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WEED DYNAMICS AND PRODUCTIVITY OF WETLAND RICE AS INFLUENCED BY ESTABLISHMENT METHODS AND INTEGRATED WEED MANAGEMENT

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Key words: Weed dynamics, Wetland rice, Integrated weed management

Abstract

Significantly lower weed density/m^2 and dry weight were recorded in system of rice intensification (SRI) with butachlor 50 EC@ 1.5 kg a.i./ha at 3 DAT + cono-weeding at 20 DAT at par with integrated crop management (ICM). The highest weed control efficiency was recorded with SRI methods and in butachlor 50 EC @ 1.5 kg a.i./ha at 3 DAT + cono-weeding at 20 days after transplanting. The grain, straw and biomass productivity were significantly higher with SRI at par with ICM with highest harvest index. Hand weeding twice at 20 and 40 DAT was recorded highest harvest index at par with butachlor 50 EC@1.5 kg a.i. /ha at 3 DAT + cono-weeding at 20 DAT.

Introduction

Transplanted wetland rice (*Oryza sativa* L.) is a unique system with standing water that has consequential influence on weed flora during the growing period. The nature and extent of weed flora in low land rice eco-system are influenced by the puddling, establishment methods, standing water, management practices and the season. However, in the present day rice cultivation, the weed flora and their types are also influenced by the use of herbicides for selective management of weeds (Rajkhowa *et al*. 2007, Mukherjee and Maity 2011). Wetland rice in West Garo Hills district of Meghalaya covers about 17.35 thousand hectare with the production of 30.0 thousand metric tonnes and productivity of 1729 kg/ha which is lower than the national average (2177 kg/ha) (Anon. 2008 - 2009). The loss of rice due to weed competition varies from 20 to 50% depending upon the various conditions of rice culture in Meghalaya which is much more than any other factor reducing the crop yield (Hazarika *et al*. 2001). The use of herbicides offers selective and economic control of weeds right from the beginning, giving crop an advantage of good start and competitive superiority (Saha 2005). A number of pre-emergence herbicides like butachlor, pretilachlor, anilofos etc. have been recommended for the control of early flushes of grassy weeds in transplanted rice field (Budhar *et al.* 1991). Integrated weed management in rice cultivation could result in a broad spectrum weed control especially when herbicides were applied as pre-emergence spray (Sanjay *et al*. 2006). In this context, new technologies like System of Rice Intensification (SRI) and Integrated Crop Management (ICM) appeared to have potential that saves inputs, protects the environment and could improve productivity and soil health (Satyanarayana *et al.* 2006 and Balasubramanian *et al*. 2007). Therefore, the present investigation was undertaken to find out the efficacy of weed management practices under different establishment methods to realize the higher productivity of wetland rice.

