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Weed control in transplanted and wet-seeded rainy season rice (*Oryza sativa*)

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ABSTRACT

A field study was conducted at Cooch Behar during the rainy seasons of 2006 and 2007 to find out the economically viable weed control practices in transplanted and wet seeded rice (*Oryza sativa* L.). In transplanted rice, *Monochoria hastate* Prest., *Ludwigia parviflora* Roxb., *Nymphoides indicum* (L) and Barnyardgrass [*Echinochloa crus-galli* (L.)] were dominant weed. In wet seeded rice *Monochoria hastate* Prest., *Ludwigia perennis* Roxb., Flatsedge [*Cyperus flavidus* (L.)], *Cyperus difformis* (L.), *Scirpus juncoides* (L.) and Bermudagrass [*Cynodon dactylon* (L.)] were aggressive and important weeds. In transplanted rice, butachlor 1.0 kg/ha at 3 days after transplanting + almix 20 WP (Chlorimuron-ethyl + Metsulfuron-methyl) 4.0 g/ha at 20 days after transplanting registered higher weed control efficiency and grain yield (3.17 and 3.50 tonne/ha) comparable with season long weed-free condition. This treatment gave maximum monetary returns of ₹ 14 843 and 17 728/ha as well as benefit:cost ratio of 1.09 and 1.31 during 2006 and 2007, respectively. In wet-seeded rice, drum seeding, followed by brown manuring [seeding of *dhaincha* (*Sesbania rostrata*) with rice seeds, followed by 2,4-D 0.50 kg/ha application at 25 days after sowing and subsequent incorporation of dried *dhaincha* with rotary weeder at 35 DAS, was comparable with season long weed-free condition in terms of yield (3.03 and 3.32 tonnes/ha) and thus resulting in maximum monetary benefit of ₹ 14 204 and 16 829/ha with benefit:cost ratio of 1.10 and 1.30 in 2006 and 2007, respectively. Weeds in complete weedy situation removed 30.1 to 34.3 kg N, 5.8 to 7.4 kg P and 37.8 to 42.9 kg K/ha in transplanted rice and 37.7 to 50.9 kg N, 10.3 to 15.7 kg P and 47.4 to 63.7 kg K/ha in wet-seeded rice, respectively, during 2006 and 2007. Butachlor 1.0 kg/ha at 3 days after transplanting + almix 20 WP (Chlorimuron-ethyl 10% + Metsulfuron-methyl 10%) 4.0 g/ha at 20 days after transplating in transplanted rice and practice of brown manuring in wet-seeded rice were found effective to control weeds and these weed control practices prevented removal of 24.1 to 28.1 kg N, 5.4 to 6.9 kg P and 30.1 to 35.0 kg K/ha in transplanted rice and 30.7 to 42.4 kg N, 9.1 to 13.8 kg P and 38.3 to 52.9 kg K/ha in wet-seeded rice by the weeds-respectively.

Key words: Brown manuring, Nutrient removal by weeds, Transplanted *kharif* rice, Weed management practices Wet-seeded rice

In *terai* region of West Bengal rice (*Oryza sativa* L.) is mostly cultivated in transplanted condition. However, in some parts it is traditionally grown in wet direct-seeded condition. Hand weeding is a common practice in these areas although scarcity of labour during peak season delays weed control. This result in higher weed-crop competition. Uncontrolled weeds caused yield reduction to the tune of 43 to 69% in different rice ecosystems (Singh *et al.* 2007, Singh *et al.* 2007). Though herbicide use in India is low, it is very much popular in rice. Butachlor is the most widely used rice herbicide contributing more than 80% of the herbicides used in different crops (Kathiresan 2002). Dhyani *et al.* (2007) observed that broadcasting *Sesbania* in direct-seeded rice and 2,4-D application (0.50 kg/ha) at 25 days after sowing along with mechanical incorporation or manual weeding at 35 days after sowing recorded highest grain yield. As the crop and weed seeds germinate concurrently in wet-seeded rice and the growth rate of weeds is faster, information on integrated weed management with dual cropping of *dhaincha* (*sesbania rostrata*) and rice; and pre-emergence herbicide application is essential. Farmers in this region usually grow rice without having proper knowledge on use of herbicide and its integration in weed management practices. Therefore, present study was planned to find out suitable economically viable weed control practices in transplanted and wet-seeded rainy season rice.

