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Weed management in rice established by different methods

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ABSTRACT

The field experiment was conducted at Agronomy Department Farm, College of Agriculture, Dapoli, during *Kharif* (rainy) seasons 2016 and 2017 to study the effect of established by different methods of rice establishment on weeds. The field 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 , sowing of sprouted seeds (*Rahu*) by drum seeder in puddled field, broadcasting of sprouted seeds (*Rahu)* in puddled field, system of rice intensification (SRI) method and conventional transplanting. The vertical strips consisted five weed management practices, *viz.* need based two hand weedings at 20/30 and 40/60 DAS/DAT, pre-emergence application of oxadiargyl 80 WP 100 g/ha + 1 hand weeding at 20/30 DAS/DAT, pre-emergence application of oxadiargyl 80 WP 100 g/ha + 1 hand weeding at 40/60 DAS/DAT, pre-emergence application of oxadiargyl 80 WP 100 g/ha + post-emergence application of Almix 20 WP 4 g/ha and unweeded control. SRI method with two hand weedings carried out at 20 and 40 DAT recorded highest grain and straw yield of rice and lowest weed density and dry weight of weeds as compared to remaining treatment combinations during both the seasons.

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important staple food crop of the world, feeding more than half of its population every day. Globally it is cultivated in an area of 161.28 million hectares with an annual production of 715.75 million tonnes (Anonymous, 2016a). In Asia, about 90% of the rice is produced and consumed as a staple food.

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, the productivity of India (2.39 t/ha) is lower than the world average yields (4.4 t/ha) 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, which contributes 3.6% of area and 2.8% of production of rice at national level.

Rice is grown either by direct seeding or by transplanting. In Konkan region, rice is mostly grown by transplanting method. Weed infestation and weed competition are more in direct-seeded rice as compared to transplanted rice, because the land is exposed till the initial seedling establishment in direct-seeded rice. Crop establishment and weed management techniques are critical in rice farming.

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 decreases labour input by 8% in West Bengal, India (Sinha and Talati 2007). Besides, it enhances soil health with reduction in input use such as seeds, water, labours, *etc*. Krishna *et al.* (2008) reported an enhanced tillering, early flowering, higher yield and better grain quality in SRI practices compared to conventional methods. The traditional system of transplanting gives the crop a 14 to 21 day growth advantage over the weeds. The transplanting also enables rice to capture space earlier. This is because the young rice plants have leverage over germinating weeds due to shading and earlier establishment of root system. The immediate flooding

after transplanting limits the establishment of many weeds. Similarly, in direct seeded method, the use of high seed rates could reduce weed infestation to a large extent. Therefore, the rice cultivation trend has been increasingly shifting to direct-seeding as labour prices become higher. So, keeping this point in the view present investigation conducted during rainy (*Kharif*) season of 2016 and 2017 with following objectives:

1. To find out suitable rice establishment method that can be an alternative for cost involving manual transplanting method.
2. To find out effective weed management practices for *Kharif* rice.
3. To study the interaction effects between establishment methods and weed management practices on growth and yield of *Kharif* rice.

MATERIALS AND METHODS

The field experiment was conducted at College of Agriculture, Dapoli Dist. Ratnagiri is situated at 17-0.45' N latitude and 730.1' E longitude having altitude of 250 meters above the mean sea level during *Kharif* 2016 and 2017. The soil of the experimental plot was sandy clay loam in texture, low in available nitrogen (216.12 kg/ha), phosphorus (9.22 kg/ha) and potassium (205.75 kg/ha), moderately high in organic carbon (0.94%) and slightly acidic in reaction (5.80). The meteorological data revealed that the weather was, congenial for the growth and development of *Kharif* rice without incidence of any major pests or diseases during both the years.

The field 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, sowing of sprouted seeds (*Rahu*) by drum seeder in puddled field, broadcasting of sprouted seeds (*Rahu)* in puddled field, System of Rice Intensification (SRI) method and conventional transplanting. The vertical strips consisted five weed management practices, *viz.* need based two hand weedings at 20/30 and 40/60 DAS/DAT, pre-emergence application of oxadiargyl 80 WP 100 g/ha + 1 hand weeding at 20/30 DAS/DAT, pre-emergence application of oxadiargyl 80 WP 100 g/ha + 1 hand weeding at 40/60 DAS/DAT, pre-emergence application of oxadiargyl 80 WP 100 g/ha + post-emergence application of almix 20 WP 4 g/ha and unweeded control . The gross plot size was 4.50 m x 3.60 m and truthful seed of long bold seeded early rice variety, '*Ratnagiri-1*' was used in the present investigation.

