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Impact of Different Seed Rates on Yield and Economics of Direct Seeded Rice in Eastern Vidharbha Zone of Maharashtra, India

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A B S T R A C T

An experiment was conducted, for three consecutive years to evaluate the effect of seed rates on yield and economic traits in Bold as well as Fine seeded rice variety in terms of Direct-Seeded technique. The experiment was laid out in Factorial Randomized Block design and replicated thrice. Study concluded that Pooled means of seed rates at Sakoli indicated that sowing of 75 kg seed ha^{-1} (3458 kg ha^{-1}) was expressively higher in grain yield but was at par with sowing of 50 kg seedha^{-1}. As well as pooled mean at Sindewahi indicated that Variety Sye-2001 was higher in grain yield (3631 Kg ha^{-1}) of Rice than PKV HMT. The pooled mean of grain yield over three seasons and two locations revealed that variety Sye-2001 was significantly higher in grain yield over PKV HMT Variety. Among seed rates, 75 kg seedha^{-1} recorded significantly higher grain yield over other seed rates but was at par with 50 kg seedha^{-1}. Interaction effect showed the variety Sye-2001 was significantly highest in grain yield at 75 kg seedha^{-1} and PKV HMT variety at 50 kg ha^{-1}. Also the highest GMR, NMR and B:C ratio was recorded in Sye-2001 with 75 kg seed rate ha^{-1} and in PKV HMT at 50 kg Seedha^{-1}.

Introduction

Seed rate has a great impact on plant density and the competitiveness of the crop stand, tiller, time to maturity and yield. Low plant density and improper sowing method are the most important factors of agronomic constraints for obtaining higher yields and have a positive influence on the yield of rice. Optimum plant density is the primary factor for obtaining higher yield in rice (Sivaesarajah *et al.,* 1995). The increase in plant density increases total plant weight per unit area and decreases the total weight per plant (Yoyock *et al.,* 1979). The number of plants per unit area has an impact on plant architecture, modifies growth and development pattern and effects on the production photosynthesis (Abuzar *et al.,* 2011). The increase in plant density increases the yield up to a limit and thereafter a leveling off or decline in yield (Sivaesarajah *et al.,* 1995). The reason for the reduction in yield is due to the reduction in resources per plant. So the reduction in yield

will not be compensated by increasing plant number. Direct seeding technique offers a useful option to reduce the limitations of transplanted rice. Direct seeding is being practiced in many developed countries where labour is scarce and expensive (Pingali *et al.,* 1994). Direct-seeded rice occupies 26% of the total rice area in South Asia (Gupta *et al.,* 2006). Direct seeding of rice avoids puddling, does not need continuous submergence, and thus reduces the overall water demand for rice culture. When rainfall at planting time is highly variable, direct seeding may help reduce the production risk (Singh *et al.,* 2006). Direct seeding can also reduce the risk by avoiding terminal drought that lowers the yield of transplanted rice, especially if the latter is established late due to delayed rainfall. Direct seeding can facilitate crop intensification (Singh *et al.,* 2008). In Vidharbha region of Maharashtra, rice is majorly grown by puddled transplanting method, which is laborious and costly method. The peak period of rice transplanting is in the month of July, which results in labour shortage at the time of transplanting. For this instance, the present study aimed to find out the suitable seed rate for bold and fine seeded rice under drill condition, effect of different seed rates on yield and yield attributing characters of drilled rice and the economics

