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Integrated weed management in direct-seeded upland rice under Tripura condition

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ABSTRACT

A field experiment was conducted at KVK, South Tripura during the *Kharif* season of 2013 and 2014 to study the integrated weed management in direct-seeded upland rice. The predominant weed flora in the experimental field were *Amaranthus viridis, Oldenlendia corymbosa, Spilanthes acmella, Ludwigia parviflora, Cleome rutidosperma, Malvestrum coromondalianeum* among the broad-leaf weeds, *Digitaria sanguinalis* among grasses and *Cyperus iria* among sedges. The results revealed that though the hand weeding thrice at 15, 30 and 45 DAS recorded lowest weed dry weight and the highest grain yield, it was not economically viable. The pre-emergence application of pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac-sodium at 25 g/ha at 20 DAS recorded the highest net returns and return per rupee invested and appeared to be the most promising and remunerative weed management practices for direct-seeded rice under Tripura condition followed by pendimethalin at 1.0 kg/ha at 2 DAS + one hand weeding at 30 DAS.

Key words: Bispyribac-sodium, Integrated weed managment, Herbicide, Pendimethalin, Weed managment

Rice is the fundamental principal food crop for about half of the world's population supplying 20% of the calories consumed worldwide. India is the second largest rice producing country in the world. The method of direct-seeding escapes the transplanting and puddling operations, which is an attractive alternative to traditional transplanting of rice. A major impediment in the successful cultivation of direct-seeded rice (DSR) in tropical countries is heavy infestation of weeds, which often range from 50-91% (Paradkar *et al.* 1997). No single method like manual, mechanical, biological or chemical, could reach to the desired level of weed control because of the vast diversity of weeds in crop fields. Hence the present study was carried out to find effective integrated weed management practices to control the weeds in direct-seeded upland rice under Tripura condition.

MATERIALS AND METHODS

A field experiment was conducted at Krishi Vigyan Kendra, South Tripura during the *Kharif* (rainy) season of 2013 and 2014 to evaluate the effective integrated weed management practices for direct-seeded upland rice under Tripura conditions. Twelve treatments *viz.* pendimethalin at 1.0 kg/ha at 2 DAS, bispyribac-sodium at 25 g/ha at 25 DAS, pendimethalin at 1.0 kg/ha at 2 DAS + one hand weeding at 30 DAS, pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac-sodium at 25 g/ha at 20 DAS, metsulfuron-methyl + chlorimuron-ethyl (Almix) at 4 g at 10 DAS followed by bispyribac-sodium at 25 g at 20 DAS, pyrazosulfuron-ethyl at 25 g/ ha at 3 DAS followed by bispyribac-sodium at 25 g at 20 DAS, fenoxaprop-p-ethyl at 60 g/ha + metsulfuron-methyl + chlorimuron-ethyl (Almix) at 4 g/ha at 15 DAS, stale seed bed + smother crop (cowpea) in between two rows of rice, stale seed bed + one hand weeding at 30 DAS, *Sesbania* (broadcast) 25 kg/ha during sowing of rice + 2,4-D at 500 g/ha at 25 DAS, hand weeding at 15, 30 and 45 DAS, weedy check were assigned in a randomized block design replicated thrice. Rice variety '*NDR-97*' was used for the experimental purpose with recommended package of practices. Five tonnes of farm yard manure per hectare were applied at the time of field preparation for the rice crop. Chemical fertilizers were applied to meet 60 kg nitrogen in the form of urea, 40 kg phosphorus in the form of single superphosphate and 40 kg potassium in the form of muriate of potash.

Weed counts at different stages (15, 30, 60 and at harvest stage) was taken by placing quadrat at random at three sites in each plot and calculating the average. Weed sample from any of the quadrat was taken, grouped into grasses, broad-leaved weed and sedges, dried and weighed. Weed dry matter was expressed category wise in g/m^2. Weed control

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efficiency was calculated during different stages, *viz*. 30, 60 and harvest stage. Yield and yield attributing characters were also studied. Economics was also calculated for each treatment separately. The data generated from the experiment were subject to analysis of variance (ANOVA) as applied to randomized block design describe by Cochran and Cox (1965).

