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Review/Overview

Effect of customized fertilizer on productivity and nutrient uptake of rice (*Oryza sativa*)

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) season of 2011 and 2012 Raipur, Chhattisgarh, to study the effect of customized fertilizer on yield, economic efficiency and nutrient uptake in 'Mahamaya' rice (*Oryza sativa* L.). Amongst the different doses of customized fertilizer (CF) and other nutrient management practices, best result was observed under 150% dose of CF, where it recorded the highest growth and yield-attributing characters, viz. grain yield of rice (7.0 t/ha) with harvest index (HI) (46.39 %) and maximum net returns (₹60,062/ha) as well as benefit: cost ratio (2.31). The uptake of NPK and Zn was also higher under this treatment. Other different doses of customized fertilizer, i.e. 50% and 75% dose of CF and recommended dose of fertilizer (RDF) (T_7) failed to provide considerable yield advantage and uptake of nutrients in plant as compared to optimum level of customized fertilizer.

Key words **:** Crop productivity, Customized fertilizer, NPK and Zn, Rice

Rice is the most consumed cereal grain in the world, constituting the dietary staple food for more than half of human population of the planet. India is the second largest producer after China and has an area of over 42.2 million ha and production of 104.32 million tonnes with productivity of 2.37 t/ha (DAC, New Delhi, 2013). Even then rice self-sufficiency in India is precarious. The country's population of more than a billion is growing at 1.8%/year, outpacing the 1.4% annual growth rate of rice production. India's population is expected to be 1.4 billion by the year 2025 and 300 million tonnes of foodgrains will be required by 2025. India need to raise its foodgrains targets at a rate of more than 4 million tonnes per annum and to maintain self-sufficiency, annual production needs to increase by two million tonnes every year (IGKV, Raipur, 2011). The annual consumption of fertilizers, in nutrient terms (N, P and K), has increased from 0.07 million tonnes in 1951-52 to more than 28 million tonnes in 2010–11 and per hectare consumption has increased from less than 1 kg in 1951–52 to the level of 135 kg in 2010–11(DoF, 2012). In Chhattisgarh, rice plays a vital role in Indian production and economy. The livelihood of almost 83% of rural population of the state is dependent only on rice cultivation, but productivity of rice in the state is very low (1.3 t/ha) even below the national average (2.37 t/ha). The prime causes of low productivity of rice in Chhattisgarh are insufficient and unbalanced amount of macro and micro nutrient, limited irrigation and lack of improved varieties suitable to different ecosystems. In cultivation of rice, health and nutrient status of soil declined even in irrigated areas due to application of inadequate and unbalanced quantity of fertilizers (Sharma *et al*., 2003). There is yield gap due to inadequate and imbalance supply of fertilizers and lack of distinct fertilizer recommendation for plenty of varieties and hybrid of rice. Hence there is need for application of these nutrients in balance quantity as a customized fertilizer (CF) with special reference to location/region specific for attaining optimum growth, development and enhancing the yield of rice. The Central Fertilizer Committee has included customized fertilizers in the Fertilizer Control Order (FCO) 1985, as a new category of fertilizers that are area/soil/crop specific. Customized fertilizers are multinutrient carriers facilitating the application of the complete range of plant nutrients in right proportion to suit the specific requirements of a crop during its stages of growth. Soil fertility status, climate, and cropping pattern in a region gave the way for the development of customized fertilizer formulations. Customized fertilizers are unique and ready-to-use granulated fertilizers, formulated on sound scientific plant nutrition principles integrated with soil information, extensive laboratory studies and evaluated

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through field research. The FCO recognizes customized fertilizers importance and defined as: Multi-nutrient carriers designed to contain macro, secondary and/or micronutrient both from inorganic sources and/or organic sources, manufactured through a systematic process of granulation, satisfying the crop's nutritional needs, specific to its site, soil and stage validated by a scientific crop model, capability developed by an accredited fertilizer manufacturing/marketing company (Rakshit *et al*., 2012). Therefore a study was carried to find out response of rice to customized fertilizer.

MATERIALS AND METHODS

A fixed plot field experiment was carried out at Research Cum Instructional Farm of the Indra Gandhi Krishi Vishwavidalaya, Raipur during the rainy (*kharif*) season of 2011 and 2012. This region comes under dry moist to sub humid climatic condition. The region receives on an average of 1,200–1,400 mm rainfall annually. The total rainfall of 1,216.3 and 1,382.1 mm was received during *kharif* 2011 and 2012 respectively. The maximum temperature ranged in crop seasons from 28.3°C to 33.4°C and 25.8°C to 31.9°C during *kharif* 2011 and 2012 respectively. The minimum temperatures during the same seasons was 15.2°C–25.8°C and 17.3°C to 25.8°C. The open pan evaporation mean values ranged from 2.8 to 4.7 mm/and 1.5 to 4.8 mm/day. The other weather parameters were normal during both the seasons.

