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Effect of crop establishment methods and irrigation scheduling on growth and yield of direct dry seeded rice

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Abstract
Field experiment was conducted at Soil and Water Management Research Institute, Kattuthottam, Thanjavur during *kharif* season (July - October) of 2018 to study the effect of crop establishment methods and irrigation scheduling on growth and yield of direct dry seeded rice. The experiment was laid out in split plot design with three replications. The treatments comprised of two different crop establishment methods *viz*., Raised bed with manual sowing (M_1), Flat bed with manual sowing (M_2) in main plots and six irrigation scheduling in sub plots *viz.*, Irrigation on the day of disappearance of ponded water (I_1), Irrigation at 1 day after disappearance of ponded water (I_2), Irrigation on 3 days after disappearance of ponded water (I_3), Irrigation on 5 days after disappearance of ponded water (I_4), Irrigation on 7 days after disappearance of ponded water (I_5), Irrigation on 9 days after disappearance of ponded water (I_6).It was found that raised bed panting with manual sowing (M_1) recorded significantly higher plant height, number of productive tillers m^{-2}, number of grains $panicle^{-1}$ than flat bed planting with manual sowing (M_2). But, there was no significant yield (kg/ha) difference between the raised bed and flat bed planting methods. Among the different irrigation treatments, irrigation on the day of disappearance of ponded water recorded highest grain and straw yield.

Keywords: Direct dry seeded rice, raised bed, flat bed, growth, yield, DADPW

Introduction
Rice is traditionally grown as transplanted crop in puddled condition, which is labour, water and energy intensive. The reason for low profitability of rice cultivation is increased cost of cultivation and water scarcity. A shortage of labour during peak periods increase labour wages and makes the operation costly. DSR is a resource conserving technology as it reduce water consumption by about 30% as it eliminates raising of seedlings in a nursery, puddling, transplanting under puddled soil. On the other hand, it also reduces the labour required for these operations. It matures earlier (7-10 days) than the transplanted crop due to the absence of transplanting shock, higher tolerance to water deficit, lesser methane emissions, and often higher profit in areas with assured water supply.

The method of establishment is one of the cultural practices, which influences growth and development of the rice crop. The better germination of seeds in bed sowing compared to that of flat sowing might be attributed to the availability of more volume of loose soil and almost uniform moisture conditions to all seeds sown on beds. Raised bed system having the benefits of fewer weeds, facilitates seeding into relatively dry soils, vigorous and better crop stands, better drainage increases crop yield by 10- 20%, saved 30-40% of irrigation water, reduced seed rate and reduced production cost over the conventional system (BARI, 2006) [1] and also promotes crop intensification and diversification.

Rice production is known to be less water efficient as it requires 4000- 5000 litres of water to produce 1 kg of rice. Hence to increase the water use efficiency, irrigation is given after the disappearance of ponded water. Several studies have shown that irrigation after disappearance of ponding water saved 33.3% irrigation water without affecting the grain yield significantly (Chandra, 2008) [3]. There was no significant difference in yield between continuous submergence throughout the crop season and one day after disappearance of ponded water (DADPW) (Parihar, 2004) [8]. Keeping these aspects in view, the present study was taken up on "Effect of crop establishment methods and irrigation scheduling productivity of direct dry seeded rice".

Materials and methods
The field experiment was conducted during *kharif* 2018 at Soil and Water Management Research Institute, kattuthottam, Thanjavur.

The experimental field was located in New Cauvery Delta Zone of Tamil Nadu geographically at 10° 45'N latitude, 79 °E longitude with an altitude of 50 m above mean sea level. The soil of the experimental site was sandy loam in texture with neutral pH (6.6), EC (0.13 dSm^{-1}) and medium organic carbon (0.58%), With regard to nutrient status, the soil was low in available nitrogen (215 kg ha^{-1}), medium in phosphorus (22 kg ha^{-1}) and medium in potassium (112 kg ha^{-1}), respectively.