RESULTS AND DISCUSSION

Effect on weeds

The upland direct-seeded rice of Tripura was infested by different grassy, broad-leaved weeds and sedges. *Amaranthus viridis, Oldenlendia corymbosa, Spilanthes acmella, Ludwigia parviflora, Cleome rutidosperma, Malvestrum coromondalianeum* among the broad-leaf weeds (37.89%); *Digitaria sanguinalis* among grasses (37.89%) and *Cyperus iria* among sedges (31.96%) were predominant in the experimental field. The effect of various weed management practices on dry weight of grasses, broad-leaved, sedges and all weeds showed highly significant differences at 60 DAS (**Table 1**). There was no remarkable changes in dry weight of grasses, broad-leaved, sedges and total weeds between the two years. It is evident from the data that in both the years weed dry weight of grassy (141.09 g/m^2 in 2013 and 136.27 g/m^2 in 2014), broad-leaved (67.67 g/m^2 in 2013 and 64.66 g/m^2 in 2014), sedges (42.81 g/m^2 in 2013 and 40.51 g/m^2 in 2014) and total weed (251.57 g/m^2 in 2013 and 241.44 g/m^2) was the highest in weedy check. Unchecked weed growth exploited the available nutrients and water resulting in better growth and dry matter production. Similar observations have been made by Singh *et al.* (2014) and Kashid *et al.* (2015). The lowest dry weight for grasses (24.89 g/m^2 in 2013 and 20.12 g/m^2 in 2014), broad-leaved (18.99 g/m^2 in 2013 and 15.63 g/m^2 in 2014), sedges (5.14 g/m^2 in 2013 and 2.84 g/m^2 in 2014) and total weed (49.02 g/m^{2}in 2013 and 38.59 g/ m^2 in 2014) was recorded with hand weeding thrice at 15, 30 and 45 DAS, closely followed by pendimethalin + one hand weeding and pendimethalin + bispyribac-sodium. This is in conformity with the findings of Valverde *et al.* (2005), and Singh *et al.* (2005b).

Weed control efficiency

Weed control efficiency for grassy (82.4% in 2013 and 85.7% in 2014), broad-leaved weeds (71.9% in 2013 and 76.7% in 2014), sedges (88.0% in 2013 and 93.3% in 2014) and total weeds (80.5% in 2013 and 84.6% in 2014) was the highest with hand weeding thrice at 15, 30 and 45 DAS and this treatment was followed by pendimethalin + one hand weeding and pendimethalin + bispyribac sodium in case of grassy, broad-leaved weeds and total weeds for both the years (**Table 2**). This was in conformity with the report of Jhon *et al*. (2012). It was also evident that the weed control efficiency was improved when the chemical was integrated with one manual weeding, which implied that the persistence of the herbicide was short and for season long weed control, it has to be integrated with other control methods. This is in conformity with the report of Pannu *et al.* (1991).

Table 1. Dry weight (g/m^2) of grassy, broad-leaved, sedges and all weed at 60 days after sowing

Treatment	Grassy weed		Broad-leaved weed		Sedges		Total weed	
	2013	2014	2013	2014	2013	2014	2013	2014
Pendimethalin at 1.0 kg/ha at 2 DAS	76.91	72.02	39.49	36.45	29.17	26.15	145.57	134.61
Bispyribac -sodium at 25 g/ha at 25 DAS	95.69	91.08	43.90	40.72	9.09	8.49	148.67	140.28
Pendimethalin at 1.0 kg/ha at 2 DAS+ one hand weeding at 30 DAS	28.39	23.21	23.55	20.40	9.39	6.49	61.33	50.10
Pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac -sodium at 25 g/ha at 20 DAS	29.85	23.84	26.01	20.50	9.58	7.48	65.44	51.82
Metsulfuron-methyl+ chlorimuron-ethyl (Almix) at 4 g at 10 DAS followed by bispyribac -sodium at 25 g at 20 DAS	88.81	84.29	43.33	40.55	8.89	7.71	141.03	132.55
Pyrazosulfuron-ethyl at 25 g/ha at 3 DAS followed by bispyribac - sodium at 25 g at 20 DAS	78.70	73.94	37.39	34.65	16.77	14.08	132.87	122.67
Fenoxaprop-p-ethyl at 60 g/ha + metsulfuron-methyl+ chlorimuron-ethyl (Almix) at 4 g/ha at 15 DAS	82.44	77.88	40.74	37.34	15.90	12.85	139.08	128.07
Stale seed bed + smother crop (cowpea) in between two rows of rice	117.16	111.51	40.44	36.94	30.40	27.72	188.00	176.17
Stale seed bed + one hand weeding at 30 DAS	92.95	88.03	41.89	38.38	23.76	21.19	158.60	147.60
Sesbania (broadcast) 25 kg/ha during sowing of rice + 2,4-D at 500 g/ha at 25 DAS	113.14	108.87	37.18	33.88	29.76	27.30	180.08	170.05
Hand weeding at 15, 30 and 45 DAS	24.89	20.12	18.99	15.63	5.14	2.84	49.02	38.59
Weedy check	141.09	136.27	67.67	64.66	42.81	40.51	251.57	241.44
LSD (p=0.05)	7.76	7.66	4.16	4.05	3.37	3.35	8.26	8.96