The soil was *Inceptisols* (sandy loam), locally known as Matasi. The soil had neutral pH (7.42), electrical conductivity (EC) 0.19 dS/m, being low in organic carbon (0.47%), available N (200.7 kg/ha) and available zinc (0.49 ppm), while medium in available phosphorus (13.0 kg/ha) and high in available potassium (394.01 kg/ha). The experiment was laid out in randomized block design (RBD), replicated thrice, to evaluate the effect of a customized fertilizer (CF) product. The grade of CF (CF-11-12) was 14 : 21 : 8 : 0.6 (N-P_2O_5-K_2O-Zn) and rate of CF was taken @ 11.25/kg. The data were analyzed as per Gomez and Gomez (1984). The level of significance used in F test was given at 5%. Both experiments consisted of 8 treatments (Table 1).

The planting was done at a spacing of 20 cm × 10 cm. The different plant parts, viz. grain and straw, were grinded and analysed for N, P, K and Zn at harvest. Cost of production for all treatments was worked out on the basis of the prevailing input and market price of the produce. The economic returns to rice yield were computed at prevailing market rate during 2011 and 2012 for the rice crop. The variety 'Mahamaya' for rice crop was used as test crop. During both the years of experimentation, the crop was transplanted on 25 July 2011 and 18 July 2012 and harvested on 16 November 2011 and 10 November 2012.

RESULTS AND DISCUSSION

Growth and yield attributes of rice

Customized fertilizer had significant effect on growth parameters such as plant height and dry-matter accumulation (Table 2). Plant height at harvest was the highest under treatment 150% dose of customized fertilizer (CF) and was found on a par with 125% dose of CF, 100% dose of CF and RDF+5 t FYM/ha. However, the dry matter was higher with 150% dose of CF and which was found at par with 125% dose of CF. Important yield-attributing characters such as total number of effective tillers/hill was recorded significantly maximum under 150% dose of CF and it was found at par with 125% dose of CF and RDF+5 t FYM/ha. Panicle length and filled grains/panicle were also significantly the highest under application 150% dose of CF. Pandey *et al.* (2007) also reported good response of rice to NPK and Zn application. In case of test weight,

Table 1. Details of fertilizer treatments used in rice

Treatment	Quantity (kg/ha)	Nutrient supplied through Customized fertilizer and at basal (kg/ha)				N applied in split (kg/ha)		Total N applied (kg/ha)
		N	P	K	Zn	I	II	
T_1, Control	0	0	0	0	0	0	0	0
T_2, 50% dose of CF	156.2	21.8	32.8	12.5	0.93	22	19.0	62.8
T_3, 75% dose of CF	234.3	32.8	49.2	18.7	1.40	33	28.5	94.3
T_4, 100% dose of CF*	312.5	43.7	65.6	25.0	1.87	44	38.0	125.7
T_5, 125% dose of CF	390.6	54.6	82.0	31.2	2.34	55	47.5	157.1
T_6, 150% dose of CF	468.7	*65.6*	*98.4*	*37.5*	*2.81*	*66*	*57.0*	*188.6*
T_7, RDF (Nutrient dose recommended for CG state)	50.0	60.0	40.0	0	25	25.0	100.0	
T_8, RDF + 5 t FYM/ha	-	75.0	70.0	65.0	1.02	25	25.0	125.0

*100% Customized fertilizer (312.5 kg/ha) contains N-P_2O_5-K_2O-Zn in the quantities of 14%, 21%, 8% and 0.6%, respectively

non-significant difference was observed.

Yield of rice

Different doses of customized fertilizer significantly improved yield. Among different treatments significantly higher grain yield was recorded under treatment T_6, i.e. 150% dose of customized fertilizer CF. Treatment 150% dose of CF (T_6) provide N, P, K and Zn in sufficient quantity to produce maximum yield, the required amount through Customized fertilizer showed the efficient response on rice yield (Chandrapala *et al.* 2010). Grain yield compared with the application of recommended dose of fertilizer (RDF), 150% dose of CF, 125% dose of CF, 100% dose of CF, 75% dose of CF and RDF+5 t FYM gave 26.4, 15.63, 9.63, 2.18 and 6.36% more yield respectively. The maximum straw yield was also recorded in 150% dose of CF, which found on a par with 125% dose of CF. Our findings confirm the results of Pandey *et al*. (2007). The higher straw yield can be described to higher number of tillers and maximum leaf area. However, the maximum harvest index was also observed under 150% dose of CF (46.39 %), harvest index mainly governed by grain yield and with respective straw yield. As we know that the higher grain yield may be owing to the application of sufficient nutrients in combination which resulted to greater availability of essential nutrients to plants, improvement of soil environment which facilitate in better root proliferation leading to higher absorption of water and nutrients and ultimately resulting in higher yield. Reddy *et al.* (2009) and Mandal *et al*. (2004) also reported superiority of combined application of N, P, K, Zn and FYM over recommended fertilizer application.

NPK and Zn uptake

The plant samples were analysed for nitrogen, phosphorus, potassium and zinc at harvest (Table 3)**.** The uptake of N, P, K and Zn was significantly higher under the application of 150 % dose of customized fertilizer (CF) and the minimum was observed under control. The higher nutrient uptake was mainly due to higher biological (straw+grain) yield. Pandey *et al*. (2007) also reported similar findings. Application of customized fertilizer helps to provide essential nutrient to get the targeted yield. This shows that NPK and Zn combination is useful for rice growth and yield. Singh (2006) and Das *et al*. (2003) also reported similar findings for N, P, K and Zn.

