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Productivity and economics of rice (*Oryza sativa* L.) as influenced by establishment methods and nutrient management

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Abstract
Field experiment was conducted at Indira Gandhi Krishi Vishwavidyalaya, Raipur during *kharif*, 2017 to study the effect of Productivity and Economics of rice (*Oryza sativa* L.) as influenced by establishment methods and nutrient management. The result revealed that in case of establishment method highest number of panicle m^{-2} was observed under line sowing before onset of monsoon (M_1). However, panicle weight was significantly higher under transplanting but remained on par with line sowing after onset of monsoon(M_2). Number of filled grains was significantly higher under transplanting method (M_3) which was comparable with line sowing after onset of monsoon (M_2). The maximum number of unfilled grains and sterility percentage was noticed under line sowing before onset of monsoon which was statistically at par with line sowing after onset of monsoon (M_2) for unfilled grains. Highest grain yield and harvest index was recorded under Line sowing before onset of monsoon (M_1) which was statically at par with transplanting method (M_3) and with line sowing after onset of monsoon (M_2) for grain yield and harvest index respectively. Straw yield was found maximum under transplanting (M_3). In case of nutrient management number of panicle, panicle length and panicle weight were significantly higher under the application of 150% RDF (N_3) which was comparable with application of 100% RDF (N_1) and LCC based nitrogen application (N_4) for Number of panicle and panicle length. Application of 150% RDF (N_3) produced significantly higher number of filled grains than that of other treatments. Maximum number of unfilled grains and sterility percentage was found under farmer's practice (N_5). The lowest number of unfilled grains and sterility percentage were noticed under the application of 150% RDF (N_3). Significantly higher grain and straw yield was produced by application of 150% RDF (N_3) than other nutrient management practices. However, the application of 100% RDF (N_1) was as good as 150% RDF (N_3) for straw yield. The lowest grain and straw yield was observed under farmer's practice which was at par with 75% RDF + 25% (equivalent to N dose) through FYM. In case of economics the highest cost of cultivation was incurred under transplanting (M_3) and 150% RDF (N_3). Gross return, net return and B:C ratio were maximum under line sowing before onset of monsoon (M_1) and application of 150% RDF (N_3).

Keywords: Rice, yield, establishment methods, nutrient management and LCC (leaf colour chart)

Introduction
Rice (*Oryza sativa* L.) is one of the important cereal crop which provides half of the daily food for one of three persons on earth. More than 90 per cent of total rice production in the world is consumed by Asian countries, where it is a staple food for a majority of the population (Mohanty, 2013) [9]. During 2015 -16, India has recorded production of rice to the tonne of 104.32 million tonnes but considering the present growth rate of population as well as per capita income, the demand for rice has been projected as 156 million tonnes by 2030 (Anonymous, 2016) [2]. Direct seeding helps to reduce water consumption by about 30% (0.9 million liters $acre^{-1}$) as it eliminates raising of seedlings in a nursery, puddling, transplanting under puddled soil and maintaining 4-5 inches of water at the base of the transplanted seedlings. The farmer can save about Rs 1400 $acre^{-1}$ in cultivation cost because direct seeding avoids nursery raising, seedling uprooting, puddling and transplanting, thus reduces the labour requirement (Anonymous, 2011) [1]. At present, 23% of total rice cultivated area in world is under direct-seeded (Rao *et al*., 2007) [11]. In Asia, dry seeding is extensively practised in rainfed lowlands, uplands, and flood-prone areas, while wet seeding remains a common practice in irrigated areas (Azmi and Mashhor, 1995) [3].

