

Original Research Article

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Bio-Efficacy of Sequential Application of Herbicides on Weeds and Yield in Direct Seeded Rice (*Oryza sativa*)

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ABSTRACT

Keywords

Direct seeded rice, effective tillers, filled grains, grain yield, herbicides, weed control efficiency.

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A field experiment was conducted during *kharif* 2012 to evaluate the efficacy of different pre and post emergence herbicides in direct seeded rice. The chemical treatments included two pre-emergence herbicides namely pendimethalin 1000 g/ha and oxadiargyl 100 g/ha and four post-emergence herbicides *viz.* bispyribac-sodium 25 g/ha, fenoxaprop 67 g/ha, ethoxysulfuron 18.75 g/ha and chlorimuron-ethyl +metsulfuron-methyl RM 4 g/ha at 25 DAS. Weed free and weedy check were also included. Among chemical treatments, sequential application of pendimethalin 1000 g/ha *fb* bispyribac-sodium 25 g/ha and chlorimuron-ethyl+ metsulfuron-methyl RM 4 g/ha produces minimum density of *Echinochloa glabrescens*, *Cyperus* spp. and *Ammania* spp. at 45 DAS which was statistically at par with weed free. This treatment also had highest efficacy against *Echinochloa glabrescens*, *Cyperus* spp. and *Ammania* spp. at 45 DAS. Sequential application of pendimethalin 1000 g/ha *fb* bispyribac-sodium 25 g/ha and chlorimuron-ethyl+ metsulfuron-methyl RM 4 g/ha gave maximum number of effective tillers (209.3), filled grains/panicle (83.7), grain yield (3.97 t/ha) and B:C (2.37) among chemical weed control treatments which was at par with weed free.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops of India and a staple food of more than 65% of its population. In India, the crop occupies an area of nearly 44.1 m ha with total production of 105.5 m t and productivity of 2391 kg/ha (Anonymous, 2014).

In India, it is commonly grown by transplanting seedlings into puddled soil which benefits rice by reducing water percolation losses, controlling weeds, facilitating easy seedling establishment and creating anaerobic conditions to enhance nutrient availability (Bhurer *et al.*, 2013). But,

repeated puddling adversely affects soil physical properties by destroying soil aggregates, reducing permeability in sub-surface layers and forming hard-pans at shallow depths (Sharma *et al.*, 2003). All these factors demand a major shift from puddle-transplanted rice (CT-TPR) to direct seeding of rice (DSR) in irrigated areas. In addition, DSR matures earlier than the transplanted rice allowing timely planting of succeeding wheat crop (Singh *et al.*, 2006). DSR by eliminating puddling and continuous submergence of fields reduces the overall water application for rice culture. But weed control is major limitation for the success of

DSR (Chauhan, 2012). Aerobic systems are subjected to much higher weed pressure than conventional puddled transplanting system (Rao *et al.*, 2007) in which weeds are suppressed by standing water and by transplanted rice seedlings, which have a “head start” over germinating weed seedlings (Moody, 1983). Success of DSR depends largely on weed control especially with chemical methods. Various herbicides have been used for controlling weeds in DSR but efficiency of chemical methods based on single herbicide treatment may be unsatisfactory because of their narrow spectrum of weed control. Therefore, application of several herbicides in sequence can be more useful (Chauhan and Yadav, 2013). So, this experiment, involving multitudinous herbicide combinations was undertaken to achieve an effective broad-spectrum weed control.

Materials and Methods

The study was conducted during the *kharij* 2012 at Students’ Farm of College of Agriculture, CCS Haryana Agricultural University; campus Kaul (Kaithal). The soil of the experiment field was clay loam in texture and slightly alkaline in reaction. The soil was low in organic carbon, low in available nitrogen, medium in available phosphorus and high in available potassium. The treatments included pre and post emergence herbicides (T₁: pendimethalin 1000 g/ha *fb* bispyribac sodium 25 g/ha, T₂: pendimethalin 1000 g/ha *fb* bispyribac sodium 25 g/ha + ethoxysulfuron 18.75 g/ha, T₃: pendimethalin 1000 g/ha *fb* bispyribac sodium 25 g/ha + chlorimuron-ethyl and metsulfuron-methyl ready mix 4 g/ha, T₄: pendimethalin 1000 g/ha *fb* fenoxaprop 67 g/ha, T₅: pendimethalin 1000 g/ha *fb* fenoxaprop 67 g/ha + ethoxysulfuron 18.75 g/ha, T₆: pendimethalin 1000 g/ha *fb* fenoxaprop 67 g/ha + chlorimuron-ethyl and metsulfuron-methyl ready mix 4 g/ha, T₇: oxadiargyl 100