MATERIALS AND METHODS

The field experiments were conducted during rainy (*kharif*) seasons of 2006 and 2007 at Cooch Behar, West Bengal to work out economics of weed control practices in

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transplanted and wet-seeded rice. The climate in this region is humid and characterized with high rainfall (300 cm/annum). The soil was sandy to sandy loam in texture with *p*H 5.58, organic carbon 0.62% and available N, P and K were 175.4, 21.3 and 78.3 kg/ha, respectively. Two separate experiments, one in transplanted rice and other in wet-seeded rice were conducted. There were eight treatment combinations in transplanted rice (Table 1) and 10 treatment combinations (Table 2) in wet-seeded rice laid out in a randomized block design with three replications.

'Swarnamasuri (MTU 7029)' rice was grown both in transplanted and wet seeded rice. In case of wet-seeded rice 40 kg/ha seeds of rice were sown with the help of drum seeder and 50 kg/ha *dhaincha* seeds were broadcast after that. A thin film of water was maintained after drum seeding. Crops were sown in rows 22.5 cm apart with the plot size of 8 m × 4 m. The fertilizer dose was 60 kg N + 13.1 kg P + 33.3 kg K/ha in both the experiment. Nitrogenous fertilizer was applied in three splits in transplanted rice, i e $^1/_3$ as basal, $^1/_3$ at 25 days after transplanting and $^1/_3$ at 45 days after transplanting, whereas 4 splits in wet seeded rice, i e $^1/_4$ as basal, $^1/_4$ at 25, $^1/_4$ at 45 and $^1/_4$ at 60 days after sowing in all the treatments. Weed count was made in quadrat having the size of 0.25 m × 0.25 m from four randomly selected points of individual plot and total dry weight of the weeds was measured. Data on weed dry weight was analyzed after subjecting to square-root transformation $\{\sqrt{(X + 1)}\}$. Economic analysis was done on the basis of prevailing market price of inputs used and output obtained from each treatment. In transplanted rice sale price of output/tonne was: rice grain, ₹ 7 500; rice straw, ₹ 1 000; input price (kg): rice seed ₹ 10; urea, ₹ 4.78; single super phosphate, ₹ 3.22; muriate of potash, ₹ 4.45; herbicides (litre or kg): butachlor, ₹ 180; pretilachlor, ₹ 480; almix 20 WP (Chlorimuron-ethyl + Metsulfuron-methyl), ₹ 13125; man days required for each hand weeding in transplanted rice 22.5/ha, man-days required for spraying of herbicide 5/ha, man-days required for each paddy weeder operation 15/ha, labour wage ₹ 75.10/man-day whereas in wet-seeded rice sale price of output/tonne and input price (kg) of rice seed, rice straw, fertilizers and herbicides (litre or kg) were similar with transplanted *kharif* rice, however, price of other input (kg) was: seed of *Sesbania rostrata,* ₹ 10; 2,4-D sodium salt, ₹ 220; man-days required for each hand weeding in wet-seeded rice 30/ha, man days required for spraying of herbicide 5/ha.

RESULTS AND DISCUSSION

Effect on weeds

Weed flora of transplanted rice comprised one grass, three sedges and four broad-leaved weeds. At the initial phase of crop growth, *Monochoria hastate* Prest. (26%), *Ludwigia parviflora* Roxb. (24%), *Nymphoides indicum* (L.) (14%) and Barnyardgrass [*Echinochloa crusgalli* (L.)] (21%) were dominant weed. Flat sedge [*Cyperus iria* (L.) (14%), *Scirpus maritimus* (L.) (9%), *Fimbristylis miliacea* (L.) Rahl (7%) and *Sphenochlea zeylanica* (Gaertn.) (11%) appeared at the later part of the crop growth. *Monochoria hastate* Prest., *Ludwigia parviflora* Roxb., *Nymphoides indicum* (L.) and Barnyardgrass [*Echinochloa crusgalli* (L.)] became aggressive in transplanted rice because of their long emergence profile.

