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# Effect of inorganic and organic sources of nutrients on yield and economics of direct seeded rice under rainfed situations

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**Abstract**
An experiment was conducted during the Kharif season of 2022 to evaluate the effects of various inorganic and organic nutrient sources on the yield and economics of direct seeded rice in rainfed midland conditions at the Shaheed Gundadhur College of Agriculture and Research Station, Kumhrawand, Jagdalpur, Chhattisgarh. The study area had Inceptisols soil with slight acidity, medium organic carbon content, low available nitrogen, and medium phosphorus and potassium levels. The climate of the Bastar Plateau is sub-humid, with a total rainfall of 1803.5 mm during the cropping season, and temperatures ranging from 18.70 °C to 33.53 °C. Twelve treatments were replicated thrice in a randomized block design. Results showed that treatment $T_8$ (100% NPK + 5t FYM + ZnSO4 @25 kg ha$^{-1}$ + lime 3 q ha$^{-1}$) consistently outperformed other treatments in growth parameters such as plant height, tiller number, dry matter accumulation. Additionally, $T_8$ induced late flowering and maturity. Treatment $T_8$ also produced significantly higher seed numbers per panicle and yielded higher grain, straw, and biological yields compared to other treatments, although harvest index was higher in treatment $T_{10}$ (50% NPK + 5t FYM ha$^{-1}$). Economically, treatment $T_2$ (100% NPK) had the highest net income and benefit-cost ratio. In conclusion, treatment $T_8$ demonstrated superior performance in terms of yield, economics, suggesting its potential for enhancing direct-seeded rice production in similar agro-climatic conditions.

**Keywords:** Inorganic, organic source, direct seeded rice, yield, economics

## Introduction

Rice (*Oryza sativa*) stands as one of the paramount staple food crops globally, belonging to the Poaceae family and originating in South East Asia. Its cultivation spans approximately 165.22 million hectares worldwide, yielding 509.29 million tonnes in the 2022-23 period (Anonymous, 2022) [4]. In India, rice cultivation covers 45 million hectares, yielding 127.93 million tonnes with a productivity of 23.9 q ha$^{-1}$ in 2021-22 (Anonymous, 2021) [3]. Chhattisgarh contributes significantly to this production, cultivating rice across 4.04 million hectares, producing 8.0 million tonnes, with a productivity of 16.83 q ha$^{-1}$ in 2019-20.

In Bastar, rice is cultivated over 208.12 hectares, yielding 327.5 tonnes, with a productivity of 12.85 q ha$^{-1}$ during 2019-20 (Anonymous, 2019) [2]. Inorganic, organic, and biofertilizers constitute the primary sources for replenishing plant nutrients in agricultural soils (Masarirambi *et al*., 2012) [9]. However, continuous use of inorganic fertilizers can lead to soil degradation, affecting its chemical, physical, and biological properties (Mahajan *et al*., 2008) [8]. In light of these concerns, interest has surged in organic fertilizers as alternative nutrient sources (Satyanarayana *et al*., 2002; Mahajan *et al*., 2008) [15, 8]. Combinations of organic and inorganic nutrients have been shown to enhance nutrient use efficiency and boost rice growth and yield (Sannathimmappa *et al*., 2015) [14]. Integrated nutrient management (INM) emerges as a crucial approach for sustaining soil fertility and optimizing productivity (Roy, 1995). INM involves maintaining or adjusting soil fertility and nutrient supply to sustain desired productivity levels by leveraging various nutrient sources in an integrated manner. This method, which combines inorganic fertilizers with organic sources, aims to enhance soil nutrient status and improve soil physicochemical and biological properties (Sannathimmappa *et al*., 2015) [14].

