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Effect of Herbicides Alone and in Combination on Direct Seeded Rice

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ABSTRACT

Progressive increase in doses of both pendimethalin (from 1.0 to 2.0 kg ha^{-1}) and anilofos (from 0.4 to 0.8 kg ha^{-1}) resulted in decreased density and dry weight of all the weeds at 60 days stage. However, both the herbicides were more effective when 2, 4-D at 0.5 kg ha^{-1} or bentazon at 0.72 kg ha^{-1} were applied as follow up application. With follow up treatment pendimethalin at 1.0 kg ha^{-1} with 2, 4-D at 0.5 kg ha^{-1} recorded highest grain yield and weed control efficiency. Among alone applications oxyfluorfen at 0.25 kg ha^{-1} was most effective as it was able to control both broad-leaved weeds and grasses, however, it was not as effective as herbicide combinations in obtaining grain yield.

INTRODUCTION

Rice production systems are undergoing several changes and one of such changes is shift from transplanted rice to direct seeding. Direct seeding of rice establishment is spreading rapidly in Asia particularly Philippines, Malaysia and Thailand as the farmers seek high productivity and profitability to offset increasing costs and scarcity of farm labour (Pandey and Valesco, 2002). Direct seeding rice serves several advantages i. e. saves labour, faster and easier planting helps in timely sowing, less drudgery, early crop maturity by 7-10 days, less water requirement, high tolerance to water deficit, often high yield, low production cost and more profit, better soil physical condition for following crops and less methane emission (Balasubramanian and Hill, 2002). Despite several advantages, various production obstacles are also encountered and heavy weed infestation is major one. Weeds cause heavy damage to direct seeded crop which can be to the tune of 5-100% (Moody and Mian, 1979; Kolhe, 1989). Notwithstanding the labour scarcity and increasing labour costs weeding in rice under moist conditions is the last choice of agricultural labourers which has given momentum to the use of herbicides for weed management in rice. Direct seeded rice crop suffers from complex weed flora and several herbicides like pendimethalin and anilofos have been tested for this. These herbicides have differential effects on these weeds. That is why to control all types of weeds (grasses, sedges and broad-leaved weeds) strategy should be such that may provide broad spectrum weed control. Considering above facts, present investigation was undertaken to see the effect of different herbicides alone and in combination in direct seeded rice.

MATERIALS AND METHODS

Field trial during the rainy seasons of 2001 and 2002 was conducted at Crop Research Centre of Govind Ballabh Pant University of Agriculture & Technology, Pantnagar to find out the efficacy of pendimethalin, anilofos, bentazon and 2, 4-D alone and in combination in direct seeded rice. The soil of the experimental plot was silty clay loam in texture, high in organic carbon (0.90%), medium in available phosphorus (19 kg P ha^{-1}) and high in available potassium (225 kg K ha^{-1}) with pH 7.65. Treatments consisted various doses of pendimethalin (1.0, 1.5 and 2.0 kg ha^{-1} applied alone as pre-emergence), anilofos (0.4, 0.6 and 0.8 kg ha^{-1} applied alone as pre-emergence), pendimethalin at 1.0 kg ha^{-1} pre-emergence followed by 2, 4-D at 0.5

