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Research Paper

Effect of weed management practices on weeds, nutrient depletion and yield of rice (*Oryza sativa*)

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ABSTRACT

Field experiments were conducted during Navarai (*rabi*) seasons of 2011 and 2012 with ADT-36 rice (*Oryza sativa* L.) variety to evaluate the effect of weed management practices. Pooled data of the two years revealed that application of butachlor @ 1.5 kg a.i/ha followed by weekly cono-weeding from 21 to 42 days after transplanting (DAT) resulted in least weed count, dry-matter production and nutrient removal which resulted in the highest weed control efficiency, productive tillers/hill, grains/panicle, number of filled grains/panicle and enhanced the grain yield, which was 0.73 and 0.46 t/ha more compared to twice hand weeding and conventional method of butachlor application followed by hand weeding.

Key words **:** Butachlor, Conoweeding, Grain yield, Weed control efficiency, Weed, Yield parameters

Globally, threats to rice production has increased due to burgeoning population, wide spread malnutrition, biotic and abiotic stresses. In India, during 2016–17, rice was cultivated in an area of 43.39 mha with a production of 104.32 mt (Annual Report, 2016–17). The productivity is low (2.4 t/ha) in India compared to world average (4.44 t/ha). In 2020, to feed 1.5 billion people, India would need 165 mt of rice. To sustain present food self sufficiency, alleviate poverty and to meet future food demands, India has to increase rice productivity by 3% per annum. The mean growth rate in rice productivity is stagnant in India at 0.54%. Stagnant productivity on one hand and the higher food grains demand to feed the ever growing population on the other are becoming the major challenges in India. System of Rice Intensification (SRI) is an important strategy with twin objectives like increasing the productivity and high water-use efficiency. SRI methods promote greater root growth and higher soil biological activity in the rhizosphere. By adopting this system of cultivation, one could save water, protect soil productivity, save environment by checking methane gas from water submerged paddy cultivation practices, save some input cost, besides increasing the production for providing food to the growing population. SRI crops are more resistant to most pests and diseases, and better able to tolerate adverse climatic conditions such as drought, storms, hot spells or cold snaps. Besides, the length of the crop cycle is also reduced, with higher yields. The resistance of SRI rice plants to lodging caused by wind and or rain is due to their larger root systems and stronger tillers. Weed control in over populated areas of Asia was done through a combination of water management and hand weeding (HW), but the latter is becoming less common in areas with an increasing labour shortage problem. The present investigation was undertaken to identify the best combination of easily practicable components for weed control.

MATERIALS AND METHODS

Field experiments were conducted at the experimental farm, Annamalai University, Chennai (11° 24' N, 79° 44' E and at an elevation of + 5.79 m above mean sea-level). The experiment was laid in a randomized block design with 3 replications during *Navarai* (winter season) of 2011 and 2012 with 'ADT-36' rice cultivar. The soil was clayey loam with low in available N (229–237 kg/ha), medium in available P (18–20 kg/ha), high in available K (241–312 kg/ha) and *p*H 8.15. The experiment consisted of ten treatments, viz. T_1, unweeded control; T_2, handing-weeding (HW) twice on 20 and 35 days after transplanting (DAT); T_3, butachlor @ 1.5 kg a.i/ ha + HW on 35 DAT; T_4, butachlor @ 1.5 kg a.i/ ha + almix @ 20 g /ha on 21 DAT; T_5, cono-weeding on 10, 20, 30 and 40 DAT; T_6, butachlor @ 1.5 kg a.i/ ha + cono-weeding on 25 and 40

