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EFFECT OF DIFFERENT HERBICIDES USED IN TRANSPLANTED RICE ON WEED MANAGEMENT IN RICE-LATHYRUS CROPPING SYSTEM

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ABSTRACT
A field experiment was carried out to study the effect of different herbicides used in transplanted rice on weed management in rice-lathyrus cropping system at Central Research Farm (New Alluvial Zone), Gayeshpur, Nadia, West Bengal (23ºN latitude, 89ºE longitude). The experimental results revealed that Imazosulfuron 10% SC @ 100 g a.i. ha^{-1} applied at 5 days after transplanting (DAT) effectively controlled most of the rice weeds, exhibiting no phytotoxicity symptoms to the rice crop and increased both grain and straw yields (4.55 and 5.68 t ha^{-1} resprctively) vis-a-vis benefit : cost ratio (1.35). This treatment shows no statistical divergence with hand weeding twice. Similar trend of observations were documented in the succeeding crop of the sequence lathyrus. So, the findings of the experiment provide us with a great opportunity of using new herbicides with very low doses to cope up with the labour crisis and minimize the cost of cultivation, therefore, maximizing benefit cost ratio.

INTRODUCTION

Among the several factors responsible for the low productivity of rice, severe infestation of weeds in rice field offers the major obstacle to achieve higher yield. Weeds are the silent but virulent robbers of plant nutrients, moisture and solar energy occupying the space which would otherwise be available to the main crop, harbor of insect-pests and disease causing organisms, agents causing adverse allelopathic effects and increasing cost of production indirectly. Kulshrestha and Parmar (1992) opined that out of the total annual losses caused by different sources in India, weeds cause the maximum loss *i.e.* 33% and in terms of money it is about Rs. 1980 crores, out of total loss of Rs. 6000 crores. The yield loss due to uncontrolled weed growth ranged between 18-20% in transplanted rice, 30-35% in direct sown puddled rice and more than 50% in direct seeded upland rice (Balasubramanian and Duraisamy, 1996). For combating weed menace, manual weeding is usually practiced, but it is labour intensive, tedious and does not ensure weed removal at critical stage of crop-weed competition. For the last many years, a number of herbicides like butachlor, thiobencarb and anilofos are being applied as pre-emergence for effective control of weeds but these herbicides effectively control grassy weeds only and the other weed flora, particularly of sedges and broad-leaved group are left uncontrolled, as a result, crop growth and yield is distressed. These aforesaid herbicides are required to be applied in high doses and so their continuous application promotes the problems of envi-ronmental pollution, resistance in weeds and shift of weed flora (Kathiresan, 2001). The new generation herbicides claim closer attention should be given with respect to efficient eradication of weeds and ensure an important berth in the arsenal against this pest. Herbicides belonging to the Sulfonyl urea group viz. Imazosulfuron, Ethoxysulfuron etc are such of new generation herbicides which are very effective in controlling all kinds of weeds with very low dose having minimum negative environmental effects (Pal *et al*., 2008). Considering these views the present investigation was undertaken with the focal objectives of studying some new generation herbicides with proper effective dose to control weeds in rice based cropping sequence; studying the bio-efficacy of new herbicides in comparison to hand weeding; evaluating the effect of these herbicides on the growth and yield of crops and developing a safe, farmer's acceptable economic method of chemical weed control by making use of different herbicides.

