Int.J.Curr.Microbiol.App.Sci (2018) *7*(7): 2930-2941

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 07 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.707.343

Effect of Row Spacing on Growth, Yield and Economics of Direct Seeded Rice in Eastern Vidharbha Zone of Maharashtra, India

Usha R. Dongarwar[1], Nitin Patke[2], L. N. Dongarwar[3] and Sumedh R. Kashiwar[4*]

[1]*Krishi Vigyan Kendra, Bhandara (Sakoli), Maharashtra - 441802, India*
[2]*Zonal Agricultural Research Station, Sindewahi, Maharashtra - 441222, India*
[3]*Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola, Maharashtra – 444001, India*
[4]*Institute of Agriculture, Visva-Bharati, Santiniketan, West Bengal - 731236, India*

**Corresponding author*

Keywords

Drilled rice, DSR, spacing, Vidharbha, PKV HMT

Article Info

Accepted:
20 June 2018
Available Online:
10 July 2018

A B S T R A C T

The field experiments were conducted in the *kharif* seasons of 2013-2014, 2014-2015, and 2015-2016 at the research farm of Krishi Vigyan Kendra, Bhandara (Sakoli) and Zonal Agricultural research Station, Sindewahi. The experiments were laid out in Randomized Block Design (RBD) with three replications and eight treatments. Higher number of effective tillers (390.0 m^{-2}) observed in T_2:- Row spacing 20cm x plant-to-plant spacing 10 cm at both the locations. The pooled mean of grain yield at two location and three seasons revealed that the row spacing of T_2- 20 cm x plant-to-plant spacing 10 cm (3376 Kgha^{-1}) was highest over all other treatments and it was par with T_1. The highest GMR, NMR and B: C ratio has recorded in T_2 followed by treatment T_1. Sowing of drill rice at row spacing of 20 cm and plant to plant spacing of 10 cm (T_2) was highest in grain yield (3376.49 kg ha^{-1}), GMR, NMR and B:C ratio (1.91) over other treatments and it was at par with 20x15 cm drilling of rice with grain yield (3305.46 kgha^{-1}) GMR,NMR and B:C ratio (1.86).

Introduction

Rice (*Oryza sativa* L.) is grown in regions having the necessary warmth and abundant moisture favorable to its growth, be it under lowland or upland condition. It is one of the most important and indispensable caloric cereal food crop. Beyond providing sustenance through growing, earning income, and consuming, rice plays an integral, but important cultural role in many rural communities. For instance, products of rice plant are used for a number of purposes, such as fuel, thatching, industrial starch, artwork, and festivities (Gangwar *et al.*, 2008). No groundwater recharge in rainy (*kharif*) season, late commencement of monsoon and farm operations often delays rice (*Oryza sativa* L.) transplanting which leads to late vacation of fields, forcing farmers to plant wheat after the optimum sowing time (Singh *et al.*,2005). Labour shortage at the time of transplanting leads to delay in transplanting and it is one of the reasons for low yields of rice. Transplanted rice in puddled field requires continuous standing water although this leads to nutrient loss through leaching. Although puddling helps in reducing water losses through percolation and controlling weed by submergence of rice fields, but besides being costly, bulky and time intense, it results in degradation of soil and other natural resources, and afterwards poses difficulties in seedbed preparation for succeeding next crop in crop rotation. Transplanting of rice mainly done by migratory labour, which has an element of seasonality and thus becoming a serious concern for timely transplanting of rice and maintaining a plant population sufficient to achieve the higher rice productivity (Gupta *et al.,* 2006, Dongarwar *et al.,* 2018a, Dongarwar *et al.,* 2018b, Kashiwar *et al.,* 2016). Rice production systems are undergoing various changes, one of which is a shift from transplanting to direct seeding as farmers seek alternatives to offset increasing costs. The main driving force for this changes are the rising wage rates, scarcity of labour and at the same time, the availability of option to manage weeds in direct-seeded rice (Mahajan *et al.,* 2009). In Maharashtra state of India, rice is cultivated on 15.13 lakh hectares area in nearly all four regions named Vidharbha (7.95 lakh ha.), Konkan (3.83 lakh ha.), Western Maharashtra (3.23 lakh ha.) and Marathwada (0.12 lakh ha.) with annual production of 41.71 lakh tons unmilled (brown rice) and 28.78-lakh tons milled rice. The area (7.95 lakh ha.) and production (16.81 lakh tons unmilled rice) of rice crop is more in Vidharbha region while as highest productivity was observed in Konkan region (2.75 t ha^{-1}) (AMSEWPR 2014). Row spacing 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 at. 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

