



Influence of varying seed rates and integrated nutrient management on performance of direct-seeded hybrid rice (*Oryza sativa*)

HEMRAJ MEENA¹, M K SINGH² and MEENA RANI³

Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh 221 005, India

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ABSTRACT

A field experiment was conducted during *kharif* season of 2016 and 2017 in direct-seeded hybrid rice (*Oryza sativa* L.) under varying seeding rates and integrated nutrient management. The experiment consisted of three seed rates (16, 20 and 24 kg/ha) and five nutrient management, viz. 100% RDF through inorganic fertilizer, 100% RDF through inorganic fertilizer + ZnSO₄.7H₂O 25 kg/ha + 0.2% FeSO₄ and 0.2% Borax foliar spray at 20 and 40 DAS, 75% RDN through inorganic fertilizer + 25% N through FYM, 50% RDN through inorganic fertilizer + 50% N through FYM, 75% RDN through inorganic fertilizer + 25% N through vermicompost. Seed rate of 20 kg/ha recorded superior performance with respect to number of tillers/m², dry matter accumulation, LAI, SPAD value, grain and straw yields and nutrient uptake as compared to seed rate of 16 and 24 kg/ha. Amongst integrated nutrient management treatments, application of 50% RDN by urea + 50% N by FYM recorded better performance with respect to tillers/m², dry matter accumulation, LAI, SPAD value, grain and straw yields and nutrient uptake while 100% RDF through inorganic fertilizer recorded lowest growth and yield.

Key words: Direct seeded hybrid rice, Integrated nutrient management, Seed rate

Under direct-seeded rice (DSR), optimum seed rate and plant density is the principal factor for obtaining higher yield. Farmers are using 30-60 kg/ha for DSR for inbred varieties, however, with the introduction of hybrids in direct-seeded rice, present quantity of seed rate seems to be higher on account of price of hybrid seeds and growth behavior of hybrid rice (Choudhary and Suri 2014, 2018a). Thus, standardization of seed rate of hybrid rice under DSR is crucial for harnessing higher yields. These crop plants also require a sufficient supply of essential mineral elements (both micro and macro) for optimal crop growth and final harvest in terms of crop yield (Choudhary and Suri 2018a, b; Dass *et al.* 2016, 2017). An insufficient availability of essential nutrients may cause stunted growth and limits the crop productivity (Harish *et al.* 2017, 2019). It is also important to promote the integrated use of organic fertilizers in combination with chemical fertilizers to restore soil fertility and productivity (Paul *et al.* 2014, 2016). At the same time, Zn, Fe and B are essential micronutrients

for plant growth and have key role in plant metabolism (Harish *et al.* 2017, 2018). Supplementation of macro and micronutrients through organic manures application or direct micronutrients application along with macronutrients might be an option to overcome the deficiency of these nutrients under direct seeded rice and breaking the yield barrier under direct seeded hybrid rice (Choudhary and Suri 2018b). FYM and vermicompost (VC) are good source of plant nutrients that can be used as an alternative to chemical fertilizers in rice cultivation (Paul *et al.* 2014, 2016). Hence, it is imperative to study the effect of zinc, iron, boron and organic manures on growth, yield and economics of direct seeded rice. Hence, the present study aimed at assessing the performance of integrated nutrient management with seeding rate on growth and productivity of rice (*Oryza sativa* L.) under direct seeded hybrid rice.

MATERIALS AND METHODS

A field experiment was carried out in rice during *kharif* seasons of 2016-17 and 2017-18 at the Agricultural Research Farm, Banaras Hindu University, Varanasi situated at 25° 18' N latitude, 83° 03' longitudes and an altitude of 129 m. Total rainfall received during the crop growth period was 1187.8 mm in 2016 and 644.8 mm in 2017. The site was well drained sandy clay loam soil, non-saline (EC 0.22 and 0.26 dSm⁻¹) with pH 7.52 and 7.43 (1:2.5 soil: water) and medium in organic carbon (0.53% and 0.55%), low in available N (178 kg/ha), medium in available P (23 kg/ha)

¹Assistant Professor, School of Agriculture Science and Technology, Sangam University, Bhilwara, Rajasthan 311 001; ²Professor (mksingh194.m@gmail.com), Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221 005; ³Agriculture Development Officer, Kheti Bhawan, Aslamabad, Hoshiarpur 146 001.