MATERIALS AND METHODS

A field experiment was conducted at Central Research Farm, Gayeshpur, Nadia, West Bengal (23°N latitude, 89° E longitude) during the year 2010-11 and 2011-12 in a randomized block design (RBD) with eight treatments (T_1: Imazosulfuron 10% SC @ 40 g a.i ha^{-1} at 5 DAT, T_2: Imazosulfuron 10% SC @ 50 g a.i ha^{-1} at 5 DAT, T_3: Imazosulfuron 10% SC @ 60 g a.i ha^{-1} at 5 DAT, T_4: Imazosulfuron 10% SC @ 100 g a.i ha^{-1} at 5 DAT, T_5: Ethoxysulfuron 15% WDG @ 15 g a.i ha^{-1} at 10 DAT, T_6: Oxadiargyl 80% WP @ 100 g a.i ha^{-1} at 10 DAT, T_7: Hand weeding twice at 20 and 40 DAT and T_8: Unweedy check) replicated thrice. The soil of the experimental site was of sandy clay loam type having 6.9 pH, 0.045 % total N and 45 and 240 kg ha^{-1} available P_2O_5 and K_2O respectively. The varieties of rice and lathyrus were IET-4786 (*Satabdi*) and *Nirmal*

respectively. Twenty two days old seedlings of rice were transplanted. One third of recommended dose of Nitrogen @ 60 kg ha^{-1} through urea along with full amount of Phosphorus @ 30 kg ha^{-1} through Single Super Phosphate and full dose of Potassium @ 30 kg ha^{-1} through Muriate of Potash were applied as basal during final land preparation and remaining Nitrogen was top dressed in two equal splits, half at active tillering and another half at panicle initiation stage of the crop. Herbicides were applied with Knapsack sprayer as pre-emergence at 5 DAT for imazosulfuron and 10 DAT for both ethoxysulfuron and oxadiargyl using water @ 500L ha^{-1}. Excluding weed management practices, all the recommended improved packages of practices including plant protection measures were followed in the experiment to raise the crop. Observations on weed density and dry weight were taken at 30, 45, 60 and 75 DAT in case of rice and 30 and 60 DAS in case of lathyrus by placing a quadrat of 0.5 m × 0.5 m randomly at five places in each plot. Numbers of tillers m-2 and leaf area index (LAI) were documented at harvest. Grain yield was expressed at 12% moisture status. Weed index for both the crops in the sequence was calculated by using the formula stated below

$$\text{Weed Index (\%)} = \frac{X - Y}{X} \times 100$$

Where, X = Grain yield from weed free treatment.

Y = Grain yield from treatment for, which weed index is to be worked out.

Leaf area index (LAI) was deliberated by dividing leaf area with ground area (Watson, 1947). Data for each character were statistically analysed (Gomez and Gomez, 1984). Benefit: cost ratio of each weed control treatment was worked out accordingly.

RESULTS AND DISCUSSION

The predominant weed found in the experimental plots were grasses like, *Cynodon dactylon* (bermuda grass), *Leersia hexandra* (rice cutgrass) and *Echinochloa crusgalli* (barnyard grass); sedges like, *Cyperus rotundus* (purple nut segde), *Cyperus irria* L. (yellow nut segde), *Cyperus difformis* L. (umbrella sedge) and *Fimbristylis littoralis* Gaud (hoorah grass) and broad leaf weeds like *Marsilea quadrifoliata* and *Ludwigia parviflora* Roxb. (water purslane).

Both the weed density and dry weight of weeds were significantly reduced in different treatment plots as compared to unweeded check. Imazosulfuron 10% SC @ 100 g a.i. ha^{-1} applied at 5 DAT (T_4) and hand weeding twice at 20 and 40 DAT were at par and caused maximum reduction in weed growth during both the years (Table 1). Similar findings also were recorded by Bhattacharya *et al*. (2005) and Channappagoudar *et al*. (2013). Reduced weed growth under these treatments might be due to the better control of weeds. Second highest dose of Imazosulfuron 10% SC i.e. 60 g a.i. ha^{-1} applied at 5 DAT also provided very good weed control and was found almost equally effective in minimizing complex weed flora as Imazosulfuron 10% SC @ 100 g a.i. ha^{-1} applied at 5 DAT. The results conformed to the findings of Bhowmick *et al*. (2000).