Study aimed to investigate, the effect of different spacing’s on growth, yield and economic traits of PKV HMT rice variety. Study conducted during three rainy (*kharif*) seasons of 2013, 2014 and 2015 at two locations Krishi Vigyan Kendra, Bhandara (Sakoli), Maharashtra, India and Zonal Agricultural Research Station, Sindewahi, Maharashtra, India. The experiment laid in Randomized Block Design having three replications and eight treatments. The experimental material comprised of well-known rice variety named PKV-HMT with eight different treatment combinations like T_1- Row spacing 20 cm x plant-to-plant spacing 15 cm, T_2:- Row spacing 20cm x plant-to-plant spacing 10 cm, T_3- Row spacing 20 cm x plant-to-plant spacing 20 cm, T_4- Row spacing 20 cm x plant-to-plant spacing 7 cm, T_5- Row spacing 20 cm x plant-to-plant spacing 5 cm, T_6- Drilling of paddy at 20 cm spacing, T_7- Row spacing 25 cm x plant-to-plant spacing 25 cm, T_8- Sowing by broadcasting method. The soil of experimental site has analyzed for initial soil nutrient status (Table 1) and date of Sowing and harvesting has strictly followed for consequent three years (Table 2). Application of Pendimethaline @ 3.33 lit ha^{-1} within 48 hrs. After sowing and one weeding at 30 DAS and 5 t FYM ha^{-1} + Azospirilum + PSB seed treatment are common in all the treatment combinations.

Results and Discussion

Growth and yield traits

Average results observed in growth traits as influenced by various row spacing's throughout three-year shows, as row spacing increases the plant height, grains $panicle^{-1}$, length of panicle and effective tillers sq. m^{-1}gets affected eventually (Table 3). The highest plant height has recorded in T_1 (97.47 cm), T_2 (97.0 cm) and T_7 (97.00 cm) as these were superior all over the treatments. The lowest plant height has been recorded (91.07 cm) in T_8 (Sowing by Broadcasting method). The utmost number of tillers sq. m^{-1} has recorded in T_8 (826.67 sq. m^{-1}) followed by T_6 (744.67 sq. m^{-1}), T_2 (644.33 sq. m^{-1}), T_4 (635.0 sq. m^{-1}) and lowest number of tillers has recorded in T_7 (520.33 sq. m^{-1}).Number of effective tillers sq. m^{-1} has recorded highest in T_2 (390.0 sq. m^{-1}) followed by T_7 (370.66 sq. m^{-1}), T_1 (351.0 sq. m^{-1}) and lowermost has noted in T_6 (275.33 sq. m^{-1}).In terms of length of panicle (cm), T_1 (20.60 cm) followed by T_2 (20.55) has found superior over all the treatments as well as the T_6 (18.20 cm) has recorded the lowest. The Number of grains $panicle^{-1}$ has recorded high in T_2 (172.92 grains $panicle^{-1}$) followed by T_1 (170.47 grains $panicle^{-1}$). The Grain Yield of T_2 (566.67g m^{-2}) and T_1 (500.67 g M^{-2}) has been recorded highest apart from these treatments (Table 3), T8 (316.0 g m^{-2}), T_6 (350.0 g m^{-2}), T_3 (383.33 g m^{-2}) has lowest readings. Overall the treatment T_2 (Row spacing 20 x plant-to-plant spacing 10 cm) was superior in term of plant height (97.0 cm), number of tillers (644.33 Sq. m^{-1}), number of effective tillers (390.0 Sq. m^{-1}), length of panicle (20.55 cm), number of grains (172.92 $panicle^{-1}$), grain yield (566.67 g sq. m^{-1}) and test weight (14.49 g). 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. This is in agreement with the studies reported by Mahajan et.al 2004, Hardev *et al.,* 2014, Dongarwar *et al.,* 2015, Dongarwar *et al.,* 2018a, Dongarwar *et al.,* 2018b, Kashiwar *et al.,* 2016 and Rajiv *et al.,* 2013.Similar results showing that yield of rice linearly increased with seed density has been reported by Baloch *et al.,* 2002. The plants at low seed population have sufficient space and this enables to utilize more nutrients, water and solar radiation for better photosynthesis. 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, Dongarwar *et al.*, 2018a, Dongarwar *et al.*, 2018b, Kashiwar *et al.*, 2016 and Abou-Khalifa *et al.*, 2014.