Weed flora of wet-seeded rice comprised one grass, several sedges and four broad-leaved weeds. The broad-leaved weeds, *Monochoria hastate* Prest. (35%) and *Nymphoides indicum* (L.) (24%) were dominant up to active tillering stage. The broad-leaved weed *Ludwigia perennis* Roxb. (38%), the sedges, Flatsedge [*Cyperus flavidus* (L.)] (15%), *Cyperus difformis* (L.) (14%) and *Scirpus juncoides* (L.) (12%) and Bermudagrass [*Cynodon dactylon* (L.)] (7%) were present throughout the crop growth. *Fimbristylis miliacea* (L.) Rahl (5%) and *Oldenlandia umbellate* (L.) (3%) appeared at later part of crop growth.

Among the weed control practices farmers' practice the treatment butachlor 1.0 kg/ha + almix 20 WP (Chlorimuron-ethyl 10% + Metsulfuron-methyl 10%) 4 g/ha recorded lowest weed dry weight in transplanted rice resulting in highest weed control index of 71.3 and 73.5% and lowest weed competition index of 0.9 and 3.3% at harvest in 2006 and 2007, respectively (Table 1), followed by farmers' practice. Highest value of weed control index and lowest value of weed index of this treatment reflected its selectivity in controlling weeds.

In wet-seeded rice, farmers' practice recorded lowest weed dry weight closely followed by brown manuring treatment resulting in highest weed control index of 74.4 and 76.3% and lowest weed competition index of 3.5 and 2.4% at harvest in 2006 and 2007, respectively (Table 2). The high growth rate of *dhaincha* at initial growth stage and subsequent killing with 2,4-D @ 0.50 kg/ha, followed by incorporation of *dhaincha* with rotary paddy weeder might have suppressed the weeds effectively under brown manuring treatment during active tillering stage of rice. This finding is in close conformity with the result reported by Yadav (2004), Joseph *et al.* (2008) and Ravisankar *et al.* (2008).

Effect on crop

Yield: In transplanted rice butachlor 1.0 kg/ha + almix 20 WP 4 g/ha resulted in higher grain (3.17 and 3.50 tonne/ha) and straw (4.64 and 5.05 tonne/ha) yields comparable with grain (3.20 and 3.62 tonne/ha) and straw (4.66 and 5.12 tonne/ha) yields of season long weed-free condition during both the years of experimentation (Table 1). The possible reason for this might be the higher weed control index without phytotoxicity leading to higher values of yield-contributing characters (panicles/m^2, effective spikletets/pacicle and test weight) and yields. The grain and straw yields obtained in farmers' practice and butachlor + paddy weeder were also comparable with butachlor 1.0 kg/ha + almix 20 WP 4 g/ha. In wet-seeded rice, brown manuring recorded grain (3.03 and

Table 1 Effect of treatments on weed dry weight, weed control index, weed competition index, yield-attributing characters and yield of transplanted rice

