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Quality seed production of rice (*Oryza sativa* L.) as influenced by integrated nutrient management during *kharif* season in the western undulating zone of Odisha

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Abstract
A field experiment was undertaken to study the effect of integrated nutrient management on crop growth, yield and seed quality of rice CV Mrunalini during *kharif* season of 2018. The experiment was conducted with eleven different nutrient management practices i.e. T1–Control, T2– RDF, T_3–RDF+ ZnSO4 @ 25 kg ha^{-1}, T_4–RDF + Borax @ 4 kg ha^{-1}, T_5–RDF + ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1}, T_6– GM+ RDF + ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1}, T_7-100:50:50, T_8-100:50:50+ZnSO4 @ 25 kg ha^{-1}, T_9-100:50:50+ Borax @ 4 kg ha^{-1},T_{10}- 100:50:50 + ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1} and T_{11}-GM+100:50:50 + ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1} respectively in randomized block design comprising of 3 replications. The results of the experiment revealed that rice seed production plots treated with the combination of T_{11}-GM+100:50:50 + ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1} recorded the highest seed yield of 4.05 t ha–1 which was 4.11% more yield (3.89 t ha–1) than the treatment T_{10}–100:50:50 + ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1}.

Keywords: Rice seed production, integrated nutrient management, seed yield

Introduction

Rice (*Oryza sativa* L.) is the most important staple food crop among the cereals consumed by more than half of the worlds population. India has the largest area under rice in the world and ranks second in production. Rice is one of the significant cereal commodities. The genetic classification of rice plant belongs to genus *Oryza* family Gramineae (Poaceae). The genus *Oryza* includes 24 species of which 22 are wild and 2 viz., *Oryza sativa* and *Oryza glaberrima* are cultivated. *Oryza sativa* is grown in all rice growing areas, but *Oryza glaberrima* is confined to the West Africa only (Singh 1998) [16]. In India during 2014-15 the production of rice was 104.7 million tons from 43.61 million ha and it stands second in position in the world production after China. In Uttar Pradesh area, production and productivity is 5.19 million ha, 10.80 million tons and 20.8 q/ha respectively (CRRI Annual Report 2014-15). Integrated nutrient management has been shown to considerably improve rice yields by minimizing nutrient losses to the environment and managing the nutrient supply and thereby results in high nutrient use efficiency (Parkinson 2013) [9]. The nutrients, their sources, method and time of application form an important component of fertilizer management strategies. In addition to N, P and K, it also supplies considerable amount of secondary and micronutrients and causes the improved growth and high yield of various crops. Besides major nutrients, Zn is the most important micronutrients particularly in our country because most of Indian soil is deficient. Zinc is directly or indirectly required by the several enzymic systems and closely involved in the nitrogen metabolism of plant. Zinc application through soil or foliar sprays and dipping of rice seedlings in ZnO (Jat *et al.* 2011) [7] has been found to ameliorate Zn deficiency. Studies on Zn fertilizer proved that the application of Zn greatly influences growth, yield and quality of rice (Patnaik *et al.* 2011) [10].

The crops have started responding to micronutrient fertilizers in view of the widespread deficiency of micronutrients such as zinc, boron and to a limited extent iron, manganese, copper and Molybdenum (Gupta 2005) [5]. Increasing zinc concentration in rice grain has twain benefits for human nutrition health and also increasing crop production through better germination and seedling vigour of rice plants grown on soils with limited Zn supply (Phattarakul *et al.*, 2012) [11]. Zinc is one of the essential micronutrients, which serves as a co-

Zinc is one of the essential micronutrients, which serves as a co-factor for more than 300 enzymes involved in the metabolism of carbohydrates, lipids, proteins, and nucleic acids, hence is important for normal growth and development of plants and animals (Roohani *et al.*, 2013; Sadeghzadeh 2013) [12, 13]. It is estimated that agricultural production must increase by 70% by 2050 to feed over 9 billion people worldwide. India is no exception. Analysis of over 256,000 soil samples from all over India showed that about 50% of the soils were deficient in zinc and that this was the most common micronutrient problem affecting crop yields in India (Singh 2009) [15]. Wheat and rice is major staple food in India constitute about 60-70% of daily calorie uptake.

Zinc deficiency in rice causes a deficiency disorder called Khaira disease. Seedling stage of the crop is highly prone to Zn deficiency. Leaves develop brown blotches and streaks, the streaks and blotches may fuse to cover the entire leaf, plants remain stunted and in severe case of deficiency the plant may die. Zinc deficiency decreases the tillering, increases the spikelet sterility and delay the crop maturity (IRRI, 2000) [6]. Slaton *et al.* (2001) [17] reported that Zn deficient rice plant show poor root respiration especially in submerged soils.