Pooled means at ZARS, Sindewahi location (Table 4) revealed that, row spacing T_1- Row spacing 20 cm x plant to plant spacing 15 cm (3939.70 Kg ha^{-1}) recorded significantly higher as well as at par with each other in grain yield followed by T_2- Row spacing 20 x plant to plant spacing 10 cm (3883.23 kg ha^{-1}) and T_3- Row spacing 20 x plant to plant spacing 20 cm (3660.70 kg ha^{-1}) (Table 4). A good number of tillers give a good number of panicles, which is a significant component of the output, which occurs during the vegetative phase, influenced by factors such as the fertilization, water stress, and other farming techniques (Lacharme, 2001, Dongarwar *et al.*, 2018a, Dongarwar *et al.*, 2018b, Kashiwar *et al.*, 2016, Dongarwar *et al.*, 2015).

Pooled mean of KVK, Sakoli(Table 5) indicated that T_2 (2869.73 Kg ha^{-1}) was recorded significantly highest grain yield over all other treatments followed by Treatment T_1 (2671.14 kg ha^{-1}) and T_3 (2287.70 kg ha^{-1}) (Table 5). Treatment T_8-Sowing by broadcasting method (1852.19 kg ha^{-1}) has recorded the lowest pooled mean among all the treatment combinations. Lacharme *et al.*, 2001; Singh *et al.*, 2004; Gala *et al.*, 2011 and Sanogo *et al.*, 2010, Dongarwar *et al.*, 2018a, Dongarwar *et al.*, 2018b, Kashiwar *et al.*, 2016, Dongarwar *et al.*, 2015 also report the relevant results.

Pooled mean from three years of ZARS, Sindewahi and KVK, Sakoli (Table 6) indicated that T_2 (3376.49 Kg ha^{-1}) was recorded expressively highest grain yield over all other treatments followed by Treatment T_1 (3305.46 kg ha^{-1}) and T_3 (2974.21 kg ha^{-1}) (Table 6). Treatment T_8- Sowing by broadcasting method (2496.15 kg ha^{-1}) has recorded the lowest pooled mean among all the treatment combinations. All the treatments combinations with pooled analysis found to be significant throughout the three growing seasons Lacharme *et al.*, 2001, Singh *et al.*, 2004, Gala *et al.*, 2011, Dongarwar *et al.*, 2015, Sanogo *et al.*, 2010, Dongarwar *et al.*, 2018a, Dongarwar *et al.*, 2018b, Kashiwar *et al.*, 2016 also report the relevant results.

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

Particulars	Locations		Method used
	ZARS Sindewahi	KVK, Sakoli	
***p*H**	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^{-1}	221.00	234.00	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 kg ha^{-1}	30.2	25.6	Olsen's method (Jackson,1967)
Available K_20 kg ha^{-1}	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

Particular	Date of sowing	
	Sindewahi	Sakoli
First Year	02/07/2013	08/07/2013
Second Year	02/07/2014	08/07/2014
Third Year	01/07/2015	08/07/2015
	Date of Harvesting:	
First Year	08/11/2013	15/11/2013
Second Year	15/11/2014	19/11/2014
Third Year	10/11/2015	20/11/2015
Previous Crop	Rice	Rice

Table.3 Ancillary characters of Rice as influenced by different treatments

Treatments	**Plant Height (cm)**	**No. of tillers^{-1} m^2**	**No. of effective tillers^{-1} m^2**	**Length of panicle (cm)**	**No. of grains per panicle**	**Grain yield^{-1} m^2 (g)**	Test weight (g)
T_1:Row spacing 20 cm x plant to plant spacing 15 cm	97.47	550.0	351.0	20.60	170.47	500.67	**14.50**
T_2:Row spacing 20 x plant to plant spacing 10 cm	97.0	644.33	390.0	20.55	172.92	566.67	**14.49**
T_3:Row spacing 20 x plant to plant spacing 20 cm	94.20	524.6	295.66	18.40	145.40	383.33	**14.41**
T_4:Row spacing 20 x plant to plant spacing 7 cm	96.20	635.0	321.00	19.0	152.07	416.67	**14.43**
T_5:Row spacing 20 x plant to plant spacing 5 cm	96.33	533.3	326.33	19.07	157.67	433.33	**14.44**
T_6:Drilling of paddy at 20 cm spacing	94.13	744.67	275.33	18.20	141.73	350.0	**14.39**
T_7:Row spacing 25 x plant to plant spacing 25 cm	97.0	520.33	370.66	19.47	167.67	450.0	**14.51**
T_8:Sowing by Broadcasting method	**91.07**	**826.67**	**327.00**	**18.13**	**101.80**	**316.0**	**14.33**