and available K (219 kg/ha) as estimated using standard procedures (Rana *et al.* 2014). The experiment was carried out in split-plot design with three replications. A treatment combination of 3 seed rates, viz. S_1 -16 kg/ha, S_2 -20 kg/ha, S_3 -24 kg/ha and 5 INM treatments, viz. T_1 -100% RDF through inorganic fertilizer, T_2 -100% RDF through chemical fertilizer + $ZnSO_4 \cdot 7H_2O$ 25 kg/ha *fb* 0.2% $FeSO_4$ and 0.2% Borax foliar spray at 20 and 40 DAS, T_3 -75% RDN through inorganic fertilizer + 25% N through FYM, T_4 -50% RDN through inorganic fertilizer + 50% N through FYM, T_5 - 75% RDN through inorganic fertilizer + 25% N through vermicompost (VC). Hybrid rice cultivar Arize-6444 was directly sown manually with the help of *kudal* (local furrow maker) at a row spacing of 20 cm after placing fertilizers and manures in furrows and covered with soil on 29 June 2016 and 26 June 2017, respectively. One day after sowing irrigation was applied for proper germination. Recommended dose of fertilizer of nitrogen (140 kg/ha), P_2O_5 (60 kg/ha) and K_2O (60 kg/ha) were applied through urea, single super phosphate and muriate of potash. In T_3 (25% through N urea and 25% N through FYM), T_4 (50% N through FYM) and in T_5 (25% through N urea and 25% N through VC) was applied as basal, and rest 50% nitrogen was applied in two equal splits at active tillering and panicle initiation stages. In T_2 treatment, zinc was applied in soil as basal dose, whereas iron and boron was applied as foliar spray, i.e. 0.2% $FeSO_4$ and 0.2% Borax applied at 20 and 40 DAS. Standard practices were followed to record biometrical observations and yield (Rana *et al.* 2014). Data were recorded on growth attributes, viz plant height, tillers, leaf area index, dry matter accumulation, SPAD value, yield

(grain and straw yields), N, P, K and Zn uptake. The SPAD-502, a hand held chlorophyll meter (Minolta Corporation, Ramsey, N J) was used for rapid non-destructive estimation of extractable chlorophyll in green leaves.

RESULTS AND DISCUSSION

Effect on crop growth parameters

At 90 DAS, seed rate of 20 kg/ha had significantly better performance of number of tillers/m², dry matter accumulation (DMA), and SPAD value in comparison to 16 and 24 kg/ha during both the years. Significantly taller plants were recorded with the seed rate of 16 kg/ha as compared to 24 kg/ha, which at par with seed rate of 20 kg/ha in both the years (Table 1). In case of leaf area index (LAI), seed rate of 20 kg/ha was found to be at par with 24 kg/ha during both the years and significantly higher than 16 kg/ha only during second year. Growth is one of the most prominent characteristic of crop plants. Reduced seed rate might have resulted in optimum plant density and reduced competition among the plants for nutrients, moisture and light. In other rice crop production technologies like system of rice intensification reduced planting density is being used for enhanced crop growth attributes and yield (Choudhary and Suri 2018a, b; Dass *et al.* 2016, 2017). At 90 DAS, amongst the integrated nutrient management (INM) treatments, T_4 (50% RDN through inorganic fertilizer + 50% N through FYM) recorded significantly higher plant height, number of tillers/m², DMA, LAI and SPAD value and it was at par with T_3 (75% RDN through inorganic fertilizer + 25% N through FYM) during both the years. In case of

Table 1 Effect of varying seed rates and integrated nutrient management growth at 90 DAS and yields in direct-seeded hybrid rice

Treatment	Plant height (cm)		Number of tillers/m ²		SPAD value		Grain yield (kg/ha)		Straw yield (kg/ha)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
<i>Seed rate(kg/ha)</i>										
S_1 - 16	106.3	110.2	369.4	375.0	31.4	30.4	4811.8	4998.0	6612.1	7160.5
S_2 - 20	103.3	105.9	469.2	488.8	39.7	39.8	6089.7	6343.3	8552.0	9117.7
S_3 - 24	96.5	98.4	429.3	436.5	36.8	35.6	5595.8	5691.0	7826.3	8289.8
SEm±	1.5	2.2	7.6	7.9	0.61	0.61	114.2	148.1	151.2	158.1
CD (P=0.05)	6.1	8.6	30.1	31.1	2.41	2.42	448.5	581.5	593.9	620.8
<i>Integrated nutrient management</i>										
T_1 - 100% RDF	94.1	92.7	375.2	367.8	31.8	29.7	4866.1	4824.6	6426.3	7021.4
T_2 - 100 % RDF + $ZnSO_4 \cdot 7H_2O$ 25 kg/ha <i>fb</i> 0.2 % ($FeSO_4$ + Borax) at 20 and 40 DAS	101.8	104.5	409.2	421.7	35.0	34.5	5346.6	5563.4	7333.6	7903.4
T_3 - 75% RDN + 25% N by FYM	106.7	110.8	452.0	467.3	38.3	38.1	5874.7	6098.6	8430.9	8925.9
T_4 - 50% RDN + 50% N by FYM	107.8	114.3	470.9	493.3	39.9	40.2	6111.6	6457.3	8913.8	9315.4
T_5 - 75% RDN + 25% N by Vermicompost	100.0	101.9	405.7	417.0	34.4	33.8	5296.5	5444.7	7212.7	7780.6
SEm±	1.9	1.8	7.1	9.6	0.53	0.7	84.7	130.7	148.3	149.7
CD (P=0.05)	5.7	5.3	20.8	28.1	1.56	2.2	247.3	381.6	432.9	437.1