In case of sedges, metsulfuron-methyl+ chlorimuron-ethyl (Almix) at 4 g at 10 DAS followed by bispyribac -sodium at 25 g at 20 DAS recorded the highest weed control efficiency (79.2% in 2013 and 84.9% in 2014) of sedges, better than pendimethalin treated plot (78.1% and 81.7% in 2013 and 2014 respectively) and after the hand weeding thrice at 15, 30 and 45 DAS (88.0% in 2013 and 93.3% in 2014) for both the years. The practical implication of the above response is that, though pendimethalin is a safe and effective herbicide for the rice, it is not recommendable in areas where sedge predominates or the herbicide must be integrated with any other herbicide which can control sedges. This was in conformity with the findings of Yaduraju and Mishra (2004) who reported that pre-emergence application of pendimethalin controlled only grasses, few broad-leaved weeds but not the sedges.

Effect on yield parameters and yield

It was clear from the data presented in **Table 3** that different weed management practices did have a positive role in determining the yield and other yield attributing characters of upland rice. Among different treatments, hand weeding thrice at 15, 30 and 45 DAS recorded highest number of panicles/m^2 (339.4 in 2013 and 322.2 in 2014), number of grains/panicle (67.67 in 2013 and 71.28 in 2014), grain yield/ha

Table 2. Effect of treatments on weed control efficiency (%) at 60 DAS

Treatment	Grassy weed		Broad-leaved weed		Sedges		Total weed	
	2013	2014	2013	2014	2013	2014	2013	2014
Pendimethalin at 1.0 kg/ha at 2 DAS	45.49	48.66	41.65	45.73	31.85	38.5	42.14	46.14
Bispyribac -sodium at 25 g/ha at 25 DAS	32.18	35.07	35.13	39.37	78.77	80.0	40.90	43.87
Pendimethalin at 1.0 kg/ha at 2 DAS+ one hand weeding at 30 DAS	79.88	83.45	65.20	69.62	78.07	81.7	75.62	79.95
Pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac -sodium at 25 g/ha at 20 DAS	78.84	83.00	61.56	69.48	77.63	82.4	73.99	79.27
Metsulfuron-methyl+ chlorimuron-ethyl (Almix) at 4 g at 10 DAS followed by bispyribac -sodium at 25 g at 20 DAS	37.05	39.91	35.97	39.62	79.24	84.9	43.94	46.97
Pyrazosulfuron-ethyl at 25 g/ha at 3 DAS followed by bispyribac -sodium at 25 g at 20 DAS	44.22	47.29	44.74	48.40	60.82	66.9	47.18	50.92
Fenoxaprop-p-ethyl at 60 g/ha + metsulfuron-methyl+ chlorimuron-ethyl (Almix) at 4 g/ha at 15 DAS	41.57	44.48	39.80	44.40	62.85	69.8	44.71	48.76
Stale seed bed + smother crop (cowpea) in between two rows of rice	16.96	20.50	40.23	45.00	28.99	34.8	25.27	29.51
Stale seed bed + one hand weeding at 30 DAS	34.12	37.24	38.10	42.86	44.49	50.1	36.95	40.94
Sesbania (broadcast) 25 kg/ha during sowing of rice + 2,4-D at 500 g/ha at 25 DAS	19.81	22.39	45.05	49.55	30.49	35.8	28.42	31.96
Hand weeding at 15, 30 and 45 DAS	82.36	85.66	71.94	76.72	88.00	93.3	80.52	84.56
Weedy check	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3. Yield attributing characters and yield of upland rice as effected by different weed management practices

