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Yield and yield attributes of rice (*Oryza sativa* L.) as influenced by nutrient and weed management in direct seeded rice

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Abstract
A field experiment was conducted during *Kharif* season 2015 at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur. The experiment was laid out in split-split plot design with three P and K application as main plot, two brown manuring as sub plot and four weed management practices as sub-sub plot with three replications. The results revealed that significantly highest panicle length, panicle weight, test weight, grain yield, straw yield, harvest index and N, P, K uptake were recorded under treatment 50 % P and K at sowing and 50 % P and K at 30-35 DAS. Brown manuring produced significantly highest panicle length, maximum panicle weight, test weight, grain yield, straw yield, harvest index, N, P and K uptake as compare to without brown manuring. In case of weed management, pre-emergence herbicide pyrazosulfuron 20 g ha^{-1} followed by *biasi* followed by hand weeding recorded maximum panicle length, panicle weight and test weight, grain yield, straw yield, harvest index and N, P, K uptake kg ha^{-1} over other weed management practices which was found at par with *biasi* operation followed by hand weeding and pre emergence herbicide pyrazosulfuron 20 g ha^{-1} followed by post emergence herbicide bispyribac-Na 20 g ha^{-1}. Interaction amongst the P and K application, brown manuring and weed management practices found significant for grain yield and non-significant difference was recorded in other yield parameters and N, P, K uptake of rice. Significantly highest grain yield was recorded with 50 % P and K at sowing and 50 % P and K at 30-35 DAS, brown manuring and pre emergence herbicide pyrazosulfuron 20 g ha^{-1} followed by *biasi* followed by hand weeding.

Keywords: Brown manuring, direct seeded rice, nutrient uptake of rice crop and weed management

Introduction
Rice is the most consumed cereal grain in the world, constituting the dietary staple food for more than half of the planets human population. Globally, rice is the second most widely consumed cereal next to wheat and it has occupied an area of 163.7 million hectares, with a total production of 749.8 million tonnes (Anonymous, 2015) [3]. Rice provides about two-third of the calorie intake for more than two billion people in Asia and a third of the calorie intake of nearly one billion people in Africa and Latin America (Shastry *et al.*, 2000) [13]. Hence there is a need to increase the productivity of rice.

India is the second largest producer after china. In India, rice occupies an area of 43.95 million hectare with an average production of 103.61 million tonnes with productivity of 2424 kg ha^{-1}, 2015-16 (Anonymous, 2016 a) [1]. Rice being the main source of livelihood for million rural household and is the backbone of the Indian agriculture. Rice plays a very vital role in the national food security.

Chhattisgarh is popularly known as "Rice bowl of India". In *kharif* season, it occupies an area of around 3.76 million hectares and production of 7.71 million tonnes with productivity of 2050 kg ha^{-1} in 2014-15 (Anonymous 2016 b) [2]. The prime causes of low productivity of rice in Chhattisgarh are limited irrigation, lack of improved varieties suitable to different ecosystem, low imbalance, use of fertilizer and insufficient weed management.

Nitrogen, phosphorus and potassium are essential inputs and their deficiency is major constraint in the successful cultivation of rice. In recent years, it is noticed that for increasing the yield of rice, a major constraint is unbalanced used of nutrients. Hence, there is need for application of these nutrients in balance quantity for attaining optimum growth, development and enhancing the yield of rice but its uptake greatly varies under different moisture regimes. Not only are these, but also use of proper ratio of these nutrients required to obtain optimum response in terms of grain yield of rice. The inappropriate combination of these nutrients may

The inappropriate combination of these nutrients may decrease the grain yield of rice. It is well established fact that advantage of these nutrients can be obtained under optimum and sufficient moisture level and soil status.

The average productivity of rice is very low due to several constraints. Among these, in direct seeded rice, weeds are one of the major constraints for low productivity of rice because both rice and weed germinate almost simultaneously. Direct seeded rice is grown under conducive condition for profuse weed growth. As such during the early stages of crop growth, severe crop weed competition is big constraint for improving rice productivity. In rice ecosystem of this region, weeds play a dominant role by competing for nutrients, water and space with the rice crop. A weed free period for the first 30-35 DAS is required to avoid any loss in yield because the dry weight of weeds increases greatly from 30 DAS in direct seeded rice. Based on research findings, it was estimated that extent of yield reduction in rice due to weeds alone is about 15-20 per cent for transplanted rice, and 30-35 per cent for direct seeded rice under severe weed infestation (Choubey *et al.*,2001) [5]. However, if the weed population could effectively be controlled, direct seeded rice cultivation may offer a unique advantage of raising yield at par with transplanted rice.