Apart from better rice establishment method, an appropriate crop management strategy to increase the efficient use of inputs is needed to enhance the productivity (Pandey and chandra, 2013) [10]. Discriminate use of fertilizer leads to deteriorate the fertility status of soil. Application of organic with inorganic fertilizer not only reduces the cultivation cost but also sustain the soil health. The cost of nitrogenous fertilizer is increasing day by day therefore judicious use is required for increasing the efficiency of nitrogenous fertilizer. Leaf colour chart (LCC) based N application is a simple and may be an option for increasing the efficiency of nitrogenous fertilizer. Requirement of nutrients are differs with rice establishment methods. Therefore, nutrient requirements need to be standardized under different establishment methods of rice. The increasing demand for rice grain production has to be achieved by using the efficient rice establishment methods and integration with nutrient management to maintain the sustainability in crop production. Keeping the above cited facts into consideration, a study entitled Productivity and economics of rice (*Oryza sativa* L.) as influenced by establishment methods and nutrient management was conducted during the kharif 2017-18 of rice crop.

Materials and methods

A field experiment was conducted at Indira Gandhi Krishi Vishwavidyalaya, Raipur during *kharif* season of 2017. Experimental soil was *Vertisols*, texturally clay and locally known as *"kanhar"*. Soil fertility was medium (0.56%), low (198.25 kg ha^{-1}), high (27.45 kg ha^{-1}) and high (304.64 kg ha^{-1}) for available orgainic carbon, nitrogen, phosphorus and potassium. The experiment comprised 3 establishment method in main plot *viz* M_1- line sowing before onset of monsoon, M_2- line sowing after onset of monsoon and M_3- transplanting and 5 nutrient management in sub plot *viz* N_1- 100% recommended dose of fertilizer (RDF), N_2- 75% RDF + 25% (equivalent to N dose) through FYM, N_3- 150% RDF, N_4- LCC Based N application, N_5- Farmer's practice (80:57.5:0 kg NPK ha^{-1}). The experiment was laid out in split plot design (SPD) with three replications. Rice variety "Rajeshwari" was grown with a spacing of 20cm X 10 cm. Twenty-five days old seedlings were transplanted at the spacing of 20 cm row to row and 10 cm plant-to-plant distance. Two to three seedlings per hill were transplanted. After 10 days of seeding the missing plant in the rows as per treatment were replanted (gap filling) with the seedling uprooted for the same plot where it had high density. After transplanting the soil was kept saturated until planted seedlings got well established, this was judged by the emergence of new leaves. Afterwards the water levels in the plots were maintained at 5±2 cm during vegetative growth and development phases. Before seeding, full dose of phosphorus and potassium and 25% N was applied as basal in line sowing before onset of monsoon, line sowing after onset of monsoon and 50% N with full dose of phosphorus and potassium was applied as basal in transplanted rice plots through urea (46% N), single super phosphate (16% P_2O_5) and Murate of potash (60% K_2O), respectively and incorporated into soil, as per dose required in a particular treatment. The remaining quantity of nitrogen was top dressed in two splits: at tillering (50% in line sowing before onset of monsoon and line sowing after onset of monsoon and 25% in transplanted rice plots) and at panicle initiation stage 25%N was applied in all plots as per the treatment. In treatment involving application of nitrogen on the basis of leaf colour chart (LCC), full recommended dose of phosphorus, potassium and half of the recommended dose of nitrogen (50 kg/ha) was applied as basal and remaining nitrogen was top dressed at the rate of 25 kg N/ha two times, when the average of the reading of the leaves of selected rice plants was found less than 4 in leaf colour chart (LCC). Duration of crop is 120-125 days. Five plants were selected at random and tagged for recording of observation. Yield attributes *viz.* Number of panicles (m^{-2}), Panicle length (cm), Panicle weight (g), Filled and unfilled grains panicle^{-1}, Sterility percentage, Test weight (g), Grain and straw yield (q ha^{-1}) were recorded. Harvest index and econom ics were also computed. The data pertaining to the experiment were subjected to statistical analysis suggested by Gomez and Gomez (1984) [5].