Materials and Methods

The study was aimed to investigate the effect of different seed rates on yield and growth traits of bold and fine seeded rice varieties. Study conducted during three rainy (*kharif*) seasons of 2013-2016 at two locations Krishi Vigyan Kendra, Bhandara (Sakoli), Maharashtra, India and Zonal Agricultural Research Station, Sindewahi, Maharashtra, India. The experimental material comprised of two well-known rice varieties *viz.,* Bold seeded: Sye-2001 (V_1) and Fine seeded: PKV-HMT (V_2) with five different seed rate combinations like Sowing of 50 kg seed ha^{-1} (S_1), 75 kg seed ha^{-1} (S_2), 100 kg seed ha^{-1} (S_3), 125 kg seed ha^{-1} (S_4) and 150 kg seed ha^{-1} (S_5). The experiment was planned in a Factorial Randomized Block Design and replicated thrice. The soil of experimental site was analyzed for initial soil nutrient status (Table 1) and the application of recommended dose of 125:62.5:62.5 kg NPK ha^{-1} was common in all combinations. Date of Sowing and harvesting was strictly followed for consequent three years (Table 2).

Results and Discussion

Growth traits

Average results observed in growth traits as influenced by various seed rates on Bold and Fine seeded variety throughout three-year shows, as seed rate increases the plant height, grains $panicle^{-1}$, length of panicle and effective tillers sq. m^{-1} decreases eventually (Table 3). In term of plant height V_1 showed up 94.09 cm, was at its best among entire treatment combinations for three years followed by V1V2S3 attended 90.36 cm and V1V2S2 was at 89.30 cm. Number of tillers sq. m^{-1} was recorded highest in V_1 (531.73) but the fine seeded variety V_2 showed 442.73 tillers sq. m^{-1} (Table 3). Some different trends had been noticed like the number of tillers sq. m^{-1} was increasing as seed rate increases in both varieties. Number of effective tillers sq. m^{-1} was noticed superior at V1V2S3 (289.17) and V1V2S2 (285.33) in Bold as well as Fine seeded variety. Seed rate of 50 and 75 kg ha^{-1} results the average panicle length of 20.95 cm and 20.25 cm but V_1 showed the highest panicle length of 21.59 cm in consecutive three years average record (Table 3). The fine seeded variety V_2 recorded the highest 179.09 $grains\ panicle^{-1}$ afterward $V_1V_2S_2$ and $V_1V_2S_3$ were at par to each other throughout the growing seasons. Miller *et al.,* (1991) found that panicle is a key factor that determines and contributes 89 % of differences in yield. These results are in line with those of Kenneth *et al.,*

(1996) who reported rough rice has gained high yield in the optimum plant stand. $V_1V_2S_3$ and $V_1V_2S_2$ showed the significantly highest grain yield sq. m^{-1} of 389.33 and 377.20 but in terms of variety V_1 results the high in grain yield. This is in agreement with the studies reported by Mahajan *et al.,* (2004), Hardev *et al.,* (2014) and Rajiv *et al.,* (2013). Basically V_1 is Bold seeded variety so it has the high test weight of 25.72 g and V_2 was at 14.34 g. Similar results showing that yield of rice linearly increased with seed rate (density) has been reported by Baloch *et al.,* (2002). The plants at low seed rate have sufficient space and this enables to utilize more nutrients, water and solar radiation for better photosynthesis. Hence, the individual plants performed better. This is in agreement with the studies reported by Baloch *et al.,* (2002), Akbar *et al.,* (2004), Prasad *et al.,* (1999), IRRI (2008), Subbaiah *et al.,* (2002), Gill *et al.,* (2008), Sharma *et al.,* (1992), Mahajan *et al.,* (2006), Dongarwar *et al.,* (2015) and Abou-Khalifa *et al.,* (2014).