Materials and Methods

A field experiment was conducted at Instructional cum Research Farm Indira Gandhi Krishi Vishwacidyalaya, Raipur during the *Kharif* season of 2015. Recommended dose of N, P_2O_5 and K_2O *i.e.* 80:60:40 kg ha^{-1} was applied through urea, single super-phosphate and muriate of potash, respectively. Nitrogen was applied in three splits *viz.*, 40 kg N ha^{-1} as basal, and the remaining 40 kg N in two equal splits at the maximum tillering and panicle initiation. The soil of the experimental field was sandy loam in texture neutral in reaction (pH: 7.24), EC 0.17 ds m^{-1} low in available nitrogen (252.97 kg ha^{-1}), low in available phosphorus (10.23 kg ha^{-1}), high in available potash (347 kg ha^{-1}) and low in organic carbon content (0.50 %). The experiment was laid out in split-split plot design with three P and K application as main plot, two brown manuring as sub plot and four weed management practices as sub-sub plot with three replications. The treatment consisted of three P and K application for study *viz.* N_1- full P and K at 30 – 35 DAS, N_2-50 % P and K at sowing and 50 % P and K at 30 – 35 DAS, and N_3- full P and K at sowing in main plots, B_1- no manuring and B_2- brown manuring in sub plot and W_1- *biasi* operation followed by hand weeding, W_2- pre emergence herbicide pyrazosulfuron 20 g ha^{-1} followed by *biasi* followed by hand weeding, W_3- pre emergence herbicide pyrazosulfuron 20 g ha^{-1} followed by post emergence herbicide bispyribac-Na 20 g ha^{-1} and W_4- early post emergence azimsulfuron 35 g ha^{-1} followed by late post emergence bispyribac- Na 20 g ha^{-1} in sub-sub plots.

Results and Discussions

Yield attributing characters

P and K application, brown manuring and weed management treatments had significant effect on panicle length, panicle weight and test weight. longest panicle, higher panicle weight and 1000 grain weight were obtained from the treatment 50 % P and K at sowing and 50 % P and K at 30-35 DAS (27.74 cm, 4,44 g and 32.28 g, respectively) over rest of the treatments. This increase in panicle length, panicle weight and in 1000 grain weight may be due to continuous supply of P and K to the crop during crop growth stages. The efficient P and K uptake by rice plant results in better growth and development when applied at maximum tillering stage. Similar results were also observed by Dey *et al*. (2014) [6], Kalita *et al*. (2002) [8] and Saha *et al*. (2008) [11].

Brown manuring treated rice having significantly higher panicle length, panicle weight and 1000 grain weight was found 26.75cm, 4.27 g and 31.43 g, as compare to untreated rice was 21.8 cm, 3.22 g and 29.32 g, respectively. It might be due to brown manures not only supply essential nutrients to plant but also improves soil physical and biological health. These results are similars with the findings of Swarup and Yaduvanshi (2000) [16] and Yadana *et al*. (2009) [17].

Among the weed management treatment the highest panicle length, panicle weight and test weight was found in the treatment pyrazosulfuron 20 g ha^{-1} (PE) followed by *biasi* followed by hand weeding the values were 24.92 cm, 3.96 g and 31.08 g, respectively. This might be attributed to better growth of plants on account of reduced crop weed competition resulting in increased availability of nutrients, water and light.

Grain yield, straw yield and harvest index

The effect of P and K application, brown manuring and weed management treatments on grain and straw yield was significant except harvest index. Highest grain and straw yield was recorded under treatment 50 % P and K at sowing and 50 % P and K at 30-35 DAS (5.48 and 7.85 t ha^{-1}). The increased grain yield of rice due to split application of P and K was attributed directly to continuous supply of P and K to the crop during crop growth stages. The rice plant ultimately proved more beneficial and resulted in a significant increase in panicle length, panicle weight, number of grains per panicle and 1000 grain weight ultimately resulted in maximum paddy yield. Similarly, Ghosh *et al*. (1995) [7] and Saha *et al*. (2008) [11] have also reported that split application of P and K increased growth and yield of rice.

The highest grain and straw yield was recorded in brown manuring treated rice (5.26 and 7.01 t ha^{-1}) as compare to untreated rice (4.98 and 6.28 t ha^{-1}). This was due to application of organic source which helped in improving the physical condition of the soil for better root proliferation leading to higher absorption of water and nutrients and ultimately resulting in higher yield. Similar result was also reported by Singh *et al*. (2008) [15], Maity and Mukherjee (2011) [9], Samant (2017) [12] and Singh *et al*. (2009) [14].

