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Effect of Different Establishment Methods and Weed Management Practices on Growth and Yield of *Kharif* Rice (*Oryza sativa* L.)

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The field experiment was conducted at Agronomy Department Farm, College of Agriculture, Dapoli during *kharif* seasons of 2016 and 2017 to study the effect of different establishment methods and weed management practices on growth and yield of *kharif* rice (*Oryza sativa* L.). The experiment was laid out in a strip plot design comprising of twenty five treatment combinations replicated thrice. The horizontal strips comprised five rice establishment methods *viz*., sowing of dry seeds by drum seeder at onset of monsoon (M_1), sowing of sprouted seeds (*Rahu*) by drum seeder on puddled field (M_2), broadcasting of sprouted seeds (*Rahu*) on puddled field (M_3), SRI (System of Rice Intensification) method (M_4) and conventional transplanting (M_5). The vertical strips consisted five weed management practices *viz*., need based two hand weedings at 20/30 and 40/60 DAS/DAT (W_1), pre-emergence application of Oxadiargyl 80 WP @ 100 g ha^{-1} + 1 hand weeding at 20/30 DAS/DAT (W_2), pre-emergence application of Oxadiargy l 80 WP @ 100 g ha^{-1} + 1 hand weeding at 40/60 DAS/DAT (W_3), pre-emergence application of Oxadiargyl 80 WP @ 100 g ha^{-1} + post emergence application of Almix 20 WP @ 4 g ha^{-1} (W_4) and unweeded control (W_5). The highest grain and straw yield from *kharif* rice were obtained when rice crop was established by SRI method with two hand weedings carried out at 20 and 40 DAS (M_2W_1) or pre-emergence application of Oxadiargyl + 1 hand weeding carried out at 20 DAS (M_2W_2) as compared to remaining treatment combinations during both the seasons as well as in pooled analysis.

(***Key words:*** *Drum seeding, Puddling, Rice, SRI, Weed, Yield*)

Rice (*Oryza sativa* L.) is the most important staple food crop of the world and India, feeding more than half of the world's population every day. Rice provides 20% of the world's dietary energy supply, while wheat supplies 19% and maize 5%. In Asia, it has a special significance, where about 90% of the rice is produced and consumed as a staple food. It is a predominant crop in lowland ecosystem. Globally it is cultivated in an area of 161.28 million hectares with an annual production of 715.75 million tonnes (Anonymous, 2016a). Among the various rice growing countries of the world, India has the largest area under rice and in case of production it stands next to China.

In India, rice is the most important and extensively grown food grain crop, occupying an area of 44.11 million hectares with production of 105.48 million tonnes. However, productivity of India (2.39 t ha^{-1}) is lower than the world average yields (4.4 t ha^{-1}) and is much behind than the rice productivity of Egypt, Japan and China (Anonymous, 2016b). Rice is also an important cereal food crop of Maharashtra state, which contributes 3.6% of area and 2.8% of production of rice at the national level. Total area, production and productivity of rice were 14.71 lakh hectares, 25.17 lakh tonnes and 1.71 t ha^{-1}, respectively. Rice is the main food crop grown in *Konkan* region, which occupies an area of 3.79 lakh hectares with production 9.94 lakh tonnes and productivity of 2.61 t ha^{-1} (Anonymous, 2016c).

Rice is grown either by direct seeding or by transplanting. The System of Rice Intensification (SRI), a technique for rice culture is being practiced in almost 22 countries. The proponents of SRI have claimed substantial increases in rice yields, sometimes as high as 3 to 4 times, with the consequent increase in the productivity of land, water and capital (Uphoff, 2002). SRI increases rice yield over the conventional method of cultivation by 32% and net returns by 67%, while it decreases labour input by 8% in West Bengal, India (Sinha and Talati, 2007). System of Rice Intensification (SRI), a revived method of transplanted rice cultivation

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by exploiting the genetic potential of rice provides a favourable growing environment to increase the productivity and economic returns. Besides, it enhances soil health with reduction in input use such as seeds, water, labour, etc. Krishna *et al*. (2008) reported an enhanced tillering, early flowering, higher yield and better grain quality in SRI practices compared to conventional methods. Keeping the above facts in view, the present study was conducted to evaluate different rice establishment and weed management methods.