Treatment	Weed dry weight at harvest (g/m^2)		Weed control index at harvest (%)		Weed competition index (%)		Panicles/m^2		Test Weight (g)		Effective spikelets/ panicle		Grain yield (tonnes/ha)		Straw yield (tonnes/ha)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Butachlor (1.0 kg/ha) at 3 DAT + rotary paddy weeder at 35 DAT	7.7 (59.0)	7.3 (51.9)	64.3	71.3	8.1	5.5	198.3	210.0	20.0	20.0	70.3	71.5	2.94	3.42	4.55	5.01
Pretilachlor (0.75 kg/ha) at 3 DAT + rotary paddy weeder at 35 DAT	7.9 (62.0)	7.9 (62.7)	62.5	65.4	11.3	8.8	194.0	206.0	19.5	19.5	69.7	70.9	2.84	3.30	4.42	4.84
Almix 20 WP (4 g/ha) at 20 DAT	8.3 (68.6)	8.9 (77.5)	58.5	57.2	23.4	24.0	187.0	193.7	19.4	19.4	69.4	70.2	2.45	2.75	3.88	4.20
Butachlor (1.0 kg/ha) at 3 DAT + almix 20 WP (4 g/ha) at 20 DAT	6.9 (47.4)	7.0 (48.1)	71.3	73.5	0.9	3.3	205.7	215.3	20.2	21.1	73.6	75.2	3.17	3.50	4.64	5.05
Rotary paddy weeder at 20 and 40 DAT	8.1 (65.5)	8.3 (68.4)	60.4	62.2	18.8	21.6	190.0	194.0	19.1	19.3	68.9	69.2	2.60	2.84	3.91	4.33
Weedy check	12.9 (165.2)	13.5 (181.2)	0.00	0.00	43.1	52.2	114.7	98.3	18.3	18.5	37.9	38.6	1.82	1.73	2.41	2.08
Weed-free check	1(0.0)	1(0.0)	100	100	0.00	0.00	210.0	215.7	20.2	21.1	73.7	75.9	3.20	3.62	4.66	5.12
Farmer's practice (2 hand weeding at 20 and 40 DAT)	7.1 (48.9)	7.3 (52.5)	70.4	71.0	7.2	7.2	201.0	208.3	20.2	20.1	70.5	73.9	2.97	3.36	4.58	4.97
S Em ±	0.15	0.25					3.4	4.7	0.22	0.30	0.8	1.2	0.14	0.11	0.36	0.28
CD (*P* = 0.05)	0.33	0.53					7.4	10.1	0.47	0.64	1.8	2.5	0.31	0.25	0.76	0.60

Values in parentheses are means of original values; DAT, days after transplanting

3.32 tonne/ha) and straw (4.41 and 4.86 tonne/ha) yields, which was statistically at par with season long weed-free condition (Table 2). Brown manuring reduced the state of crop-weed competition by lowering weed biomass, leading to increase in values of yield-contributing characters.

The grain yield during first year was lower than second year because of erratic rainfall pattern of monsoon in 2006 leading to moisture stress during initial growth stage of rice. However, rainfall pattern of monsoon in 2007 was well distributed resulting in better crop performance.

Economics

In transplanted rice butachlor @ 1.0 kg/ha + almix 20 WP 4 g/ha registered maximum net returns (₹ 14 843 and 17 728/ha) and highest benefit : cost ratio (1.09 and 1.31) during both the years, followed by butachlor + paddy weeder (Table 3). This might be owing to high weed control efficiency with least man-days engagement and higher grain yield.

In wet-seeded rice, brown manuring registered highest net returns (₹ 14 204 and 16 829/ha) and benefit:cost ratio (1.10 and 1.30) in 2006 and 2007, respectively (Table 4). In both transplanted and wet seeded rice net returns and benefit:cost ratio were lower in farmers' practice. It might be because of more man-days engaged in uprooting weeds at different times that in turn increased cost of cultivation.

Nutrient removal by weeds

Weeds in complete weedy situation removed 30.1 to 34.3 kg N, 5.8 to 7.4 kg P and 37.8 to 42.9 kg K/ha in transplanted rice (Table 3) and 37.7 to 50.9 kg N, 10.3 to 15.7 kg P and 47.4 to 63.7 kg K/ha in wet seeded rice (Table 4), respectively, during 2006 and 2007. Saving of nutrient against its removal by weeds was to the tune of 24.1 to 28.1 kg N, 5.4 to 6.9 kg P and 30.1 to 35.0 kg K/ha by the treatment Butachlor 1.0 kg/ha + almix 20 WP 4.0 g/ha in transplanted rice and 30.7 to 42.4 kg N, 9.1 to 13.8 kg P and 38.3 to 52.9 kg K/ha by the treatment brown manuring in wet-seeded rice, respectively, during 2006 and 2007.

