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Studies on bioefficacy of low doses high efficiency herbicides in transplanted rice (*Oryza sativa* L.)

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ABSTRACT
To evaluate the efficacy of low dose herbicide either alone or in combination on weeds and yield of transplanted rice, a field experiment was conducted during *kharif* season of 2001 and 2002 at Agricultural Researche Farm of Banaras Hindu University, Varanasi. The weed flora of the experimental site were dominated by *Echinochloa colona, Echinochloa crus-galli, Cyperus rotundus, Cyperus iria, Fimbristylis miliacea, Ammania baccifera and Ludwigia parviflora.* Amongst different herbicide pre-emergence application of almix + 2,4-DEE 15+500 g ha^{-1} provided excellent control of weeds and their biomass production and significantly superior to all other treatments and was at par with almix 25 g ha^{-1}. These treatments caused significant lower depletion on nutrients (N, P, K) by weeds. Application of almix + 2,4-DEE 15+500 g ha^{-1} results in significant improvement in all yield attributing characters and maximize grain yield (5930 kg ha^{-1}) and was at par with hand weeding (5930 kg ha^{-1}). Per cent increase in grain yield with almix + 2,4-DEE 15+500 g ha^{-1} was 85.5 % over weedy checks.

Key words : Rice, Weed, Herbicide, Yield

INTRODUCTION

Rice is a major food crop in the tropics in general and India in particular. It suffers from various constraints in production and one of them is the competition through weeds. Weeds caused on reduction of 45-55% of grain yield (Banerjee and Bhattacharya, 2003; Mukherjee *et al*., 2003). Transplanted rice infested by heterogeneous type of weed flora, which is one of the serious limitations of their control. Weeds compete to rice crop for nutrient mainly as it is very limited resource. Weeds grow faster than crop plant and thus absorb the available nutrient earlier resulting in lack of nutrient for growth of crop plants (Singh *et al*., 2004). The use of herbicide offer selective and economic control of weeds right from the beginning giving crop an advantage of good head start and competitive superiority.

Most of weed flora belonging to grasses, sedges and broad-leaved weeds provide tough competition to rice crop. As a result with the continuous use of grassy herbicide like anilofos, butachlor and pretilachlor, the broad-leaved weeds and sedges coming up at faster rate in transplanted rice. So, their application window is very narrow and abele to control only few group of weeds. One of the major drawback of these herbicide are they are not eco-friendly because their application rate is quite high and persist in environment for very long time (Mukherjee *et al*., 2003). This will distort our ecosystem and ultimately deleterious environment and crop quality. Thus a field experiment was planned to evaluate the effectiveness of herbicide as alone and tank mixture to control weeds in transplanted rice.

MATERIALS AND METHODS

A field experiment was conducted during the rainy seasons of 2001and 2002 at the Research farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to studies on bioefficacy of low doses high efficiency herbicides in transplanted rice (*Oryza sativa* L.).The soil was sandy clay loam (typical ustochrepts) having pH 7.3, organic carbon 0.44% and available N, P_2O_5 and K_2O 205, 14.9 and 232.8 kg ha^{-1}, respectively. The experiment comprising various dose of metsulfuron methyl (MSM), chlorimuron ethyl (CME), almix, MSM + 2, 4-DEE , CME + 2, 4-DEE , almix + 2, 4-DEE, anilofos and anilofos +2, 4-DEE along with hand weeding and weedy check (Table 1). The experiment was laid out in randomized block design with three replication. Twenty five days old seedlings of rice variety Sarju 52 were transplanted on July 22 and 24, 2001 and 2002, respectively. One third of the recommended dose of N (40 kg ha^{-1}) and full dose P_2O_5 and K_2O (60 kg ha^{-1} each) were applied before transplanting and remaining amount of N was top dressed in two equal splits, half at active tillering and half at panicle initiation stages. Herbicides were sprayed 8 days after transplanting (DAT) using 600 litre water ha^{-1} with the help of knapsack sprayer, fitted with flat fan nozzle. The data on weed population and weed biomass were taken at 60 DAT with the help of random quadrate (0.5 m ´ 0.5 m) at two places and then converted into per square meter and collected weed were dried at 60 $\pm$ 5^{0}C to get the dry weight and further used for chemical analysis. These were subjected to square root transformation $\sqrt{x+0.5}$ to normalize their distribution. Nitrogen, phosphorous and potassium contents in weeds were detetmined by modified kjeldal method, vandomolybdate phosphoric acid yellow colour method and flame photometer, respectively (Jackson, 1977).