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DAT; T_7, butachlor @ 1.5 kg a.i/ ha + weekly cono-weeding from 21 to 42 DAT (21, 28, 35 and 42 DAT); T_8, butachlor @ 1.5 kg a.i/ha + cono-weeding on 20, 30 and 40 DAT; T_9, butachlor @ 1.5 kg a.i/ha + cono-weeding on 30, 40 and 50 DAT and T_{10}, fortnightly cono-weeding on 15, 30 and 45 DAT. Seedlings (14 day-old) raised by mat nursery were transplanted with a spacing of 25 cm × 25 cm. Standard cultivation practices were followed for both the experiments. Butachlor was applied to respective plots on 3 DAT by mixing with sand @ 50 kg/ha and post-emergence herbicide Almix was applied with help of Knapsack sprayer fitted with flood jet deflector nozzle by using 500 litres of water/ha on 21 DAT. In each treatment plot, observations on weed count were made randomly at four places by using 0.25 m^2 quadrat 60 DAT, computed and expressed. The data on weed count was subjected to square root transformation to normalise their distribution. Similarly, from each treatment plot, weeds were pulled out from four quadrats each of 0.25 m^2 area, air dried and oven dried at 65±5^O C, computed and expressed. These data were used to calculate WCE. At harvest, the weed samples were collected plot wise, powered and NPK contents were determined by standard procedures. The treatment-wise total NPK removal by weeds were determined by multiplying with DMP at harvest and their respective NPK content. The yield parameters were recorded from 5 randomly selected plants/plot before harvest and the mean values were recorded. The plot-wise yield was recorded for grain and straw and computed on hectare basis. The added cost of cultivation for various weed management treatments ranged from ₹730 to ₹2,630. The benefit cost ratio (BCR) was worked out by dividing the gross income with cost of cultivation.

RESULTS AND DISCUSSION

Effect on weeds

Out of 6 weeds noticed as predominant, three were grasses (*Panicum repens* L.*, Leptochloa chinensis,* and *Echinocloa colonum* L.), two sedges (*Cyperus rotundus* L. and *Cyperus iria* L.) and one broad leaved weed (*Masilia quadrifoliata* L.). The relative proportion of grasses, sedges and broad leaved weeds in the pooled data were 96.7, 2.34 and 0.95, respectively. At 60 DAT, the highest weed density was noticed in unweeded control (Table 1). Among the treatments, application of butachlor @ 1.5 kg/ha followed by (fb) weekly cono-weeding from 21 to 42 DAT ranked first and reduced the weed density up to 71.6% compared to unweeded control. This might be due to the combined effect of butachlor which effectively controlled the predominantly present monocot weeds and conoweeding incorporated the seedlings. Radhamani *et al.* (2012) reported similar results. The two treatments viz. application of butachlor @ 1.5 kg a.i/ha + hand-weeding (HW) on 35 DAT and butachlor @ 1.5 kg/a.i/ha + almix @ 20 g/ha on 21 DAT exerted similar effects in reducing the weed density. HW twice significantly redued the weed density up to 21.6% over unweeded control. The same trend was noticed in terms of weed DMP. The highest WCE of 77.2% was noticed in the application of butachlor @ 1.5 kg a.i/ha fb weekly cono-weeding from 21 to 42

Table 1. Effect of weed management practices on weeds in SRI rice (pooled data of 2 years)

Treatment	Total weed count at 60 DAT	DMP at harvest (g/m^2)	WCE	Nutrient removal by weeds (kg/ha)		
				N	P	K
Unweeded control	126.7 (11.3)	123.4		49.9	16.3	34.7
HW twice on 20 and 35 DAT	77.7 (8.8)	64.3	48.8 (44.3)*	40.1	15.2	27.6
Butachlor @ 1.5 kg a.i/ha + HW on 35 DAT	27.7 (5.3)	24.0	79.6 (63.2)	10.4	10.2	15.5
Butachlor @ 1.5 kg a.i/ha + Almix @ 20 g/ha on 21 DAT	31.6 (5.7)	26.7	83.4 (66.0)	12.4	11.0	18.2
Cono-weeding on 10, 20, 30 and 40 DAT	46.5 (6.9)	40.0	65.6 (54.1)	38.5	14.0	24.7
Butachlor @ 1.5 kg a.i/ha + cono-weeding on 25 and 40 DAT	12.1 (3.5)	6.6	94.2 (76.1)	3.9	2.0	4.7
Butachlor @ 1.5 kg a.i/ha + Weekly cono-weeding from 21 to 42 DAT (21, 28, 35 and 42 DAT).	9.8 (3.2)	5.7	95.1 (77.2)	3.4	1.7	3.4
Butachlor @ 1.5 kg a.i/ha + Cono-weeding on 20, 30 and 40 DAT	42.5 (6.6)	28.7	76.2 (60.8)	14.4	11.4	20.2
Butachlor @ 1.5 kg a.i/ha + Cono-weeding on 30, 40 and 50 DAT	45.8 (6.8)	25.8	76.6 (61.1)	12.9	12.5	22.6
Fortnightly cono-weeding on 15, 30 and 45 DAT	118.3 (10.9)	63.4	46.2 (42.8)	41.7	14.5	28.3
SEm±	0.15	0.16		0.10	0.22	0.18
CD (P=0.05)	1.01	1.07		0.69	1.45	1.18

