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Integrated nutrient management in scented rice (*Oryza sativa* L.)

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Abstract
The present experiment was conducted at Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Kharif* season 2019-20 entitled with integrated nutrient management in scented rice including organic and inorganic nutrients source with recommended dose of fertilizers (RDF) 100: 60: 40 NPK kg ha^{-1}. Experiment was laidout at randomized block design (RBD) with the ten treatments and three replications, taking variety of scented rice Chhattisgarh sugandhit bhog. The investigation of result found that between the different organic and inorganic treatments T_6 (75% RDF + 5 tonne Vermicompost ha^{-1} enriched with consortia), result indicated that the highest grain yield 35.78 q ha^{-1} was observed which was significantly superior over other treatments but was at par with T_5 (75% RDF + 5 tonne FYM ha^{-1} enriched with consortia) with 34.24 q ha^{-1} grain yield closely followed by the treatments T_4, T_3, T_2 and T_{10}. The higher growth, yield and yield attributes characters under the T_6 has been affiliated with higher no. of plant height(94.14 cm), highest no. of effective tillers (315.14), highest no. of panicles per m^2 (349.36) also significantly superior and highest B:C ratio and net profit observed in treatments T_5 2.6 and 60918 Rs ha^{-1} respectively.

Keywords: Integrated nutrient management, scented rice

Introduction
Rice (*Oryza sativa* L.) is the world's largest staple food crop. It is the rich energy source and contains reasonable protein (6-10 percent), carbohydrate (70-80 percent), minerals (1.2-20%) and vitamins (Riboflavin, Thiamine, Niacin and Vitamin E). (Anonymous 2014) [1]. This data shows that in the 2018 crop year about 167.13 million hectare. India covers more than 30% of total cultivated area and contributes more than 40% of total production. In India rice production for 2015-16 amounts to 104.41 million tonnes, 2400 kg ha^{-1} of production covering an area of 434.99 lakh hectares. The field size decreased to 431.94 lakh hectare in 2016-17 with an increase in 110.15 million tonnes of output and 2500 kg ha^{-1} productivity (Annual report of 2017-18). India has 42.95 million hectare acreage with 111.01 million tonnes of production. According this data published by Indian stat (Anonymous, 2018) [1]. The state leader in rice in India is Uttar Pradesh, the rice is cultivated in an area of 5.95 million hectare (mha) with gross output of 13.53 hectare. In rice responsible for its scent, 2-Acetyl-1 pyrroline (2-AP) is most common; almost every state in the country has its own set of aromatic rice that has a good performance in.

Chhattisgarh is historically known as an Indian bowl of rice. More than 23,250 rice varieties were reported in state. In Chhattisgarh, rice is grown in 3.79 million hectare (mha) area and covers 8.58 percent of India, with average yield of 6.91 million tonne. (Anonymous, 2018) [1]. In the state of Chhattisgarh, there are many scented rice varieties that are cultivated and popular for their cultivation. Rice varieties are being grown in Chhattisgarh *i.e.* Jeeraphool, Dubraj, Vishnubhog and Jawaphool. Indira Gandhi Krishi Vishwavidyalaya developed medium length and short height of scented rice "Chhattisgarh Sugandhit Bhog". Several studies have highlighted the role of integrated nutrient management activities to increase crop yields and improve soil quality in long term. The use of organic manures plays an significant role in the use of fertilizers performance, lower cost of supply of nutrients, increase production under rainfed conditions and require less capital investment, particularly under unfavourable weather conditions.

Organics supplies nutrients during peak adsorption and also supplies micro nutrients and alters soil physical behaviour and increase the performance of applied nutrients. Use of organic and inorganic fertilizers mixture which increases the nutrient use efficiency and minimum losses

of nutrients. The nitrogen loss processes occur by leaching and de-nitrification. Reasonable and fertilizer use can increase markedly the yield and the rice quality improved. PSB (Phosphorus Solubilizing Bacteria) plays an important role amongst soil microorganisms in the solubilisation of P for plants and use of phosphatic fertilizers.