The experiment was laid out in split plot design with three replications. The treatments comprised of two different crop establishment methods *viz*., Raised bed with manual sowing (M_1), Flat bed with manual sowing (M_2) in main plots and six irrigation scheduling in sub plots *viz.*, Irrigation on the day of disappearance of ponded water (I_1), Irrigation on 1 day after disappearance of ponded water (I_2), Irrigation on 3 days after disappearance of ponded water (I_3), Irrigation on 5 days after disappearance of ponded water (I_4), Irrigation on 7 days after disappearance of ponded water (I_5) and Irrigation on 9 days after disappearance of ponded water (I_6). The regular common irrigation practice was followed till 30 DAS for proper establishment. After 30 DAS, the irrigation treatments were imposed as per the treatment schedule. Irrigation water was applied through Parshall flume and its quantity was measured. The short duration rice variety ADT 45 was used as the test variety with seed rate of 60 kg ha^{-1}. The recommended dose of 150:50:50 kg ha^{-1} of nitrogen, phosphorus and potassium in the form of Urea (46% N), Single Super Phosphate (16% P_2O_5) and Muriate of Potash (60% K_2O) were applied. Pendimethalin (1 kg a.i/ha) was applied as pre emergence herbicide at 3 DAS, while Bispyribac sodium (25 g a.i/ha) was applied as early post emergence herbicide at 15 DAS and one hand weeding was given at 30 DAS. In order to evaluate the effect of crop establishment methods and irrigation scheduling practices on growth and yield parameters, the data were statistically analyzed using "Analysis of variance test". The critical difference at 5% level of significance was calculated to find out the significance of different treatments over each other.

Result and discussion

Plant height

Plant height is an important trait for growth and increased plant height would allow greater biomass production and yield potential in rice. Thus, crop establishment methods and irrigation scheduling have significantly influenced the growth parameters of rice. Raised bed with manual sowing (M_1) recorded the taller plants in all the stages as shown in Table. 1. Raised bed provides good anchorage to the crop and thus induces plant to grow taller. Flat bed with manual sowing (M_2) recorded shorter plants in all stages. This is because flat bed showed signs of surface crusting, which reduced plant emergence compared with the beds. The results were found in accordance with Beecher *et al.* (2006) [2].

Table 1: Effect of crop establishment methods and irrigation scheduling on Plant height (cm) of direct seeded rice.

Treatments	Plant height (cm)											
	At Active Tillering				At Flowering				At Maturity			
	M_1	M_2		Mean	M_1	M_2		Mean	M_1	M_2		Mean
I_1	43.8	42.1		43.0	97.1	92.7		94.9	107.5	100.8		104.1
I_2	41.6	38.9		40.3	90.7	87.5		89.1	97.8	93.9		95.8
I_3	38.2	36.9		37.5	85.0	81.5		83.3	93.2	87.9		90.5
I_4	38.2	32.0		35.1	77.0	72.3		74.7	85.0	79.4		82.2
I_5	35.4	30.5		33.0	69.0	67.9		68.5	74.7	72.6		73.6
I_6	29.8	27.6		28.7	66.2	59.3		62.7	70.0	63.0		66.5
Mean	37.8	34.7			80.8	76.9			88.0	82.9		
	M	I	M at I	I at M	M	I	M at I	I at M	M	I	M at I	I at M
SEd	0.55	0.67	1.26	0.95	0.90	0.85	1.74	1.20	1.14	0.84	1.92	1.18
CD (p=0.05)	2.39	1.40	3.44	1.98	3.88	1.77	5.18	2.50	4.91	1.74	6.26	2.47

Among different irrigation scheduling, irrigation on the day of disappearance of ponded water (I_1) produced taller plants. This might have stimulated and increased activity of meristematic cells and cell elongation of internodes resulting in higher growth rate of stem in turn promoting the plant height (Chowdhury *et al*. 2014 [4]. Irrigation on 9 days after disappearance of ponded water produced the shorter plants. This might be due to water stress imposed at any growth stage of rice before anthesis significantly reduced the plant height was reported by Sariam and Anuar (2010) [10]. Among interactions, raised bed with manual sowing along with irrigation on the day of disappearance of ponded water (M_1I_1) recorded taller plants (43.8, 97.4, 102.8 at active tillering, flowering and maturity stage respectively)followed by flatbed with manual sowing along with irrigation on the day of disappearance of ponded water (42.1,92.7, 100.8 at active tillering, flowering and maturity stage respectively) and shorter plants (27.6, 59.3 and 63 at active tillering, flowering and maturity stage respectively) were produced under flat bed with manual sowing along with irrigation on 9 days after disappearance of ponded water (M_2I_6).

Number of tillers m^{-2}

Tillering is the most key growth character of rice cultivars. In general, tiller production starts slowly in the beginning, increases steadily and attains to its peak and then started to decline as the age of the crop advances. Raised bed with manual sowing (M_1) recorded the higher number of tillers m^{-2}(225, 273 and 264 at active tillering, flowering and maturity stage respectively). This might be due to increased plant height and LAI increased the photosynthetic activity which in turn paved the way for increased tiller production. Higher number of tillers were produced with decreased plant density. Flat bed with manual sowing (M_2) recorded less number of tillers m^{-2} (204, 243 and 236 at active tillering, flowering and maturity stage respectively). This might be due to reduced plant height and LAI. This findings was in line with Mirza *et al*., (2009) [6].

