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Study of Effect of Crop Establishment Techniques and Seed Rate on Growth and Yield of Direct Seeded Hybrid Rice (*Oryza sativa* L.)

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A B S T R A C T

In order to find out suitable crop establishment technique and seed rate for obtaining optimum growth and yield of direct seeded hybrid rice, Arize AZ-8433 DT, an experiment was carried out during *kharif* 2019 at Instructional-cum-Research Farm IGKV, Raipur, Chhattisgarh in split-plot design with three replications. The crop establishment techniques used as main plot were line sowing with seed priming (M1), line sowing without seed priming (M2), broadcasting with seed priming (M3) and broadcasting without seed priming (M4). Seed priming was done with 1% KCl solution. The seed rate treatments incorporated as sub-plot were 15"kg ha^{-1} (S1), 20 kg ha^{-1} (S2), 25 kg ha^{-1} (S3) and 30 kgha^{-1} (S4). The seeds primed with 1% KCl and sown in line (M1) recorded the maximum values for emergence percentage, number of total tillers m^{-2}, number of leaves m^{-2}, dry matter m^{-2}, number of effective tillers m^{-2}, panicle weight and number of filled grains panicle^{-1} which resulted in higher grain yield, straw yield, harvest index, gross return, net returns and B:C ratio. With regard to seed rate, growth parameters were maximum at 30 kg ha^{-1} (S4) seed rate during initial stages but at later stages, dry matter m^{-2} was highest under 25 kg ha^{-1} (S3). However, at all stages, both the seed rate treatments were at par with each other. Panicle weight and number of filled grains panicle^{-1} were significantly higher under seed rate of 15 kg ha^{-1} (S1), but still seed rate 25 kg ha^{-1} (S3) gave highest grain yield due to significantly higher number of effective tillers m^{-2}under it. Straw yield was highest under highest seed rate of 30 kg ha^{-1} (S4). Seed rate 25 kg ha^{-1} was optimum for direct seeded hybrid rice as it gave highest gross return, net returns and B:C ratio.

Introduction

Rice (*Oryza sativa* L.) is the staple food crop of millions of mankind feeding more than two-third of the world population and is the main activity and source of income for around 100 million Asian and African households. This makes rice, a crop of global importance. In India, rice is cultivated in an area of about 43.79 million hectares which is the highest amongst all rice growing countries of the world. The annual production recorded was 116.42 million tonnes having average productivity of 26.59 q ha^{-1} (Anonymous, 2019). Chhattisgarh is popularly known as "Rice bowl". About 75 per cent area of rice in the state is under broadcasting, 15-17 per cent under transplanting and 8-10 per cent area is covered by direct drilling method of rice seeding (Pandey *et al.,* 2018). The introduction of hybrid varieties revolutionized the rice production across the globe. Hybrid rice seeds are produced from crossing two genetically different parents that results in heterosis (hybrid vigour) which is expressed during the plant's early vegetative and reproductive growth stages consequently giving higher yields (Barclay, 2007). Rice hybrids gained popularity among the farmers because of high tillering ability, rapid expansion of leaf area and heavier and increased yield. Thus, hybrid rice varieties present a potential to deal with food security issues. The major constraint in adoption of hybrid rice technology is higher seed cost coupled with inability to use the seeds from one season to another (Nirmala *et al.*, 2013). Rice is grown by mainly two methods *i.e.,* transplanting and direct seeding. In general, hybrid rice is established by transplanting method since the seed requirement under direct seeding is more. Transplanting is preferred because plant population is ensured and puddling benefits rice by reducing losses due to percolation and controlling weeds. In recent years, many researchers have highlighted the challenges with puddled transplanted rice (PTR) including delayed maturity due to transplanting shock, low nutrient and water productivity and rising labor scarcity, altogether which have led to reduced profitability (Ditzler *et al.*, 2018) and warrant a major change from PTR to direct seeding of rice (DSR) (Kumar and Ladha, 2011). Agronomic studies claim that direct seeding enhances land productivity and labor efficiency besides improving nitrogen use efficiency. Since direct seeded rice takes less time to mature than transplanted crop, it can be easily incorporated into various cropping systems. There are two methods of direct seeding namely, wet seeding and dry seeding. In each case, the seeds can be either broadcasted or line sown. Wherein, line sowing comes with the advantages of ease of intercultural operations (Mahmood *et al.,* 2002), broadcasting method has much lower labour requirement and saves time. Overall, with good water management, grain yield of DSR is similar to PTR. However, constraints such as rapid growth of weeds and poor crop establishment under stress conditions restrict the adoption of DSR amongst farmers. The seed priming has appeared as an important tool for better germination and plant population. Seed priming requires partial hydration to the point where germination-related metabolic processes start, but the radicle does not fully emerge. Amongst different types of seed priming, osmo-priming that uses osmotic solution, enhances the starch hydrolysis and made more sugars available for embryo growth (Farooq *et al.,* 2006). Osmopriming with KCl improves germination percentage and vigour index (Yari and Sheidaie, 2011), stand establishment and tiller number (Hasan *et al.,* 2016), grain yield and harvest index (Rehman *et al.,* 2015). Greater efficiency of osmohardening with KCl is related to the osmotic advantage that K^+ have in improving cell water saturation, and that it act as co-factor in the activities of numerous growth enzymes (Taiz and Zeiger, 2002). However, this cheap technology needs to be tested for direct seeded hybrid rice. The practice of direct seeding of hybrid rice can be a major opportunity to change production practices to attain high water productivity, reduce labour cost and save time.