The deficiency of boron (B) is spreading and it is most common in rice growing soils. Though it is required in small amounts but proved essential for plant growth. Boron is associated with one or more process of calcium utilization, cell division, flowering/fruiting, disease resistance, water relations and act as catalyst for several reactions (Spraque, 1951) [18]. It is also very much essential for the metabolism of carbohydrate, transport of sugars, synthesis of nucleotide, respiration and pollen viability (Dell and Huang, 1997) [3].

Materials and methods

The field experiment was conducted at the Seed production farm of Krishi Vigyan Kendra, Kalahandi, Bhawanipatna of Odisha during the year 2018-19. The present investigation has been planned to study the influence of integrated nutrient management on growth and yield attributes of Rice cv. Mrunalini in quality seed production. The design of experiment adopted was randomized block design (RBD) with three replications

The source of N, P_2O_5 and K_2O were urea, diammonium phosphate (DAP) and muriate of potash (MOP) respectively. Full dose of phosphorus and potassium were applied just before transplanting as per treatment. Nitrogen was applied in three splits viz. just before transplanting (TP), at active tillering (AT) stage and at panicle initiation (PI) stage as per treatment. Well rotten FYM was procured from local farmer and vermicompost from K.V.K., Kalahandi. FYM and vermicompost were incorporated as per treatment one day prior to transplanting and the plot was leveled. The field was irrigated as and when required.

Table 1: Details of Integrated nutrient management

Sl. No	Treatments	Particulars
1	T1	Control
2	T2	80:40:40 (RDF)
3	T3	RDF+ ZnSO4 @ 25 kg ha^{-1}
4	T4	RDF + Borax @ 4 kg ha^{-1}
5	T5	RDF + ZnSO4 @ 25 + Borax @ 4
6	T6	GM+ RDF + ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1}
7	T7	100:50:50
8	T8	100:50:50++ ZnSO4 @ 25 kg ha^{-1}
9	T9	100:50:50+ Borax @ 4 kg ha^{-1}
10	T10	100:50:50 + ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1}
11	T11	GM+100:50:50 + ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1}

Plant height

Plant height was measured from ground level up to the tip of the top most leaf of each sampling hill starting from 30 DAT at 30 days interval till maturity. Then the average figure was worked out. The height at maturity was recorded from ground level up to the tip of the topmost panicle. The plant height was expressed in cm.

Number of tillers hill^{-1}

Total number of tillers in tagged hills from each plot was counted starting from 30 DAT at 30 days interval till maturity, averaged to find out the mean number of tillers hill^{-1} and subsequently converted to tillers m^{-2} for each plot.

Number of effective tillers hill^{-1}

Numbers of effective tillers (panicles) were counted from all the 5 tagged hills used for taking the bio-metric observations and converted into number of effective tillers (panicles) per m^{-2}.

Length of panicle

Length of ten panicles randomly selected from the tagged hills of each plot was measured in cm from the neck node to the tip of the top most grain and averaged to get the mean length of the panicle for each plot.

Number of filled grains panicle^{-1}

The total number of filled grains of each sampled panicle used for determining panicle length was counted separately and the average number of filled grains panicle^{-1} was calculated.

Panicle weight

The ten panicles randomly selected from tagged hills of each plot were weighed separately and averaged to find out weight panicle^{-1}.

1000-grain weight

The 1000-grain weight in gram was obtained from the ten panicles sampled for taking panicle length and filled grains per panicle by randomly selecting 500 grains. The weight of these 500 grains were taken and multiplied by 2 to get 1000-grain weight in gram.

Grain yield

The sun dried bundles from the net plot area were threshed plot-wise using a pedal operated paddy thresher. The yield of grain was converted into kg ha^{-1} after it was adjusted to 13 % moisture content. Grains of ten panicles from each plot kept for recording yield attributing characters were also added to the net plot yields.

Straw yield

After threshing, the straw bundles were dried under sun to reduce the moisture content. The yield was converted into kg ha^{-1} after it was adjusted to 13 % moisture content.

Harvest index (HI)

The harvest index was calculated as the ratio of economic yield and biological yield (economic + by-product) expressed in percentage and was calculated by using the following formula as suggested by Nichiporovic (1960).

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where economic yield is the grain yield and biological yield is the total biomass (grain + straw) yield.

Results and disscussions

Plant height

The data presented in table 1 showed Different nutrient management approaches exerted significant effect on Plant height of Rice 'Mrunalini'. The highest plant height were observed under 100:500:50 kg N-P_2O_5-K_2O $ha^{-1}$with green manuring, Zinc sulphate and Borax (T_{11}). T_{11} showed highest plant height of 131.65 cm followed by T_6 (128.58 cm) and T_{10} (127.61 cm). T_9, T_8, T_7 showed (125.86 cm), (125.43 cm) and (123.27 cm) respectively.