g/ha *fb* bispyribac sodium 25 g/ha, T₈: oxadiargyl 100 g/ha *fb* bispyribac sodium 25 g/ha + ethoxysulfuron 18.75 g/ha, T₉: oxadiargyl 100 g/ha *fb* bispyribac sodium 25 g/ha + chlorimuron-ethyl and metsulfuron-methyl ready mix 4 g/ha, T₁₀: oxadiargyl 100 g/ha *fb* fenoxaprop 67 g/ha, T₁₁: oxadiargyl 100 g/ha *fb* fenoxaprop 67 g/ha + ethoxysulfuron 18.75 g/ha, T₁₂: oxadiargyl 100 g/ha *fb* fenoxaprop 67 g/ha + chlorimuron-ethyl and metsulfuron-methyl ready mix 4 g/ha) which were compared with weedy check and weed free treatments in randomized complete block design with three replications (Table 1). Rice variety PUSA 1121 was seeded on 19th June 2012 in rows 22.5 cm apart using seed drill. Herbicides were applied as spray in aqueous media at the rate of 500 litre of water per ha, using a Knapsack sprayer with a flat fan nozzle. The amount of herbicides and water was computed on the basis of gross area to be sprayed. In weed free plots, weeds were removed as and when required after sowing, manually. Nitrogen, phosphorus, potassium and zinc were applied at the rate of 60, 30, 30 and 25 kg/ ha respectively through urea, diammonium phosphate, muriate of potash and ZnSO₄. Half dose of nitrogen and full dose of phosphorus, potassium and ZnSO₄ were drilled at the time of sowing. Remaining half of nitrogen was top dressed in two equal splits; first at active tillering stage and second at panicle initiation stage. Weed density (number/m²) were recorded species wise in each plot using quadrat of 50 cm × 50 cm (0.25 m²) from the area selected randomly for observations. The weed control efficiency (WCE) was calculated by using the following formula (Singh *et al.*, 2000).

$$\text{WCE} = (\text{DMC} - \text{DMT}) / \text{DMC} \times 100$$

Where, DMC is dry matter of weeds (g) in weedy check and DMT is dry matter of weeds (g) in a particular treatment.

Table.1 Effect of different weed control treatments on weed density and weed control efficiency at 45 DAS in direct seeded rice

Treatment		Dose (g/ha)	Time of application (DAS)	Weed density (No/m ²) 45 DAS				Weed control efficiency (%) 45 DAS			
				<i>Echinochloa glabrescens</i>	<i>Leptochloa chinensis</i>	<i>Cyperus</i> spp.	<i>Ammania baccifera</i>	<i>Echinochloa glabrescens</i>	<i>Leptochloa chinensis</i>	<i>Cyperus</i> spp.	<i>Ammania baccifera</i>
T1	Pendimethalin fb bispyribac-Na	1000 fb 25	3 fb 25	3.3(9.9)	5.6(30.8)	5.6(30.5)	3.2(9.3)	75.3	44.9	58.0	45.1
T2	Pendimethalin fb bispyribac-Na +ethoxysulfuron	1000 fb 25 +18.75	3 fb 25	3.2(9.2)	5.1(25.5)	2.3(5.1)	2.5(5.3)	77.0	54.5	93.0	70.2
T3	Pendimethalin fb bispyribac-Na + metsulfuron methyl + chlorimuron ethyl RM (Almix)	1000 fb 25 +4	3 fb 25	2.9(7.2)	5.5(29.6)	2.2(4.4)	1.8(2.7)	82.0	47.1	93.9	84.9
T4	Pendimethalin fb fenoxaprop	1000 fb 67	3 fb 25	4.2(17.2)	2.3(4.1)	5.3(28.2)	3.2(9.3)	56.9	92.7	61.2	46.2
T5	Pendimethalin fb fenoxaprop +ethxysulfuron	1000 fb 67 + 18.75	3 fb 25	4.1(16.4)	2.4(4.7)	2.4(6.0)	2.3(5.3)	58.9	91.6	91.7	69.3
T6	Pendimethalin fb fenoxaprop + metsulfuron methyl + chlorimuron ethyl RM (Almix)	1000 fb 67 + 4	3 fb 25	3.9(14.8)	2.4(4.5)	2.4(5.5)	1.8(2.7)	62.9	91.9	92.5	84.2
T7	Oxadiargyl fb bispyribac-Na	100 fb 25	3 fb 25	3.7(13.1)	5.6(30.3)	5.6(30.7)	3.6(12.0)	67.3	45.9	57.8	30.7
T8	Oxadiargyl fb bispyribac-Na +ethoxysulfuron	100 fb 25 + 18.75	3 fb 25	3.7(12.8)	5.7(31.5)	2.6(7.2)	3.0(8.0)	67.9	43.7	90.1	53.8
T9	Oxadiargyl fb bispyribac-Na + metsulfuron methyl + chlorimuron ethyl RM (Almix)	100 fb 25 + 4	3 fb 25	3.5(11.2)	6.0(35.7)	2.5(6.1)	2.7(6.7)	71.9	36.1	91.6	61.5
T10	Oxadiargyl fb fenoxaprop	100 fb 67	3 fb 25	4.7(21.2)	2.4(4.5)	6.7(43.7)	3.8(13.3)	46.9	91.9	39.9	23.1
T11	Oxadiargyl fb fenoxaprop+ ethoxysulfuron	100 fb 67 + 18.75	3 fb 25	4.5(20.1)	2.6(5.7)	2.6(7.3)	3.0(8.0)	49.7	89.7	89.9	52.9
T12	Oxadiargyl fb fenoxaprop + metsulfuron methyl + chlorimuron ethyl RM (Almix)	100 fb 67 + 4	3 fb 25	4.4(18.4)	2.6(5.6)	2.5(6.7)	2.7(6.7)	53.9	90.0	90.8	60.7
T13	Weed free	1000 fb 25	3 fb 25	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	100.0	100.0	100.0	100.0
T14	Weedy check	1000 fb 25 +18.75	3 fb 25	7.0(48.4)	7.5(56.0)	8.6(72.6)	4.2(17.3)	0.0	0.0	0.0	0.0
	SEm±			0.2	0.2	0.3	0.3	-	-	-	-
	CD (P=0.05)			0.7	0.6	1.0	0.8	-	-	-	-