Materials and Methods

Field experiments were conducted at Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (C.G.) during *Kharif* season 2019-20. The experimental plot soil has been classified as black group, known as clayey loam soil. pH in soil was 6.2, Electrical conductivity was recorded 0.25 dSm^{-1}, OC 0.64 and available nitrogen was 150 kg ha^{-1}, phosphorus and potassium was 13.88 kg ha^{-1} and 204.96 kg ha^{-1} respectively. The present experiment was laid out in Randomized Block Design (RBD) with ten treatments and three replications. Ten treatments of the experiment *viz*., T_1 – Control, T_2 – 100% RDF (100:60:40 kg NPK ha^{-1}), T_3 – 75% RDF + 5 tonne FYM ha^{-1}, T_4 – 75% RDF + 5 tonne Vermicompost ha^{-1}, T_5 – 75% RDF + 5 tonne FYM ha^{-1} enriched with consortia, T_6 – 755 RDF + 5 tonne Vermicompost ha^{-1} enriched with consortia, T_7 – 50% RDF + 5 tonne FYM ha^{-1}, T_8 – 50% RDF + 5 tonne Vermicompost ha^{-1}, T_9 – 50% RDF + 5 tonne FYM ha^{-1} enriched with consortia, T_{10} – 50% RDF + 5 tonne Vermicompost ha^{-1} enriched with consortia. Rice variety "Chhattisgarh sugandhit bhog" used as an experimental variety. Recommended dose of fertilizers for scented rice *i.e.*, 100:60:40kg NPK ha^{-1} was application as urea, single super phosphate (SSP) and murate of potash (MOP). Available nitrogen, phosphorus and potassium content sample was determined by Alkaline permanganate method (Subbiah and Asija, 1956) [14], Olsen's method and Flame photometer. Data subjected was statistical analysis as prescribed by.

Result and Discussion

Plant Height

Plant height (in cm) was measured in 30, 60, 90 and at harvest DAS (Days after sowing) data presented in Table-1. Plant height was increase with crop of age. The integrated nutrient management practices were significantly affected the plant height of rice at all the growth stages.

Table 1: Effect of integrated nutrient management on plant height (in cm)

	Treatments	Days after sowing			
		30	60	90	Harvest
T_1	Control	32.95	59.48	71.36	71.76
T_2	100% RDF(100:60:40 kg N:P:K ha^{-1})	38.83	68.24	84.85	85.22
T_3	75% RDF + 5 tonne FYM ha^{-1}	39.35	71.57	87.86	87.92
T_4	75% RDF + 5 tonne Vermi-compost ha^{-1}	39.59	71.72	89.79	89.87**
T_5	75% RDF + 5 tonne FYM ha^{-1}enriched with consortia	41.76	75.00	92.00	93.23*
T_6	75% RDF + 5 tonne Vermi-compost ha^{-1} enriched with consortia	42.75	76.64	92.36	94.14*
T_7	50% RDF + 5 tonne FYM ha^{-1}	38.23	63.79	79.30	79.91
T_8	50% RDF + 5 tonne Vermi-compost ha^{-1}	38.38	64.59	80.98	81.8
T_9	50% RDF + 5 tonne FYM ha^{-1} enriched with consortias	39.16	65.77	83.20	83.31
T_{10}	50% RDF + 5 tonne Vermi-compost ha^{-1} enriched with consortia	35.01	68.04	83.57	83.81
S.Em±		0.69	1.06	1.11	1.43
CD(0.05)		2.04	3.15	3.29	4.24

The data revealed that the application of 75% RDF + 5 tonne Vermicompost ha^{-1} enriched with consortia in treatment (T_6) resulted in highest plant height at different growth satges of crop *viz*., plant height in 30, 60, 90 and at harvest DAS (42.75 cm, 76.64 cm, 92.36 cm and 94.14 cm respectively) which has significantly superior over other treatments and at par with treatment T_5 (75% RDF + 5 tonne FYM ha^{-1} enriched with consortia). The results shall be in accordance with the finding of Raj *et al*., (2013) [9]. Sharma *et al*., (2017) [10]. Farooq *et al*., (2018) [4]. Kumar *et al*., (2018) [7]. Kumar *et al*., (2018) [7]. Dinka *et al*., (2018) [3]. Lowest plant height recorded by treatment T_1 (Control) at all crop growth stages.

Dry matter accumulation

Application of 75% RDF + 5 tonne Vermicompost ha^{-1} enriched with consortia) observed in that results highest number of tillers. T_5 which was at par with T_4 and T_3. Highest dry matter accumulation observed in treatment T_6 at 30, 60, 90 and at harvest (8.34, 12.14, 15.96 and 16.27 g $plant^{-1}$) then T_5 followed by T_4, T_3, T_2 and T_{10}. After the treatment T_6 highest dry matter accumulation recorded T_5. Mondal *et al*., (2015) [8]. Shinde *et al*., (2017) [11]. Sharma *et al*., (2017) [10]. Apon *et al*., (2018) [2] and Farooq *et al*., (2018) [4].