Augmenting soil resources is imperative for sustaining soil nutrients and achieving higher crop yields with optimal input levels (Dahiphale *et al*., 2003) [6]. Modern farming practices and the adoption of INM are essential for meeting global standards of crop quantity and quality. However, the increased use of inorganic fertilizers, driven by high-yielding cultivars with elevated nutrient requirements, raises concerns about sustainability and soil health (Hossain and Singh, 2000) [7]. To address these challenges, it's essential to recognize that neither organic manures nor chemical fertilizers alone can ensure sustainable yields under modern intensive farming practices. Organic manures enhance soil health, but their nutrient levels may be insufficient to meet plant requirements. Hence, integrating organic manures with inorganic fertilizers becomes necessary to maintain soil fertility and ensure optimal yields (Ramalakshmi *et al*., 2012) [12]. Among micronutrients, zinc (Zn) deficiency poses a significant threat to global and regional food security, being the most deficient micronutrient in soils worldwide (Cakmak, 2002; Shivay *et al*., 2008) [5, 17]. Zinc plays a crucial role in various biochemical processes essential for plant growth, and its deficiency can lead to reduced grain yields and malnutrition in humans (Anonymous, 2000; Tiong *et al*., 2014) [1, 18]. Liming, a common practice to improve soil fertility, may also affect micronutrient availability, such as Zn, due to its influence on soil pH and ion concentrations (Shamshuddin and Anda, 2012) [16]. Therefore, understanding the interactions between lime application and micronutrient availability is vital for sustainable rice production. In this context, this study aims to investigate the impact of integrated nutrient management, including inorganic fertilizers, organic sources, and lime application, on rice growth, yield, and soil health in the Bastar region. By elucidating these interactions, we aim to provide insights into sustainable rice production practices tailored to the local agro-climatic conditions.

## Material and methods Experimental site

This field experiment was conducted at the Research cum Instructional farm, S.G. College of Agriculture and Research Station, Jagdalpur (C.G.).

## Experiment design and treatment

The experiment design used randomized block design (RBD) with three replications. The experimental treatments were comprised of twelve treatments *viz*., $T_1$: Absolute control, $T_2$: RDF of 100:60:40 NPK kg $ha^{-1}$, $T_3$: 100% PK, $T_4$: 100% NK, $T_5$: 100% NP, $T_6$: 100% NPK + 5t FYM $ha^{-1}$, $T_7$: 100% NPK + 5t FYM $ha^{-1}$ + ZnSO4@25 kg ha- 1, $T_8$: 100% NPK +5t FYM $ha^{-1}$ + ZnSO4@25 kg $ha^{-1}$ + 3q $ha^{-1}$ Lime, $T_9$: 50% NPK, $T_{10}$: 50% NPK + 5t FYM $ha^{-1}$, $T_{11}$: 50% NPK + 5t FYM $ha^{-1}$ + ZnSO4 @ 25 kg $ha^{-1}$ and $T_{12}$: 50% NPK + 5t FYM $ha^{-1}$ + ZnSO4 @25 kg $ha^{-1}$ + lime@3 q $ha^{-1}$.

## Results and Discussion

### Growth parameter Plant height (cm)

Plant height increased with advancement of growth stages are presented in Table 1. The data shows that treatment $T_8$ recorded significantly taller plant at all the growth stages of rice but it had found statistically comparable with treatment $T_2$, $T_6$, $T_7$, $T_9$, $T_{10}$, $T_{11}$ and $T_{12}$ at all the growth stages while treatment on par during all the growth stages, treatment $T_1$ recorded significantly smaller plant during course of study.

Number of tillers at different growth stages Number of tillers are affected due to inorganic and organic source of nutrients are presented in Table 1. The data reveals that treatment $T_8$ produced significantly higher number of tillers at all the growth stages but it was found on par with treatment $T_2$, $T_6$, $T_7$, $T_{11}$ and $T_{12}$, respectively lowest number of tillers were recorded in treatment $T_1$. Similar findings were reported by Puli *et al*., 2017 [11].