LAI and SPAD value, T_2 (100 % RDF + $ZnSO_4 \cdot 7H_2O$ 25 kg/ha *fb* 0.2 % ($FeSO_4$ + Borax) at 20 and 40 DAS was found to be at par with T_3 (75% RDN through inorganic fertilizer + 25% N through FYM) at 90 DAS during both the years. Growth characters are resultant of absence of growth limiting factors like nutrient, integration of various sources of nutrients might have made nutrients available slowly in treatments where nutrients were supplemented by 50% N by FYM.

Yield and interaction effects

Varying seed rates significantly influenced the grain and straw yields of hybrid rice and 20 kg/ha seed rate recorded significantly higher rice grain and straw yields in both the years of experimentation. Application of 20 kg seed rate recorded maximum grain and straw yields than other seed rate treatments (16 kg and 24 kg/ha) (Table 1). The grain yield of a crop is the integrated results of a number of physiological processes. Optimum seed rate (20 kg/ha) facilitated maximum light interception as indicated by dry matter accumulation, number of tillers/m², LAI and SPAD value for obtaining the maximum yield. Amongst various INM treatments, T_4 (50% RDN through inorganic fertilizer + 50% N through FYM) had significantly higher grain and straw yields, however, it was on par with T_3 (75% RDN through inorganic fertilizer + 25% N through FYM) during both the years except straw yield which was significantly higher in T_4 as compared to all the integrated nutrient management treatment in first year. This might be due to increased growth attributes, *viz.* number of effective tillers, dry matter accumulation (g running/m), leaf area index and SPAD value in T_4 , which resulted in higher yield owing to balanced plant nutrition (Choudhary and Suri 2014, 2018b; Dass *et al.* 2016, 2017). Interaction effects

of seed rates and INM practices revealed that S_2T_4 (seed rate 20 kg/ha and 50% RDN through inorganic fertilizer + 50% N through FYM) recorded highest SPAD value and grain yield amongst all the seed rate and integrated nutrient management treatment combinations and it was at par with S_2T_3 treatment combinations and significantly superior over rest of the treatment combinations in both the years except SPAD value in first year (Table 2). Optimum seed rate of 20 kg/ha along with integration of inorganic and organic sources of nutrients, *i.e.* 50% N through inorganic fertilizer + FYM (50% RDN) and 50% N through inorganic fertilizer + FYM (25% RDN) might have supplied the essential nutrients and worked as catalyst for efficient use of applied nutrients for increasing the grain and straw yields (Choudhary and Suri 2014). Also initial slow release nature of FYM which was applied as basal dose might have synchronized with crop growth demand (Choudhary and Suri 2014, 2018b).

Nutrient uptake

A perusal of data presented in Table 3 revealed that the significantly higher nitrogen, phosphorus and zinc uptake in grain and straw were recorded in seed rate treatment S_2 (20 kg/ha). In case of potassium uptake, seed rate 20 kg/ha recorded significantly higher uptake in grain during both the years. Since nutrient uptake is the outcome of the nutrient concentration and the crop output, the higher grain and straw yields of hybrid rice resulted in its higher values of N, P, K and Zn uptake in seed rate of 20 kg/ha. T_4 (50% RDN through inorganic fertilizer + 50% N through FYM) recorded significantly higher of N, P, K and Zn uptake in grain and straw during both the year. Higher nutrient uptake with the application of 50% RDN through inorganic fertilizer + 50% N through FYM might be due to higher

Table 2 Interaction of varying seeding rates and integrated nutrient management on SPAD value at 90 DAS and grain yield in direct-seeded hybrid rice