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RESULTS AND DISCUSSION

Effect on weeds

The experiment site were dominated by *Echinochloa colona* (L.) Link (16.7 %), *Echinochoa crus-galli* (L.) Baeuv (6.5%), *Cyperus rotundus* (L.) (24.9 %), *Cyperus iria* (8.2%), *Fimbristylis miliacea* Vahl (4.3%), *Ammenia baccifera* (L.) (14.6%) and *Ludwigia parviflora* (L.) (9.8%).

Of the herbicides, almix + 2,4- DEE 15+500 g ha^{-1} was the most potential killer of weeds and significantly superior to all herbicidal treatments to check weed population. It gave excellent control of *Echiochloa colona, Echiochloa crus-galli*, *Cyperus rotundus* and *Cyperus iria* (Table 1). The next best treatment was almix 25 g ha^{-1}, which gave an excellent control of sedges viz., C*yperus rotundus*, *Cyperus iria* but failed to bring about noticeable change in *Echinochloa* populations. Chlorimuron ethyl 20 g ha^{-1} effectively suppresses density of *Echinochloa crus-galli* and *Echinochloa colonum* and satisfactory control over *Cyperus difformis*. The different behavior of sulfonylurea herbicides may be attributed to their differential reaction to weed species (Bhattacharya *et. al*., 2002).

All the weed controlled treatments reduced total weeds density significantly over weedy check (Table 2). Almix + 2, 4-DEE 15 +500 g ha^{-1} was found to be significantly superior to other herbicidal measures and remained at par with almix 25 g ha^{-1} in reducing the total weed density. This treatment reduced weed population by 80.60 and 78.05 % as compared to weedy checks in 2001 and 2002,

Table 1: Effect of treatment on major weeds in rice field.

