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Influence of different establishment methods and irrigation management practices on morphological and yield parameters in rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted to know the effect of influence of different establishment methods and irrigation management on morphological and yield parameters in rice (*Oryza sativa* L.) at Agricultural Research Station Dhadesugur, during *kharif* 2017. The experiment was laid out in a split plot design and treatments were replicated thrice. Rice plants were grown under three establishment methods *viz.*, transplanted rice, direct seeded rice (DSR), and system of rice intensification (SRI) with different irrigation management practices *viz.*, Alternate wetting and drying (AWD), critical stage approach, continuous saturation and Farmers irrigation practice. Morphological parameters *viz.*, plant height, number of tillers per hill, LAI (leaf area index), dry matter accumulation in different plant parts recorded significantly higher values in SRI method of rice establishment where as DSR recorded significantly lower morphological parameters. AWD irrigation practise have been reported with higher plant height (98.25 cm), number of tillers per hill (19.53), dry matter accumulation (78.93 g $hill^{-1}$) and LAI (6.93). Higher values of yield parameters *viz.*, higher number of productive tillers per hill (13.93), panicle length(22.72 cm), test weight (23.95 g), number of grains per panicle (149.92), grain yield (5096.97 kg ha^{-1}) and straw yield of rice (5711.42 kg ha^{-1}) was noticed in SRI method of rice establishment where as lower values were recorded in DSR at harvesting stage. Alternate wetting drying was found more significant on no. of productive tillers per hill (14.16), Panicle length (22.62 cm), test weight (23.81g), no. of grains per panicle (150.67), grain yield (4985.70 kg ha^{-1}) and straw yield of rice (5488.56 kg ha^{-1}), while lower values were recorded with critical stage irrigation approach at harvesting stage.

Keywords: SRI, AWD, establishment methods, irrigation management practice and LAI

Introduction
Rice (*Oryza sativa* L) is an important staple food crop of many countries. World acreage under rice cultivation is 158.8 million hectare with a production of 751.9 million tonnes (mt) (FAO, 2017) [5]. In India, rice is grown in an area of 43.95 m ha with an annual production of about 106.54 mt and the productivity is about 2.37 tonnes per ha (Anon., 2017) [1].
Transplanting is the major method of rice cultivation in India. However, transplanting is becoming increasingly difficult due to scarcity of water and reduced profit. The System of Rice Intensification (SRI), a revived method of transplanted rice cultivation by exploiting the genetic potential of rice provides a favourable growing environment to increase the productivity. Besides, it enhances soil health with reduction in input use such as seeds, water, *etc* (Gujja and Thiyagarajan, 2009) [7]. Direct seeding of rice refers to the process of establishing the crop from seeds sown in the field rather than by transplanting seedlings from the nursery (Farooq *et al*., 2011) [6]. Direct seeding avoids three basic operations, namely, puddling a process where soil is compacted to reduce water seepage, transplanting and maintaining standing water.
Continuous flooding is the commonly used practice in traditional irrigation for rice production, but is now regarded as water consuming. Quite often water is very uneven in distribution, either in excess or not sufficient. One of the most commonly practiced water saving irrigation (WSI) techniques is AWD. In AWD, water is applied to irrigate the field depending on the weather condition or until some fine cracks appear on the soil surface. AWD is an irrigation technique where water is applied to the field a number of days after disappearance of ponded water. Keeping all the above view in mind, experiment was conducted to study the effect of different establishment methods and irrigation management on morphological parameters of rice.

Material and methods
A field experiment was carried out at Agricultural Research Station Dhadesugur, during *kharif* 2017. It is situated in Northern Dry Zone (Zone-3) of Karnataka at

15^{0}46″ N latitude and 76^0 45 ″ E longitude with an altitude of 358 m above mean sea level. The soil of the experimental site is medium deep black and clayey in soil texture. The experiment was laid out in a split plot design and treatments were replicated thrice. Treatment includes three establishment methods *viz.*, transplanted rice, direct seeded rice (DSR), and system of rice intensification (SRI) with different irrigation management practices namely Alternate wetting and drying (AWD), critical stage approach, continuous saturation and farmers irrigation practice.

The morphological parameters *viz*., plant height, no. of tillers, leaf area index, dry matter accumulation in leaf, stem and panicle were recorded at different growth stages of rice crop. Yield and yield attribute i.e number of productive tillers per hill, panicle length, test weight, grains per panicle, grain yield, straw yield at harvest. LAI was worked out by the formula given by Watson (1952) [13].

