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

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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. M1-RDF (100: 60: 40 kg NPK ha⁻¹), M2-150% RDF; M3-RDF (N- LCC) (Basal application of 30% N and full P+K and top dressing of Nitrogen as per LCC) and M4-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-I 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 M4-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 M4-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 population. In world, rice occupies an area of 162.31 million hectares 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) [1]. 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) [6].

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 (Truong 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 Chattisgarh and lies between 23°10’ N latitude and 83°15’ E longitude having an altitude of 623 meter above mean sea level. It is the head quarter of district Surguja of Chattisgarh. 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. M₁-RDF (100: 60: 40 kg NPK ha⁻¹), M₂-150% RDF, M₃-RDF (N– LCC) (Basal application of 30% N and full P+K and top dressing of Nitrogen as per LCC) and M₄ (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. 1st 10 DAT, 2nd 30 DAT and 3rd 60 DAT in all treatment viz. M₁, M₂ and M₃ except M₄. In case of treatment M₄ 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 M₂-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 M₂-150 % RDF at 30, 60 and 90 DAT. Whereas, lowest plant height was recorded under M₄- 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 V₃-Maheshwari at 30, 60, 90 DAT and at harvest stage of crop and which was statistically at par with V₁-Rajeshwari at all growth stages of crop. Whereas, lowest plant height was recorded under V₄-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) [8].

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 M₂-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 M₂-150 % 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 M₁-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. V₃-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 V₄-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 M₂-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 M₂-150% RDF at 30 and 60 DAT. Whereas, lowest number tillers hill⁻¹ was recorded under M₁-RDF (100: 60: 40 kg NPK ha⁻¹).

Among different varieties, V₃-Maheshwari recorded significantly higher number of tillers hill⁻¹ at 30 and 60 DAT of crop growth and which was at par with V₁-Rajeshwari at 30 and 60 DAT. Whereas, the lowest number of tillers hill⁻¹ was recorded under V₄-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 V₃-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 M₄–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 M₂–150% RDF at 30, 60, 90 DAT and at harvest. Whereas, lowest dry matter accumulation (g plant⁻¹) was recorded under M₁–RDF (100: 40 kg NPK ha⁻¹). Among the varieties, V₃-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 V₄–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 M₄–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 M₁–RDF (100: 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 V₃-Maheshwari and which was at par with V₁–Rajeshwari at all the growth stages of crop. Whereas, lowest crop growth rate (g day⁻¹ hill⁻¹) was recorded under V₄–Karma masuri at 60, 90 DAT and at harvest and 30 DAT it was similar with V₅–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 M₄–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 M₂– 150% RDF. Whereas, the lowest grain yield (55.53 q ha⁻¹) was recorded under M₁–RDF (100: 40 kg NPK ha⁻¹).

Among the varieties, V₃–Maheshwari produced the significantly higher grain yield (60.83 q ha⁻¹) and found at par V₁–Rajeshwari (58.83 q ha⁻¹). Whereas, the lowest grain yield was recorded under V₄–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) [4].

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**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) | | |
| M₁– RDF (100: 60: 40 kg NPK ha⁻¹) | 49.17 | 62.53 | 102.13 | 108.27 | 110.03 |
| M₂– 150% RDF | 49.27 | 64.42 | 103.04 | 109.43 | 111.78 |
| M₃– 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 |
| M₄– 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) | | |
|-------------------------|----------------------------|---------------------------------------------|
| V₁– Rajeshwari | 49.42 | 64.93 | 108.55 | 114.87 | 116.87 |
| V₂– Durgeshwari | 49.25 | 62.50 | 106.50 | 113.12 | 115.12 |
| V₃– Maheshwari | 49.50 | 67.50 | 110.53 | 116.92 | 118.89 |
| V₄– Karma Masuri | 48.88 | 61.39 | 84.03 | 91.18 | 92.78 |
| V₅– 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± | CD (5%) |
|---------------------|------|---------|
| NS | 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 | 23.47 | 35.87 | 36.37 | 0.20 | 0.47 | 0.67 | 0.78 | 54.42 |
| V₅– Indira Aerobic-1 | 6.12 | 21.21 | 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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