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Materials and Methods

The field experiment was conducted at farmer's field in West Garo Hills district of Meghalaya, India during kharif season of 2010 and 2011. The soil of the experimental plot was sandy loam in texture, acidic in nature (pH 5.09), medium in organic carbon (0.51%), low available N (229.32 kg/ha) and P (8.27 kg/ha) and medium in available K (246.29 kg/ha). The field experiment was laid in a split plot design with 15 treatment combinations including three treatments in main plot *viz.*, M_1: system of rice intensification (SRI), M_2: integrated crop management (ICM) and M_3 : conventional rice culture (CRC) and five treatments in sub-plot *viz.,* W_1: control, W_2: hand weeding twice at 20 and 40 days after transplanting (DAT), W_3: cono-weeding twice at 20 and 40 DAT, W_4: cono-weeding at 20 DAT + hand weeding at 40 DAT and W_5: butachlor 50 EC @1.5 kg a.i. /ha at 3 DAT + cono-weeding at 20 DAT replicated thrice. For SRI, ten days old seedlings @ 1 seedling per hill at 25 cm × 25 cm spacing were transplanted and for ICM, 20 days old seedlings @ 2 seedlings per hill at a spacing of 20 cm × 20 cm were transplanted. Whereas, under CRC method, 30 days old seedlings @ 3 seedlings/hill with a spacing of 20 cm × 15 cm was used for transplanting. FYM @ 5 tonne/ha at 20 days ahead of transplanting the crop. The normal recommended dose of 80 kg N/ha, 60 kg P/ha and 40 kg K/ ha was applied in the form of urea, single superphosphate and muriate of potash. Nitrogen 50% and full dose of P and K were applied as basal. Remaining 25% of nitrogen was applied at active tillering stage and 25% at panicle initiation stage. The wetland rice variety Ranjit was used as test crop. The data on weed dynamics were subjected to square root transformation $\sqrt{(x + 0.5)}$ to normalize their distribution (Gomez and Gomez 1984). The weed control efficiency was calculated by subtracting the dry weight of weeds in treated plot from dry weight of weeds in control plot and then divided by the dry weight of weeds in control plot multiplied by 100 and expressed as percentage. The weed index was calculated by subtracting yield of treated plot from yield of minimum weed competitive plot (2HW) and then divided by yield of minimum weed competitive plot (2HW) multiplied by 100 and expressed as percentage (Kondap and Upadhya 1985). The harvests index (HI) was calculated as economic yield divided by biological yield multiplied by 100. A simple correlation and regression analysis was made between selected parameters. In order to find out the linear relationship between grain yield and weed population, weed dry weight, regression analysis was carried out by using the regression equation of $Y = a + bx$, where 'Y' is the yield value of wetland rice expected to obtain corresponding to any given x (weed population/weed dry weight), 'a' is constant or intercept and 'b' is regression coefficient (Gomez and Gomez 1984).

Results and Discussion

The major weed floras observed in the experimental fields were *Echinochloa colounum* (L.) Link, *Echinochloa crussgalli* (L.) Beauv, *Echinochloa glabrascens* Munro *ex* Hook.f., *Eleusine indica* (L.) Gaertn., *Digitaria sanguinalis* (L.) Scop., *Cyperus difformis* L., *Cyperus iria* L. etc. among monocot weeds while *Fimbristylis milliacea* (L.) Vahl, *Ammania baccifera* L., *Panicum repens* L., *Commelina bengalensis* L., *Ludwigia parviflora* Walt, *Monochoria vaginalis* (Burm.f.) Kunth among dicot weeds. Similar weed species were also reported in rice field by Acharya *et al.* (2007), Banerjee *et al.* (2008) and Singh *et al.* (2008). The dicot weed was significantly low which might be due to low initial growth of dicot weeds. Total weed density at 20 days after transplanting (DAT) in wetland rice was recorded significantly higher at system of rice intensification (SRI) method followed by conventional rice culture (CRC) and integrated crop management (ICM) which might be due higher spacing as well as intermittent wetting and drying of field for higher growth of weeds compared to ICM and CRC. Similar result was also reported by Sharma *et al.* (1994). Grain yield showed a significant and negative correlation with total weed density (r = 0.658*, 0.689* and 0.589*) at 20, 40, 60 DAT, respectively. Similarly, grain yield had significantly negative correlation with dry weight of weeds at 20 DAT (r = 0.721), 40 DAT (r = 0.669), 60 DAT (r = 0.771) and at harvest (r = 0.671). The decrease in grain yield by increase in these parameters was also reported by Sharma *et al.* (2001). However, positive correlation between grain yield and weed control efficiency at 20 DAT (r = 0.828*), 40 DAT (r = 0.839*), 60 DAT (r = 0.817*) and at harvest (r = 0.771*) which indicated the increasing efficiency of weed management treatments for higher productivity of wetland rice (Mukharjee 2006 and Singh *et al.* 2008). The highest coefficient of determination was recorded at 40 DAT in monocot (R^2 = 0.473), 60 DAT in dicot (R^2 = 0.7242) and at 40 DAT in total weed density (R^2 = 0.4749) which indicated 47.30, 72.42 and 47.49 per cent variation in grain yield of wetland rice.