However, high seeding rate is generally used in direct seeding of rice. Cost of hybrid seeds make the use of such high seeding rates in DSR prohibitively expensive which will encourage farmers to reduce the seed rates. Therefore, efforts are needed to reduce seed rate of hybrid rice under DSR conditions without sacrificing grain yield. Further, the pressure to reduce costs can also be balanced while managing the risks associated with poor emergence.

The combination of appropriate sowing technique and optimum seeding rate of the direct-seeded hybrid rice along with ensured proper crop establishment through cheap seed priming technologies can help economically weak farmers to harness the benefits of hybrid rice and earn higher better monetary benefits from it.

Materials and Methods

The experiment was conducted at Research-cum-Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur ($21^0$16'N, $81^0$36'E) Chhattisgarh, India. The climate of this region is sub-humid having mean annual rainfall of 1326 mm. Rice hybrid Arize AZ 8433-DT was grown during *kharif*, 2019. The crop received good rainfall of total 961 mm during the entire crop duration. Weakly mean maximum and minimum temperature of 35.5℃ and 15.5℃ was recorded during the entire crop period. The soil at the experimental site has pH of 7.74 and organic carbon of 0.46%. The soil was sandy loam and low in available nitrogen (175.6 kg ha^{-1}) with medium content of available phosphorus (16.2 kg ha^{-1}) and potassium (293 kg ha^{-1}). The experiment was laid out in split plot design incorporating crop establishment techniques as main plot factor with four levels namely, line sowing with seed priming (M1), line sowing without seed priming (M2), broadcasting with seed priming (M3) and broadcasting without seed priming (M4). Both the line sown methods incurred a row-to-row spacing of 20 cm. Further, seed priming in two of the establishment techniques was done before sowing with 1% potassium chloride (KCl) solution. The sub-plot has four varying seed rates *viz.*15kg ha^{-1}(S1), 20kg ha^{-1} (S2), 25 kg ha^{-1}(S3) and 30 kg ha^{-1} (S4).

Results and Discussion

Growth of rice

Primed rice seeds sown in line (M1) gave the highest seed emergence percentage which was significantly higher than other treatments whereas, the least emergence percentage was recorded in case of broadcasting of non-primed seed (M4) (Table 1). Similar results reporting least final emergence count under broadcasted DSR compared to line-sown were also observed by Ishfaq *et al.,* (2018).

Plant height was highest in line sowing with seed priming (M1) at all growth stages (Table 1). It was significantly higher than rest of the treatments. Significantly lowest value of plant height was recorded with broadcasting of non-primed seed (M4) at all growth stages. Similar results reporting taller plants under line sowing treatments were also given by with Ishfaq *et al.,* (2018) and Kour *et al.,* (2018). Plant height was significantly influenced by seed rate at 30 DAS and 60 DAS. At 30 DAS, tallest plant was observed under 30 kg ha^{-1} (S4) seed rate. Lowest height was observed under 15 kg ha^{-1} (S1). At 60 DAS, plant height decreased significantly with the increase in seed rate which is in contrast to the trend observed in 30 DAS. The highest plant height at this stage was observed under 15 kg ha^{-1} (S1) seed rate which was at par with that in 20 kg ha^{-1} (S2). Mahajan *et al.,* (2010) further justified such contrasting trends between early and later crop stages by revealing that under high seed rates (30 kg ha^{-1}), plant height was higher at initial stages (30 DAS) due to more intra-specific competition for light offered by the crop, but later, plants suffered due to higher competition for nutrients resulting in reduced plant height at later stage with increasing seed rate. At 90 DAS and at harvest, plant height remained unaffected due to varying seed rates.