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

Treatments	Grain yield (Kg ha^{-1})			Pooled mean (Kg ha^{-1})
	2013-14	2014-15	2015-16	
T_1:Row spacing 20 cm x plant to plant spacing 15 cm	3792.79	4085.73	3940.80	3939.70
T_2:Row spacing 20 x plant to plant spacing 10 cm	3669.44	4008.64	3971.63	3883.23
T_3:Row spacing 20 x plant to plant spacing 20 cm	3330.25	3868.33	3783.54	3660.70
T_4:Row spacing 20 x plant to plant spacing 7 cm	3438.18	3592.36	3526.06	3518.86
T_5:Row spacing 20 x plant to plant spacing 5 cm	3499.85	3438.18	3430.47	3456.16
T_6:Drilling of paddy at 20 cm spacing	3037.31	3530.68	3359.55	3309.18
T_7:Row spacing 25 x plant to plant spacing 25 cm	3746.53	3484.86	3466.73	3632.70
T_8:Sowing by Broadcasting method	2806	3376.51	3237.75	3140.09
' F ' Test	**Sig**	**Sig**	**NS**	**Sig**
SEm±	192.93	137.03	251.19	100.82
CD at 5 %	585.20	415.65	--	305.83
CV %	9.79	6.42	--	4.89

Table.5 Pooled Mean of Rice grain yield of Rice (Kg ha^{-1}) as influenced by various treatments at KVK Sakoli

Treatments	Grain yield (Kg ha^{-1})			Pooled mean (Kg ha^{-1})
	2013-14	2014-15	2015-16	
T_1:**Row spacing 20 cm x plant to plant spacing 15 cm**	2341.97	2315.0	3356.46	2671.14
T_2:**Row spacing 20 x plant to plant spacing 10 cm**	2477.65	2605.51	3526.06	2869.73
T_3:**Row spacing 20 x plant to plant spacing 20 cm**	1958.06	2025.0	2880.05	2287.70
T_4:**Row spacing 20 x plant to plant spacing 7 cm**	1850.14	2025.0	2880.05	2251.73
T_5:**Row spacing 20 x plant to plant spacing 5 cm**	1853.22	1887.30	2784.46	2174.99
T_6:**Drilling of paddy at 20 cm spacing**	1939.56	1888.49	2782.92	2203.65
T_7:**Row spacing 25 x plant to plant spacing 25 cm**	1905.64	1954.62	2207.46	2022.57
T_8:**Sowing by Broadcasting method**	1794.64	1830.10	1931.85	1852.19
' F ' Test	**Sig**	**Sig**	**Sig**	**Sig**
SEm±	94.92	73.86	135.62	61.11
CD at 5 %	287.91	224.04	411.38	185.38
CV %	8.16	6.22	8.41	4.62

Table.6 Pooled mean of Rice grain yield (Kg ha^{-1}) as influenced by different treatments at both locations (Sakoli and Sindewahi)

Treatments	Grain yield (Kg ha^{-1})		Pooled mean (Kg ha^{-1})
	Sindewahi	Sakoli	
T_1:Row spacing 20 cm x plant to plant spacing 15 cm	3939.77	2671.14	3305.46
T_2:Row spacing 20 x plant to plant spacing 10 cm	3883.23	2869.73	3376.49
T_3:Row spacing 20 x plant to plant spacing 20 cm	3660.70	2287.70	2974.21
T_4:Row spacing 20 x plant to plant spacing 7 cm	3518.86	2227.85	2873.36
T_5:Row spacing 20 x plant to plant spacing 5 cm	3456.16	2174.99	2815.58
T_6:Drilling of paddy at 20 cm spacing	3309.18	2203.65	2756.42
T_7:Row spacing 25 x plant to plant spacing 25 cm	3632.70	2022.57	2827.64
T_8:Sowing by Broadcasting method	3140.09	1852.19	2496.15
' F ' Test	**Sig**	**Sig**	**Sig**
SEm±	100.82	61.11	56.64
CD at 5 %	305.83	185.38	171.80
CV %	4.89	4.62	3.35

Table.7 Gross Monetary Returns (INR ha^{-1}) of drilled rice as influenced by different spacing at Sindewahi and Sakoli during 2013-14, 2014-15 and 2015-16