*Original values are in parenthesis and before statistical analysis were subjected to square root transformation ($\sqrt{x+1}$)

Table.2 Effect of different weed control treatments on yield attributes, yield and economics of direct seeded rice

Treatment		Dose g/ha	Time DAS	Effective tillers/m ²	Filled grains/panicle	1000 grain weight (g)	Grain yield (t/ha)	B:C
T1	Pendimethalin <i>fb</i> bispyribac-Na	1000 <i>fb</i> 25	3 <i>fb</i> 25	184.5	79.7	25.9	3.57	2.27
T2	Pendimethalin <i>fb</i> bispyribac-Na +ethoxysulfuron	1000 <i>fb</i> 25 +18.75	3 <i>fb</i> 25	206.7	82.0	26.4	3.83	2.35
T3	Pendimethalin <i>fb</i> bispyribac-Na + metsulfuron methyl + chlorimuron ethyl	1000 <i>fb</i> 25 +4	3 <i>fb</i> 25	209.3	83.7	27.3	3.97	2.37
T4	Pendimethalin <i>fb</i> fenoxaprop	1000 <i>fb</i> 67	3 <i>fb</i> 25	180.0	79.3	25.9	3.57	2.21
T5	Pendimethalin <i>fb</i> fenoxaprop +ethxysulfuron	1000 <i>fb</i> 67 + 18.75	3 <i>fb</i> 25	193.3	82.3	26.1	3.71	2.26
T6	Pendimethalin <i>fb</i> fenoxaprop + metsulfuron methyl + chlorimuron ethyl	1000 <i>fb</i> 67 + 4	3 <i>fb</i> 25	198.7	83.3	26.5	3.77	2.29
T7	Oxadiargyl <i>fb</i> bispyribac-Na	100 <i>fb</i> 25	3 <i>fb</i> 25	174.7	76.3	26.0	2.93	1.80
T8	Oxadiargyl <i>fb</i> bispyribac-Na +ethoxysulfuron	100 <i>fb</i> 25 + 18.75	3 <i>fb</i> 25	182.3	77.7	25.3	3.25	1.97
T9	Oxadiargyl <i>fb</i> bispyribac-Na + metsulfuron methyl + chlorimuron ethyl	100 <i>fb</i> 25 + 4	3 <i>fb</i> 25	188.3	79.3	25.8	3.47	2.10
T10	Oxadiargyl <i>fb</i> fenoxaprop	100 <i>fb</i> 67	3 <i>fb</i> 25	165.3	77.0	25.0	2.77	1.73
T11	Oxadiargyl <i>fb</i> fenoxaprop+ ethoxysulfuron	100 <i>fb</i> 67 + 18.75	3 <i>fb</i> 25	166.7	73.3	26.4	2.87	1.77
T12	Oxadiargyl <i>fb</i> fenoxaprop + metsulfuron methyl + chlorimuron ethyl	100 <i>fb</i> 67 + 4	3 <i>fb</i> 25	168.0	74.7	25.2	2.94	1.80
T13	Weed free	1000 <i>fb</i> 25	3 <i>fb</i> 25	210.7	85.3	27.1	4.12	2.01
T14	Weedy check	1000 <i>fb</i> 25 +18.75	3 <i>fb</i> 25	97.3	71.7	25.0	1.52	0.97
	SE(m) ±			6.8	1.6	1.0	0.15	
	CD at 5%			20.0	4.7	NS	0.43	