Treatment	No. of panicles/m^2		No. of filled grains/panicle		Grain yield (t/ha)		Harvest index (%)	
	2013	2014	2013	2014	2013	2014	2013	2014
Pendimethalin at 1.0 kg/ha at 2 DAS	240.54	198.16	52.95	50.66	2.15	2.36	35.60	35.82
Bispyribac -sodium at 25 g/ha at 25 DAS	232.90	235.13	44.03	54.68	2.21	2.26	37.69	34.77
Pendimethalin at 1.0 kg/ha at 2 DAS+ one hand weeding at 30 DAS	324.17	335.10	65.23	69.66	3.30	3.59	39.62	39.82
Pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac-sodium at 25 g/ha at 20 DAS	317.24	336.27	66.67	68.01	3.26	3.41	40.14	39.73
Metsulfuron-methyl+ chlorimuron-ethyl (Almix) at 4 g at 10 DAS followed by bispyribac -sodium at 25 g at 20 DAS	216.54	253.73	45.45	56.19	2.49	2.65	40.14	36.29
Pyrazosulfuron-ethyl at 25 g/ha at 3 DAS followed by bispyribac -sodium at 25 g at 20 DAS	249.42	291.24	60.35	61.14	2.71	2.80	40.15	36.68
Fenoxaprop-p-ethyl at 60 g/ha + metsulfuron-methyl+ chlorimuron-ethyl (Almix) at 4 g/ha at 15 DAS	182.93	168.85	49.15	51.81	1.89	1.98	32.97	33.18
Stale seed bed + smother crop (cowpea) in between two rows of rice	188.75	173.30	52.18	52.82	1.86	2.01	32.92	33.27
Stale seed bed + one hand weeding at 30 DAS	228.11	259.80	57.31	54.80	1.86	2.10	33.42	35.10
Sesbania (broadcast) 25 kg/ha during sowing of rice + 2,4-D at 500 g/ha at 25 DAS	198.00	218.61	53.07	53.81	1.81	1.93	32.79	34.13
Hand weeding at 15, 30 and 45 DAS	339.36	322.18	67.67	71.28	3.45	3.60	40.33	40.57
Weedy check	119.55	101.86	32.65	33.18	0.58	0.74	16.85	20.76
LSD (p=0.05)	61.76	45.51	10.03	7.97	0.34	0.37	3.88	2.35

(3.45 t/ha in 2013 and 3.60 45 t/ha in 2014) and harvest index (40.33 in 2013 and 40.57 in 2014) during both the years. This treatment was at par with pendimethalin + one hand weeding and pendimethalin + bispyribac-sodium.

The efficacy of pendimethalin in combination with hand weeding was reported effective in controlling weed in dry direct seeded rice by Ramamoorthy *et al*. (1998) . Effective and timely weed management under these treatments reduced the density as well as dry weight of weeds which facilitated the crop to have sufficient space, light, nutrient and moisture and thus the number of panicles/m^2, number of grains/panicle and finally the grain yield/ha and harvest index was increased.

Economics

Among the various treatment, highest cost of cultivation was recorded with treatment hand weeding thrice at 15, 30, 45 DAS followed by pendimethalin + one hand weeding (**Table 4**). The highest net return and return per rupee invested was recorded with pendimethalin + bispyribac-sodium. Though the treatment hand weeding thrice at 15, 30, 45 DAS recorded highest gross return but the high cost involvement showed that the treatment was uneconomic.