MATERIALS AND METHODS

The field experiment was conducted on plot No. 24 of 'B' block of Agronomy Department Farm, College of Agriculture, Dapoli (Dist. Ratnagiri), Maharashtra during *kharif* 2016 and 2017. The soil of the experimental plot was uniform, level and well drained. It was sandy clay loam in texture, low in available nitrogen (216.12 kg ha^{-1}), phosphorus (9.22 kg ha^{-1}) and potassium (205.75 kg ha^{-1}), high in organic carbon (0.94%) and slightly acidic in reaction (pH 5.80).

The field experiment was laid out in a strip plot design comprising of twenty five treatment combinations with three replications. The horizontal strips comprised of five rice establishment methods *viz*., sowing of dry seeds by drum seeder at onset of monsoon (M_1), sowing of sprouted seeds (*Rahu*) by drum seeder on puddled field (M_2), broadcasting of sprouted seeds (*Rahu*) on puddled field (M_3), SRI (System of Rice Intensification) method (M_4) and conventional transplanting (M_5). The vertical strips consisted five weed management practices *viz*., need based two hand weedings at 20/30 and 40/60 days after sowing (DAS)/days after transplanting (DAT) (W_1), pre-emergence application of Oxadiargyl 80 WP @ 100 g ha^{-1} + 1 hand weeding at 20/30 DAS/DAT (W_2), pre-emergence application of Oxadiargyl 80 WP @ 100 g ha^{-1} + 1 hand weeding at 40/60 DAS/DAT (W_3), Pre-emergence application of Oxadiargyl 80 WP @ 100 g ha^{-1} + post emergence application of Almix 20 WP @ 4 g ha^{-1} (W_4) and unweeded control (W_5).

The sowing of dry seeds by drum seeder was done at onset of monsoon as per the treatments. The nursery for conventional transplanting and SRI method was done on the same day of sowing of dry seeds by drum seeder. Similarly, seeds were kept for soaking in water on the same day of nursery sowing for sowing of sprouted seeds (*Rahu*) by drum seeder and broadcasting sprouted seeds (*Rahu*) on puddled field. Two days sprouted seeds were sown in the puddled field by drum seeder and broadcasting as per the treatments. In SRI and conventional transplanting methods 12 and 21 days old seedlings were transplanted, respectively on puddled field as per the treatments. FYM, half N and full dose of P_2O_5 and K_2O was applied as basal dose and remaining half dose of N was applied at tillering and panicle initiation stages in equal splits. The other usual common packages of practices were followed time to time and periodical growth observations were recorded at an interval of 30 days. Crop was harvested at physiological maturity and data on yield attributes and yield were recorded.

RESULTS AND DISCUSSION

Effect of establishment methods on growth and yield of *kharif* rice

SRI method of rice transplanting recorded maximum and significantly higher growth and yield attributes *viz*., plant height (cm), number of functional leaves m^{-2}, number of tillers m^{-2}, dry matter accumulation m^{-2}, number of panicles m^{-2}, length of panicle (cm), weight $panicle^{-1}$ (g), number of filled grains $panicle^{-1}$, test weight (g), grain and straw yield (t ha^{-1}) over rest of the establishment methods followed by conventional transplanting during individual years as well as in pooled data (Tables 1, 2 and 3). Sowing of dry seeds by drum seeder recorded significantly lower growth and yield attributes from *kharif* rice as compared to remaining establishment methods. On the basis of pooled data, the magnitude of increase in grain yield recorded under broadcasting of sprouted seeds on puddled field, sowing of sprouted seeds by drum seeder on puddled field, conventional transplanting and SRI method over sowing of dry seeds by drum seeder were 4.06, 6.57, 15.18 and 17.77 %, respectively. The increase in yield attributes and grain yield in SRI method might be due to square geometry of hills with wider spacing and planting of single seedling $hill^{-1}$ which reduced the above and

Table 1. *Mean plant height, no. of functional leaves, no. of tillers and dry matter accumulation of rice as influenced by different treatments during kharif 2016 and 2017*