Economics

Mean cost of cultivation of rice varied from ₹23,091 to 29,968/ha during both years, owing to the use of different doses of customized fertilizer (CF) and recommended treatment (Table 2). Among all the treatments, highest net

Table 2. Growth, yield attributes, yield and economics of rice as influenced by customized fertilizer (mean data of 2 years)

Treatment	Plant height (cm)	Dry matter accumulation (g/hill)	Effective tillers/ plant (No.)	Panicle length (cm)	Filled grains/ panicle (No.)	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (HI %)	Cost of cultivation ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio
T_1, Control	101.8	22.4	4.2	20.5	104.3	32.2	3.1	4.4	41.8	23.1	18.7	0.80
T_2, 50% dose of CF	116.5	28.7	5.9	22.1	110.9	32.9	4.6	5.8	44.1	25.5	34.5	1.42
T_3, 75% dose of CF	120.9	32.7	6.1	22.8	127.9	34.4	5.6	6.8	45.4	26.5	46.9	1.90
T_4, 100% dose of CF	125.1	35.2	6.7	23.1	132.3	34.1	6.0	7.3	45.8	27.7	50.8	2.02
T_5, 125% dose of CF	127.4	39.2	7.2	23.7	137.0	34.6	6.4	7.6	46.0	28.9	53.8	2.10
T_6, 150% dose of CF	129.5	43.9	8.3	25.1	150.5	35.1	7.0	8.0	46.4	30.0	60.1	2.31
T_7, RDF	120.3	32.8	6.2	22.6	126.0	33.6	5.5	6.8	44.5	26.1	45.9	1.87
T_8, RDF + 5 t FYM/ha	124.5	36.0	7.3	23.1	134.9	33.9	5.9	6.9	45.5	27.6	48.5	1.93
SEm±	2.56	1.61	0.33	0.59	3.72	-	0.17	0.18	0.60	-	-	-
CD (P=0.05)	7.76	4.89	1.02	1.80	11.30	NS	0.54	0.54	1.83	-	-	-

RDF, Recommended dose of fertilizer; CF, Customized fertilizer

Table 3. Nutrient uptake of rice as influenced by customized fertilizer (mean data of 2 years)

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)			Zn uptake (g/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1, Control	22.4	13.4	36.9	3.5	1.3	4.8	14.7	119.9	134.6	124.5	201.8	322.4
T_2, 50% CF dose	35.5	21.8	60.8	10.2	3.2	13.4	26.2	144.1	170.3	137.4	220.2	350.9
T_3, 75% CF dose	50.4	27.4	80.4	12.0	4.2	16.2	34.2	196.6	230.8	152.8	236.8	386.2
T_4, 100% CF dose	62.7	35.9	98.1	16.9	5.1	22.0	36.8	230.1	266.9	165.4	244.1	410.7
T_5, 125% CF dose	82.9	40.8	124.9	20.1	5.5	25.7	47.5	249.7	297.2	176.0	264.8	445.7
T_6, 150% CF dose	99.5	47.7	146.6	22.9	5.9	28.8	63.5	277.6	341.1	185.8	286.3	477.3
T_7, RDF	56.4	26.8	86.7	15.1	4.4	19.4	38.2	221.9	260.2	147.2	243.1	390.0
T_8, RDF + 5 t FYM/ha	76.5	34.0	111.3	17.4	5.1	22.5	55.5	236.4	291.9	165.1	252.2	419.8
SEm±	1.58	0.95	1.83	0.40	0.11	0.40	0.65	8.51	8.24	3.79	5.16	6.56
CD (P=0.05)	4.81	2.89	5.57	1.22	0.34	1.21	1.99	25.82	25.00	11.51	15.65	19.92

RDF, Recommended dose of fertilizer; CF, Customized fertilizer

returns (60,062/ha) were observed under 150% dose of CF. Owing to the higher yields recorded under this treatment as discussed earlier, fetched 6,266/ha more over 125% dose of CF, 9,228/ha over 100% dose of CF, 14,168/ha over RDF, and 11,575/ha RDF+5 t FYM. Benefit: cost ratio was also highest under application of 150% dose of CF. A 150% dose of CF gave the highest net returns compared to the other treatments; it gave 23.58% more return than RDF (T_7). Rather than 150% dose of CF, application of 125% dose of CF and 100% dose of CF was also proved superior to other doses of CF and other nutrient management practices for yield (6.4 t/ha) and (6.0 t/ha), net returns (53,796/ha) and (5,0834/ha), benefit: cost ratio (2.10) and (2.02) respectively. However, treatment RDF + 5 t FYM (T_8) produced good result as compared with other treatment; it gave (5.9 t/ha) grain yield and net return (48,487/ha). Similar findings were observed by Reddy *et al.* (2011).

On the basis of two year experimentation, it can be concluded that the application of 150% dose of CF is best for higher yield and monetary return than any other doses of customized fertilizer, it provide sufficient nutrient for rice crop growth and maximization of yield.

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