Treatments	2013-2014		2014-2015		2015-2016		Pooled GMR ha^{-1}
	SKL	SYE	SKL	SYE	SKL	SYE	
T_1:**Row spacing 20 cm x plant to plant spacing 15 cm**	35772	68270	41670	73543	60416	70934	60550
T_2:**Row spacing 20 x plant to plant spacing 10 cm**	36216	66050	44124	72155	58140	70795	61857
T_3:**Row spacing 20 x plant to plant spacing 20 cm**	35245	59944	36450	69630	54616	68103	54527
T_4:**Row spacing 20 x plant to plant spacing 7 cm**	33302	61887	35244	64662	57308	63469	52669
T_5:**Row spacing 20 x plant to plant spacing 5 cm**	33358	62997	33582	61887	55837	61748	51570
T_6:**Drilling of paddy at 20 cm spacing**	34912	54971	35658	63552	55726	60471	50491
T_7:**Row spacing 25 x plant to plant spacing 25 cm**	34301	57437	37374	66327	55445	62401	51835
T_8:**Sowing by Broadcasting method**	32303	50508	33576	60777	54199	58279	45649
F Test	NS	SIG	SIG	NS	SIG	NS	SIG
SEm±	1314.0	3472	637.8	24.66.6	2002.1	4515.4	1034.79
CD at 5%	--	10533	1934.8		6072.8	--	3138.70
CV%	--	9.79	3.97		6.14	--	3.34

Table.8 NMR (INR ha^{-1}) and B: C Ratio of drilled rice as influenced byDifferent spacing at Sindewahi and Sakoli during 2013-14, 2014-15 and 2015-16

Treatments	2013-2014		2014-2015		2015-2016		Pooled NMR ha^{-1}	B:C Ratio
	SKL	SYE	SKL	SYE	SKL	SYE		
T_1:Row spacing 20 cm x plant to plant spacing 15 cm	3372.4	35870	9270	41143	28016	38534	28150	1.86
T_2:Row spacing 20 x plant to plant spacing 10 cm	3816.4	33650	11724	39755	25740	38395	29452	1.91
T_3:Row spacing 20 x plant to plant spacing 20 cm	2845	27544	4050	37230	22216	35703	22132	1.69
T_4:Row spacing 20 x plant to plant spacing 7 cm	902	29487	2844	32262	24908	31069	20254	1.61
T_5:Row spacing 20 x plant to plant spacing 5 cm	958	30597	1182	29487	23437	29348	19150	1.61
T_6:Drilling of paddy at 20 cm spacing	2512	22271	3258	31152	23059	28071	18057	1.55
T_7:Row spacing 25 x plant to plant spacing 25 cm	1901	35037	4974	33927	23045	30001	19445	1.61
T_8:Sowing by Broadcasting method	503	18708	1776	28977	22399	26479	13619	1.45
F Test	NS	SIG	SIG	SIG	NS	NS	SIG	
SEm±	1314	3472.7	637.8	2466	1992	4515	1034.79	-
CD at 5%	-	10533.5	1937.8	7481	-	-	3178.70	-
CV%	-	20.64	22.68	12.48	-	-	8.42	-

Economic trait

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(Table 7), T_2 recorded the highest GMR with 61857 INR ha^{-1}, in the same combination Net monetary return was also noticed higher with 29452 INR ha^{-1} with the B:C Ratio of 1.91 (Table 8). Whereas other combinations were not up to the mark for recommendations. This is in agreement with the studies reported by Huang *et al.,* 2013, Mehala *et al.*, 2016, Dongarwar *et al.,* 2015, 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, Dongarwar *et al.*, 2018a, Dongarwar *et al.*, 2018b, Kashiwar *et al.,* 2016 and Mazher *et al.,* 2017. The cost of cultivation of entire combinations has shown the normal phenomenal results of cultivars as the row spacing increases the cost of cultivations also increases. 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 *et al.,* 2011 and Dongarwar *et al.,* 2015 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, the Row spacing 20 x plant-to-plant spacing 10 cm has recommended. This is in agreement with the studies reported by Dongarwar *et al.*, 2015, Husaain *et al.*, 2013, Awan *et al.*, 2005, Kumar *et al.*, 2011, Iqbal *et al.,* 2015, Seharawat *et al.*, 2010, Gangawar *et al.,* 2008, Sidhu *et al.*, 2014, Dongarwar *et al.,* 2018a, Dongarwar *et al.,* 2018b and Kashiwar *et al.,* 2016.