Treatment	Dose (g ha^{-1})	Grassy weed (No.m^{-2})				Sedges (No. m^{-2})			
		Echinochloa colonum		*Echinochloa crusgalli*		*Cyperus rotundus*		*Cyperus iria*	
		2001	2002	2001	2002	2001	2002	2001	2002
Unweeded	-	6.1 (37.3)	6.2 (40.7)	3.5 (12.0)	3. 9 (14.7)	7.8 (60.3)	8.0 (64.0)	4. 5 (19.3)	4.2 (20.0)
Hand weeding (20, 40 and 60 DAT)	-	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)
MSM	4	4.3 (18.6)	5.1 (25.6)	3.8 (14.0)	3.8 (14.0)	6.4 (41.0)	6.6 (44.0)	3.9 (15.0)	4.0 (16.0)
MSM	6	3.9 (15.3)	4.3 (18.3)	3.3 (8.7)	3.1 (9.3)	6.1 (37.7)	6.2 (38.0)	3.1 (14.6)	3.7 (13.6)
MSM	8	3.9 (15.3)	3.9 (15.3)	3.0 (8.6)	3.0 (9.0)	5.6 (31.3)	5.9 (35.0)	3.4 (11.6)	3.6 (12.6)
CME	10	3.8 (14.0)	4.3 (18.0)	3.0 (8.6)	3.8 (9.0)	6.0 (35.6)	6.5 (42.0)	3.7 (13.3)	3.9 (15.3)
CME	15	3.5 (12.3)	4.1 (16.6)	2.8 (7.6)	3.3 (8.7)	5.6 (31.6)	5.7 (32.6)	3.6 (12.6)	3.7 (13.6)
CME	20	3.3 (11.0)	3.4 (11.3)	2.7 (7.3)	2.8 (7.6)	5.3 (27.6)	5.6 (31.3)	3.5 (12.3)	3.29 (10.3)
Almix	15	4.1 (16.3)	4.4 (19.0)	3.4 (11.6)	3.4 (10.0)	6.0 (36.0)	6.2 (38.0)	3.6 (12.6)	3.9 (15.0)
Almix	20	3.6 (13.0)	3.4 (11.6)	2.6 (6.7)	2.79 (7.3)	4.1 (16.3)	4.4 (19.3)	3.1 (9.3)	3.2 (10.0)
Almix	25	2.9 (8.3)	3.2 (10.3)	2.1 (6.3)	2.2 (4.3)	2.5 (6.0)	2.6 (6.6)	2.5 (6.0)	2.1 (4.0)
MSM+2,4 DEE	4+500	3.9 (15.3)	4.3 (18.3)	2.7 (8.3)	2.9 (8.3)	5.2 (26.7)	5.4 (29.3)	3.6 (13.0)	3.8 (14.0)
CME+2,4-DEE	10+500	3.6 (13.0)	4.0 (16.0)	2.7 (7.0)	2.8 (7.3)	5.0 (25.3)	5.3 (27.6)	3.6 (12.6)	3.7 (13.6)
Almix+2,4DEE	15+500	2.1 (4.3)	2.5 (6.0)	1.5 (2.0)	1.6 (2.3)	4.4 (19.0)	4.4 (19.6)	3.0 (8.6)	3.1 (9.3)
Anilofos	400	4.3 (18.6)	4.8 (22.3)	3.0 (8.7)	3.0 (9.0)	5.7 (32.0)	5.7 (32.7)	3.5 (12.0)	3.7 (13.6)
Anilofos +2, 4 -DEE	400+500	3.1 (9.3)	3.7 (13.0)	2.5 (5. 0)	2.2 (4.3)	5.1 (25.7)	5.2 (27.0)	2.9 (8.3)	3.0 (9.0)
CD (P=0.05)	-	0.22	0.16	0.18	0.29	0.22	0.27	0.22	0.29

respectively. Metsulfuron methyl and chlorimuron ethyl at lower doses, recorded the highest density of total weeds amongst the herbicides due to poor efficacy on grasses and sedges. This corroborates the finding of Mukherjee and Bhattacharya (1999).

Weed control measures registered a significant reduction in weed dry matter over weedy check throughout the crop growth (Table 2). Almix +2, 4-DEE 15 + 500 g ha^{-1} recorded least weed dry matter production amongst various herbicidal treatments and was on par with almix 25 g ha^{-1} and significantly superior to rest of the treatments. However, higher weed dry matter accumulation was recorded with metsulfuron methyl 4 g ha^{-1}. Similar kind of observation was made by Bhattacharya *et al*. (2002).

Weed control practices gave differential response to the nutrient removal by weeds (Table 2). Herbicidal treatment with almix + 2,4-DEE 15 + 500 g ha^{-1} had recorded least nutrient (N, P, K) uptake by weed and was at par with almix 25 g ha^{-1} and significantly superior to rest of the chemical treatments. Weeds associated with almix + 2,4-DEE 15 + 500 g ha^{-1} and almix 25 g ha^{-1} took up 54.8, 52.6, 56.3 and 52.2, 46.8, 53.4 % less N, P and K respectively compared with weedy check.

Effect on crop

The maximum values of all the yield attributing characters viz., effective tillers, panicle length, panicle weight, filled grains panicles^{-1} and thousent grains weight of rice was recorded with alimix + 2,4-DEE 15 + 500 g ha^{-1} (Table 3) and was at par with hand weeding

Table 2 : Effect of weed control on total weed density, biomass of weed and nutrition depletion by weed.