HW, Hand-weeding; DAT, days after transplanting; DMP, dry-matter production; WCE, weed control efficiency; Figures in parenthesis are square root transformed values. *Figures in parenthesis are arc-sign transformed values

DAT. This might be due to the better weed control effect of butachlor from the initial stages of crop growth and incorporation of weeds as and when they germinate by cono-weeding. This finding is in agreement with the findings of Nalini and Chinnusamy (2012) and Sujatha *et al.* (2012). The next best treatment was application of butachlor @ 1.5 kg a.i/ha fb cono-weeding on 25 and 40 DAT. Herbicide application fb cono-weeding on 40 DAT resulted in reduced weed density and higher WCE also reported by Sangeetha *et al.* (2015). Increased efficiency (11.3%) was noticed due to cono-weeding four times over cono-weeding three times alone. Sarkar *et al.* (2017) reported WCE of 71% due to cono-weeding. Pre-emergence application of butachlor @ 1.5 kg a.i/ha fb by cono-weeding at 20, 30 and 40 DAT or at 30, 40 and 50 DAT resulted in increased efficiency to the tune of 17.96 and 18.3% over cono-weeding alone at fortnightly interval for three times.

Effect on nutrient depletion by weeds

The highest depletion of NPK was noticed in unweeded control. The least depletion of NPK (3.39, 1.68 and 3.37) was recorded due to the application of butachlor @ 1.5 kg a.i/ha fb weekly cono-weeding from 21 to 42 DAT. Conventional method of pre-emergence application of butachlor fb HW on 35 DAT was better than application of pre-emergence and post-emergence herbicides (Table 1).

Effect on yield parameters

Application of butachlor @ 1.5 kg a.i/ha fb weekly cono-weeding from 21 to 42 DAT outstripped all other treatments and resulted in 22.8 productive tillers (Table 2). This was followed by butachlor application @ 1.5 kg a.i/ha fb cono-weeding on 25 and 40 DAT. Conventional method of application of butachlor @ 1.5 kg a.i/ha fb HW on 35 DAT was numerically superior than butachlor application @ 1.5 kg a.i/ha fb almix @ 20 g/ha on 21 DAT. Twice HW significantly increased the number of productive tillers up to 5.0 over unweeded control. With regard to number of grains/panicle, the best treatment resulted in 170.5 grains/panicle. The next in order was butachlor application @ 1.5 kg a.i/ha fb cono-weeding on 25 and 40 DAT. Pre-emergence application of butachlor @ 1.5 kg a.i/ha supplemented with either HW on 35 DAT or with almix @ 20 g/ha on 21 DAT were comparable and better than twice HW. Unweeded control recorded least number of grains per panicle.

Application of butachlor @ 1.5 kg a.i/ha fb weekly cono-weeding from 21 to 42 DAT ranked first and increased the total number of filled grains/panicle to the tune of 7.4 over butachlor application @ 1.5 kg a.i/ha fb cono-weeding on 25 and 40 DAT, which ranked second. This might be due to the combined effect of butachlor which effectively checked the growth of grassy weeds which were predominantly present in the field plus cono-weeding in both the directions of the rice field provided a competition free environment and increased the availability of nutrients to the rice crop. Besides, better aeration, microbial activity and source to sink conversion contributed for more number of productive tillers and filled grains/panicle. Higher yield components and yield were obtained by Pasha *et al.* (2012) due to butachlor application fb cono-weeding thrice at 15 days interval. Cono-weeding four times at 10, 20, 30 and 40 DAT increased the filled

Table 2. Effect of weed management practices on yield components and yield of SRI rice (pooled data of 2 years)