Result and discussion

Morphological parameters

Among the different establishment methods of rice cultivation SRI method recorded higher plant height (99.89 cm) as compared to transplanting (96.96 cm) and direct seeded rice (87.84 cm) at harvest (Table 1.). AWD irrigation practice recorded higher plant height (98.25 cm) compared to critical stage approach (92.49 cm), farmers practice (94.72 cm) and continuous saturation irrigation (92.25 cm) at harvest (Table 1). Increased length of internode and plant height might be due to better plant water content, higher chloroplast and photosynthetic activity (Kobata and Takami, 1983; Packiaraj and Venkatraman, 1991) [8, 9].

Among different establishment methods SRI method recorded higher Number of tillers per plant (19.53) compared to transplanting (17.51) and direct seeded rice (15.21) at harvest. AWD irrigation practice recorded higher Number of tillers per plant (18.95) compared to critical stage approach (15.79) and farmers practice (17.63) at harvest. Increase in the no. of tllers per hill with SRI method may be due to less trauma to the root system and the plants recover from the shock of transplanting more quickly which preserve the potential of the plant for much greater tillering. Among different establishment methods SRI method recorded higher Leaf area index (7.94) compared to transplanting (6.62) and direct seeded rice (4.60) at 90 DAS. AWD irrigation practice recorded higher Leaf area index (7.22) compared to critical stage approach (5.64) and farmers practice (6.41) at 90 DAS (Table 1). SRI method recorded higher dry matter accumulation in leaf, stem, panicle and higher total dry matter (25.83, 30.01, 24.50 and 81.08 g hill^{-1} respectively) accumulation compared to transplanting (23.72, 27.83, 22.91 and 76.29, respectively) and direct seeded rice (21.06, 25.63, 21.86 and 69.61, respectively) at harvest. AWD irrigation practice recorded higher dry matter accumulation in leaf, stem, panicle and higher total dry matter (24.39, 29.07, 24.61 and 78.93, respectively) compared to critical stage approach (22.66, 26.72, 21.57 and 72.37, respectively) and farmers practice (23.68, 27.86, 23.45 and 76.54, respectively) at harvest. Increase in dry matter accumulation in SRI method might be due to adequate available nutrients and water due to wider spacing which might also helped in production of more no. of effective tillers (Borkar *et al.*, 2008) [3].

Yield parameters

Significantly higher no. of productive tillers per hill (13.93), Panicle length (22.72 cm), test weight (23.95 g), number of grains per panicle (149.92), grain yield (5096.97 kg ha^{-1}) and straw yield of rice (5711.42 kg ha^{-1}) was noticed in SRI method of rice establishment followed by transplanted rice at harvesting stage. DSR recorded significantly lower values in all the above mentioned yield parameters (Table 3). Among the scheduling of irrigation practice effect of alternate wetting drying found significantly more on number of productive tillers per hill (14.16), Panicle length (22.62 cm), test weight (23.81g), number of grains per panicle (150.67), grain yield (4985.70 kg ha^{-1}) and straw yield of rice (5488.56 kg ha^{-1}), while lower values were recorded with critical stage irrigation approach at harvesting stage. The higher grain yield was mainly due to higher yield attributing characters *viz.*, number of productive tillers m^{-2}, panicle length, number of filled grains panicle^{-1} and thousand grain weight. The large root volume, profuse and strong tillers with big panicles and well filled spikelets with higher grain weight contributed to higher yield. Similar results were observed by Satyanarayana and Babu (2004) [10]. The lower yield in DSR was due to lesser production of yield attributing characters because of competition by closer spacing. The results were in line with the findings of Barison and Uphoff (2011) [2] and Elamathi *et al*. (2012) [4]. AWD strengthens the air exchange between soil and the atmosphere (Tan *et al.*, 2013) [11], thus sufficient oxygen is supplied to the root system to accelerate soil organic matter mineralization and inhibit soil N mobilization, all of which should increase soil fertility and produce more essential plant-available nutrients to favour rice growth (Tan *et al.*, 2013) [11]. A elevated ABA level in rice plants under AWD regimes during grain filling could increase the grain-filling rate of spikelets, enhance the remobilization of pre-stored assimilates in vegetative tissues to grains and reduce stomatal conductance, consequently, increase grain weight, harvest index and water productivity (Yang and Zhang, 2010) [14].

Conclusion

SRI method of establishment and AWD irrigation management practice produced higher growth parameters, yield and yield components and grain yield, it may be due to better root growth which enhanced nutrient uptake, higher leaf area index which produced more photosynthetic area, and wider spacing maximise the radiation use efficiency etc finally higher yield.