The study led to the conclusion that, to get the highest grain yield, Gross monetary returns and net monetary returns from drilled rice in Eastern Vidarbha Zone of Maharashtra the sowing of drill rice at row spacing of 20 cm and plant-to-plant spacing of 10 cm must be adopted for increasing yield.

References

Abou Khalifa A A., ELkhoby, W., and Okasha, E. M. 2014. Effect of sowing dates and seed rates on some rice Cultivars. African Journal of Agricultural Research. 9 (2): 196-201

Abuzar M.R., Sadozai G.U., Baloch M.S., Shah A.A., Javaid T., and N. Hussain N., Effect of plant population densities on yield of maize, *The J. of Ani. and Plant Sci*., 21(4), 692-695 (2011)

Akbar N. and Ehsanullah. 2004. Agro-Qualitative Responses of Direct Seeded Fine Rice to Different Seeding Densities, *Pak. J. of Agric*. Sci., 41, 1-2.

Annual Maharashtra State Rice Workshop Progress Report, 4-5 March, 2014 pp. 12.

Awan, T. H., I. Ali, C. M. Anwar, G. M. Sarwar, C. M. Ahmad, Z. Manzoor and M. Yaqub (2005). Economic effect of different plant establishment techniques on rice production. In Proc. Int. Seminar on Rice Crop, RRI, KSK, Lahore, Punjab- Pakistan. 2-3, October 2005. Pp: 226- 231.

Baloch A.W., Soomro A.M., Javed M.A. and

Ahmed M., Optimum plant density for high yield in rice, *Asian J. Plant Sci.,* 1, 25–27 (2002)

Chauhan BS, Singh VP, Kumar A and Johnson DE. 2011. Relations of rice seeding rates to crop and weed growth in aerobic rice. *Field Crops Research* 121: 105-115.

Dongarwar, U. R., Khedikar, G. R., Kashiwar S. R., and Dongarwar L., 2015, Effect of different Organic Sources Available with Farmers on Paddy (Oryza sativa) in Bhandara District of Maharashtra, Journal of Agricultural Engineering and Food Technology, 2 (2), 142-144.

Gala B, Camara Y, Keli Z (2011). Rentabilités des engrais minéraux en riziculture pluvial de plateau cas de la zone de Gagnoa dans le centre ouest de la cote d'ivoire. J. Appl. Biosci. 46:3153-3162

Gangwar, K.S., Tomar. O.K. and Pandey D.K. 2008. Productivity and economics of transplanted and direct-seeded rice (Oryza sativa)-based cropping systems in Indo-Gangetic plains. Indian J. Agric. Sci. 78: 655-58.

Gill M.S., Ashwini K. and Pardeep K. 2008. Growth and yield of rice (*Oryza sativa*) cultivars under various methods and times of sowing. Indian Journal of Agronomy. 51(2): 123-127.

Gupta R K, Ladha J K, Singh S, Singh R G, Jat M L, Saharawat Y, Singh V P, Singh S S, Singh G, Sah G, Gathala M, Sharma R K, Gill M S, Alam Murshad, Mujeeb Ur Rehman Hafiz, Singh U P, Mann, Riaz A Pathak, Chauhan H, Bhattacharya B S and Malik P R K. 2006. Production Technology for direct seeded rice. *Rice- Wheat Consortium for the Indogangetic Plains*, pp 16. New Delhi.

Hardev, R. Singh, J. P. Bohra, J. S. Singh K. R. and Sutaliya, J. M. 2014. Effect of seedling age and plant spacing on growth, yield, nutrient uptake and economics of rice genotypes under system of rice intensification. Indian J. Agron., 59 (2): 256-260.

Huang, H.-P., S.-M. Ma, E.-D. Lin, *et al.*, 2013: Benefits comparison analysis of different rice and wheat cropping patterns to adapt to climate change. Adv. Clim. Change Res., 4(3), *doi*:*10.3724/SP.J.1248.2013.182*.

International Rice Research Institute (IRRI). 2008. Rice Production Training Module: Method of Planting Rice. IRRI, Los Barios, Laguna, Philippines. pp. 1-13.

Iqbal., M. F., Hussain, M., Waqar, M. Q., and Ali., M. A. 2015. Effect of sowing methods on disease of paddy. Int. J. Adv. Mutli-discip. Res. 2(10):4-7.

Jackson, M.L., 1973. Soil Chemical Analysis. Printice Hall Inc. Engiewood Cliffs. N. J. U.S.A.