Table 1: Effects of treatments on total weed density, total weed biomass, no. of tillers m^2, LAI, grain and straw yield, weed index and B: C ratio in rice (pooled data of two years)

Treatment	Total Weed density(no. m^{-2})				Total Weed dry weight(g m^{-2})			Tillers no. m^{-2}	LAI	Grain yield (t ha^{-1})	% increase over unweeded control	Straw yield (t ha^{-1})	% increase over unweeded control	Weed Index(%)	B: C ratio
	30 DAT	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT							
T_1	177.33	200.33	226.01	247.33	22.94	25.32	28.43	29.27	301.1	4.3	4.08	29.52	4.80	24.35	14.47	1.15
T_2	161.33	181.67	213.33	233.33	19.15	21.68	25.04	26.70	313.5	4.5	4.14	31.43	5.06	31.09	13.21	1.18
T_3	119.67	143.00	166.33	177.33	15.82	18.34	21.07	22.92	328.8	4.8	4.27	43.03	5.31	37.56	10.48	1.24
T_4	76.66	95.67	110.99	124.99	11.44	13.42	14.69	15.59	339.6	5.2	4.55	44.44	5.68	47.15	4.61	1.35
T_5	163.00	191.33	222.67	242.33	26.59	29.17	31.26	33.97	290.7	4.0	3.73	18.41	4.45	15.28	21.80	0.97
T_6	193.33	213.99	234.66	251.67	23.35	26.01	29.03	30.43	295.8	4.1	3.87	22.88	4.66	20.73	18.87	1.04
T_7	66.67	68.33	99.67	115.67	9.50	9.95	12.36	13.45	345.8	5.4	4.77	51.43	6.03	56.22	-	1.17
T_8	305.33	348.67	384.67	417.33	41.20	42.54	46.14	48.50	268.2	3.8	3.15	-	3.86	-	33.96	0.70
S. Em. (±)	5.29	5.47	5.86	6.29	0.70	0.72	0.88	0.87	5.41	0.06	0.16	-	0.20	-	-	-
C.D. at 5%	16.04	16.58	17.78	19.08	2.12	2.20	2.65	2.65	16.41	1.79	0.48	-	0.61	-	-	-

Table 2: Effects of treatments on total weed density, total weed biomass, seed yield, weed index and B: C ratio in lathyrus (pooled data of two years)

Treatment	Weed density (no. m^{-2})		Weed dry weight (g m^{-2})		Seed yield (t ha^{-1})	% increase over unweeded control	Weed Index (%)	B: C ratio
	30 DAS	60 DAS	30 DAS	60 DAS				
T_1	147.01	187.34	9.19	13.72	1.40	35.96	26.72	1.92
T_2	127.99	174.67	7.79	12.49	1.41	36.93	26.19	1.94
T_3	113.00	150.33	6.90	11.29	1.77	71.62	7.49	2.69
T_4	68.33	101.00	4.43	8.27	1.87	82.02	1.89	2.83
T_5	168.33	201.99	12.53	18.39	1.14	11.08	40.13	1.38
T_6	162.00	202.01	11.51	15.10	1.76	71.33	7.65	2.67
T_7	56.01	84.99	4.14	7.46	1.91	85.52	-	2.98
T_8	274.34	343.00	27.41	33.78	1.03	-	46.10	1.15
S. Em. (±)	3.28	3.32	0.58	0.55	0.11	-	-	-
C.D. at 5%	9.95	10.08	1.75	1.68	0.31	-	-	-

[N.B: T_1: Imazosulfuron 10% SC @ 40 g a.i ha^{-1}, T_2: Imazosulfuron 10% SC @ 50 g a.i ha^{-1}, T_3: Imazosulfuron 10% SC @ 60 g a.i ha^{-1}, T_4: Imazosulfuron 10% SC @ 100 g a.i ha^{-1}, T_5: Ethoxysulfuron 15% WDG @ 15 g a.i ha^{-1}, T_6: Oxadiargyl 80% WP @ 100 g a.i ha^{-1}, T_7: Hand weeding twice at 20 and 40 DAT and T_8: Unweedy check; Herbicide Imazosulfuron 10% SC was applied at 5 DAT, Ethoxysulfuron 15% WDG and Oxadiargyl 80% WP were applied at 10 DAT]