Table 2: Effect of crop establishment methods and irrigation scheduling on number of tillers m^{-2} in direct seeded rice.

Treatments	Number of tillers m^{-2}											
	At Active Tillering				At Flowering				At Maturity			
	M_1	M_2		Mean	M_1	M_2		Mean	M_1	M_2		Mean
I_1	309	282		296	369	338		354	358	329		344
I_2	281	268		275	351	311		331	339	304		322
I_3	252	231		242	298	274		286	292	268		280
I_4	211	194		202	254	231		242	246	223		234
I_5	167	132		150	206	165		186	197	156		177
I_6	131	118		125	159	141		150	152	133		143
Mean	225	204			273	243			264	236		
	M	I	M at I	I at M	M	I	M at I	I at M	M	I	M at I	I at M
SEd	2.4	3.3	6.0	4.7	3.9	4.1	8.0	5.8	3.1	3.6	6.9	5.1
CD (p=0.05)	10.1	7.0	15.6	9.8	16.6	8.5	22.9	12.1	13.3	7.6	19.0	10.7

Among different irrigation scheduling, irrigation on the day of disappearance of ponded water (I_1) recorded higher number of tillersm^{-2} (296, 354, and 344at active tillering, flowering and maturity stage respectively). This was due to better water availability facilitated higher uptake of nutrients and other resources which is responsible for vigorous crop growth. This was in concordance with Rolaniya *et al*., (2015) [9]. Irrigation on 9 days after disappearance of ponded water (I_6) recorded less number of tillers m^{-2} (125, 150, and 143 at active tillering, flowering and maturity stage respectively). This might be due to increased water stress reduced the photosynthetic rates, thus resulted in lower number of tillers. Among interactions, raised bed with manual sowing along with irrigation on the day of disappearance of ponded water (M_1I_1) recorded more number of tillers and flat bed with manual sowing along with irrigation on 9 days after disappearance of ponded water (M_2I_6) recorded lower number of tillers m^{-2}.

Grain and straw yield

Crop establishment methods and irrigation scheduling have significantly influenced the grain and straw yield of rice and are shown in Table.3. Crop establishment methods did not show significant difference in yield. Grain and straw yield was found to be higher in flat bed with manual sowing (M_2) due to better vegetative growth, nutrient utilization, root growth, increased number of productive tillers m^{-2} and filled grains $panicle^{-1}$ over raised bed sowing (M_2). This was found to be in accordance with Ockerby and Fukai (2001) [7].

Table 3: Effect of crop establishment methods and irrigation scheduling on grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) of direct seeded rice.

Treatments	Grain yield (kg ha^{-1})				Straw yield (kg ha^{-1})				Harvest index			
	M_1	M_2		Mean	M_1	M_2		Mean	M_1	M_2		Mean
I_1	5281	5529		5405	5869	6269		6069	0.47	0.47		0.47
I_2	4632	4850		4741	5206	5437		5322	0.47	0.47		0.47
I_3	3976	4215		4096	4437	4839		4638	0.47	0.47		0.47
I_4	3256	3432		3344	3796	4024		3910	0.46	0.46		0.46
I_5	2628	2781		2705	3328	3524		3426	0.44	0.44		0.44
I_6	1048	1195		1121	1299	1481		1390	0.45	0.45		0.45
Mean	3637	3834			3989	4262			0.46	0.46		
	M	I	M at I	I at M	M	I	M at I	I at M	M	I	M at I	I at M
SEd	53	67	101	94	64	77	118	109	0.009	0.014	0.025	0.020
CD (p=0.05)	NS	139	NS	NS	NS	160	NS	NS	NS	NS	NS	NS

Among different irrigation treatments, irrigation on the day of disappearance of ponded water recorded higher grain (5405 kg ha^{-1}) and straw yield (6069kg ha^{-1}). This might be due to the availability of water throughout the cropping period leads to better growth and yield attributes with high fertility percentage thereby increased rice yield (Majeed *et al.* 2017) [5]. The yield reduction of 50% and 79% was recorded in irrigation on 7 days and 9 days after disappearance of ponded water over irrigation on the day of disappearance of ponded water. Irrigation on 9 days after disappearance of ponded water recorded the lowest grain (1121 kg ha^{-1}) and straw yield (1390 kg ha^{-1}). This yield loss might be due to unavailability of water during critical growth stages and also failed to meet evaporation and transpiration loss.

Conclusion

Both the establishment methods raised bed with manual sowing and flat bed with manual sowing were on par. Among the different irrigation treatments, irrigation on the day of disappearance of ponded water recorded highest grain and straw yield. With holding irrigation beyond 7 days after disappearance ponded water reduced more than 50% yield over irrigation on the day of disappearance of ponded water.

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