The results revealed that the remuneration from the rice crop was highly dependent on weed management practices adopted. Pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac-sodium at 25 g/ha at 20 DAS recorded the highest net return (` 23847/- in the first year and ` 26010/- in the second year) and return per rupee invested (2.02 and 2.11) in both the years and was found to be the most remunerative weed management practices (**Table 4**). The herbicide pendimethalin at 1.0 kg/ha + one hand weeding at 30 DAS registered net return of ` 21427/- and 25573/- in the first year and second year respectively and was the next best treatment. This is simply due to higher grain and straw yield of the crop obtained from these treatments and comparatively lower cost involved in the cultivation of crop under these treatments. Similar result was reported by Yakadri *et al.* (2016). Though the rice yield and gross return were the highest under hand weeding at 15, 30 and 45 DAS, the data on net income and return per rupee invested showed that it was less remunerative than pendimethalin at 1.0 kg/ ha at 2 DAS + bispyribac-sodium at 25 g/ha at 20 DAS and pendimethalin at 1.0 kg/ha + one manual weeding at 30 DAS, which implied that it was uneconomic and unnecessary to give three hand weeding during the entire crop growth.

The net income was found negative under weedy check due to greater competition between rice and weed which led to poor growth of the crop, lower grain and straw yield. This again emphasized the importance of weed management in profitable rice production. This is in conformity with the study conducted by Prashanth *et al.* (2016) who reported that the lowest net returns and B:C ratio was obtained in unweeded check in transplanted rice. Kashid *et al.*

Table 4. Economics of rice cultivation under different weed management practices

Treatment	Cost of cultivation (x10^3 `/ha)	Gross Returns x10^3 `/ha)		Net Returns (x10^3 `/ha)		Return/ Rupee invested	
		2013	2014	2013	2014	2013	2014
Pendimethalin at 1.0 kg/ha at 2 DAS	20.55	31.89	34.85	11.34	14.30	1.55	1.70
Bispyribac -sodium at 25 g/ha at 25 DAS	21.73	32.38	33.56	10.65	11.83	1.49	1.54
Pendimethalin at 1.0 kg/ha at 2 DAS+ one hand weeding at 30 DAS	26.55	47.98	52.12	21.43	25.57	1.81	1.96
Pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac -sodium at 25 g/ha at 20 DAS	23.45	47.30	49.46	23.85	26.01	2.02	2.11
Metsulfuron-methyl+ chlorimuron-ethyl (Almix) at 4 g at 10 DAS followed by bispyribac -sodium at 25 g at 20 DAS	22.60	36.09	39.15	13.49	16.54	1.60	1.73
Pyrazosulfuron-ethyl at 25 g/ha at 3 DAS followed by bispyribac - sodium at 25 g at 20 DAS	22.68	39.32	41.17	16.64	18.49	1.73	1.82
Fenoxaprop-p-ethyl at 60 g/ha + metsulfuron-methyl+ chlorimuron-ethyl (Almix) at 4 g/ha at 15 DAS	20.48	28.39	29.67	7.91	9.19	1.39	1.45
Stale seed bed + smother crop (cowpea) in between two rows of rice	23.48	27.97	30.09	4.49	6.61	1.19	1.28
Stale seed bed + one hand weeding at 30 DAS	26.03	27.89	31.23	1.86	5.20	1.07	1.20
Sesbania (broadcast) 25 kg/ha during sowing of rice + 2,4-D at 500 g/ha at 25 DAS	19.79	27.28	28.87	7.49	9.08	1.38	1.46
Hand weeding at 15, 30 and 45 DAS	32.43	50.05	52.14	17.62	19.71	1.54	1.61
Weedy check	15.83	10.48	12.38	-5.35	-3.45	0.66	0.78
LSD (p=0.05)	-	4.72	5.23	4.72	5.23	0.22	0.23

(2015) reported that significantly the highest net return and return per rupee invested was obtained with the pre-emergence application of herbicide integrating with one hand weeding or one post emergence herbicide. Sharma *et al*. (2004) reported that pendimethalin + one hand weeding and pendimethalin + criss cross sowing + one hand weeding were better than the other treatments in terms of increasing grain, biomass yields and net returns.

Acceptability of any farming practices essentially depends upon its economic viability. The result of the present study revealed that the economics favoured the pre-emergence use of pendimethalin at 1.0 kg/ha at 2 DAS followed by bispyribac-sodium at 25 g/ha at 20 DAS in direct seeded upland rice. Hence the integration of pendimethalin and bispyribac-sodium is the best integrated weed management practices for direct seeded upland rice under Tripura condition.

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