Significantly maximum seed and straw yield were recorded in treatment Pyrazosulfuron 20 g ha^{-1} (PE) followed by *biasi* followed by hand weeding (5.49 and 7.06 t ha^{-1}). This might be due to good aeration of soil and least weed population observed in these treatments, which reduced crop weed competition for soil moisture, plant nutrients, solar radiation and space during active crop growth period.

Interaction amongst the P and K application, brown manuring and weed management practices found significant for grain yield of rice. Significantly highest grain yield was recorded with 50 % P and K at sowing and 50 % P and K at 30-35 DAS, brown manuring and pre-emergence herbicide pyrazosulfuron 20 g ha $^{-1}$ followed by *biasi* followed by hand weeding while, lowest grain yield was recorded under full P and K at 30-35 DAS, no manuring and early post-emergence azimsulfuron 35 g ha^{-1} followed by late post-emergence bispyribac-Na 20 g ha^{-1}.

Nutrient uptake by crop

There was a significant variation in Nutrient uptake by crop due to the split application of P and K. The highest nutrient

uptake by crop was found in treatment 50 % P and K at sowing and 50 % P and K at 30-35 DAS. The split application of these nutrients improved the availability of these nutrients is root zone when required urgently. The split application also increased the quantum of available nitrogen, phosphorus and potassium in the soil which ultimately favoured the increased NPK uptake by crop. Similar result, were also reported by Zaidi *et al*. (2007).

Nutrient uptake by crop was significantly higher in brown manuring treated rice as compare to without brown manuring. Better performance under these treatments might also be due to favourable soil environment, which encouraged better root proliferation and ensured higher nutrient uptake. Chongtham *et al*. (2015) [4] found similar results.

Pyrazosulfuron 20 g ha^{-1} (PE) followed by *biasi* followed by hand weeding recorded higher nutrient uptake. Higher nutrient uptake of crop in these treatments was mainly due to lower weed population and weed dry weight which helped the crop to grow well and absorb more nutrients from the soil.

Table 1: Effect of P and K application, brown manuring and weed management on yield attributes and yield by rice in broadcast *biasi* system of rice cultivation

Treatment	Panicle length (cm)	Panicle weight (g)	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
P and K application						
N_1- Full P and K at 30 – 35 DAS	20.86	3.1	28.5	4.69	5.65	45.35
N_2-50 % P and K at sowing and 50 % P and K at 30 – 35 DAS	27.74	4.44	32.22	5.48	7.85	41.11
N_3- Full P and K at sowing	24.22	3.69	30.39	5.18	6.44	44.57
SEm±	0.6	0.09	0.31	0.1	0.12	0.61
CD (P = 0.05)	2.39	0.36	1.23	0.29	0.47	NS
Brown manuring						
B_1- No manuring	21.8	3.22	29.32	4.98	6.28	44.22
B_2- Brown manuring	26.75	4.27	31.43	5.26	7.01	42.86
SEm±	0.21	0.1	0.52	0.11	0.18	0.82
CD (P = 0.05)	0.73	0.35	1.79	0.38	0.65	NS
Weed management						
W_1- *Biasi* operation fb hand weeding	24.78	3.91	30.23	5.18	6.96	42.67
W_2- Pyrazosulfuron 20 g ha^{-1} (PE) fb *biasi* fb hand weeding	24.92	3.96	31.08	5.49	7.06	43.74
W_3- Pyrazosulfuron 20 g ha^{-1} (PE) fb bispyribac-Na 20 g ha^{-1} (PoE)	24.58	3.59	30.11	5.02	6.57	43.3
W_4- Azimsulfuron 35 g ha^{-1} (PoE) fb bispyribac- Na 20 g ha^{-1} (PoE)	22.8	3.51	30.08	4.84	5.99	44.69
SEm±	0.54	0.1	0.68	0.09	0.21	0.9
CD (P = 0.05)	1.55	0.3	NS	0.25	0.61	NS
Interaction	NS	NS	NS	S	NS	NS

Table 2: Grain yield (t ha^{-1}) of rice as influenced by interaction effect of nutrient, brown manuring and weed management under *biasi* system of rice cultivation.