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 put 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 in 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 in puddled field as per the treatments. FYM (7.5 t/ha), 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 and weed observations were recorded at an interval of 30 days. The pre- and post-emergence herbicides are oxadiargyl and almix is applied at 2 to 3 and 20 to 25 DAS/DAT. Crop was harvested at physiological maturity and data on yield attributes and yield were recorded.

RESULTS AND DISCUSSION

Effect of establishment methods on density and dry weight of weeds

The following dominant weeds observed in the *Kharif* rice crop:

Botanical name	Family	Common name
A) Grassy weeds		
Echinochloa colona	Poaceae	Pakhad
Echinochloa glabrescens	Poaceae	Pakhad
Ischaemum globosa	Poaceae	Dhur
B) Sedges		
Cyperus iria	Cyperaceae	Lavala
Cyperus difformis	Cyperaceae	Lavala
C) Broad-leaved weeds		
Celosia argentea	Amaranthaceae	Cocks comb
Mimosa pudica	Leguminaceae	Lajaloo
Alternanthera sessilis	Amaranthaceae	Reshim kata
Ageratum conyzoides	Asteraceae	Osadi
Ludwigia octovalvis	Onagraceae	Kadu Chinch

The sowing of dry seeds by drum seeder at onset of monsoon (**Table 1** and **2**) recorded significantly maximum weed density and dry weight of weeds (3.04 and 3.07 t/ha) as compared to rest of the rice establishment methods during both the years of experimentation. Further, the other rice

establishment methods, *viz*. SRI method (2.36 and 2.43 t/ha), conventional transplanting (2.39 and 2.46 t/ha), sowing of sprouted seeds by drum seeder (2.44 and 2.53 t/ha) and broadcasting of sprouted seeds on puddled field (2.48 and 2.56 t/ha) remained at par with each other and recorded significantly minimum weed intensity and dry weight of weeds during both the years of study.

Effect of different weed management practices on density, dry weight of weeds, weed index and weed control efficiency

Weed management practices recorded significantly (**Table 1** and **2**) lower weed density and dry weight of weeds as compared to unweeded control (3.92 and 4.05 t/ha) during both the years. Two hand weedings at 20/30 and 40/60 DAS/DAT

Table 1. Mean number of grassy, sedges and broad-leaved weeds/m^2 as influenced by different treatments during *Kharif* 2016 and 2017

Treatment	Weed density/m^2					
	Grassy weeds		Sedges		Broad-leaved weeds	
	2016	2017	2016	2017	2016	2017
Establishment method						
Sowing of dry seeds by drum seeder	7.15 (56.7)	7.17 (56.9)	6.91 (51.5)	6.95 (51.9)	4.98 (26.8)	5.00 (26.9)
Sowing of sprouted seeds by drum seeder	4.99 (26.8)	5.00 (26.9)	4.84 (25.0)	4.96 (25.9)	3.64 (13.8)	3.65 (13.9)
Broadcasting of sprouted seeds	5.00 (26.8)	5.01 (26.9)	4.85 (25.0)	4.94 (25.7)	3.65 (13.9)	3.66 (13.9)
SRI method	4.90 (25.7)	4.89 (25.6)	4.84 (24.9)	4.90 (25.4)	3.64 (13.8)	3.64 (13.8)
Conventional transplanting	4.92 (25.8)	4.92(25.7)	4.83 (24.9)	4.92 (25.7)	3.60 (13.5)	3.63 (13.7)
LSD (p=0.05)	0.57	0.55	0.27	0.37	0.14	0.08
Weed management practice						
Oxadiargyl (PE) +1 HW at 20/30 DAS/DAT	4.60 (21.9)	4.60 (22.0)	4.56 (21.6)	4.56 (21.6)	3.63 (12.9)	3.62 (12.9)
Oxadiargyl (PE) +1 HW at 40/60 DAS/DAT	4.02 (15.9)	4.03 (15.9)	3.88 (14.9)	4.09 (16.5)	2.93 (8.2)	2.94 (8.3)
Oxadiargyl (PE) + Almix (POE)	6.52 (43.2)	6.51 (43.1)	6.24 (39.5)	6.25 (39.6)	4.40 (19.8)	4.42 (20.0)
Two hand weeding	3.82 (14.4)	3.83 (14.5)	3.87 (14.8)	4.07 (16.3)	2.77 (7.3)	2.78 (7.3)
Unweeded control	8.00 (66.3)	8.01 (66.5)	7.71 (60.5)	7.72 (60.6)	5.80 (33.6)	5.81 (33.7)
LSD (p=0.05)	0.51	0.50	0.36	0.40	0.15	0.13
Interaction effect						
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
General mean	5.39 (32.3)	5.40 (32.4)	5.25 (30.3)	5.33 (30.9)	3.90 (16.3)	3.92 (16.4)