Table 1. Effect of treatments on weed density (No. m^{-2}) at 60 days stage

Treatment	Application stage (DAS)	Dose (kg ha^{-1})	*E. colona*		*P. maximum*		*C. axillaris*		*C. iria*		*I. rugosum*	
			2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Pendimethalin	3	1.0	2.7	2.6	3.1	3.9	6.4	7.2	3.3	0.27	1.2	1.9
			(7.0)	(6.5)	(10.0)	(14.5)	(40.5)	(55.6)	(10.5)	(0.5)	(1.5)	(4.5)
Pendimethalin	3	1.5	1.9	1.9	1.9	1.8	6.2	6.5	2.4	0.0	0.9	1.4
			(3.5)	(4.5)	(4.5)	(4.0)	(38.0)	(46.5)	(6.5)	(0.0)	(0.5)	(2.0)
Pendimethalin	3	2.0	0.9	1.5	1.4	1.7	5.8	6.4	1.6	1.08	0.0	1.3
			(1.5)	(2.5)	(2.0)	(3.5)	(33.0)	(39.0)	(3.0)	(4.0)	(0.0)	(1.5)
Anilofos	3	0.4	3.4	2.9	1.9	1.8	8.6	8.8	2.9	1.89	1.1	1.4
			(14.0)	(11.2)	(4.5)	(4.0)	(74.5)	(80.5)	(9.5)	(9.0)	(1.0)	(2.0)
Anilofos	3	0.6	2.2	2.7	1.8	1.7	8.6	8.6	2.0	1.0	0.0	0.0
			(5.0)	(6.7)	(4.0)	(3.5)	(73.5)	(75.5)	(3.5)	(3.5)	(0.0)	(0.0)
Anilofos	3	0.8	2.1	2.3	1.1	1.5	7.9	8.0	2.0	0.82	0.0	0.0
			(4.0)	(5.5)	(1.0)	(2.5)	(64.0)	(70.0)	(3.5)	(1.5)	(0.0)	(0.0)
Pendimethalin fb 2,4-D	3 & 35	1.0-0.5	2.0	2.1	2.8	3.2	3.6	3.8	0.9	0.67	0.0	0.9
			(5.0)	(4.2)	(7.5)	(9.5)	(12.5)	(15.5)	(0.5)	(1.5)	(0.0)	(0.5)
Anilofos fb 2,4-D	3 & 35	0.4-0.5	2.6	3.1	1.4	2.7	4.1	4.4	1.3	0.0	0.0	0.0
			(7.5)	(9.1)	(2.0)	(6.8)	(16.5)	(20.0)	(1.5)	(0.0)	(0.0)	(0.0)
Anilofos	7	0.4	3.2	3.4	2.6	2.5	7.4	7.9	2.6	0.59	0.9	0.0
			(10.5)	(12.5)	(6.5)	(6.0)	(54.0)	(60.5)	(6.5)	(2.5)	(0.5)	(0.0)
Anilofos fb 2,4-D	7 & 35	0.4-0.5	2.8	3.2	1.5	2.2	4.3	4.7	1.5	0.0	0.0	0.0
			(7.5)	(9.5)	(3.5)	(4.5)	(18.0)	(23.0)	(2.5)	(0.0)	(0.0)	(0.0)
Pendimethalin fb Bentazon	3 & 35	1.0-0.72	2.4	2.8	2.3	2.2	3.2	3.4	0.0	0.0	0.9	0.0
			(6.0)	(7.6)	(5.0)	(4.5)	(12.0)	(14.0)	(0.0)	(0.0)	(0.5)	(0.0)
Anilofos fb Bentazon	3 & 35	0.4-0.72	2.5	2.1	1.8	2.3	5.2	5.2	1.1	0.0	0.0	0.0
			(6.0)	(4.2)	(3.5)	(4.4)	(26.5)	(27.0)	(1.0)	(0.0)	(0.0)	(0.0)
Oxyfluorfen	3	0.25	2.3	2.2	0.0	1.05	3.5	3.7	1.3	0.7	0.0	0.0
			(5.0)	(4.5)	(0.0)	(0.9)	(12.5)	(14.8)	(2.0)	(0.5)	(0.0)	(0.0)
Weed-free	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Weedy	-	-	4.7	4.5	4.1	4.4	9.2	9.6	3.9	1.16	1.8	2.3
			(24.0)	(22.0)	(16.5)	(20.5)	(86.5)	(99.5)	(15.0)	(3.0)	(3.0)	(5.0)
LSD (P=0.05)			1.4	1.6	1.3	1.5	1.07	1.2	1.2	1.06	0.5	0.6

Figures in parentheses are original values.

Table 2. Effect of treatments on total weed dry weight, yield and yield attributes

Treatment	Application stage (DAS)	Dose (kg ha^{-1})	Total dry weight of weeds		No of panicles m^{-2}		No. of grains panicle^{-1}		1000-grain weight (g)		Grain yield (t ha^{-1})	
			2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Pendimethalin	3	1.0	4.91 (136.5)	5.43 (253.5)	229	196	196	193	23.6	23.4	3.85	3.34
Pendimethalin	3	1.5	4.52 (91.8)	4.92 (170.7)	248	172	204	186	23.8	24.1	3.92	3.40
Pendimethalin	3	2.0	4.22 (67.6)	4.77 (142.1)	249	162	198	205	23.1	23.6	3.62	3.23
Anilofos	3	0.4	5.17 (181.0)	5.42 (234.5)	227	190	194	189	33.4	24.1	3.92	2.86
Anilofos	3	0.6	5.00 (148.3)	5.31 (209.2)	219	172	201	207	24.6	23.1	3.50	2.17
Anilofos	3	0.8	4.76 (118.6)	4.45 (244.6)	209	163	199	179	23.7	22.1	3.10	2.09
Pendimethalin fb 2,4-D	3 & 35	1.0-0.5	3.42 (30.5)	3.94 (54.3)	285	171	214	172	23.8	24.1	5.13	4.56
Anilofos fb 2,4-D	3 & 35	0.4-0.5	3.78 (43.2)	4.51 (109.2)	279	144	175	192	24.3	23.2	4.72	3.72
Anilofos	7	0.4	5.06 (158.4)	4.33 (78.3)	265	127	165	213	23.3	23.6	4.39	4.06
Anilofos fb 2,4-D	7 & 35	0.4-0.5	3.90 (49.7)	4.61 (127.0)	306	230	203	209	23.7	23.5	4.92	4.13
Pendimethalin fb Bentazon	3 & 35	1.0-0.72	3.7 (40.3)	4.31 (80.4)	245	116	203	219	23.5	24.1	4.32	3.59
Anilofos fb Bentazon	3 & 35	0.4-0.72	3.7 (40.1)	5.22 (229.6)	272	146	202	182	24.2	22.4	4.65	2.91
Oxyfluorfen	3	0.25	3.71 (41.7)	5.16 (183.1)	258	151	203	152	23.4	23.4	4.61	4.06
Weed-free	-	-	0.0 (0.0)	0.0 (0.0)	429	331	206	137	24.7	24.1	5.96	5.65
Weedy	-	-	6.0 (404.7)	6.11 (462.7)	0.0	79	0.0	154	0.0	20.7	6.0	2.11
LSD (P=0.05)			0.27	0.78	52	73	26.4	39.5	1.3	3.2	0.25	1.32