Treatments	Plant height (cm)		No. of functional leaves m^{-2}		No. of tillers m^{-2}		Dry matter accumulation (g m^{-2})	
	2016	2017	2016	2017	2016	2017	2016	2017
Establishment methods								
M_1: Sowing of dry seeds by drum seeder	67.55	65.97	1175.53	1173.93	271.93	270.40	534.53	521.73
M_2: Sowing of sprouted seeds by drum seeder	72.10	70.95	1205.27	1204.33	281.60	280.53	600.94	585.07
M_3: Broadcasting of sprouted seeds	70.69	69.69	1188.93	1188.40	275.47	274.53	571.03	558.68
M_4: SRI method	80.52	79.90	1199.60	1200.07	280.87	281.40	633.84	620.73
M_5: Conventional transplanting	78.58	77.86	1223.53	1222.93	286.13	285.13	624.60	611.67
S.Em. ±	0.58	0.27	0.50	0.37	0.33	0.32	0.94	0.63
C.D. at 5%	1.90	0.89	1.62	1.20	1.06	1.03	3.08	2.06
Weed management practices								
W_1: Two hand weedings	78.49	76.70	1208.07	1207.20	284.13	283.60	622.76	610.93
W_2: Oxadiargyl (PE) +1 HW at 20/30 DAS/DAT	75.59	74.65	1202.27	1202.00	282.40	281.67	607.88	595.87
W_3: Oxadiargyl (PE) +1 HW at 40/60 DAS/DAT	74.14	73.31	1198.33	1197.80	279.53	279.00	598.53	584.07
W_4: Oxadiargyl (PE) + Almix (POE)	72.02	71.33	1194.40	1193.93	276.60	275.93	580.50	567.34
W_5: Unweeded control	69.20	68.37	1189.80	1188.73	273.33	271.80	555.27	539.67
S.Em. ±	0.38	0.20	0.49	0.35	0.17	0.24	1.20	0.78
C.D. at 5%	1.24	0.65	1.59	1.14	0.55	0.77	3.93	2.54
Interaction effect								
S.Em. ±	1.35	0.76	1.89	1.74	1.57	1.47	7.95	8.69
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
General mean	73.89	72.87	1198.57	1197.93	279.20	278.40	592.99	579.58

Table 2. *Number of panicles, length of panicle, weight panicle^{-1} and no. of filled grains panicle^{-1} of rice as influenced by different treatments during kharif 2016 and 2017*

Treatments	No. of panicles m^{-2}		Length of panicle (cm)		Weight panicle^{-1} (g)		No. of filled grains panicle^{-1}	
	2016	2017	2016	2017	2016	2017	2016	2017
Establishment methods								
M_1: Sowing of dry seeds by drum seeder	271.93	270.40	20.08	20.00	3.06	3.03	101.00	100.07
M_2: Sowing of sprouted seeds by drum seeder	281.60	280.53	21.41	21.29	3.38	3.23	106.00	105.40
M_3: Broadcasting of sprouted seeds	275.47	274.53	21.21	21.08	3.29	3.17	104.47	103.07
M_4: SRI method	280.87	281.40	23.61	23.61	3.57	3.48	114.60	114.13
M_5: Conventional transplanting	286.13	285.13	23.05	23.01	3.49	3.38	113.47	112.13
S.Em. ±	0.33	0.32	0.26	0.22	0.03	0.02	0.21	0.34
C.D. at 5%	1.06	1.03	0.83	0.71	0.06	0.07	0.68	1.12
Weed management practices								
W_1: Two hand weedings	284.13	283.60	23.68	23.65	3.63	3.52	110.93	110.07
W_2: Oxadiargyl (PE) +1 HW at 20/30 DAS/DAT	282.40	281.67	22.57	22.51	3.49	3.39	109.73	108.80
W_3: Oxadiargyl (PE) +1 HW at 40/60 DAS/DAT	279.53	279.00	22.08	21.86	3.39	3.27	108.27	107.40
W_4: Oxadiargyl (PE) + Almix (POE)	276.60	275.93	21.10	21.09	3.21	3.11	106.73	105.60
W_5: Unweeded control	273.33	271.80	19.92	19.89	3.06	2.99	103.87	102.93
S.Em. ±	0.17	0.24	0.19	0.24	0.02	0.01	0.38	0.11
C.D. at 5%	0.55	0.77	0.63	0.77	0.07	0.04	1.25	0.36
Interaction effect								
S.Em. ±	1.57	1.47	0.29	0.41	0.05	0.06	1.09	1.16
C.D. at 5%	NS	NS	NS	NS	NS	NS	3.15	3.33
General mean	279.20	278.40	21.87	21.80	3.36	3.26	107.91	106.96