Treatment	Dose (g ha^{-1})	Weed population (No. m^{-2})		Weed biomass (g m^{-2})		Nutrient depletion by weed (kg ha^{-1})					
						Nitrogen		Phosphorus		Potassium	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Unweeded	-	15.2	15.8	10.8	11.1	3.5	3.7	2.3	2.5	3.7	4.3
		(230.3)	(250.7)	(117.0)	(123.8)	(12.5)	(13.8)	(5.2)	(5.9)	(13.3)	(15.7)
Hand weeding	-	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
(20,40 & 60)		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
MSM	4	12.6	12.2	7.5	7.9	2.3	2.2	1.6	1.6	2.4	2.2
		(145.0)	(148.3)	(56.6)	(62.5)	(5.1)	(4.7)	(2.1)	(2.3)	(5.5)	(5.8)
MSM	6	11.2	11.3	7.1	7.4	2.1	2.1	1.5	1.5	2.3	2.3
		(126.3)	(129.3)	(49.9)	(54.3)	(3.9)	(4.3)	(1.9)	(2.3)	(4.9)	(4.9)
MSM	8	10.7	10.8	6.5	6.7	2.0	2.1	1.4	1.4	2.2	2.2
		(115.0)	(117.6)	(41.7)	(47.5)	(3.8)	(4.1)	(1.6)	(1.6)	(4.6)	(4.7)
CME	10	11.3	11.8	7.2	7.5	2.2	2.2	1.6	1.6	2.3	2.4
		(127.3)	(141.0)	(52.6)	(57.0)	(4.7)	(4.4)	(2.2)	(2.2)	(5.0)	(5.4)
CME	15	10.5	10.7	6.6	7.0	2.1	2.1	1.5	1.5	2.3	2.4
		(111.3)	(114.0)	(44.3)	(48.6)	(4.1)	(4.2)	(1.9)	(2.0)	(4.9)	(5.4)
CME	20	10.1	10.1	6.2	6.4	2.1	2.1	1.4	1.4	2.2	2.2
		(101.0)	(102.3)	(38.9)	(41.1)	(3.9)	(4.4)	(1.4)	(1.5)	(4.4)	(4.0)
Almix	15	11.1	11.6	6.8	7.1	2.7	2.2	1.6	1.6	2.3	2.4
		(122.3)	(136.0)	(46.6)	(50.0)	(4.1)	(4.4)	(2.0)	(2.1)	(5.1)	(5.3)
Almix	20	8.8	9.9	5.6	5.7	1.8	1.7	1.3	1.3	1.8	1.8
		(77.6)	(99.3)	(31.4)	(33.1)	(2.8)	(2.5)	(1.2)	(1.2)	(3.0)	(3.0)
Almix	25	6.9	7.5	5.1	5.2	1.8	1.7	1.2	1.2	1.8	1.8
		(53.6)	(56.0)	(25.7)	(27.1)	(2.7)	(2.5)	(1.1)	(1.7)	(2.7)	(2.7)
MSM+2,4 DEE	4+500	10.5	11.2	6.6	7.0	2.1	2.0	1.3	1.7	2.1	2.2
		(110.3)	(126.6)	(43.8)	(49.4)	(3.5)	(3.5)	(1.4)	(1.4)	(4.2)	(4.9)
CME+2,4-DEE	10+500	10.0	10.5	6.1	6.3	2.0	1.9	1.3	1.3	2.1	2.1
		(99.6)	(110.0)	(36.9)	(40.34)	(3.6)	(3.3)	(1.4)	(1.4)	(4.2)	(4.2)
Almix+2,4DEE	15+500	6.7	7.4	4.8	5.2	1.7	1.6	1.2	1.1	1.7	1.7
		(44.6)	(55.0)	(22.8)	(27.0)	(2.4)	(2.2)	(1.0)	(0.7)	(2.5)	(2.4)
Anilofos	400	10.4	10.6	6.5	6.8	2.1	2.1	1.5	1.5	2.2	2.3
		(108.6)	(117.7)	(42.8)	(46.9)	(4.1)	(4.2)	(1.9)	(1.9)	(4.7)	(4.8)
Anilofos +2,4 - DEE	400+500	9.3	9.9	6.2	6.0	1.8	1.7	1.3	1.3	1.9	1.7
		(86.3)	(98.0)	(38.7)	(36.4)	(2.8)	(2.6)	(1.8)	(1.2)	(3.1)	(2.6)
CD (P = 0.05)	-	0.27	0.42	0.45	0.29	0.16	0.20	0.10	0.18	0.12	0.14

Figure in parenthesis are original value

Table 3: Effect of treatment on yield attributes and grain yield.