Crop establishment techniques and seed rates significantly influenced number of total tillers m^{-2}, number of leaves m^{-2} and dry matter (g m^{-2}) (Table 2). At all growth stages, significantly higher value for these parameters was obtained with line sowing of primed seed (M1) whereas significantly lowest value for them was recorded at broadcasting of non-primed seeds (M4). It can be observed that both the line sown treatments recorded better growth compared to the broadcasted ones at all growth stages. Kour *et al.,* (2018) stated that the reason may be the line spacing provides more area to the plant for better uptake of nutrients and solar radiation absorption for more development of the tillers and increased the leaf number due to sustainable conditions and thus resulted in increased biomass. Further, primed treatments showed better results than their non-primed analogue. This is in agreement with earlier research which indicated that rice seeds osmo-primed with KCl have higher tillering (Rehman *et al.,* 2015) and total dry weight (Rehman *et al.,* 2011).

In general, number of total tiller m^{-2}, number of leaves m^{-2}, and dry matter (gm^{-2}) at 30 and 60 DAS, increased with the increase in seed rate. At all growth stages, highest value for these parameters was recorded at 30 kg ha^{-1} (S4) which was at par with that recorded under 25 kg ha^{-1} (S3) seed rate. However, at 90 DAS, dry matter $m^{-2}$was highest with 25 kg ha^{-1} (S3) and at par with that in 30 kg ha^{-1} (S4). Lowest value was obtained at lowest seed rate under study *i.e.,* 15 kg ha^{-1} (S1), in all stages of observation. Higher number of tillers and leaves per unit area was also reported by Ahmed *et al.,* (2016).During early stages, dry matter increased as the seed rate increased because there was less intra-crop competition which resulted in better photosynthesis to support initial growth. This finding was confirmed by Jayanti *et al.,* (2015). At 90 DAS, dry matter production increased with increase in plant population up to a certain extent and declined thereafter. This is also reported by Ahmed *et al.,* (2016) who revealed that at higher seed rates, no further increase in biomass occurred at flowering and physiological maturity. The reason for this may be less number of panicle bearing tillers and more tiller mortality and leaf senescence at high seeding rate.

Yield of rice

Crop establishment techniques significantly influenced the grain and straw yield and harvest index of direct seeded hybrid rice (Table 3). Highest grain and straw yield as well as harvest index was recorded in line sowing of primed seeds (M1) which was statistically higher than rest of the treatments. Broadcasting of non-primed seeds (M4) recorded lowest value for both the parameters. The results are in agreement with Kour *et al.,* (2018) who reported higher yield and harvest index in line sowing as compared to broadcasting. Proper crop geometry in line sowing resulted in better harnessing of weather parameters and ideal rhizosphere environment that might have contributed to higher nutrient uptake and thus production of greater source (Kanthi *et al.,* 2014). This in turn caused better accumulation of photosynthates during vegetative growth and efficient translocation of photosynthates during the reproductive phase and consequently gave elevated kernel yields. The result also supports the findings of Rehman *et al.,* (2015) who reported improved grain yield and harvest index due to osmohardening with KCl.

Grain yield increased with seed rate up to 25 $kgha^{-1}$ (S3) and declined thereafter. The highest grain yield was recorded with seed rate 25 $kgha^{-1}$ (S3) which was at par with that in seed rate 30 $kgha^{-1}$ (S4) whereas, it was lowest under seed rate 15 $kgha^{-1}$ (S1). Similar findings were reported by Jayanti *et al.,* (2015) and Ahmed *et al.,* (2016). Results reporting highest yield of direct seeded hybrid rice under seed rate 25 $kgha^{-1}$ were also given by Jana *et al.,* (2018). The reason for the reduction in grain yield are weaker plants that high seed rate brings about due to problems of mutual shading and intra-specific competition for below-ground resources.

Straw yield increased as the seed rate increased with maximum recorded at seed rate of 30 kg ha^{-1} (S4) which was at par with that obtained under seed rate 25 kg ha^{-1}(S3). Significantly lower straw yield than the other treatments was recorded under 15 kg ha^{-1} (S1) seed rate. Similar results were also observed by Jayanti *et al.,* (2015). The significant difference in the production of straw yield between low seed rate and high seed rate was possibly attributed to lower number of tillers and leaves m^{-2} at low plant density. Harvest index of direct-seeded hybrid rice remained unaffected by varying seed rates as also reported by Yadav *et al.,* (2007).

Gross returns, net returns and benefit-cost ratio were significantly influenced by crop establishment techniques with remarkably highest values for all of them recorded in line sowing of primed seeds (M1) (Table 3). The establishment technique involving broadcasting of non-primed seeds (M4) recorded lowest monetary returns and B:C ratio amongst all the treatments.