Yield traits

Pooled means of three consecutive years at ZARS Sindewahi location point to bold seeded variety V_1 - Sye-2001 for highest grain yield of 3631 Kg ha^{-1} than PKV HMT at 3167 kg ha^{-1}. $V_1V_2S_2$ (75 kg ha^{-1} seed rate) was recorded significantly highest yield over other treatment with 3710 kg ha^{-1} of yield (Table 4). Interaction effects between variety and seed rate resulted as significant. V_1 - Sye-2001 recorded 4162 kg ha^{-1} grain yield, which was superior, over all other combinations, and V_2 - PKV HMT, recorded significantly higher yield, in seed rate S_1 - 50 kg seed ha^{-1} of 3710 kg ha^{-1} (Table 5). This is in agreement with the studies reported by Zhao *et al.,* (2007), Chauhan *et al.,* (2011), Gill *et al.,* (2006), Phuong *et al.,* (2005), Dongarwar *et al.,* (2015) and Kaun *et al.,* (2014). Pooled means of KVK, Bhandara (Sakoli) location for entire three years indicated that, variety V_1 - Sye-2001 was significantly higher, in grain yield of rice, with 3225 kg ha^{-1} of grain yield, Whereas V_2- PKV HMT recorded grain yield of 2581 kg ha^{-1}. Among various seed rates, $V_1V_2S_2$ (75 kg seed ha^{-1}) showed 3458 kg ha^{-1} of grain yield was higher but was at par with sowing of $V_1V_2S_1$ (50 kg seed ha^{-1}) with the yield of 3319 kg ha^{-1} (Table 6). The seed rate 50 kg and 75 kg ha^{-1}) were at par with each other and significantly superior over other treatments. Pooled means of interaction of variety and seed rate at KVK, Bhandara (Sakoli) revealed that variety bold seeded V_1-Sye-2001 was higher yield at S_2 (75 kg ha^{-1}) and fine seeded PKV HMT recorded best results at S_1 (50 kg ha^{-1}) seed rates (Table 7). Zhao *et al.,* (2007), Chauhan *et al.,* (2011), Gill *et al.,* (2006), Phuong *et al.,* (2005) and Kaun *et al.,* (2014) also reported similar results. The results of pooled mean of grain yield over three seasons of both locations revealed that bold seeded V_1 - Sye-2001 variety recorded 3578 kg ha^{-1} of grain yield, which was expressively higher grain yield over fine seeded V_2 - PKV HMT Variety with 2874 kg ha^{-1} of yield.

Among different seed rates $V_1V_2S_2$ (75 kg seed ha^{-1}) recorded 3584 kg ha^{-1} of grain yield which was significantly higher grain yield, over other seed rates but was at par, with S_1 (50 kg seed ha^{-1}) which was with 3485 kg ha^{-1} of yield (Table 8). Interaction effect between variety and seed rate revealed that that V_1 Sye-2001 variety recorded 4167 kg ha^{-1} of grain yield, which was significantly higher grain yield at S_2 - 75 kg seed ha^{-1}. V_2 PKV HMT variety recorded yield of 3483 kg ha^{-1} at S_1 (50 kg seed ha^{-1}) (Table 9). This is in agreement with the studies reported by Kumhar *et al.,* (2016), Payman *et al.,* (2008), Walia *et al.,* (2009), Baloch *et al.,* (2002), Akbar *et al.,* (2004), Prasad *et al.,* (1999), IRRI 2008, Subbaiah *et al.,* (2002), Gill *et al.,* (2008), Sharma *et al.,* (1992), Mahajan *et al.,* (2006) and Abou-Khalifa *et al.,* (2014).

Table.1 Initial soil fertility status of ZARS Sindewahi and KVK, Bhandara (Sakoli), Maharashtra, India

Particulars	Locations		Method used
	ZARS Sindewahi	KVK, Sakoli	
pH	7.30	7.30	*p*H meter (Piper,1966)
EC (dsm-1)	0.22	0.18	Conductivity meter (Jackson,1967)
Organic Carbon (%)	0.48	0.49	Walkley and Black method (Jackson,1967)
Available N kg/ha	221.00	234.00	Alkaline permanganate method (Subbiah & Asija, 1956)
Available P2O5 kg/ha	30.2	25.6	Olsen's method (Jackson,1967)
Available K20 kg/ha	290.00	318.00	Neutral normal ammonium acetate method (Jackson,1967)

Table.2 Dates of sowing and harvesting at ZARS Sindewahi and KVK, Bhandara (Sakoli), Maharashtra, India