Table 2: Effect of integrated nutrient management on Dry matter accumulation (g $plant^{-1}$)

	Treatments	Days after sowing			
		30	60	90	Harvest
T_1	Control	3.77	4.98	6.51	7.243
T_2	100% RDF (100:60:40 kg N:P:K ha^{-1})	6.04	9.81	13.07	13.07
T_3	75% RDF + 5 tonne FYM ha^{-1}	6.18	10.77	13.18	14.05
T_4	75% RDF + 5 tonne Vermicompost ha^{-1}	7.12	10.90	13.34	14.26**
T_5	75% RDF + 5 tonne FYM ha^{-1} enriched with consortia	8.01	11.97	15.02	15.31*
T_6	75% RDF + 5 tonne Vermi-compost ha^{-1} enriched with consortia	8.34	12.14	15.96	16.27*
T_7	50% RDF + 5 tonne FYM ha^{-1}	5.60	7.10	9.22	10.29
s T_8	50% RDF + 5 tonne Vermicompost ha^{-1}	5.68	7.10	10.11	11.14
T_9	50% RDF + 5 tonne FYM ha^{-1} enriched with Consortia	5.78	8.19	11.35	12.26
T_{10}	50% RDF + 5 tonne Vermicompost ha^{-1} enriched with Consortia	5.92	8.83	11.62	12.54
S.Em±		0.23	0.37	0.69	0.28
CD(0.05)		0.70	1.11	2.05	0.84

Crop Growth Rate (CGR)

Crop growth data (CGR) were determined by taking the rate of change in dry matter production per square meter between 30-60, 60-90 and 90 days after sowing (DAS) up to harvest and are presented in Table:- 4.5 and Fig-5. From the data provided in Table:- 3, it would be obvious that the crop growth rate (CGR) gradually increased to 90 days after sowing (DAS) and subsequently declined.

Table 3: Effect of integrated nutrient management on Crop Growth Rate (CGR)

	Treatment	CGR (g/day/m^2)		
		30-60 DAS	60-90 DAS	90 DAS- Harvest
T_1	Control	2.97	1.84	1.37
T_2	100% RDF (100:60:40 kg N:P:K ha^{-1})	4.81	3.50	1.66
T_3	75% RDF + 5 tonne FYM ha^{-1}	4.88	3.65	1.63
T_4	75% RDF + 5 tonne Vermicompost ha^{-1}	5.06	4.64	1.33
T_5	75% RDF + 5 tonne FYM ha^{-1} enriched with consortia	5.23	4.83	1.59
T_6	75% RDF + 5 tonne Vermicompost ha^{-1} enriched with consortia	5.33	4.92	1.60
T_7	50% RDF + 5 tonne FYM ha^{-1}	3.60	2.41	1.43
T_8	50% RDF + 5 tonne Vermicompost ha^{-1}	3.89	2.94	1.48
T_9	50% RDF + 5 tonne FYM ha^{-1} enriched with Consortia	4.56	3.33	1.49
T_{10}	50% RDF + 5 tonne Vermicompost ha^{-1} enriched with Consortia	4.75	3.40	1.73

Between 30-60 days after sowing (DAS), the rate of increase was higher. In all treatments, the crop growth rate was least in 90 days after sowing (DAS) to harvest. T_6 (75% RDF + 5 tonne Vermicompost ha^{-1} enriched with consortia) recorded the highest crop growth rate (CGR) (5.33g/day/m^2) of treatments followed by T_5 (75% RDF + 5 tonne FYM ha^{-1} enriched with consortia) with 5.23g/day/m^2 between 30-60 days after sowing (DAS). T_7 (50% RDF + 5 tonne FYM ha^{-1}) and T_1 (Control) recorded between 30-60 days after sowing (DAS) a minimum CGR of 3.60 and 2.97g/day/m^2.

Relative Growth Rate (RGR)

Relative growth rate data as affected by various integrated Nutrient management treatments at different growth stages is provided in Table:- 4

Table 4: Effect of integrated nutrient management on Relative Growth Rate

	Treatments	RGR (g g^{-1} day^{-1})	
		30-60 DAS	60-90 DAS
T_1	Control	0.011	0.055
T_2	100% RDF (100:60:40 kg N:P:K ha^{-1})	0.025	0.086
T_3	75% RDF + 5 tonne FYM	0.022	0.078
T_4	75% RDF + 5 tonne Vermicompost ha^{-1}	0.023	0.079
T_5	75% RDF + 5 tonne FYM ha^{-1} enriched with consortia	0.025	0.088
T_6	75% RDF + 5 tonne Vermi compost ha^{-1} enriched with consortia	0.026	0.097
T_7	50% RDF + 5 tonne FYM ha^{-1}	0.017	0.068
T_8	50% RDF + 5 tonne Vermi compost ha^{-1}	0.017	0.069
T_9	50% RDF + 5 tonne FYM ha^{-1} enriched with consortia	0.019	0.075
T_{10}	50% RDF + 5 tonne Vermi compost ha^{-1} enriched with consortia	0.021	0.075