It may be concluded that weed control practices, like butachlor 1.0 kg/ha at 3 days after transplanting + almix 20 WP (Chlorimuron-ethyl 10% + Metsulfuron-methyl 10%) 4.0 g/ha at 20 days after transplanting or butachlor 1.0 kg/ha at 3 days after transplanting + rotary paddy weeder at 35 days after transplanting in transplanted rice and practices of brown manuring [seeding of *dhaincha* (*Sesbania rostrata)* with rice seeds, followed by 2,4-D @ 0.50 kg/ha application at 25 days after sowing and subsequent incorporation of dried *dhaincha* with rotary weeder at 35 days after sowing] in wet-seeded rice may be effective for controlling weeds, restriction on undue removal of nutrients by weeds, getting higher yield and higher monetary returns during rainy season under *terai* agro-climatic region of West Bengal. Drum seeding operation was effective in puddled soil without standing water,

Table 2 Effect of treatments on weed dry weight, weed control index, weed competition index, yield-attributing characters and yield of wet-seeded rice

Treatment	Weed dry weight at harvest (g/m^2)		Weed control index at harvest (%)		Weed competition index (%)		Panicles/m^2		Test Weight (g)		Effective spikelets/ panicle		Grain yield (tonnes/ha)		Straw yield (tonnes/ha)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Butachlor (0.50 kg/ha) at 6 DAS +hand weeding 20 DAS	9.1 (81.4)	9.7 (93.5)	57.2	61.2	33.1	27.9	170.7	172.7	19.9	20.2	67.2	68.7	2.10	2.45	3.25	3.75
Butachlor (1.0 kg/ha) at 6 DAS	9.3 (85.1)	10.5 (109.4)	55.3	54.6	35.7	34.7	162.3	165.0	19.8	20.1	65.7	66.9	2.02	2.22	3.17	3.42
Almix 20 WP (8 g/ha) at 20 DAS	9.6 (90.8)	10.7 (112.6)	52.3	53.3	39.2	42.9	149.3	155.0	19.4	19.5	64.8	65.2	1.91	1.94	2.94	3.12
Brown manuring	7.1 (48.8)	7.6 (57.3)	74.4	76.3	3.5	2.4	200.3	206.3	20.2	21.2	70.7	71.3	3.03	3.32	4.41	4.86
Butachlor (0.5 kg/ha) at 6 DAS + Almix 20 WP (8 g/ha) at 20 DAS	8.6 (73.8)	9.8 (96.1)	61.2	60.2	18.2	21.2	171.0	176.3	19.1	19.1	69.1	70.2	2.57	2.68	3.92	4.32
Pretilachlor (0.5 kg/ha) at 3 DAS + hand weeding at 20 DAS	8.9 (79.3)	10.4 (107.4)	58.4	55.5	20.1	23.5	166.3	168.7	18.3	18.2	68.8	70.1	2.51	2.60	3.75	3.93
Pretilachlor (0.75 kg/ha) at 3 DAS	9.1 (82.5)	10.0 (99.5)	56.7	58.7	31.5	33.5	159.0	159.3	19.2	19.5	67.5	68.2	2.15	2.26	3.34	3.62
Weedy check	13.8 (190.4)	15.5 (241.1)	0.00	0.00	83.8	75.3	52.6	65.7	18.2	18.2	35.4	37.3	0.51	0.84	1.18	1.43
Weed-free check	1.0 (0.00)	1.0 (0.00)	100	100	0.00	0.00	202.0	207.0	20.2	21.2	71.3	72.5	3.14	3.40	4.50	5.19
Farmer's practice (three hand weeding at 15, 30 and 45 DAS)	6.9 (47.6)	7.6 (57.6)	75.0	76.1	4.5	1.8	196.0	202.3	20.1	20.8	70.6	71.4	3.00	3.34	4.38	4.93
S Em ±CD (P=0.05)	0.30	0.31					3.2	2.6	0.21	0.28	1.2	1.1	0.19	0.13	0.35	0.24
	0.63	0.64					6.7	5.5	0.44	0.58	2.5	2.3	0.40	0.27	0.73	0.51

Values in parentheses are means of original values; DAS, days after sowing

Table 3 Effect of treatments on economics and nutrient removal by weeds in transplanted rice