Parameter	Date of sowing		Date of Harvesting	
	Sindewahi	Sakoli	Sindewahi	Sakoli
First Year	01.07.2013	08.07.2013	08.11.2013	15.11.2013
Second Year	01.07.2014	08.07.2014	28.11.2014	11.11.2014
Third Year	01.07.2015	08.07.2015	10.11.2015	20.11.2015

Table.3 Average Ancillary Characters as influenced by different seed rates at ZARS Sindewahi and KVK, Bhandara (Sakoli), Maharashtra, India

Treatments	Plant Height (cm)	No. of tillers sq. m^{-1}	No. of effective tillers sq. m^{-1}	Length of panicle (cm)	No. of grains per panicle	Grain yield sq.m^{-1} (g)	Test weight (g)
V_1	91.09	531.73	275.33	21.59	114.12	371.20	25.72
V_2	84.92	442.44	236.26	19.57	179.09	303.46	14.34
$V_1V_2S_1$	86.20	461.67	232.67	20.25	137.43	288.33	20.13
$V_1V_2S_2$	89.30	481.50	285.33	20.95	156.53	377.00	19.96
$V_1V_2S_3$	90.36	469.50	289.17	21.10	159.25	389.33	20.17
$V_1V_2S_4$	88.25	512.33	253.50	20.63	148.65	351.50	20.19
$V_1V_2S_5$	85.92	520.44	218.33	19.98	131.15	280.50	19.72

Table.4 Pooled Mean of grain yield of Rice (Kg ha^{-1}) as influenced by various treatments at Sindewahi, Maharashtra, India

Treatment	Grain yield kg ha^{-1}			
	2013-14	2014-15	2015-16	Pooled mean
Main plot : Varieties				
V_1	3441	3427	4023	3631
V_2	3298	2781	3422	3167
SEm±	110	91.0	49	39
CD @ 5%	NS	554	298	236
CV %	12.62	11.36	8.10	6.42
Sub Plot Seed rates				
$V_1V_2S_1$	3578	3245	3968	3597
$V_1V_2S_2$	3612	3392	4125	3710
$V_1V_2S_3$	3448	3099	3697	3415
$V_1V_2S_4$	3217	2991	3545	3251
$V_1V_2S_5$	2994	2794	3279	3023
SEm±	114	98	119	78
CD @ 5%	341	295	356	233.0
CV %	8.26	7.75	7.80	5.60
Interaction between Variety x Seed Rate				
SEm±	161	139	168	110
CD @ 5%	NS	433	522	342
CV %	8.26	7.75	7.80	5.60

Table.5 Pooled Interaction effect of Grain yield as influenced by different seed rates at Sindewahi, Maharashtra, India

Treatments	S_1	S_2	S_3	S_4	S_5	Mean
V_1	3484	4162	3697	3514	3296	3631
V_2	3710	3257	3132	2988	2750	3167
Mean	3597	3710	3415	3251	3023	
SEm±	110					
CD @ 5%	342					
CV %	5.60					

Table.6 Pooled Mean of grain yield of Rice (Kg ha^{-1}) as influenced by various treatments at Sakoli, Maharashtra, India

Treatment	Grain yield kg ha^{-1}			
	2013-14	2014-15	2015-16	Pooled mean
Main plot : Varieties				
V_1	3424	3275	3878	3225
V_2	2436	2471	2835	2581
SEm±	118	52	61	44
CD @ 5%	720	317	370	266
CV %	15.63	7.02	7.01	5.55
Sub Plot Seed rates				
$V_1V_2S_1$	3079	3226	3652	3319
$V_1V_2S_2$	3322	3265	3788	3458
$V_1V_2S_3$	2872	2810	3276	2986
$V_1V_2S_4$	2710	2594	3183	2829
$V_1V_2S_5$	2667	2471	2884	2674
SEm±	128	139	126	74
CD @ 5%	383	416	379	222
CV %	10.67	11.82	9.22	5.95
I Interaction between Variety x Seed Rate				
SEm±	181	196	179	105
CD @ 5%	562	610	556	327
CV %	10.67	11.82	9.22	5.95