Integrated nutrient management	SPAD value						Grain yield (t/ha)					
	Seed rate (kg/ha)						Seed rate (kg/ha)					
	2016			2017			2016			2017		
	16	20	24	16	20	24	16	20	24	16	20	24
T_1 - 100% RDF	25.6	36.8	32.9	25.1	33.9	29.9	3.91	5.63	5.04	4.25	5.41	4.79
T_2 - 100 % RDF + $ZnSO_4 \cdot 7H_2O$ 25 kg/ha <i>fb</i> 0.2 % ($FeSO_4$ + Borax) at 20 and 40 DAS	32.1	38.3	34.6	30.9	37.2	35.4	4.93	5.80	5.29	5.14	5.87	5.67
T_3 - 75% RDN + 25% N by FYM	32.9	42.2	40.0	32.1	44.4	37.8	5.02	6.47	6.12	5.22	7.05	6.02
T_4 - 50% RDN + 50% N by FYM	34.6	43.9	41.1	32.4	48.0	40.2	5.29	6.73	6.30	5.35	7.62	6.39
T_5 - 75% RDN + 25% N by Vermicompost	31.9	37.2	34.0	31.2	35.4	34.8	4.88	5.79	5.21	5.00	5.74	5.57
	<i>SEm</i> ±	<i>CD</i> (<i>P</i> =0.05)		<i>SEm</i> ±	<i>CD</i> (<i>P</i> =0.05)		<i>SEm</i> ±	<i>CD</i> (<i>P</i> =0.05)		<i>SEm</i> ±	<i>CD</i> (<i>P</i> =0.05)	
N at same levels of S	0.93	2.71		1.34	3.94		0.14	0.42		0.22	0.66	
S at same or different levels of N	1.03	3.37		1.35	4.23		0.17	0.58		0.25	0.81	

Table 3 Effect of varying seeding rates and integrated nutrient management on N, P, K and Zn uptake in direct seeded hybrid rice

Treatment	Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)			Zinc uptake (g/ha)						
	Grain	Straw		Grain	Straw		Grain	Straw		Grain	Straw					
Seed rate (kg/ha)	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017				
Seed rate (kg/ha)																
S ₁ - 16	47.7	52.0	26.8	30.1	10.8	11.8	6.4	7.2	15.8	17.4	81.3	91.4	87.8	96.4	156.9	176.3
S ₂ - 20	57.8	64.1	35.9	40.1	13.8	15.2	8.5	9.5	20.5	22.4	104.9	116.9	109.7	120.9	200.4	223.7
S ₃ - 24	49.7	53.9	32.1	34.4	12.1	13.0	7.8	8.4	18.7	20.2	96.1	103.4	102.6	110.8	181.7	195.7
SEm±	2.0	1.3	1.1	1.4	0.6	0.7	0.3	0.4	0.4	0.5	2.3	3.6	3.9	5.0	7.3	8.5
CD (P=0.05)	8.1	5.2	4.4	5.7	2.3	2.7	1.2	1.6	1.6	2.0	9.2	14.3	15.5	20.0	28.9	33.7
Integrated nutrient management																
T ₁ - 100% RDF	37.7	38.0	24.2	26.1	9.2	9.2	5.9	6.3	15.9	16.2	76.6	83.2	80.7	82.6	134.7	146.8
T ₂ - 100 % RDF + ZnSO ₄ .7H ₂ O 25 kg/ha /b 0.2 % (FeSO ₄ + Borax) at 20 and 40 DAS	48.0	53.7	29.5	33.1	11.5	13.0	6.9	7.8	17.7	19.8	88.7	99.5	103.5	116.2	182.2	205.0
T ₃ - 75% RDN + 25% N by FYM	60.1	66.4	36.8	40.4	12.9	14.2	8.8	9.6	19.7	21.6	104.9	115.3	110.1	121.2	204.5	224.9
T ₄ - 50% RDN + 50% N by FYM	67.1	74.2	39.4	43.6	15.6	17.2	9.7	10.7	20.9	23.1	113.5	125.4	117.85	129.67	220.57	243.47
T ₅ - 75% RDN + 25% N by Vermicompost	45.9	51.0	28.1	31.2	11.8	13.1	6.7	7.4	17.4	19.4	86.8	96.1	88.17	97.33	156.45	172.68
SEm±	2.1	2.7	1.1	1.3	0.3	0.4	0.3	0.4	0.3	0.5	2.2	3.2	3.552	4.540	7.312	9.693
CD (P=0.05)	6.0	7.9	3.2	3.8	1.1	1.2	0.9	1.2	0.9	1.5	6.5	9.5	10.37	13.25	21.34	28.29

nutrient concentration along with higher biomass production. Application of organic manure along with chemical fertilizer accelerates the microbial activity, increases nutrients use efficiency and enhances the availability of the native as well as applied nutrients to the crop plants resulting higher nutrients uptake (Rana *et al.* 2018).

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