There was significant increase in total number tillers m^{-2} with the imposition of weed control treatments except Ethoxysulfuron 15% WDG (T_5) and Oxadiargyl 80% WP (T_6) over unweeded check in second year of the experiment (Table 1). The difference in tillering was probably due to varying degree of crop-weed competition under different treatments. Maximum LAI was recorded under hand weeding twice and Imazosulfuron 10% SC @ 100 g a.i. ha^{-1} applied at 5 DAT in both the years (Table 1). These observations were in consonance with the earlier reports of Bhowmick *et al*. (2000). The presence of weeds reduced the LAI of rice crop, since weeds robbed off the nutrients meant for rice plants, thereby reducing vegetative crop growth. Total yield could be considered to be the mirror of all the growth features. The highest grain and straw yields were recorded under hand weeding twice. None of the herbicide treatments excluding Imazosulfuron 10% SC @ 100 g a.i. ha^{-1} applied at 5 DAT were comparable to two hand weedings during first year but Imazosulfuron 10% SC @ 60 g a.i. ha^{-1} and Imazosulfuron 10% SC @ 100 g a.i. ha^{-1} were at par with the hand weedings twice in the second year of the experiment. These two chemical treatments (Imazosulfuron 10% SC @ 100 g a.i. ha^{-1} and Imazosulfuron 10% SC @ 60 g a.i. ha^{-1}) also showed 44.44 and 43.03% grain yield increase respectively in the first year over control. These results corroborate the findings of Bhowmick (2001) and Nandal *et al*. (1999).

Maximum values of benefit: cost ratio (BCR) of 1.35 and 1.40 for the two years of the experiment respectively was achieved with the use of Imazosulfuron 10% SC @ 100 g a.i. ha^{-1}. Hand weeding though performed well but it involved higher cost of cultivation resulting in much lower benefit to the farmers compared to the chemical weed control measures.

Evidently, post-emergence application of Imazosulfuron 10% SC @ 100 g a.i. ha^{-1} applied at 5 DAT may be a cost-effective alternative to conventional hand weeding practice of weed management in transplanted rice. Other two doses of Imazosulfuron 10% SC i.e. 50 and 60 g a.i. ha^{-1} may also be used wherever it becomes possible and available, especially under the situations of labour scarcity or rising labour wages.

In case of succeeding crop lathyrus, almost same type of observations was recorded with respect to weed control (Table 2). The lowest weed density and biomass were recorded with the treatment comprising of hand weeding twice (T_7) at 20 and 40 DAS whereas among the herbicidal treatments, T_4 (Imazosulfuron 10% SC @ 100 g a.i. ha^{-1}) resulted both the lowest weed density as well as biomass. Unweeded control treatment (T_8) recorded the maximum weed density and biomass which was significantly higher than all other herbicidal and cultural treatments. In case of yield the maximum seed yield was obtained in T_7 which was statistically at par with T_4, T_3 and T_6 and the minimum was recorded with the treatment T_8. These observations were similar with Saini *et al*. (2010).

From the experiment it is clear that herbicide Imazosulfuron 10% SC @ 100 g a.i. ha^{-1} at 5 DAT in rice is the best amongst the herbicidal treatments used in the field to control all kinds of weeds. This herbicide recorded the maximum economical benefit. Though the highest yield for both the crops was recorded with hand weeding twice but it depicted low economic benefit due high labour requirement. So this herbicide (Imazosulfuron 10% SC @ 100 g a.i. ha^{-1}) provides us with a great opportunity to overcome uneconomic hand weeding.

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