### Dry matter accumulation at different growth stages

Dry matter accumulation significantly affected by different treatments are presented in Table 1. Treatment T8 produced significantly higher dry matter accumulation at all the growth stages and it was recorded significantly on par with treatment $T_7$, lowest dry matter accumulation was observed in treatment $T_1$. Similar results were observed by Paul, K. *et al*., (2021) [10] through their experiment on combination of organic and inorganic source of nutrient.

Days to 50% flowering and days to maturity Days to 50 percent flowering and days to maturity influenced by different treatments are presented in Table 1. The data shows that treatment T8 induced late flowering and late maturity among all the treatments. Days to 50 percent flowering was found comparable with treatment $T_7$ where, days to maturity was recorded significantly on par to each other except in treatment $T_1$. Significantly early flowering and maturity was observed in treatment $T_1$ during the one year study.

### Yield attributing characters

Effected inorganic and organic source of nutrients on yield attributing characters are presented in Table.

The data reveals that treatment T8 produced significantly higher number of seeds per panicle among all the treatments but it had on par with treatment $T_6$, $T_7$, $T_2$, $T_{12}$, $T_{11}$ and $T_{10}$. Remaining yield attributing character i.e. test weigh were found non-significant effect due to different sources of nutrients.

**Table 1:** Effect of inorganic and organic source of nutrients on growth parameters and yield attributing characters of direct seeded rice

| Treatment | Plant height (cm) | No. of tillers ($plant^{-1}$) | Dry matter accumulation (g) | Days to 50% flowering | Days to maturity | 1000 Seed Weight (g) | No. of Seeds $Panicle^{-1}$ |
|---|---|---|---|---|---|---|---|
| $T_1$ | 76.48 | 2.40 | 44.07 | 76.33 | 106.33 | 25.67 | 83.67 |
| $T_2$ | 91.75 | 4.69 | 70.76 | 78.67 | 111.00 | 26.47 | 92.67 |
| $T_3$ | 79.68 | 3.23 | 47.45 | 77.00 | 107.67 | 25.80 | 85.33 |
| $T_4$ | 82.88 | 3.47 | 54.01 | 77.00 | 108.00 | 25.90 | 86.67 |
| $T_5$ | 83.06 | 3.50 | 55.58 | 77.33 | 108.33 | 25.97 | 86.33 |
| $T_6$ | 92.71 | 4.73 | 74.09 | 79.00 | 111.67 | 26.57 | 94.67 |
| $T_7$ | 94.71 | 4.90 | 77.89 | 79.67 | 112.00 | 26.73 | 95.00 |
| $T_8$ | 95.75 | 4.97 | 81.71 | 81.33 | 112.33 | 26.80 | 96.33 |
| $T_9$ | 84.43 | 3.53 | 57.18 | 77.67 | 109.00 | 26.13 | 88.33 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $T_{10}$ | 86.59 | 3.57 | 58.71 | 77.67 | 109.67 | 26.23 | 89.67 |
| $T_{11}$ | 89.89 | 4.58 | 61.43 | 78.00 | 110.00 | 26.33 | 90.33 |
| $T_{12}$ | 91.50 | 4.67 | 68.83 | 78.33 | 110.33 | 26.40 | 91.33 |
| S.Em± | 3.89 | 0.23 | 2.43 | 0.77 | 1.63 | 0.30 | 2.67 |
| C.D. at 5% | 11.42 | 0.67 | 7.11 | 2.27 | 4.77 | NS | 7.82 |
| C. V. % | 7.71 | 9.87 | 6.67 | 1.72 | 2.57 | 1.99 | 5.13 |

### Yield

The data recorded on economic yield, biological yield and harvest index is presented in Table 2. The table shows that treatment $T_8$ produced significantly higher grain, straw yield and biological yield among all the treatments but it had comparable with treatment $T_7$ and $T_6$ on economic yield, straw yield and biological yield. Significantly lowest yield and its products were rewarded in treatment $T_1$. As regents to harvest index, treatment $T_{10}$ recorded significantly higher but it was found on par with all the treatments expect treatment $T_1$, $T_3$ and $T_4$ respectively.