Figures in parentheses are original values.

kg ha^{-1}, anilofos at 0.4 kg ha^{-1} pre-emergence followed by 2, 4-D at 0.4 kg ha^{-1}, anilofos alone at 0.4 kg ha^{-1} early post-emergence, anilofos at 0.4 kg ha^{-1} early post-emergence followed by 2, 4-D at 0.5 kg ha^{-1}, pendimethalin at 1.0 kg ha^{-1} followed by bentazon at 0.72 kg ha^{-1}, anilofos at 0.4 kg ha^{-1} followed by bentazon at 0.72 kg ha^{-1} and oxyfluorfen at 0.25 kg ha^{-1} pre-emergence. Two treatments involving weed-free and weedy were also kept. Pre-emergence applications were made at three days after sowing, early post-emergence herbicides were applied at seven days after sowing and follow up applications were done at 35 days after sowing. Herbicides were applied as spray at spray volume of 500 l ha^{-1}. Experiment with 15 treatments and four replications was laid out in randomized block design. Rice variety Sarju-52 was sown at row spacing of 20 cm. The experimental crop was grown adopting recommended package of practices. Log (X+1) transformation was used to analyze the data on weeds.

RESULTS AND DISCUSSION

Effect on Weeds

The major weed species found in the experimental field were *Caesulia axillaris* (59.8%), *Echinochloa colona* (14.7%), *Panicum maximum* (11.7%), *Cyperus iria* (5.7%) and *Ischaemum rugosum* (2.0%). The effect of treatments was assessed on the basis of density and dry weight recorded at 60 days stage. Progressive increase in doses of both pendimethalin (from 1.0 to 2.0 kg ha^{-1}) and anilofos (from 0.4 to 0.8 kg ha^{-1}) resulted in decreased density and dry weight of all the weeds at 60 days stage (Table 1). Pendimethalin at 2.0 kg ha^{-1} recorded least population of *E. colona* among all the treatments except weed-free treatment. However, *P. maximum* population was reduced by oxyfluorfen most effectively during both the years. *C. axillaris* was controlled by follow up treatment of bentazon with pendimethalin compared to all other treatments. Both pendimethalin and anilofos applied alone were not able to reduce the population of *C. axillaris*. Broad-leaved weeds were controlled effectively by 2, 4-D and bentazon. Oxyfluorfen was able to control effectively both broad-leaved weeds and grasses. All the herbicides were also able to reduce total dry weight of weeds at 60 days stage of crop compared to weedy plot. However, again pendimethalin followed by 2, 4-D recorded least total dry weight of weeds which was at par with pendimethalin applied alone. Pendimethalin followed by 2, 4-D recorded highest weed control efficiency (92.1%) (Table 2). Herbicides used alone, recorded lower weed control efficacy (except oxyfluorfen) than combined application. Weed control spectrum was widened due to follow up application of 2, 4-D and bentazon.

Effect on Crop

The rice crop yield was higher during the first season of experiment than the second season. It was due to less density and dry weight of weeds during the first season. More weed infestation during second season had its impact on number of panicles (Table 2). However, the number of grains panicle and test weight were more or less same during both the seasons. With increase in dose of both pendimethalin (from 1.0 to 2.0 kg ha^{-1}) and anilofos (from 0.4 to 0.8 kg ha^{-1}) there was reduction in number of panicles and had its final effect on yield. As a result of higher weed control efficiency pendimethalin at 1.0 kg ha^{-1} followed by 2, 4-D at 0.5 kg ha^{-1} recorded higher yield (4.81 t ha^{-1}). However, highest yield (5.80 t ha^{-1}) was recorded under weed-free condition. Oxyfluorfen, being a broad spectrum herbicide, recorded higher grain yield when compared with other herbicides applied alone.

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