Treatment	N_1		N_2		N_3	
	B_1	B_2	B_1	B_2	B_1	B_2
W_1- *Biasi* operation fb hand weeding	4.35	4.94	5.21	5.92	4.62	5.69
W_2- Pyrazosulfuron 20 g ha^{-1} (PE) fb *biasi* fb hand weeding	4.37	5.07	5.31	61.30	4.72	5.76
W_3- Pyrazosulfuron 20 g ha^{-1} (PE) fb bispyribac-Na 20 g ha^{-1} (PoE)	4.00	4.94	5.18	5.88	4.59	5.53
W_4- Azimsulfuron 35 g ha^{-1} (PoE) fb bispyribac- Na 20 g ha^{-1} (PoE)	3.56	4.80	5.06	5.81	4.43	5.40

fb – followed by PE – pre emergence PoE – post emergence

Table 3: Effect of N, P and K content and uptake in grain and straw after harvesting of rice by various P and K application, brown manuring and weed management under *biasi* system of rice cultivation

Treatment	N content %		N uptake kg ha^{-1}		P content %		P uptake kg ha^{-1}		K content %		K uptake kg ha^{-1}	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
P and K application												
N_1- Full P and K at 30 – 35 DAS	0.9	0.41	42.21	23.16	0.24	0.04	11.25	2.26	0.2	1.29	9.38	73.01
N_2-50 % P and K at sowing and 50 % P and K at 30 – 35 DAS	0.92	0.42	50.41	32.97	0.28	0.05	15.34	3.92	0.22	1.31	12.65	102.83
N_3- Full P and K at sowing	0.93	0.45	48.17	28.98	0.28	0.05	14.5	3.22	0.21	1.26	10.87	81.14
SEm±	0.01	0.005	1.67	0.93	0.01	0.002	0.55	0.2	0.005	0.03	0.36	3.08
CD (P = 0.05)	NS	NS	6.57	3.67	NS	NS	2.18	0.77	NS	NS	1.41	12.1
Brown manuring												
B_1- No manuring	0.93	0.45	46.31	28.26	0.28	0.05	13.94	3.14	0.22	1.29	10.95	81.01
B_2- Brown manuring	0.96	0.46	50.49	32.24	0.3	0.05	15.78	3.5	0.22	1.28	11.57	89.72
SEm±	0.003	0.008	1.35	1.23	0.006	0.001	0.46	0.16	0.003	0.02	0.37	2.16
CD (P = 0.05)	NS	NS	4.66	4.01	NS	NS	1.6	NS	NS	NS	1.28	7.48
Weed management												

W_1- *Biasi* operation fb hand weeding	0.88	0.4	45.99	27.84	0.26	0.04	13.52	2.78	0.22	1.28	11.29	86.3
W_2- Pyrazosulfuron 20 g ha^{-1} (PE) fb *biasi* fb hand weeding	0.93	0.44	51.05	31.06	0.27	0.05	15.36	3.53	0.23	1.29	13.03	88.95
W_3- Pyrazosulfuron 20 g ha^{-1} (PE) fb bispyribac-Na 20 g ha^{-1} (PoE)	0.91	0.42	45.6	30.22	0.28	0.05	14.52	3.28	0.21	1.29	10.34	82.12
W_4- Azimsulfuron 35 g ha^{-1} (PoE) fb bispyribac-Na 20 g ha^{-1} (PoE)	0.92	0.41	44.52	24.55	0.26	0.05	12.76	2.99	0.22	1.28	10.82	74.27
SEm±	0.02	0.01	1.41	1.42	0.01	0.003	0.61	0.24	0.006	0.04	0.32	4.22
CD (P = 0.05)	NS	NS	4.23	4.07	NS	NS	1.75	0.56	NS	NS	0.92	12.11
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

The data on grain yield indicate that brown manuring (B_2) treatment produced significantly higher grain yield than no manuring treatment (B_1). The impact of weed management practices, application of pre-emergence herbicide pyrazosulfuron 20 g ha^{-1} followed by *biasi* followed by hand weeding (W_2) produced the significantly highest grain yield over rest of the treatment. The lowest grain yield was found under early post-emergence azimsulfuron 35 g ha^{-1} followed by late post-emergence bispyribac-Na 20 g ha^{-1} (W_4). Interaction amongst the P and K application, brown manuring and weed management practices was significant on grain yield of rice. The highest significantly grain yield was recorded due to interaction among treatment 50 % P and K at sowing and 50 % P and K at 30-35 DAS (N_2), brown manuring (B_2) and pre-emergence herbicide pyrazosulfuron 20 g ha^{-1} followed by *biasi* followed by hand weeding (W_2) while, lowest grain yield was found under full P and K at 30-35 DAS (N_1) no manuring (B_1) and early post-emergence azimsulfuron 35 g ha^{-1} followed by late post-emergence bispyribac-Na 20 g ha^{-1} (W_4).

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