Table 3. *Test weight, grain and straw yield (t ha^{-1}) of rice as influenced by different treatments during kharif 2016, 2017 and in pooled data*

Treatments	Test weight (g)		Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		
	2016	2017	2016	2017	Pooled	2016	2017	Pooled
Establishment methods								
M_1: Sowing of dry seeds by drum seeder	28.11	28.04	3.75	3.58	3.67	5.36	5.23	5.30
M_2: Sowing of sprouted seeds by drum seeder	29.55	29.49	3.96	3.86	3.91	6.02	5.86	5.94
M_3: Broadcasting of sprouted seeds	29.08	29.06	3.86	3.77	3.82	5.72	5.58	5.65
M_4: SRI method	30.68	30.68	4.39	4.26	4.32	6.37	6.22	6.30
M_5: Conventional transplanting	30.11	30.04	4.28	4.17	4.23	6.25	6.12	6.18
S.Em. ±	0.15	0.12	0.01	0.02	0.01	0.04	0.04	0.04
C.D. at 5%	0.48	0.41	0.04	0.07	0.04	0.13	0.12	0.12
Weed management practices								
W_1: Two hand weedings	30.98	30.90	4.29	4.20	4.25	6.24	6.11	6.17
W_2: Oxadiargyl (PE) +1 HW at 20/30 DAS/DAT	30.11	30.05	4.18	4.06	4.12	6.09	5.96	6.02
W_3: Oxadiargyl (PE) +1 HW at 40/60 DAS/DAT	29.79	29.77	4.09	3.97	4.03	6.00	5.85	5.92
W_4: Oxadiargyl (PE) + Almix (POE)	28.64	28.63	3.91	3.81	3.86	5.81	5.69	5.75
W_5: Unweeded control	28.01	27.95	3.77	3.61	3.67	5.60	5.39	5.50
S.Em. ±	0.16	0.13	0.02	0.02	0.01	0.23	0.21	0.22
C.D. at 5%	0.51	0.43	0.05	0.05	0.04	0.74	0.69	0.70
Interaction effect								
S.Em. ±	0.45	0.43	0.04	0.06	0.042	0.053	0.06	0.04
C.D. at 5%	NS	NS	NS	NS	.01.21	NS	NS	NS
General mean	29.51	29.46	4.05	3.93	3.99	5.94	5.80	5.87

below ground competition, enhanced solar radiation interception and nutrient uptake by crop.

Effect of different weed management practices on growth and yield of *kharif* rice

The highest grain and straw yield were recorded when the weeds were controlled by two hand weedings carried out at 20/30 and 40/60 DAS/DAT (W_1) as compared to other weed management practices during individual years as well as in pooled data (Tables 1, 2 and 3). The magnitude of increase in grain yield recorded due to pre and post emergence application of Oxadiargyl + Almix (W_4), integration of pre-emergence application of Oxadiargyl with 1 HW at 40/60 DAS/DAT (W_3) or 1 HW at 20/30 DAS/DAT (W_2) and two hand weedings at 20/30 and 40/60 DAS/DAT (W_1) over unweeded control (W_5) on pooled basis was 4.72, 9.25, 11.77 and 15.16 %, respectively. Increase in yields due to two hand weedings carried out at 20/30 and 40/60 DAS/DAT (W_1) over rest of the treatments were the results of increased growth and yield attributes *viz*., plant height (cm), number of functional leaves m^{-2}, number of tillers m^{-2}, dry matter accumulation m^{-2}, number of panicles m^{-2}, length of panicle (cm), weight $panicle^{-1}$ (g), number of filled grains $panicle^{-1}$, test weight (g), grain and straw yield (t ha^{-1}) during both the years as well as in pooled data. This might be due to less crop weed competition in treated plots.

From the results of the present investigation, it can be concluded that highest grain and straw yield from *kharif* rice was obtained when rice crop was established by SRI method with two hand weedings carried out at 20 and 40 DAT as compared to remaining treatments during both the seasons as well as in pooled analysis.

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