Note: Transformed values (Y=$\sqrt{x+0.5}$); Figures in parentheses are means of original values

Table 2. Total dry weight of weeds (t/ha) at harvest, weed index (%) and weed control efficiency (%) as influenced by different treatments during *Kharif* 2016 and 2017

Treatment	Dry weight of weeds (t/ha)		Weed index (%)		Weed control efficiency (%)	
	2016	2017	2016	2017	2016	2017
Establishment method						
Sowing of dry seeds by drum seeder	3.04 (9.9)	3.07 (10.1)				
Sowing of sprouted seeds by drum seeder	2.44 (5.9)	2.53 (6.4)				
Broadcasting of sprouted seeds	2.48 (6.1)	2.56 (6.5)				
SRI method	2.36 (5.4)	2.43 (5.8)				
Conventional transplanting	2.39 (5.6)	2.46 (6.0)				
LSD (p=0.05)	0.04	0.08				
Weed management practice						
Oxadiargyl (PE) +1 HW at 20/30 DAS/DAT	2.27 (4.7)	2.32 (4.9)	2.66	3.30	67.65	68.34
Oxadiargyl (PE) +1 HW at 40/60 DAS/DAT	2.03 (3.6)	2.09 (3.9)	4.82	5.52	74.90	75.11
Oxadiargyl (PE) + Almix (POE)	2.48 (5.7)	2.54 (6.0)	8.92	9.21	61.32	61.93
Two hand weeding	2.01 (3.6)	2.06 (3.7)	-	-	75.57	75.92
Unweeded control	3.92 (15.2)	4.05 (16.2)	11.77	13.37	-	-
LSD (p=0.05)	0.05	0.09				
Interaction effect						
LSD (p=0.05)	NS	NS				
General mean	2.54 (6.57)	2.61 (6.96)				

Note: Transformed values (Y=$\sqrt{x+0.5}$); Figures in parentheses are means of original values

(2.01 and 2.06 t/ha) and oxadiargyl (PE) with 1 HW at 40/60 DAS/DAT (2.03 and 2.09 t/ha) produced significantly lower density and weed biomass than oxadiargyl (PE) with 1 HW at 20/30 DAS/DAT (2.27 and 2.32 t/ha) and pre- and post-emergence application of oxadiargyl + Almix (2.48 and 2.54 t/ha) during both the years.

Lowest weed index was recorded under oxadiargyl (PE) + 1 HW at 20/30 DAS/DAT (2.66 and 3.30) *fb* oxadiargyl (PE) + 1 HW at 40/60 DAS/DAT (4.82 and 5.52), pre- and post-emergence application of oxadiargyl + Almix (8.92 and 9.21) and the highest weed index was recorded under unweeded control (11.77 and 13.37) during both the years of study. Two hand weeding at 20/30 and 40/60 DAS/DAT (75.57 and 75.92%) recorded the highest weed control efficiency *fb* oxadiargyl (PE) + 1 HW at 40/60 DAS/DAT (74.90 and 75.11%), oxadiargyl (PE) + 1 HW at 20/30 DAS/DAT (67.65 and 68.34%) and the lowest weed control efficiency was recorded under pre- and post-emergence application of oxadiargyl + Almix (61.32 and 61.93%) during both the years.