Zinc application significantly increased the plant height which might be attributed to the adequate supply of zinc to accelerate the enzymatic activity and auxin metabolism in plants. These results are in agreement with the findings of (Khan *et al.*, 2007; and Sudha *et al.*, 2015; Abdoli *et al.*, 2014) [19, 1]. Who reported a significant increase in plant height in safflower and bread wheat plants treated with foliar Zn application compared withcontrol. Similar results were also observed by (Saha *et al.*, 2013).

Number of effective tillers hill^{-1}

The data presented in table 1 showed Different nutrient management approaches exerted significant effect on Number of effective tillers hill^{-1} of Rice 'Mrunalini'. The highest Number of effective tillers hill^{-1}were observed under 100:500:50 kg N-P_2O_5-K_2O $ha^{-1}$with green manuring, Zinc sulphate and Borax (T_{11}). T_{11} showed highest plant height of 19.50 followed by T_{10} (17.90) and T_9 (16.50). T_6, T_8, T_5 showed (16.43), (14.73) and (14.60) respectively.

Although, effective tillers were more in Zn applied treatments. Tillering capacity is one of the most important rice components which are responsible for yield of crop. The increased tillers number by Zn application may be attributed to its role in various Zn induced enzymatic activity and auxin metabolism which control growth of plant. These results are similar to the findings of Ghani *et al.*, (1990) [4].

No. of Panicles m^{-2}

The data presented in table 1 showed different nutrient management approaches exerted significant effect on No. of Panicles m^{-2} of Rice 'Mrunalini'. The highest No. of Panicles m^{-2} were observed under 100:500:50 kg N-P_2O_5-K_2O $ha^{-1}$with green manuring, Zinc sulphate and Borax (T_{11}). T_{11} showed highest plant height of 303.67 followed by T_{10} (293.33) and T_9 (286.33). T_6, T_8, T_7 showed (278.00), (274.00) and (268.33) respectively.

Panicle length

The data presented in table 1 showed different nutrient management approaches exerted significant effect on Panicle length of Rice 'Mrunalini'. The highest Panicle length were observed under 100:500:50 kg N-P_2O_5-K_2O $ha^{-1}$with green manuring, Zinc sulphate and Borax (T_{11}). T_{11} showed highest Panicle length of 27 cm followed by T_{10} (26.87 cm) and T_9 (25.77 cm). T_8 and T_6 showed same Panicle length of (25.30 cm) while T_5 and T_3 exhibits (24.43 cm), (23.63 cm) panicle length respectively.

Filled grains panicle^{-1}

The data presented in table 1 showed Different nutrient management approaches exerted significant effect on Filled grains panicle^{-1} of Rice 'Mrunalini'. The highest Filled grains panicle^{-1} were observed under 100:500:50 kg N-P_2O_5-K_2O $ha^{-1}$with green manuring, Zinc sulphate and Borax (T_{11}). T_{11} showed highest no. of Filled grains panicle^{-1} of (121.09) followed by T_{10} (119.73) and T_9 (117.19). T_8, T_7, T_6 showed (116.26), (115.63) and (114.33) respectively.

Panicle weight

The data presented in table 1 showed Different nutrient management approaches exerted significant effect on panicle weight of Rice 'Mrunalini'. The highest panicle weight were observed under 100:500:50 kg N-P_2O_5-K_2O $ha^{-1}$with green manuring, Zinc sulphate and Borax (T_{11}). T_{11} showed highest panicle weight of 5.21g followed by T_{10} (5.16 g) and T_9 (5.03 g). T_8, T_7, T_6 showed (4.89 g), (4.70 g) and (4.60 g) respectively.

Table 1: Influence of integrated nutrient management on Morphological Characters of Rice

Sl No.	Plant Height (cms)	No. of effective tillers/hill	No. of panicles/m^2	Panicle length (cms)	No. of filled grain/panicle	Panicle weight (g)
T1-Control	95.39	5.93	195.00	20.43	71.84	3.94
T2-RDF	111.61	11.80	247.67	23.37	98.46	3.43
T3-RDF+ZnSO4	114.66	12.37	252.00	23.63	108.74	3.65
T4-RDF+Borax	115.43	13.70	256.00	23.50	109.91	3.70
T5-RDF+ZnSO4+Borax	118.38	14.60	261.33	24.43	111.65	4.33
T6-GM+RDF+ZnSO4+Borax	128.58	16.43	278.00	25.30	114.33	4.60
T7-100:50:50	123.27	13.53	268.33	23.27	115.63	4.70
T8-100:50:50+ZnSO4	125.43	14.73	274.00	25.30	116.26	4.89
T9-100:50:50+Borax	125.86	16.50	286.33	25.77	117.19	5.03
T10-100:50:50+ZnSO4+Borax	127.61	17.90	293.33	26.87	119.73	5.16
T11-GM+100:50:50+ZnSO4+Borax	131.65	19.50	303.67	27.00	121.09	5.21