Significantly lower weed density/m^2 was recorded in SRI at 20 DAT which was followed by ICM and CRC method up to 40 DAT and decreased from 60 DAT to harvesting in all the three establishment methods. Total weed density in wetland rice was recorded significantly higher at SRI plot (11.90/m^2) followed by CRC and ICM. At 60 DAT, significantly higher monocot weed density was recorded at SRI plot and lower monocot weed density at ICM followed by CRC. At harvest, significantly lower monocot, dicot and total weed density was recorded at ICM followed by CRC and SRI plot (Table 1). The minimum dry weight of weeds per unit area was lowest when ICM method of establishment was practiced followed by CRC and SRI at 20, 40, 60 DAT and at harvest (Table 2). The highest weed control efficiency was recorded with ICM establishment methods (72.50%) followed by SRI and CRC at 60 DAT and at harvesting stage. The higher weed index was recorded with SRI method (12.35) followed by ICM and CRC which indicated the productivity loss of wetland rice by 12.35 owing to weed infestation (Table 2). Significantly higher grain, straw yield of wetland rice was obtained in SRI methods (5.63 and 13.65 tonne/ha) at par with ICM (5.58 and 13.54 tonne/ha) but remained superior over CRC which might be due to conducive environment for rice to enhance the growth, yield components and yield in SRI and ICM than CRC method (Table 3). The significant effect of different establishment methods was observed on harvest index, although maximum was being recorded with ICM (41.05%) at par with SRI (41.15%). These findings were in corroboration with the findings of Thakur *et al*. (2010) and Chitale *et al.* (2006).

Significantly in lower monocot, dicot and total weed density was recorded with butachlor @ 1.5 kg a.i./ha at 3 DAT + cono-weeding at 20 DAT(W_5) which was at par with hand weeding twice at 20 and 40 DAT (W_2) in wetland rice. However, at 60 DAT, significantly lower monocot, dicot and total weed density was recorded with hand weeding twice at 20 and 40 DAT (W_2) which was at par with butachlor @ 1.5 kg a.i./ha at 3 DAT + cono-weeding at 20 DAT (W_5) which might be due to higher dicot weed population. At harvest, significantly lower monocot, dicot and total weed density was recorded with hand weeding twice at 20 and 40 DAT (W_2) which was at par with butachlor @ 1.5 kg a.i./ha at 3 DAT + mechanical weeding at 20 DAT (W_5) (Table 1). Weed dry weights per unit area at all stages of observation in wetland rice field was statistically significant as influenced by integrated weed management. The trend of weed dry weight was in ascending order from 20 to 40 DAT and descending order from 60 DAT to harvesting stage of wetland rice. Hand weeding twice at 20 and 40 DAT drastically reduced weed dry weight from 20 DAT to harvesting stage while use of chemical weeding supplemented by one mechanical weeding drastically increased weed dry weight up to 40 DAT and decreased at the later stage of crop growth (Table 2). Higher weed density and dry weight was recorded in control plot (Singh *et al*. 2008). The highest weed control efficiency (74%) was recorded at butachlor 50EC @ 1.5 kg a.i./ha at 3 DAT + cono-weeding at 20 DAT and the lowest at control plot (0.00) at the early stage of crop growth (20 DAT). However, the highest weed control efficiency (73.02, 82.99 and 87.99%) was recorded with hand weeding twice at 20 and 40 DAT at par with butachlor 50 EC

Table 1. Effect of establishment methods and integrated weed management practices on weed density (No./m^2) in wetland rice (pooled data for kharif, 2010 and 2011).