Table.1 Seed emergence percentage and plant height of direct seeded hybrid rice as influenced by crop establishment techniques and seed rate

Treatment		Seed emergence(%)	Plant height (cm)			
			30 DAS	60 DAS	90 DAS	At harvest
A) Main plot – Establishment technique :4						
M1: Line sowing with seed priming		61.1	30.4	73.1	114.9	120.9
M2: Line sowing without seed priming		54.8	28.2	71.1	114.6	120.8
M3: Broadcasting with seed priming		55.5	25.2	70.0	113.8	119.9
M4: Broadcasting without seed priming		50.4	23.0	68.5	112.4	118.3
SEm ±		0.90	0.60	0.92	0.57	0.75
CD at 5%		3.10	2.06	3.18	1.97	2.58
B) Sub-plot - Seedrate: 4						
S1: 15 kg ha^{-1}		54.8	24.4	73.3	115.1	121.2
S2: 20 kg ha^{-1}		55.0	25.5	72.8	114.1	119.6
S3: 25 kg ha^{-1}		57.1	27.4	69.4	113.3	119.4
S4: 30 kg ha^{-1}		55.0	29.5	67.0	113.1	119.8
SEm ±		1.01	0.63	0.81	1.30	0.79
CD at 5%		NS	1.84	2.35	NS	NS

Table.2 Growth parameters of direct seeded hybrid rice as influenced by crop establishment techniques and seed rate

Treatment	Total tillers (No. m^{-2})			Number of leaves (No. m^{-2})			Dry matter (g m^{-2})		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
A) Main plot – Establishment technique :4									
M1	198.8	594.6	511.2	455.1	3079.4	2501.2	59.9	1028.1	1673.1
M2	174.2	529.1	474.5	385.9	2538.8	2203.3	49.7	913.0	1454.2
M3	161.4	515.3	452.8	379.0	2397.6	2043.4	46.5	888.9	1367.8
M4	128.7	447.7	406.6	320.3	1846.8	1622.5	34.8	760.6	1155.3
SEm ±	4.19	4.27	6.68	10.49	44.46	50.20	1.18	13.31	19.71
CD at 5%	14.49	14.77	23.13	36.28	153.86	173.71	4.07	46.06	68.20
B) Sub-plot - Seedrate: 4									
S1	139.3	395.2	343.5	271.4	1879.1	1637.3	36.6	644.7	1035.6
S2	154.3	485.5	425.5	333.6	2353.2	1952.9	43.4	823.1	1328.7
S3	182.9	597.0	535.2	458.7	2759.1	2379.2	54.8	1036.6	1643.8
S4	186.7	609.0	540.8	476.5	2871.1	2401.1	56.2	1086.1	1642.4
SEm ±	4.00	6.34	6.58	6.34	47.76	47.89	0.64	17.78	21.19
CD at 5%	11.67	18.52	19.21	18.50	139.40	139.79	1.86	51.88	61.84

Table.3 Yield, harvest index and economics of direct seeded hybrid rice as influenced by crop establishment techniques and seed rate

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
A) Main plot – Establishment technique :4						
M1: Line sowing with seed priming	70.53	90.36	43.89	146719	95418	2.85
M2: Line sowing without seed priming	67.70	88.01	43.50	141026	89838	2.75
M3: Broadcasting with seed priming	63.20	87.91	41.88	132501	82200	2.63
M4: Broadcasting without seed priming	61.87	85.16	42.10	129579	79390	2.58
SEm ±	0.78	0.97	0.45	1448	1448	0.03
CD at 5%	2.70	3.35	1.54	5012	5012	0.09
B) Sub-plot - Seedrate: 4						
S1: 15 kg ha^{-1}	55.65	72.01	43.56	115867	67766	2.41
S2: 20 kg ha^{-1}	64.02	83.44	43.37	133379	83515	2.67
S3: 25 kg ha^{-1}	72.29	96.94	42.66	151018	99392	2.92
S4: 30 kg ha^{-1}	71.35	99.06	41.78	149560	96171	2.80
SEm ±	1.43	0.71	NS	2683	2683	0.05
CD at 5%	4.19	2.07	NS	7830	7830	0.15

This is evident from the data of grain yield which recorded remarkably high grain yields from line sowing of primed seeds thereby giving higher values of gross returns and net returns. Monetary returns and benefit-cost ratio were obtained significantly higher under seed rate 25 kg ha^{-1} (S3) and lowest under 15 kg ha^{-1} (S1) seed rate.

The crop establishment technique involving primed seeds sown in line reported better values of growth parameters, grain yield, straw yield and harvest index of direct seeded hybrid rice. Further, both the treatments with KCl (1%) seed priming, be it line sown or broadcasted, significantly enhanced the seed emergence percentage and improved the growth parameters, yield as well as harvest index of direct seeded hybrid rice than their non-primed counterpart. Seed rate of 25 kg ha^{-1} was found optimum and economical for increasing growth and grain yield of direct seeded hybrid rice as compared to lower seed rates as it gave highest monetary returns as well as benefit cost ratio.

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