Treatment	Economics						Removal of nutrient at harvest by weeds					
	Total cost (×10^3 ₹/ha)		Net returns (×10^3 ₹/ha)		Benefit : cost ratio		N (kg/ha)		P (kg/ha)		K (kg/ha)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Butachlor (1.0 kg/ha) at 3 DAT + rotary paddy weeder at 35 DAT	14.06	14.06	12.54	16.60	0.89	1.18	8.0	6.8	0.7	0.6	10.3	8.7
Pretilachlor (0.75 kg/ha) at 3 DAT +rotary paddy weeder at 35 DAT	14.42	14.42	11.30	15.17	0.78	1.05	8.5	8.7	0.9	1.1	11.0	11.2
Almix 20 WP (4 g/ha) at 20 DAT	12.84	12.84	9.42	11.99	0.73	0.93	9.8	11.2	1.3	1.7	12.4	14.3
Butachlor (1.0 kg/ha) at 3 DAT + almix 20 WP (4 g/ha) at 20 DAT	13.57	13.57	14.84	17.73	1.09	1.31	6.0	6.2	0.4	0.5	7.8	8.0
Rotary paddy weeder at 20 and 40 DAT	13.32	13.32	10.09	12.31	0.76	0.92	9.2	9.8	1.1	1.4	11.7	12.4
Weedy check	12.20	12.20	3.86	2.86	0.32	0.23	30.1	34.3	5.8	7.4	37.8	42.9
Weed-free check	18.96	18.96	9.70	13.31	0.51	0.70	0.00	0.00	0.00	0.00	0.00	0.00
Farmer's practice (two hand weeding at 20 and 40 DAT)	15.58	15.58	11.28	14.59	0.72	0.94	6.3	6.9	0.4	0.8	8.1	9.0
S Em ±							0.47	0.40	0.17	0.06	0.24	0.27
CD (P = 0.05)							1.01	0.85	0.36	0.12	0.52	0.57

Table 4 Effect of treatments on economics and nutrient removal by weeds in wet-seeded rice

Treatment	Economics						Removal of nutrient at harvest by weeds					
	Total cost (×10^3 ₹/ha)		Net returns (×10^3 ₹/ha)		Benefit : cost ratio		N (kg/ha)		P (kg/ha)		K (kg/ha)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Butachlor (0.50 kg/ha) at 6 DAS+ hand weeding 20 DAS	13.61	13.61	5.40	8.52	0.40	0.63	12.3	14.3	2.5	3.5	15.8	18.3
Butachlor (1.0 kg/ha) at 6 DAS	11.53	11.53	6.78	8.54	0.59	0.74	13.1	17.2	2.8	4.4	16.6	22.0
Almix 20 WP (8 g/ha) at 20 DAS	11.70	11.70	5.57	5.97	0.48	0.51	14.2	18.0	3.3	4.6	17.9	23.0
Brown manuring	12.93	12.93	14.20	16.83	1.10	1.30	7.0	8.5	1.2	1.9	9.1	10.8
Butachlor (0.5 kg/ha) at 6 DAS + Almix 20 WP (8 g/ha) at 20 DAS	12.25	12.25	10.94	12.17	0.89	0.99	10.9	14.8	2.1	3.7	14.0	18.9
Pretilachlor (0.5 kg/ha) at 3 DAS + hand weeding at 20 DAS	13.91	13.91	8.67	9.53	0.62	0.68	11.9	16.8	2.4	4.3	15.2	21.5
Pretilachlor (0.75 kg/ha) at 3 DAS	11.89	11.89	7.57	8.68	0.64	0.73	12.5	15.4	2.6	3.9	16.1	19.7
Weedy check	10.80	10.80	–5.79	–3.07	–0.54	–0.28	37.7	50.9	10.3	15.7	47.4	63.7
Weed-free check	19.81	19.81	8.24	10.88	0.42	0.55	0.00	0.00	0.00	0.00	0.00	0.00
Farmer's practice (three hand weeding at 15, 30 and 45 DAS)	17.56	17.56	9.32	12.42	0.53	0.71	6.8	8.6	1.1	2.0	8.8	10.8
S Em ±							0.14	0.26	0.14	0.17	0.40	0.26
CD (P = 0.05)							0.30	0.54	0.30	0.36	0.85	0.54

however, heavy downpour after drum seeding reduced its effectiveness by accumulating seeds in one side of the field in the direction of slope.

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