Treatments	Monocot weeds/m^2				Dicot weeds/m^2				Total weeds/m^2			
	20 DAT	40 DAT	60 DAT	Harvest	20 DAT	40 DAT	60 DAT	Harvest	20 DAT	40 DAT	60 DAT	Harvest
Establishment methods (M)												
M_1	11.87	10.80	8.07	2.81	4.09	4.98	3.36	2.17	12.55	11.90	8.84	3.50
	(185.99)	(157.91)	(89.11)	(10.22)	(20.64)	(29.53)	(12.44)	(5.38)	(206.63)	(187.43)	(101.55)	(15.60)
M_2	7.80	6.28	5.17	1.86	2.90	3.39	3.10	1.82	8.30	7.12	6.05	2.51
	(68.14)	(48.36)	(35.91)	(4.08)	(8.97)	(13.01)	(9.99)	(3.35)	(77.10)	(61.37)	(45.90)	(7.43)
M_3	8.35	7.80	5.74	2.07	2.98	3.80	3.38	1.97	8.83	8.67	6.69	2.76
	(78.25)	(69.16)	(43.40)	(5.05)	(9.52)	(15.95)	(11.75)	(4.02)	(87.77)	(85.11)	(55.15)	(9.06)
SEm ±	0.011	0.011	0.019	0.004	0.010	0.016	0.014	0.010	0.011	0.010	0.021	0.012
CD (p = 0.05)	0.042	0.045	0.074	0.018	0.037	0.063	0.056	0.029	0.042	0.039	0.084	0.046
Integrated weed management (W)												
W_1	15.69	15.24	11.39	3.82	5.35	6.68	4.84	2.99	16.58	16.66	12.37	4.86
	(277.62)	(251.93)	(130.56)	(14.95)	(30.88)	(46.76)	(23.57)	(8.80)	(308.50)	(298.69)	(154.13)	(23.75)
W_2	9.27	6.47	2.16	0.97	3.22	3.42	2.27	1.02	9.80	7.31	3.03	1.23
	(87.51)	(42.33)	(4.24)	(0.48)	(10.18)	(11.62)	(4.72)	(0.55)	(97.69)	(53.95)	(8.96)	(1.03)
W_3	9.47	9.02	8.45	2.92	3.51	4.31	3.61	2.60	10.09	10.02	9.23	3.86
	(91.33)	(90.68)	(78.47)	(9.12)	(12.34)	(19.41)	(12.81)	(6.46)	(103.67)	(110.09)	(91.27)	(15.58)
W_4	9.37	7.70	7.37	2.55	3.30	3.91	3.30	2.26	9.92	8.64	8.14	3.38
	(89.50)	(65.20)	(62.81)	(7.18)	(10.75)	(16.16)	(10.63)	(4.82)	(100.25)	(81.36)	(73.44)	(12.00)
W_5	2.90	3.03	2.26	0.98	1.25	2.00	2.39	1.05	3.07	3.52	3.20	1.27
	(8.00)	(8.92)	(4.63)	(0.52)	(1.06)	(3.51)	(5.23)	(0.60)	(9.06)	(12.43)	(9.86)	(1.13)
SEm ± =	0.82	0.86	0.57	0.19	0.25	0.31	0.06	0.07	0.86	0.91	0.55	0.19
CD (p = 0.05)	2.40	2.51	1.67	0.54	0.72	0.90	0.18	0.20	2.52	2.65	1.59	0.56
Interaction (MxW)												
SEm± =	1.276	1.330	0.889	0.287	0.383	0.477	0.095	0.104	1.336	1.409	0.846	0.297
CD (p= 0.05)	3.725	3.881	2.594	0.839	1.119	NS	0.281	0.304	3.900	4.112	2.470	0.866

The weed data is subjected to square root transformation $\sqrt{x + 0.5}$. Values within parenthesis indicates original values, Details of the treatments are given under Materials and Methods.

Table 2. Effect of establishment methods and integrated weed management practices on weeds dry weight (g/m²), weed control efficiency (%) and weed index (%) in wetland rice(pooled data for kharif 2010 and 2011).