Table 1: Influence of different methods of establishment and scheduling of irrigation on plant height (cm), Number of tillers per hill and leaf area index at different growth stages of

Treatment	Plant height (cm)			No. of tillers per hill			Leaf area index		
	Days after sowing (DAS)								
	60	90	Harvest	60	90	Harvest	60	90	Harvest
Establishment method (M)									
M_1	56.60	82.07	87.84	10.93	13.65	15.21	2.80	4.60	3.76
M_2	67.15	93.34	99.89	15.28	17.49	19.53	4.57	7.94	6.93
M_3	60.98	91.75	96.96	12.87	15.37	17.51	3.89	6.62	4.98

S.Em.±	0.93	0.32	0.71	0.26	0.33	0.2	0.05	0.25	0.22
C.D. @5%	3.67	0.98	2.17	1.03	1.29	0.78	0.19	0.97	0.87
Irrigation schedule (N)									
S_1	64.49	90.98	98.25	14.43	16.47	18.95	4.31	7.22	6.21
S_2	58.57	87.01	92.49	11.62	14.52	15.79	2.93	5.64	4.17
S_3	61.24	88.63	94.14	12.76	15.39	17.28	3.82	6.30	5.02
S_4	62.02	89.59	94.72	13.28	15.64	17.63	3.94	6.41	5.49
S.Em.±	0.80	0.35	0.7	0.38	0.25	0.42	0.15	0.23	0.21
C.D. at 5%	2.37	1.04	2.08	1.13	0.76	1.26	0.43	0.69	0.64
Interaction (M×N)									
M_1 S_1	56.47	83.49	89.52	11.73	14.38	16.53	3.08	5.37	4.51
M_1 S_2	53.28	80.66	86.58	10.10	13.23	13.61	2.27	3.75	3.24
M_1 S_3	57.86	81.80	87.33	10.67	13.39	14.77	2.89	4.78	3.42
M_1 S_4	58.80	82.28	87.91	11.26	13.61	15.93	2.96	4.46	3.87
M_2 S_1	70.47	95.81	104.82	17.31	18.96	20.12	5.28	8.59	7.98
M_2 S_2	64.92	90.67	96.62	12.92	16.20	18.57	3.48	7.33	5.90
M_2 S_3	66.41	92.95	98.75	15.27	17.17	19.88	4.65	7.85	6.49
M_2 S_4	66.83	93.93	99.39	15.55	17.62	19.53	4.82	7.98	7.36
M_3 S_1	66.53	93.68	100.41	14.23	16.08	20.18	4.57	7.70	6.17
M_3 S_2	57.54	89.71	94.27	11.88	14.13	15.20	3.05	5.72	3.36
M_3 S_3	59.45	91.09	96.33	12.33	15.61	17.25	3.91	6.27	5.15
M_3 S_4	60.43	92.55	96.85	13.06	15.67	17.43	4.04	6.80	5.22
Mean	61.58	88.80	94.90	13.03	15.51	17.41	3.75	6.39	5.23
Subplot at same level of main plot									
S.Em.±	1.38	1.44	1.21	0.66	0.44	0.73	0.25	0.4	0.37
C.D. @5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Main plot at same or different level of subplot									
S.Em.±	2.32	2.15	1.86	0.84	0.79	0.83	0.27	0.64	0.58
C.D. @5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

M_1-Direct seeded rice S_1-Alternate wetting and drying
M_2-System of rice intensification S_2-Critical stage approach
M_3-Transplanted rice S_3-Continious saturation
NS- Non significant S_4- Farmers irrigation practice

Table 2: Influence of different methods of establishment and scheduling of irrigation on dry matter accumulation in leaf, stem, panicle and total dry matter at different growth stages of rice.