Results and discussion

Yield attributes *i.e.* panicle number, panicle length and panicle weight were significantly influenced by establishment method and nutrient management practices. The effect of establishment methods on panicle length was also not found significant. The highest number of panicle m^{-2} was observed under line sowing before onset of monsoon (M_1). However panicle weight was significantly higher under transplanting (M_3) but remained on par with line sowing after onset of monsoon (M_2). In respect to nutrient management, number of panicle and panicle length were significantly higher under the application of 150% RDF (N_3) which was comparable with application of 100% RDF (N_1) and LCC based nitrogen application. Higher dose of nutrients might have helped in profuse tillering resulted in higher number of panicles. Similar findings have also been reported by Hollen *et al*. (2008). The lowest number, length and weight of panicle were observed under farmer's practice (N_5) which was at par with 75% RDF + 25% (equivalent to N dose) through FYM (120:60:45 kg NPK ha-1). Number of panicle and weight under LCC based nitrogen application and panicle weight under application of 100% RDF was at par with farmer's practice.

Number of filled grains was significantly higher under transplanting method (M_3) which was comparable with line sowing after onset of monsoon (M_2). The maximum number of unfilled grains and sterility percentage was recorded under line sowing before onset of monsoon (M_1). This treatment was statistically at par with line sowing after onset of monsoon (M_2) for number of unfilled grains. Among nutrient managements, application of 150% RDF (N_3) produced significantly higher number of filled grains than that of other treatments. Application of higher amount of nutrients enhanced the growth and increased dry matter production which ultimately increased the number of filled grains. These results are in agreement with Meshram *et al.* (2015). Number of filled grains was significantly reduced under farmer's practice might be due to inadequate supply of nutrients to the plants. The lowest number of unfilled grains and sterility percentage were noticed under the application of 150% RDF (N_3). The maximum number of unfilled grains and sterility percentage were noted under farmer's practice. However, all the treatments except application of 150% RDF (N_3) found comparable with farmer's practice (N_5) for sterility percentage.

Grain yield straw yield and harvest index were significantly influenced by establishment method and nutrient management practices. Line sowing before onset of monsoon (M_1) and transplanting method (M_3) were statistically at par and found to be significantly superior over line sowing after onset of monsoon (M_2) for grain yield. Increased in tillers number, leaf area subsequently increased the dry matter accumulation resulted in increased the grain yield. These results are in conformity with the findings of Ganesh (2002) and Mazid *et al.* (2002) [4, 7]. Higher availability of nutrients and suppression of weeds might be the reason for higher straw yield under transplanting (M_3) as compared to other methods of establishment. Similar results also reported by Surendra *et al.* (2001) [12]. Line sowing before onset or after onset of monsoon was being at par and obtained significantly higher harvest index as compared transplanting method (M_2). In respect to nutrient management, application of 150% RDF (N_3) produced significantly higher grain as well as straw yield than that of other nutrient management practices. However, application of 100% RDF (N_1) was statistically as good as 150% RDF (N_3) for straw yield. More leaf area increased the photosynthetic activities resulted in more dry matter accumulation and absorption of nutrients thereby increased the grain and straw yield. The lowest grain and straw yield was observed under farmer's practice which was at par with 75% RDF + 25% (equivalent to N dose) through FYM (120:60:45 kg NPK ha^{-1}). Statistical difference in harvest index was not significant due to different nutrient management practices.

The economics were significantly influenced by establishment method and nutrient management practices. Highest cost of cultivation was incurred under transplanting (M_3). Gross return, net return and B:C ratio were fetched maximum under line sowing before onset of monsoon (M_1). Application of 150% RDF (N_3) not only received highest cost of cultivation but also fetched maximum gross return, net return and B: C ratio. The lowest cost of cultivation, gross return, net return and B: C ratio was recorded under farmer practice (N_5).

Table 1: Panicle (No. m^{-2}), panicle length (cm), panicle weight (g) and test weight (g) as influenced by different crop establishment methods and nutrient management

Treatment		Panicle (No. m^{-2})	Panicle length (cm)	Panicle weight (g)
Establishment methods				
M_1	Line sowing before onset of monsoon	282.53	21.25	3.22
M_2	Line sowing after onset of monsoon	268.93	22.07	3.40
M_3	Transplanting	259.80	23.87	3.74
SEm±		2.84	0.77	0.08
CD (P = 0.05)		12.19	NS	0.36
Nutrient management				
N_1	100% RDF (120:60:40 kg NPK ha^{-1})	275.22	23.57	3.49
N_2	75% RDF + 25% (equivalent to N dose) through FYM (120:60:45 kg NPK ha^{-1})	265.22	20.79	3.32
N_3	150% RDF (180:90:60 kg NPK ha^{-1})	287.78	24.90	3.82
N_4	LCC Based N application (100:51.5:34.4 kg NPK ha^{-1})	269.56	23.35	3.40
N_5	Farmer's practice (80:57.5:0 kg NPK ha^{-1})	254.33	19.35	3.23
SEm±		6.16	0.86	0.10
CD (P = 0.05)		20.72	2.88	0.33