Table.7 Pooled Interaction effect of Grain yield as influenced by different seed rates at Sakoli, Maharashtra, India

Treatments	S_1	S_2	S_3	S_4	S_5	Mean
V_1	3383	4172	3515	3360	3197	3525
V_2	3255	2744	2456	2299	2151	2581
Mean	3319	3458	2986	2829	2674	
SEm±			105			
CD @ 5%			327			
CV %			5.95			

Table.8 Pooled mean of grain yield (Kgha^{-1}) as influenced by different treatments at ZARS Sindewahi and KVK, Bhandara (Sakoli), Maharashtra, India

Treatment	Grain yield (Kg ha^{-1})		
	Sindewahi	Sakoli	Pooled mean (Kg ha^{-1})
Main plot : Varieties			
V_1	3631	3225	3578
V_2	3167	2581	2874
SEm±	39	44	30
CD @ 5%	236	266	183
CV %	4.42	5.55	3.61
Sub Plot: Seed rates			
$V_1V_2S_1$	3597	3319	3458
$V_1V_2S_2$	3710	3458	3584
$V_1V_2S_3$	3415	2986	3200
$V_1V_2S_4$	3251	2829	3040
$V_1V_2S_5$	3023	2674	2848
SEm±	78	74	53
CD @ 5%	233.0	222	159
CV %	5.60	5.95	4.02
Interaction between Variety x Seed Rate			
SEm±	110	105	75
CD @ 5%	342	327	233
CV %	5.60	5.95	4.02

Table.9 Pooled Interaction effect of Grain yield as influenced by different seed rates at ZARS Sindewahi and KVK, Bhandara (Sakoli), Maharashtra, India

Treatments	S_1	S_2	S_3	S_4	S_5	Mean
V_1	3434	4167	3606	3437	3246	3578
V_2	3483	3001	2794	2644	2450	2874
Mean	3458	3584	3200	3040	2848	
F Test			Sig.			
SEm±			75			
CD @ 5%			233			
CV %			4.02			

Table.10 Average Cost of cultivation, GMR, NMR and B:C ratio as influenced by different treatments at ZARS Sindewahi and KVK, Bhandara (Sakoli), Maharashtra, India

Treatment	Pooled Grain yield (Q/ha)	Cost of cultivation	Gross Monetary Return (Rs/ha)	Net Monetary Return(Rs/ha)	B:C ratio
Main plot : Varieties					
V_1	3578	33500	50092	18047	1.49
V_2	2874	34000	51736	18714	1.52
F Test	Sig		Sig	NS	
SEm±	30		355	493	
CD @ 5%	183		2159	3001	
CV %	3.61		2.70	10.39	
Sub Plot: Seed rates					
$V_1V_2S_1$	3458	32375	55380	24271	1.71
$V_1V_2S_2$	3584	33062	56175	24506	1.69
$V_1V_2S_3$	3200	33750	50391	17850	1.49
$V_1V_2S_4$	3040	34438	47849	14568	1.38
$V_1V_2S_5$	2848	35125	44776	10760	1.27
F Test	Sig		Sig	Sig	
SEm±	53		890	1080	
CD @ 5%	159		2667	3239	
CV %	4.02		4.28	14.40	
Interaction between Variety x Seed Rate					
F Test	Sig.		Sig	Sig	
SEm±	75		1258	1528	
CD @ 5%	233		3916	4756	
CV %	4.02		4.28	14.40	

Table.11 Interaction effect on GMR as influenced by different seed rates at ZARS Sindewahi and KVK, Bhandara (Sakoli), Maharashtra, India

Treatments	S_1	S_2	S_3	S_4	S_5	Mean
V_1	48074	58341	50487	48114	45451	50093
V_2	62688	54011	50296	47586	44103	51737
Mean	55381	56176	50392	47850	44777	
SEm±			1258			
CD @ 5%			3916			
CV %			4.28			

