72	1.81	0.50	0.47
	CD (5%)	NS	NS	NS	NS	NS

Table 3: Effect of different nutrient management on dry matter accumulation (g hill-1), crop growth rate (g day-1 hill-1) and grain yield (q ha-1) of different rice varieties

Treatments		Dry matter accumulation (g hill-1)				Crop growth rate (g day-1 hill-1)				Grain yield (q ha-1)
		30 (DAT)	60 (DAT)	90 (DAT)	At harvest	30 (DAT)	60 (DAT)	90 (DAT)	At harvest	
Main Plot: Nutrient management (04)										
M1- RDF (100: 60: 40 kg NPK ha-1)		6.16	21.53	35.96	37.15	0.20	0.49	0.69	0.78	55.53
M2- 150% RDF		6.41	22.46	37.29	38.49	0.21	0.52	0.73	0.82	57.80
M3- RDF (N – LCC) (Basal application of 30% N and full P+K and top dressing of Nitrogen as per LCC)		6.26	22.24	36.56	37.76	0.21	0.50	0.70	0.80	56.67
M4- Soil test based recommended dose for 7.0 t ha-1 grain yield (214: 42: 111 kg NPK ha-1)		6.74	23.74	38.76	39.75	0.23	0.59	0.80	0.91	59.13
SEm±		0.13	0.40	0.53	0.51	0.00	0.01	0.02	0.02	0.53
CD (5%)		0.44	1.37	1.84	1.75	0.01	0.05	0.06	0.08	1.82
Sub Plot: Varieties (05)										
V1– Rajeshwari		6.45	22.43	37.42	38.92	0.22	0.54	0.75	0.85	58.83
V2– Durgeshwari		6.30	22.35	36.70	37.70	0.21	0.51	0.72	0.80	57.00
V3– Maheshwari		7.08	24.02	39.39	41.36	0.23	0.58	0.82	0.91	60.83
V4– Karma Masuri		6.00	21.47	35.87	36.37	0.20	0.47	0.67	0.78	54.42
V5– Indira Aerobic-1		6.12	22.21	36.34	37.09	0.20	0.49	0.70	0.79	55.33
SEm±		0.15	0.46	0.62	0.56	0.01	0.02	0.02	0.03	0.72
CD (5%)		0.43	1.32	1.79	1.61	0.01	0.06	0.07	0.09	2.09
Interaction (M X V)	SEm±	0.26	0.79	1.08	0.97	0.01	0.04	0.04	0.05	1.26
	CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS

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