Treatments	Weeds dry weight (g/m²)				Weed control efficiency (%)				Weed index (%)
	20 DAT	40 DAT	60 DAT	Harvest	20 DAT	40 DAT	60 DAT	Harvest	
Establishment methods (M)									
M_1	11.57	18.15	16.11	12.37	64.59	68.30	68.69	65.84	12.35
M_2	7.66	9.70	10.15	6.78	52.82	64.24	72.50	71.39	9.90
M_3	8.42	10.57	12.61	8.07	49.52	57.94	63.27	61.50	10.61
SEm±	0.023	0.037	0.073	0.060	0.13	0.15	0.70	0.310	0.067
CD(P=0.05)	0.089	0.108	0.213	0.177	0.53	0.58	2.76	0.905	0.263
Integrated weed management (W)									
W_1	17.06	26.57	28.60	19.33	0.00	0.00	0.00	0.00	29.19
W_2	8.11	6.39	4.66	2.14	50.52	73.02	82.99	87.99	0.00
W_3	8.51	13.78	14.70	11.73	48.36	49.40	48.32	39.69	8.71
W_4	8.29	10.45	11.60	9.03	49.69	60.30	60.19	54.77	3.98
W_5	4.13	6.85	5.22	3.16	74.00	71.26	81.12	82.51	1.93
SEm± =	0.77	1.73	1.12	1.09	2.37	1.61	1.43	1.50	0.39
CD (p = 0.05)	2.26	5.06	3.28	3.19	6.93	4.70	4.18	4.38	1.13
Interaction (M × W)									
SEm ± =	1.197	2.688	1.742	1.694	3.68	2.50	2.33	2.345	0.604
CD (p = 0.05)	3.496	7.846	5.088	4.946	NS	7.31	7.01	6.886	1.770

DAT = Days after transplanting. Details of the treatments are given under Materials and Methods.

Table 3. Effect of establishment methods and integrated weed management on yield and harvest index of wetland rice (pooled data for kharif 2010 and 2011).

Treatments	Yield (tonne/ha)			Harvest index (%)
	Grain	Straw	Biomass	
Establishment methods (M)				
M_1: System of Rice Intensification(SRI)	5.63	7.97	13.65	41.05
M_2 : Integrated Crop Management (ICM)	5.58	7.96	13.59	41.15
M_3 : Conventional Rice Culture (CRC)	4.91	7.62	12.66	39.13
SEm ±	0.003	0.014	0.020	0.037
CD (p = 0.05)	0.013	0.055	0.077	0.107
Integrated weed management (W)				
W_1: Control	4.14	6.67	10.78	38.17
W_2: Hand weeding twice at 20 and 40 DAT	5.89	8.26	14.21	41.59
W_3: Cono-weeding twice at 20 and 40 DAT	5.40	7.97	13.55	40.25
W_4: Cono-weeding at 20 DAT + hand weeding at 40 DAT	5.66	8.16	13.89	40.90
W_5: Butachlor 50EC@1.5 kg a.i./ha at 3 DAT + cono- weeding at 20 DAT	5.78	8.19	14.06	41.31
SEm ± =	0.15	0.08	0.21	0.43
CD (p = 0.05)	0.44	0.22	0.61	1.25
Interaction (M × W)				
SEm ± =	0.233	0.119	0.325	0.667
CD (p = 0.05)	0.680	0.348	0.950	1.948

@ 1.5 kg a.i./ha at 3 DAT + cono-weeding at 20 DAT at the stages of 40, 60 DAT and at harvest (Table 2) which might be due to the fact that the weeds disappear from 60 DAT to harvesting stage. The reduction of in yield due to presence of weeds which was observed more in control plot with weed index of 29.19% and lowest 1.93% with butachlor 50EC@1.5 kg a.i./ha at 3 DAT + cono-weeding at 20 DAT (Table 2).

Significantly higher grain yield of wetland rice was obtained with hand weeding twice at 20 and 40 DAT (5.89 tonne/ha) which was statistically at par with by butachlor 50 EC@1.5 kg a.i./ha at 3 DAT + cono-weeding at 20 DAT (5.78 tonne/ha) but remained superior over control. This might be due to less weed infestation leading to higher yield components and yield compared to control. Similar finding was also reported by Banerjee *et al.* (2008) and Uphoff (2003). The highest harvest index (41.59%) was observed with hand weeding twice at 20 and 40 DAT followed by butachlor 50EC@1.5 kg a.i./ha at 3 DAT + cono-weeding at 20 DAT (Table 3). Kiniry *et al*. (2001) reported that the values of rice harvest index varied greatly among cultivars, locations, seasons, and ecosystems, and ranged from 0.35 to 0.62, indicating the importance of this variable for yield simulation.

Hence, integrated weed management in SRI with butachlor 50EC@1.5 kg a.i./ ha at 3 DAT + cono-weeding at 20 DAT and ICM with hand weeding twice at 20 and 40 DAT gave better yield than CRC method of wetland rice cultivation.

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