S.Em (±)	0.20	0.42	4.12	0.84	3.78	0.27
C.D (p=0.05)	0.65	1.36	13.44	2.73	12.34	0.89
C.V (%)	0.29	5.08	2.69	5.94	5.98	10.72

Test weight
The data pertaining to Test weight recorded from the post harvest sample were statistically analyzed and presented in table 2. Different nutrient management approaches exerted significant effect on Test weight of Rice 'Mrunalini' with T_{11} recorded highest test weight 225.67g followed by T_{10} exhibits 223.13g. T_9 showed 219.33 g just after T_{10}.

Table 2: Influence of integrated nutrient management on Yield attributes of Rice

Sl No.	Test weight(g)	Straw Yield(t/ha)	Grain Yield (t/ha)	G:S ratio	HI
T1-Control	143.47	4.92	2.03	0.41	244.28
T2-RDF	198.33	5.58	3.26	0.58	384.01
T3-RDF+ZnSO4	199.47	5.65	3.36	0.60	396.21
T4-RDF+Borax	200.87	5.76	3.45	0.60	404.86
T5-RDF+ZnSO4+Borax	201.20	5.82	3.56	0.61	417.19
T6-GM+RDF+ZnSO4+Borax	203.23	7.11	3.65	0.51	416.03
T7-100:50:50	208.27	6.15	3.73	0.61	433.62
T8-100:50:50+ZnSO4	211.23	6.33	3.78	0.60	437.75
T9-100:50:50+Borax	219.33	6.79	3.84	0.57	440.69
T10-100:50:50+ZnSO4+Borax	223.13	7.12	3.89	0.55	443.25
T11-GM+100:50:50+ZnSO4+Borax	225.67	7.28	4.05	0.56	460.61
S.Em (±)	3.60	0.14	0.08	0.02	9.41
C.D (p=0.05)	11.74	0.47	0.27	0.06	30.69
C.V (%)	3.07	3.99	4.04	5.50	4.00

Straw yield
The data presented in table no. 2 showed that Straw yield recorded from the post harvest sample were statistically analyzed. Different nutrient management approaches exerted significant effect on Straw yield of Rice 'Mrunalini' with T_{11} recorded highest Straw yield 7.28 t/ha followed by T_{10} exhibits 7.12 t/ha. T_6 showed 7.11 t/ha just after T_{10}.

Grain yield
The observations on Grain Yield recorded from the post harvest sample were statistically analyzed and presented in table 2. Different nutrient management approaches exerted significant effect on Grain Yield of Rice 'Mrunalini' with T_{11} recorded highest Grain Yield of 4.05 t/ha followed by T_{10} exhibits 3.89 t/ha. T_9 showed 3.84 t/ha just after T_{10}.

Harvest index
The data presented to Harvest Index recorded in table 2 showed that different nutrient management approaches exerted significant effect on harvest index of Rice 'Mrunalini'. It explains that T_{11} recorded highest Harvest Index 460.61 followed by T_{10} exhibits 443.25 while T_9 showed 440.69 g just after T_{10}.

G:S Ratio
The data presented in table no. 2 showed that G:S ratio recorded from the post harvest sample were statistically analyzed. Different nutrient management approaches exerted significant effect on G:S ratio of Rice 'Mrunalini' with T_5 & T_7 recorded highest G:S ratio 0.61 each followed by T_3, T_4 and T_8 exhibits 0.60. T_2 showed G:S ratio of 0.58 just after T_3, T_4 and T_8.

Conclusion
In the present investigation, Based on the findings of the experiment on integrated nutrient management in rice seed production, it may be recommended that integrated application of G.M+ 100:50:50 kg $N:P_2O_5:K_2O$ (with split application of N as ¼ at transplanting, ½ at active tillering and ¼ at panicle initiation)+ ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1} along with 5 t FYM ha^{-1} for seed production of rice (cv. Mrunalini) during *Kharif season of 2018* followed by T_{10} i.e. application of 100:50:50 + ZnSO4 @ 25 kg ha^{-1} + Borax @ 4 kg ha^{-1} to harness the maximum productivity, profitability in Western Undulating Zone of Odisha.

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