Treatment	Dose (g ha^{-1})	Effective tiller (m^{-2})		Panicle length (cm)		Panicle weight (g)		Filled grain panicle^{-1}		Unfilled grain panicle^{-1}		1000 grain weight (g)		Grain yield (kg ha^{-1})	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Unweeded	-	267.73	258.67	21.67	21.17	1.41	1.42	68.33	62.07	11.93	11.27	21.53	21.60	3241	3052
Hand weeding (20,40 and 60 DAT)	-	400.13	389.33	27.53	27.13	2.17	2.06	82.80	80.00	8.70	8.60	23.67	23.40	6029	5831
MSM	4	288.80	278.00	23.83	22.37	1.55	1.51	73.70	71.40	11.83	10.40	22.13	22.07	3629	3476
MSM	6	312.13	289.00	24.03	25.43	1.64	1.61	78.27	74.40	10.70	9.73	22.33	22.30	4264	4065
MSM	8	325.00	311.20	24.70	25.53	1.74	1.71	78.40	75.23	10.43	9.23	22.53	22.50	4629	4451
CME	10	294.20	280.50	23.83	24.97	1.49	1.46	74.83	72.03	11.63	10.67	23.07	22.77	3860	3750
CME	15	314.70	307.70	24.17	25.00	1.72	1.69	78.70	73.87	11.10	9.73	22.63	22.51	4310	4169
CME	20	329.33	317.90	24.90	25.47	1.84	1.80	80.47	75.07	10.00	9.07	22.63	22.57	4785	4714
Almix	15	294.30	287.60	23.53	25.30	1.59	1.56	75.00	72.50	10.73	9.40	22.68	22.40	4055	3869
Almix	20	372.20	365.20	25.07	25.50	1.84	1.78	78.67	76.23	9.73	9.10	23.17	22.83	5362	5320
Almix	25	376.00	369.00	26.63	25.77	1.93	1.86	81.10	77.23	9.40	8.97	23.43	23.17	5632	5502
MSM+2,4 DEE	4+500	345.00	339.00	25.00	24.27	1.84	1.80	78.40	75.50	9.83	9.43	23.43	22.47	5090	4925
CME+2,4-DEE	10+500	348.00	344.67	25.03	24.63	1.90	1.85	79.20	75.47	9..63	9.30	23.57	22.67	5173	5120
Almix+2,4DEE	15+500	398.67	387.33	26.77	26.07	2.06	1.96	82.00	79.29	9.20	8.93	23.58	23.20	5934	5740
Anilofos	400	309.00	302.00	24.33	24.47	1.67	1.63	74.33	72.67	10.10	9.30	22.67	22.47	4556	4319
Anilofos +2,4 -DEE	400+500	354.00	347.00	24.70	25.50	1.71	1.68	78.94	76.37	9.20	.33	23.07	22.87	5339	5174
CD (P=0.05)		5.46	8.27	0.94	0.99	0.12	0.18	3.46	1.14	0.85	0.43	0.43	0.32	94	118

during both the years of observations. Beneficial effect of herbicides as results of significant reduction in weed competition and nutrient depletion by weeds reflected in substantial improvement in yield contributing characters. The extent of improvement invariably corresponded value of weed control by individual herbicides.

Due to significantly lower weed dry weight and higher value of yield attributes, alimix + 2,4-DEE 15 + 500 g ha^{-1} resulted in significantly higher rice grain yield (5837 kg ha^{-1}) over other treatments and was at par with hand weeding thrice (5930 kg ha^{-1}). Per cent increase in grain yield by almix + 2,4-DEE 15 + 500 g ha^{-1} was 85.5 % over weedy check. These results are in close conformity with the results reported by Rekha *et al*. (2002).

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