Table 2: Filled grains panicle^{-1} (No.), Unfilled grains panicle^{-1} (No.) and sterility (%) as influenced by different crop establishment methods and nutrient management

Treatment		Filled grains panicle^{-1} (No.)	Unfilled Grains panicle^{-1} (No.)	Sterility (%)
Establishment methods				
M_1	Line sowing before onset of monsoon	103.05	37.79	26.95
M_2	Line sowing after onset of monsoon	109.96	34.15	23.85
M_3	Transplanting	118.44	32.82	20.50
SEm±		2.61	0.87	0.36
CD (P = 0.05)		11.22	3.72	1.53
Nutrient management				
N_1	100% RDF (120:60:40 kg NPK ha^{-1})	111.13	34.78	24.05
N_2	75% RDF + 25% (equivalent to N dose) through FYM (120:60:45 kg NPK ha^{-1})	109.89	35.00	24.42
N_3	150% RDF (180:90:60 kg NPK ha^{-1})	122.56	30.44	20.12
N_4	LCC Based N application (100:51.5:34.4 kg NPK ha^{-1})	110.09	34.94	24.22
N_5	Farmer's practice (80:57.5:0 kg NPK ha^{-1})	98.76	39.44	26.02
SEm±		3.26	1.28	0.94
CD (P = 0.05)		10.96	4.30	3.16

Table 3: Grain yield (q ha^{-1}), straw yield (q ha^{-1}) and harvest index as influenced by different crop establishment methods and nutrient management

Treatment		Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Establishment methods				
M_1	Line sowing before onset of monsoon	49.35	61.97	44.45
M_2	Line sowing after onset of monsoon	46.57	59.59	43.98
M_3	Transplanting	48.65	67.83	41.76
SEm±		0.41	1.22	0.45
CD (P = 0.05)		1.77	5.24	1.95

	Nutrient management			
N_1	100% RDF (120:60:40 kg NPK ha^{-1})	49.19	66.57	42.93
N_2	75% RDF + 25% (equivalent to N dose) through FYM (120:60:45 kg NPK ha^{-1})	46.01	59.14	43.79
N_3	150% RDF (180:90:60 kg NPK ha^{-1})	53.53	69.67	43.49
N_4	LCC Based N application (100:51.5:34.4 kg NPK ha^{-1})	47.21	65.79	41.82
N_5	Farmer's practice (80:57.5:0 kg NPK ha^{-1})	45.00	55.49	44.95
	SEm±	0.64	1.14	0.62
	CD (P = 0.05)	2.14	3.83	NS

Table 4: Cost of cultivation, gross return, net return and B: C ratio as influenced by different crop establishment methods and nutrient management

	Treatment	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
	Establishment methods				
M_1	Line sowing before onset of monsoon	29770	76456	46686	2.57
M_2	Line sowing after onset of monsoon	32070	72136	40067	2.25
M_3	Transplanting	36890	75340	38450	2.04
	Nutrient management				
N_1	100% RDF (120:60:40 kg NPK ha^{-1})	32842	76243	43401	2.32
N_2	75% RDF + 25% (equivalent to N dose) through FYM (120:60:45 kg NPK ha^{-1})	33055	71283	38228	2.16
N_3	150% RDF (180:90:60 kg NPK ha^{-1})	35420	82977	47557	2.34
N_4	LCC Based N application (100:51.5:34.4 kg NPK ha^{-1})	32075	73177	41102	2.28
N_5	Farmer's practice (80:57.5:0 kg NPK ha^{-1})	31157	69540	38383	2.23

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