Treatment	Number of productive tillers/hill	Number of grains/ panicle	Number of filled grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)	Benefit: cost ratio
Unweeded control	10.7	103.4	89.9	2.51	4.32	1.34
HW twice on 20 and 35 DAT	15.7	114.0	105.1	5.20	7.44	2.44
Butachlor @ 1.5 kg a.i/ha + HW on 35 DAT	21.8	159.4	155.7	5.47	7.66	2.62
Butachlor @ 1.5 kg a.i/ha + almix @ 20 g/ha on 21 DAT	21.5	157.4	154.3	5.39	7.64	2.71
Cono-weeding on 10, 20, 30 and 40 DAT	17.3	128.0	119.5	5.12	7.75	2.46
Butachlor @ 1.5 kg a.i/ha + cono-weeding on 25 and 40 DAT	22.1	164.0	160.6	5.58	7.79	2.69
Butachlor @ 1.5 kg a.i/ha + weekly cono-weeding from 21 to 42 DAT (21, 28, 35 and 42 DAT).	22.7	170.5	167.9	5.93	8.12	2.74
Butachlor @ 1.5 kg a.i/ha + Cono-weeding on 20, 30 and 40 DAT	20.6	146.5	135.0	5.38	7.89	2.56
Butachlor @ 1.5 kg a.i/ha + Cono-weeding on 30, 40 and 50 DAT	19.2	140.4	132.7	5.31	7.75	2.52
Fortnightly cono-weeding on 15, 30 and 45 DAT	14.1	109.0	103.1	4.59	7.33	2.26
SEm±	0.04	0.34	0.37	0.01	0.009	
CD (P=0.05)	0.28	2.27	2.51	0.08	0.07	

HW, Hand-weeding; DAT, days after transplanting

grains/panicle to 16.5 over cono-weeding alone three times at 15, 30 and 45 DAT. A comparable effect was observed between butachlor @ 1.5 kg a.i/ha fb HW on 35 DAT and butachlor application @ 1.5 kg a.i/ha fb almix @ 20 g/ha on 21 DAT. Least number of filled grains/panicle was recorded in unweeded control.

Effect on yield

The highest grain yield (5.93 t/ha) was recorded with the application of butachlor @ 1.5 kg a.i/ha fb weekly cono-weeding from 21 to 42 DAT and it excelled rest of the treatments. This treatment increased the grain yield to the tune of 8.4% over conventional method of butachlor application fb HW on 35 DAT. This might be due to the combined effect of butachlor which controls the weed from 3 DAT besides weekly cono-weeding keeps the field as weed free up to critical period of weed competition. Further, soil stirring with cono-weeder incorporated the weeds, churns and aerated the soil which favoured better microbial activity, solubulize the nutrients, prune the roots, increased the availability of nutrients and positively influenced the yield parameters and yield. Sadhana *et al.* (2012) reported similar results. Conventional method of butachlor application @ 1.5 kg a.i/ha fb HW on 35 DAT was at par with application of butachlor @ 1.5 kg a.i/ha fb almix @ 20 g/ha application on 21 DAT and butachlor application followed by cono-weeding three times at 20, 30 and 40 DAT. Significantly higher grain yield was recorded due to the pre-emergence application of butachlor @ 1.5 kg a.i./ha fb cono-weeding at 20, 30 and 40 DAT or at 30, 40 and 50 DAT when compared to cono-weeding alone at four times. The least grain yield of 2.51 t/ha was recorded in un-weeded control. Among the treatments, the highest straw yield (8.12 t/ha) was recorded with application of butachlor @ 1.5 kg a.i/ha fb weekly cono weeding from 21 to 42 DAT which excelled all other treatments. Conventional method of butachlor application @ 1.5 kg/ha fb HW on 35 DAT did not differ significantly with the application of butachlor @ 1.5 kg a.i/ha fb almix application @ 20 g/ha on 21 DAT in influencing the straw yield. Increased straw yield was recorded up to 0.31 and 0.42 t/ha due to cono-weeding alone at four times over twice HW and cono-weeding alone three times. Unweeded control recorded with least straw yield.

Economics

The highest BCR (2.74) was observed with the application of butachlor @ 1.5 kg a.i/ha fb weekly cono-weeding from 21 to 42 DAT. The conventional method of butachlor application @ 1.5 kg/ha fb HW on 35 DAT gave an additional BCR of 0.18 and 1.28 over twice HW and unweeded control respectively. Cono-weeding 4 times at 10 days interval was better than cono-weeding 3 times at fortnightly interval.

Based on the results it can be concluded that application of butachlor @ 1.5 kg a.i/ha fb weekly cono-weeding from 21 to 42 days after transplanting resulted in least weed indices and higher grain yield.

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