Treatment	Dry matter at harvest (g hill^{-1})							
	Leaf		**Stem**		**Panicle**		**Total**	
	90DAS	**At harvest**	**90DAS**	**At harvest**	**90DAS**	**At harvest**	**90DAS**	**At harvest**
Establishment method (M)								
M_1	12.69	21.06	22.43	25.63	9.01	21.86	44.32	69.61
M_2	16.01	25.83	26.88	30.01	12.53	24.50	53.78	81.08
M_3	14.27	23.72	24.38	27.83	10.84	22.91	50.18	76.29
S.Em.±	0.24	0.44	0.26	0.51	0.42	0.27	0.57	0.68
C.D. @5%	0.96	1.73	1.00	2.02	1.66	1.08	2.25	2.09
Irrigation schedule (N)								
S_1	15.84	24.39	26.17	29.07	11.87	24.61	52.34	78.93
S_2	12.82	22.66	22.90	26.72	09.78	21.57	46.64	72.37
S_3	14.10	23.42	24.36	27.64	10.59	22.70	48.60	74.76
S_4	14.51	23.68	24.85	27.86	10.94	23.45	50.12	76.54
S.Em.±	0.42	0.22	0.42	0.4	0.2	0.39	0.65	0.47
C.D. at 5%	1.24	0.64	1.24	1.17	0.59	1.15	1.94	1.38
Interaction (M×N)								
M_1 S_1	14.47	21.67	22.98	26.71	9.65	23.65	47.10	72.59
M_1 S_2	11.26	19.89	21.06	24.64	8.25	20.25	41.31	66.12
M_1 S_3	12.28	21.11	22.82	25.49	8.89	20.93	43.98	68.53
M_1 S_4	12.74	21.56	22.88	25.7	9.25	22.59	44.87	71.19
M_2 S_1	17.59	27.32	29.55	31.6	14.21	25.76	56.13	85.02
M_2 S_2	14.36	25.06	24.68	28.68	11.68	22.35	51.35	78.08
M_2 S_3	15.55	25.45	26.23	29.69	11.98	24.65	52.76	80.14
M_2 S_4	16.54	25.49	27.07	30.07	12.25	25.25	54.86	81.07
M_3 S_1	15.47	24.20	25.91	28.91	11.76	24.42	53.80	79.20
M_3 S_2	12.83	23.03	22.97	26.84	9.40	22.10	47.25	72.91
M_3 S_3	14.52	23.69	24.02	27.72	10.89	22.56	49.05	75.64
M_3 S_4	14.27	23.98	24.62	27.85	11.31	22.51	50.63	77.35
Mean	14.32	23.54	24.57	27.83	10.80	23.09	49.43	75.65
Subplot at same level of main plot								
S.Em.±	0.72	0.37	0.72	0.68	0.34	0.67	1.16	0.81
C.D. @5%	NS	NS	NS	NS	NS	NS	NS	NS

Main plot at same or different level of subplot								
S.Em.±	0.87	0.96	0.89	1.24	0.91	0.87	1.61	1.59
C.D. @5%	NS	NS	NS	NS	NS	NS	NS	NS

M_1-Direct seeded rice
M_2-System of rice intensification
M_3-Transplanted rice
NS- Non significant

S_1-Alternate wetting and drying
S_2-Critical stage approach
S_3-Continious saturation
S_4- Farmers irrigation practice

Table 3: Influence of different methods of establishment and scheduling of irrigation on yield and yield attributes at harvesting stage of rice

Treatment	Yield and yield attributing parameters				
	Panicle length(cm)	**Test weight(g)**	**Grains per panicle**	**Productive tillers/hill**	**Grain yield (kg /ha)**
Establishment method (M)					
M_1	20.89	20.76	131.79	11.43	4180.66
M_2	22.72	23.95	149.92	13.93	5096.97
M_3	21.85	22.02	143.58	12.95	4524.58
S.Em.±	0.21	0.16	1.38	0.24	82.94
C.D. @5%	0.84	0.64	4.12	0.95	325.68
Irrigation schedule (N)					
S_1	22.62	23.81	150.67	14.16	4985.70
S_2	20.91	20.66	132.20	11.45	4197.63
S_3	21.79	22.05	139.44	12.51	4567.66
S_4	21.97	22.44	142.73	12.97	4651.96
S.Em.±	0.21	0.44	2.25	0.33	88.24
C.D. at 5%	0.62	1.30	6.68	0.99	262.18
Interaction (M×N)					
$M_1 S_1$	21.58	22.36	135.00	12.31	4706.44
$M_1 S_2$	20.34	19.09	128.05	10.25	3892.89
$M_1 S_3$	20.73	20.61	130.33	11.16	3934.44
$M_1 S_4$	20.92	20.97	133.82	12.00	4188.89
$M_2 S_1$	23.91	26.22	164.36	14.57	5406.33
$M_2 S_2$	20.97	21.65	141.39	12.98	4558.67
$M_2 S_3$	22.78	23.20	143.31	13.84	5267.55
$M_2 S_4$	23.23	24.73	150.67	14.32	5155.33
$M_3 S_1$	22.36	22.85	152.68	15.59	4844.33
$M_3 S_2$	21.42	21.24	136.33	11.11	4141.33
$M_3 S_3$	21.86	22.35	141.67	12.52	4501.00
$M_3 S_4$	21.75	21.63	143.62	12.59	4611.67
Mean	21.82	22.24	142.10	12.77	4600.74
Subplot at same level of main plot					
S.Em.±	0.36	0.76	3.89	0.58	152.84
C.D. @5%	NS	NS	NS	NS	NS
Main plot at same or different level of subplot					
S.Em.±	0.56	0.82	4.77	0.76	225.56
C.D. @5%	NS	NS	NS	NS	NS

M_1-Direct seeded rice
M_2-System of rice intensification
M_3-Transplanted rice
NS- Non significant

S_1-Alternate wetting and drying
S_2-Critical stage approach
S_3-Continious saturation
S_4- Farmers irrigation practice

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