Table 3. Number of panicles/m^2, length of panicle (cm) and weight/ panicle (g) of rice as influenced by different treatments during *Kharif* 2016 and 2017

Treatment	No. of panicles/m^2		Length of panicle (cm)		Weight/ panicle (g)	
	2016	2017	2016	2017	2016	2017
Establishment methods						
Sowing of dry seeds by drum seeder	271.93	270.40	20.08	20.00	3.06	3.03
Sowing of sprouted seeds by drum seeder	281.60	280.53	21.41	21.29	3.38	3.23
Broadcasting of sprouted seeds	275.47	274.53	21.21	21.08	3.29	3.17
SRI method	280.87	281.40	23.61	23.61	3.57	3.48
Conventional transplanting	286.13	285.13	23.05	23.01	3.49	3.38
LSD (p=0.05)	1.06	1.03	0.83	0.71	0.06	0.07
Weed management practices						
Oxadiargyl (PE) +1 HW at 20/30 DAS/DAT	282.40	281.67	22.57	22.51	3.49	3.39
Oxadiargyl (PE) +1 HW at 40/60 DAS/DAT	279.53	279.00	22.08	21.86	3.39	3.27
Oxadiargyl (PE) + Almix (POE)	276.60	275.93	21.10	21.09	3.21	3.11
Two hand weedings	284.13	283.60	23.68	23.65	3.63	3.52
Unweeded control	273.33	271.80	19.92	19.89	3.06	2.99
LSD (p=0.05)	0.55	0.77	0.63	0.77	0.07	0.04
Interaction effect						
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
General mean	279.20	278.40	21.87	21.80	3.36	3.26

Table 4. Grain and straw yield of rice as influenced by different treatments during *Kharif* 2016, 2017 and in pooled data

Treatment	Grain yield (t/ha)			Straw yield (t/ha)		
	2016	2017	Pooled	2016	2017	Pooled
Establishment methods						
Sowing of dry seeds by drum seeder	3.75	3.58	3.67	5.36	5.22	5.29
Sowing of sprouted seeds by drum seeder	3.95	3.86	3.91	6.01	5.86	5.94
Broadcasting of sprouted seeds	3.86	3.77	3.82	5.72	5.58	5.65
SRI method	4.38	4.26	4.32	6.37	6.22	6.29
Conventional transplanting	4.28	4.17	4.22	6.25	6.11	6.18
LSD (p=0.05)	0.11	0.20	0.13	0.40	0.36	0.37
Weed management practices						
Oxadiargyl (PE) +1 HW at 20/30 DAS/DAT	4.18	4.06	4.12	6.08	5.96	6.02
Oxadiargyl (PE) +1 HW at 40/60 DAS/DAT	4.09	3.97	4.03	5.99	5.85	5.92
Oxadiargyl (PE) + Almix (POE)	3.91	3.81	3.86	5.81	5.69	5.75
Two hand weedings	4.29	4.20	4.24	6.22	6.11	6.16
Unweeded control	3.77	3.60	3.69	5.60	5.39	5.49
LSD (p=0.05)	0.15	0.17	0.13	0.23	0.21	0.22
Interaction effect						
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
General mean	4.05	3.93	3.99	5.94	5.80	5.87

Effect of establishment methods on yield and yield attributes: The yield and yield attributes of rice was significantly (**Table 3** and **4**) higher when it was grown by transplanting the seedlings by SRI method or conventional transplanting as compared to sowing of either dry or sprouted seeds. System of Rice Intensification method produced maximum and significantly higher grain yield and yield attributes of rice as compared to rest of the rice establishment methods during both the years as well as in pooled data. Sowing of sprouted seeds by drum seeder on puddled field recorded significantly higher grain yield and yield attributes of rice as compared to broadcasting of sprouted seeds on puddled field and sowing of dry seeds by drum seeder during individual years and in pooled data.

Effect of different weed management practices on yield and yield attributes: Among weed management practices, two hand weedings at 20/30 and 40/60 DAS/DAT significantly increased the yield and yield attributes of rice as compared to integration of oxadiargyl (PE) with 1 HW either at 20/30 DAS/ DAT or 40/60 DAS/DAT during both the years and in pooled analysis. Application of oxadiargyl (PE) along with 1 HW at 20/30 DAS/DAT recorded significantly higher grain yield over the integration of oxadiargyl (PE) and 1 HW at 40/60 DAS/DAT as well as pre and post emergence application of oxadiargyl and Almix, respectively. Unweeded control recorded significantly lowest yield and yield attributes of rice as compared to other weed management practices during both the years as well as in pooled data.

Weeds are the major constraint in rice production systems. From the results of the present investigation, it was concluded that when rice crop was established by SRI method with two hand weedings carried out at 20 and 40 DAT reorded highest grain and straw yield of *Kharif* rice and lowest weed density and dry weight of weeds as compared to remaining treatment combinations during both the seasons. There is also a need to study weed biology and ecology in different rice ecosystems.

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