*Original values are in parenthesis and before statistical analysis were subjected to square root transformation ($\sqrt{x+1}$)

The data was analyzed using analysis of variance (ANOVA) as applicable to randomized complete block design. The significance of the treatment effects was determined using F-test at 5% significance level. Data on number and dry weight of weeds were subjected to square-root $\sqrt{(x+0.5)}$ transformation before analysis of variance.

Results and Discussion

Weed population and dry weight

Weed flora of the experimental field was mainly dominated by *Cyperus difformis*, *Cyperus rotundus*, *Leptochloa chinensis*, *Echinochloa glabrescens*, *Eclipta alba* and *Ammania* spp.

All the herbicidal treatments significantly reduced the density of all weed species compared to weedy check at 45 DAS ($p=0.05$). Among herbicidal treatments pre-emergence application of pendimethalin 1000 g/ha fb bispyribac-sodium 25 g/ha and chlorimuron-ethyl + metsulfuron-methyl RM 4 g/ha gave minimum density of *E. glabrescens*, *Cyperus* spp. and *Ammania* spp. at 45 DAS. The weed density in this treatment was statistically at par with weed free treatment (Table 1). This may be due to effective control of weeds during early stage by pendimethalin 1000 g/ha and thereafter better control by bispyribac-sodium 25 g/ha and chlorimuron-ethyl + metsulfuron-methyl 4 g/ha at later stage of crop growth. The minimum density of *L. chinensis* at 45 DAS was however obtained under application of pendimethalin 1000 g/ha as pre-emergence and fenoxaprop 67 g/ha and chlorimuron-ethyl + metsulfuron-methyl RM 4 g/ha as post-emergence. This may be due to excellent control of *Leptochloa chinensis* by fenoxprop 67 g/ha. Similar control of *L. chinensis* by fenoxaprop 56.25 g/ha was recorded by Singh *et al.*, (2004). The weed control efficiency of different weeds also followed the similar

pattern as of weed density. Among all chemical treatments, highest weed control efficiency at 45 DAS was achieved by pre-emergence application of pendimethalin 1000 g/ha fb bispyribac-sodium 25 g/ha and chlorimuron-ethyl + metsulfuron-methyl RM 4 g/ha as post-emergence. The efficiency of this treatment was 93.9 % for *Cyperus* spp, 82 % for *E. glabrescens* and 84.9 % for *Ammania* spp. For *L. chinensis* highest weed control efficiency (92.1 %) at 45 DAS was observed with pendimethalin 1000 g/ha as pre-emergence fb fenoxaprop 67 g/ha as post emergence (Table 1).

Crop growth and yield

All the treatments produced significantly higher number of effective tillers, filled grains/ panicle and grain yield than weedy check ($p=0.05$) (Table 2). Weed free treatment were recorded highest for number of effective tillers (210), filled grains/panicle (85.3) and grain yield (4.12 t/ha). Among all herbicidal treatment, sequential application of pendimethalin 1000 g/ha fb bispyribac sodium 25 g/ha and metsulfuron methyl + chlorimuron ethyl 4 g/ha had highest number of effective tillers (209.3), filled grains/panicle (83.7) and grain yield (3.97 t/ha) which was at par with weed free treatment while minimum number of effective tillers/m²(165.3), grain yield (2.77 t/ha) was obtained with application of oxadiargyl 100 g/ha followed by fenoxaprop 67 g/ha. Similar results on effective tillers, filled grains/panicle and yield of direct seeded rice were obtained by Ganie *et al.*, (2014). The effect of different weed control treatments on 1000 grain weight was found non-significant.

Economics

The highest B: C (2.37) was obtained under sequential application of pendimethalin 1000 g/ha fb bispyribac sodium 25 g/ha and metsulfuron methyl + chlorimuron ethyl 4

g/ha which was higher than under weed free treatment (2.01) (Table 2). This is due to higher cost of cultivation by employing manual weeding in weed free treatment.

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