Jehangir, W. A., Masih, I., Ahmed, S., Gill, M. A., Ahmad, M., Mann, R. A, Chaudhary, M. R., and Turral, H.2005. Sustaining crop water productivity in rice-wheat systems of South Asia: a case study from Punjab Pakistan. In: Draft Working Paper. Inter. Water Manag. Ins. Lahore, Pakistan.

Kahloon, M.H., M.F. Iqbal, M. Farooq, L. Ali, M. Fiaz and I. Ahmad. 2012. A comparison of conservation technologies and traditional techniques for sowing of wheat. J. Anim. Plant Sci. 3: 827-830.

Kashiwar, S. R., Kumar, D., Dongarwar, U. R., Mondal, B., and Nath, T. 2016. Experiences, challenges and Opportunities of Direct Seeded Rice in Bhandara District of Maharashtra. Journal of Energy Research and Environmental Technology (3) 2: 141-145

Kenneth and Ronnie S. Halms, Seeding rate effect on rough rice yield, head rice and total milled rice, *Agron. J.*, 88, 82-84 (1996)

Kumar, V. and Ladha, J. K. 2011. Direct seeding of rice: Recent developments and future research needs. Adva. Agro. 111: 297-413.

Lacharme M (2001). «Fascicule2» le plant de riz: données morphologiques et cycle de la plante. Memento technique de riziculture: 22 p.

Mahajan G, Chauhan B S and Johnson D E. 2009. Weed management in northwestern Indo-Gangetic Plains. *Journal of Crop Improvement* 23: 366–82.

Mahajan G, Sardana V, Brar AS and Gill MS. 2006. Effect of seed rates, irrigation intervals and weed pressure on productivity of direct-seeded rice (*Oryza sativa*). *Indian Journal of Agricultural Science* 76 (12):756-759.

Mahajan, G. Sardana, V. Brar, A. S. and Gill, M. S. 2004. Grain yield comparison among rice (Oryza sativa L.) varieties under direct seeding and transplanting. Haryana J. Agron., 20 (1/2):68-70.

Mazher Farid Iqbal, Muzzammil Hussain and Abdul Rasheed. (2017). Direct seeded rice: purely a site specific technology. Int. J. Adv. Res. Biol. Sci. 4(1): 53-57. DOI: http://dx.doi.org/10.22192/ijarbs.2017.04.01.006

Mehala Vinay, *et al.*, (2016) Impact of Direct Seeded Rice on Economics of Paddy Crop in Haryana. International Journal of Agriculture Sciences, Volume 8, Issue 62, pp.-3525-3528.

Miller B.C., Hill J.E. and Roberts S.R., Plant population effects on growth and yield in water seeded rice, *Agron. J*., 83, 291-297 (1991)

Naresh R.K.; Gupta Raj K.; Singh B.; Kumar Ashok; Shahi U.P.; Pal Gajendra;Singh,Adesh; Yadav Ashok Kumar;and Tomar S.S.2010. Assessment of No-Tillage and Direct Seeding Technologies in rice-wheat rotation for Saving of Water and Labor in Western IGP. Progr. Agri. Int. J. 10 (2): 205- 218.

Pingali, P.L. and Rosegrant, M.W. 1994. Confronting the environmental consequences of the green revolution. *In: Proceedings of the 18th Session of the international Rice Commission*, Rome. FAO, Rome, Italy, pp. 59-69

Piper C. S., 1966. Soil and plant analysis. Hans publishers, Bombay. 368.

Prasad, M.K., S.B. Singh, J.M Singh and RP. Sinha. 1999. Effect of seeding method, seed rate and nitrogen splitting on yield attributes of direct seeded rice. Ind. J. App. Bio. 9(1): 55-57.

Rajiv, S. K. 2013. Response of basmati (*Oryza sativa L*.) rice varieties to system of rice intensification (SRI) and conventional methods of rice cultivation. Ann. Agric. Res.,34 (1): 50-56.

Rao, A.N., Johnson, D.E., Shivaprasad, B., Ladha, J.K. and Mortimer, A.M. 2007. Weed management in direct-seeded rice. Adv. Agro. 93: 153-255.

Sanjitha Rani T. and Jayakiran K.2010.Evaluation of different planting techniques for economic feasibility in Rice. Elec. J. Envir. Agri. Food Chem. 9 (1):150-153.