Result indicated that the highest relative growth rate (RGR) (0.026g g^{-1}day^{-1}) was observed in treatment T_6 (75% RDF + 5 tonne Vermicompost ha^{-1} enriched with consortia) which was significantly superior over other treatments but was at par with T_5 (75% RDF + 5 tonne FYM ha^{-1} enriched with consortia) (0.025g g^{-1}day^{-1}) and T_2 (100% RDF) (0.025g g^{-1}day^{-1}) at 30-60 days after sowing (DAS) followed by T_4 (755 RDF + 5 tonne Vermicompost ha^{-1}) and T_3 (75% RDF + 5 tonne FYM ha^{-1}). Minimum relative growth rate (RGR) was recorded T_7 and T_1 in descending order with (0.017g g^{-1}day^{-1}) and (0.011g g^{-1}day^{-1}) during 30-60 days after sowing (DAS).

No. of Tillers

The no. of tillers (in m^2) was measured in 30,60, 90 and at harvest days after sowing data presented in Table-5. Revealed from the result, the highest no. of tillers observed in 30, 60, 90 and at harvest DAS in treatment T_6 (75% RDF + 5 tonne Vermicompost ha^{-1} enriched with consortia) (218.55, 318.90, 316.54 and 308.82 cm, respectively) which was significantly superior than other treatments. Also similar result finding was recorded by Harikesh *et al*., (2017) [5]. Wahlang *et al*., (2017) [13]. Jha *et al*. (2017) [6]. Tomar *et al*., (2018) [12].

Accordingly the tillers, the highest grain yield (35.78 qha^{-1}) were observed from the treatment T_6 (75%RDF + 5 tonne FYM ha^{-1} enriched with consortia) which was significantly superior over other treatments but was at par with T_5 (75%RDF + 5 tonne FYM ha^{-1} enriched with consortia) with (34.24 qha^{-1}). Minimum grain yield observed in treatment T_1 (Control) (13.76 qha^{-1}).

Table 5: Effect of integrated nutrient management on number of tillers (m^2)

	Treatments	Days after sowing				Grain Yield (q ha^{-1})
		30	60	90	Harvest	
T_1	Control	189.46	278.80	272.37	272.37	13.67
T_2	100% RDF (100:60:40 kg N:P:K ha^{-1})	207.79	303.85	301.19	298.12	28.35
T_3	75% RDF + 5 tonne FYM ha^{-1}	209.90	304.19	301.33	299.80	28.88
T_4	75% RDF + 5 tonne Vermi-compost ha^{-1}	211.02	305.34**	303.86	301.51	31.30
T_5	75% RDF + 5 tonne FYM ha^{-1}enriched with consortia	215.38	311.98*	309.22	305.88	34.24
T_6	75% RDF + 5 tonne Vermi-compost ha^{-1} enriched with consortia	218.55*	318.90*	316.54	308.82	35.78
T_7	50% RDF + 5 tonne FYM ha^{-1}	194.04	286.53	283.37	282.03	21.28
T_8	50% RDF + 5 tonne Vermi-compost ha^{-1}	198.01	286.72	284.78	282.10	24.32
T_9	50% RDF + 5 tonne FYM ha^{-1} enriched with consortias	202.62	291.30	288.45	286.31	26.81
T_{10}	50% RDF + 5 tonne Vermi-compost ha^{-1} enriched with consortia	207.61	298.47	295.02	293.34	27.96
S.Em±		2.06	1.77	3.37	2.26	0.72
CD(0.05)		6.12	5.25	10.02	6.72	2.13

Conclusion

From the experimental result, it could be enlightened that application of 75% RDF + 5 tonne Vermicompost ha^{-1} enriched with consortia could be considered as a better option for obtained higher production under integrated nutrient management. Integrated nutrient management was found to significantly superior results in all stages of crop, combination of organic and inorganic fertilizers without influenced the yield of rice in addition to increase in the sustainability of the production capacity of soil. Hence, integrated nutrient management, it is possible more successful and profitable, for scented rice.

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