### Economics

Economics are vary from treatments and it is depicted in Table 2. Cost of cultivation and gross income was numerically higher in treatment $T_8$ followed by treatment $T_7$ among all the treatments but in case of net income and B:C ratio, treatment $T_2$ recorded highest income and B:C ratio among all the treatments. Lowest economics were found in treatment $T_1$.

**Table 2:** Effect of inorganic and organic source of nutrients on yield and economics of direct seeded rice

| Treatment | Grain Yield (q ha$^{-1}$) | Straw Yield (q ha$^{-1}$) | Biological Yield (q ha$^{-1}$) | HI % | Cost of cultivation (Rs ha$^{-1}$) | Gross income (Rs ha$^{-1}$) | Net income (Rs ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 18.20 | 30.53 | 48.74 | 37.34 | 29399 | 41236 | 11837 | 0.40 |
| $T_2$ | 45.29 | 61.60 | 106.89 | 42.37 | 35239 | 101178 | 65938 | 1.87 |
| $T_3$ | 23.49 | 34.44 | 57.94 | 40.55 | 33850 | 52726 | 18875 | 0.56 |
| $T_4$ | 25.12 | 36.36 | 61.48 | 40.85 | 32089 | 56337 | 24248 | 0.76 |
| $T_5$ | 29.03 | 39.90 | 68.93 | 42.11 | 33938 | 64860 | 30922 | 0.91 |
| $T_6$ | 47.48 | 62.70 | 110.19 | 43.09 | 42739 | 105883 | 63143 | 1.48 |
| $T_7$ | 50.35 | 65.66 | 116.01 | 43.40 | 50239 | 112200 | 61960 | 1.23 |
| $T_8$ | 51.83 | 67.63 | 119.47 | 43.38 | 52039 | 115502 | 63462 | 1.22 |
| $T_9$ | 31.24 | 40.91 | 72.16 | 43.29 | 32319 | 69632 | 37313 | 1.15 |
| $T_{10}$ | 39.96 | 51.06 | 91.03 | 43.90 | 39819 | 88942 | 49122 | 1.23 |
| $T_{11}$ | 41.06 | 56.40 | 97.48 | 42.13 | 47319 | 91783 | 44464 | 0.94 |
| $T_{12}$ | 43.24 | 57.63 | 100.88 | 42.86 | 49119 | 96480 | 47361 | 0.96 |
| S.Em± | 1.52 | 1.82 | 3.25 | 0.61 | - | - | - | - |
| C.D. at 5% | 4.44 | 5.33 | 9.52 | 1.80 | - | - | - | - |
| C. V. % | 7.06 | 6.25 | 6.42 | 2.52 | - | - | - | - |

### Conclusion

- Based on the results of the Effect of inorganic and organic source of nutrients, it is found that application of T8 (100% NPK + 5t FYM ha$^{-1}$ + ZnSO4 @25 kg ha$^{-1}$ + lime @ 3 q ha$^{-1}$) was found to be effective for all growth parameters of rice crop.
- The yield attributing trait (number of seed panicle-1) were also observed higher in the T8 (100% NPK + 5t FYM + ZnSO4 @ 25 kg ha$^{-1}$ + lime 3 q ha$^{-1}$).
- Significantly highest grain and straw yield was recorded under T8 ((100% NPK + 5t FYM + ZnSO4 @ 25 kg ha$^{-1}$ + lime 3 q ha$^{-1}$) and harvest index was recorded under $T_{10}$ (50% NPK + 5t FYM).
- Highest gross return was recorded under T8 (100% NPK + 5t FYM + ZnSO4 @ 25 kg ha$^{-1}$ + lime 3 q ha$^{-1}$) and net return and benefit cost ratio was recorded under $T_2$ (100% NPK 100:60:40 kg ha$^{-1}$).

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