Table.12 Interaction effect on NMR as influenced by different seed rates at ZARS Sindewahi and KVK, Bhandara (Sakoli), Maharashtra, India

Treatments	S_1	S_2	S_3	S_4	S_5	Mean
V_1	17277	27067	18558	15246	12085	18047
V_2	31264	21946	17143	13889	9330	18714
Mean	24271	24506	17850	14568	10707	
SEm±			1528			
CD @ 5%			4756			
CV %			14.40			

Table.13 Treatment wise Cost of cultivation (INR ha^{-1}) at ZARS Sindewahi and KVK, Bhandara (Sakoli), Maharashtra, India

Treatments	Cost of cultivation (INR ha^{-1})
V_1S_1	32250.00
V_1S_2	32875.00
V_1S_3	33500.00
V_1S_4	34125.00
V_1S_5	34750.00
V_2S_1	32500.00
V_2S_2	33250.00
V_2S_3	34000.00
V_2S_4	34750.00
V_2S_5	35500.00

Economics traits

Labour saving of Direct Seeded Rice reduces 11.2% of total production cost as well as Direct Seeded Rice methods have several advantages over transplanting (Singh *et al.,* (2005; Naresh *et al.,* (2010). In addition to higher economic returns, Direct Seeded Rice crops are faster and easier to plant and less labor intensive (Jehangir *et al.,* (2005). Thus, it is necessary to change the cultivation system from transplanting to direct seeded rice (Sanjitha Rani and Jayakiran, 2010).

In terms of Gross monetary return, $V_1V_2S_2$ recorded the highest GMR with 56175 INR ha^{-1}, in the same combination Net monetary return was also noticed higher with 24506 INR ha^{-1} with the B:C Ratio of 1.69 (Table 10). Whereas other combinations were not up to the mark for recommendations. The interaction effect of both locations for GMR, NMR and B: C stated that V_1 was best with 58341 INR ha^{-1}, 27067 INR ha^{-1} of GMR and NMR respectively only when it is transplanted with the seed rate of S_2 - 75 kg ha^{-1}(Table 11). Effect on fine seeded variety V_2- PKV HMT was high in V_2S_1 combination, which was reported 62688 INR ha^{-1}, 31264 INR ha^{-1} of GMR and NMR respectively (Table 12). This is in agreement with the studies reported by Huang *et al.,* (2013), Mehala *et al.,* (2016), Singh *et al.,* (2005), Rao *et al.,* (2007), Naresh *et al.,* (2010), Jagagir *et al.,* (2005), Younas *et al.,* (2016), Awan *et al.,* (2005), Kahloon *et al.,* (2012) and Mazher *et al.,* (2017). The cost of cultivation of entire combinations has shown the normal phenomenal results of cultivars as the seed rate increases the cost of cultivations also increases (Table 13). These results were in accordance to Kumar *et al.,* (2011) reported that labor saving of 86% and cost saving of 87% in Direct Seeded Rice compared to manual transplanting.

In paddy, a labor saving of 95-99% in Direct Seeded Rice was recorded compared to transplanting during three years. Sehrawat *et al.,* (2010) also observed 13-16% labor saving in Direct Seeded Rice as compared to manual puddled transplanted rice. Kumar (2011) also recorded similar findings and found higher B: C ratio in Direct Seeded Rice as compared to transplanted rice. To get the highest grain yield, Gross monetary returns and net monetary returns from drilled rice in Eastern Vidarbha Zone of Maharashtra, 75 kg seed ha^{-1} for course varieties and 50 kg seed rate ha^{-1} for fine varieties with application of 125: 62.5: 62.5 kg NPK ha^{-1} is recommended. This is in agreement with the studies reported by

Husaain *et al.*, (2013), Awan *et al.*, (2005), Kumar *et al.*, (2011), Iqbal *et al.*, (2015), Seharawat *et al.*, (2010), Gangawar *et al.*, (2008) and Sidhu *et al.*, (2014).

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