Sanogo S, Camara M, Zouzou M, Keli Z, Messoum F, Sekou A (2010). Effets de la fertilisation minérale sur des variétés améliorées de riz en condition irriguée à Gagnoa, Côte d'Ivoire. J. Appl. Biosci. 35:2235-2243.

Seharawat, Y.S., Bhagat Singh, Malik, R.K., Ladha, J. K., Gathala, M., Jat, M.L. and Kumar, V. 2010. Evaluation of alternative tillage and crop establishment methods in a rice–wheat rotation in North Western IGP. Field Crops Res., 116: 260- 267.

Sharma. A. R. 1992. Effect of varying seed rates and transplanting colonel tillers on the performance of rice under intermediate deepwater conditions (0-80 cm). Journal of Agricultural Science. 119(2): 171- 177

SIDHU, A. S., KOONER, R. and VERMA, A. 2014. On-farm assessment of direct-seeded rice production system under central Punjab conditions. Journal of Crop and Weed, 10 (1): 56-60

Singh RK and Namdeo KM 2004. Effect of fertility levels and herbicides on growth, yield and nutrient uptake of direct seeded rice. Indian journal of Agronomy 49(1): 34-36.

Singh S, Ladha J K, Gupta R K, Bhushan L and Rao A N. 2008. Weed management in aerobic rice systems under varying establishment methods. *Crop Protection* 27: 660–9.

Singh Samar, Sharma R K, Govindra Singh, Singh S S, Singh U P, Gill M A, Jat M L, Sharma S K, Malik R K, Josan A S and Gupta R K. 2005. *Direct Seeded Rice: A Promising Resource Conserving Technology*. Rice-Wheat Consortium for the Indo- Gangetic Plains, New Delhi.

Singh, S.P. Sreedevi, B. Kumar, R.M. and Subbaiah, S.V. 2008. Grain yield and economics of wet direct sown rice under different establishment methods and nitrogen schedules. Oryza 45 (3):245-246.

Singh, Y. P. Singh, G. Singh, S. P. Kumar, A. Sharma, G.; Singh, M.K. Mortin, M. and Johnson, D. E. 2006. Effect of weed management and crop establishment methods on weed dynamics and grain yield of rice.Indian J. Weed Sci., 38 (1 and 2):20-24.

Sivaesarajah K., Sangakkara U.R. and Sandanam S., Effect of plant density, nitrogen and gypsum on yield parameters of groundnut (*Arachis hypogea* L.) in regosols of Batticloa district, *Trop. Agric. Res.*, 7, 112- 123 (1995)

Subbaiah S. V., Balasubramanian V. and Krishnaiah K. 2002. Evaluation of drum seeder in puddle rice fields. AMA, Agricultural Mechanization in Asia, Africa and Latin America. 33(4): 23-26.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soil.Curr. Sci. 25: 259.

Usha R. Dongarwar, Nitin Patke, L.N. Dongarwar and Sumedh R. Kashiwar. 2018**a**. Influence of Different Fertilizer doses on Growth, Yield and Economics of Direct Seeded Rice in Eastern Vidharbha Zone of Maharashtra, India, India. *Int.J.Curr.Microbiol.App.Sci.* Special Issue-7, 3837-3845.

Usha R. Dongarwar, Nitin Patke, L.N. Dongarwar and Sumedh R. Kashiwar. 2018**b**. Impact of Different Seed Rates on Yield and Economics of Direct Seeded Rice in Eastern Vidharbha Zone of Maharashtra, India. *Int.J.Curr.Microbiol.App.Sci.* 7(03): 32-42. doi: https://doi.org/10.20546/ijcmas.2018.703.004

Younas, M., Rehman, M. A., Hussain, A., Ali, L., and Waqar, M. Q. 2016. Economic Comparison of Direct Seeded and Transplanted Rice: Evidences From Adaptive Research Area of Punjab Pakistan. Asian J Agri Biol, 2016, 4(1): 1-7.

Yoyock J.Y., Effects of variety and spacing on growth, development and dry matter distribution in groundnut at 2 locations in Nigeria, *Exp. Agric.*, 15, 339-351 (1979)

How to cite this article:

Usha R. Dongarwar, Nitin Patke, L.N. Dongarwar and Sumedh R. Kashiwar. 2018. Effect of Row Spacing on Growth, Yield and Economics of Direct Seeded Rice in Eastern Vidharbha Zone of Maharashtra, India. *Int.J.Curr.Microbiol.App.Sci.* 7(07): 2930-2941.
doi: https://doi.org/10.20546/ijcmas.2018.707.343