Effect of Herbicide Combinations on Weed Count, Yield Attributes and Yield of Direct Seeded Rice

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Abstract- **Ten treatments viz bispyribac 25 g/ha (20 DAS), pre-emergence pendimethalin 1000 g/ha, oxadiargyl 100 and pyrazosulfuron each followed by (fb) bispyribac 25 g/ha (25 DAS), pendimethalin 1000 g/ha fb bispyribac 25 g/ha fb manual weeding (45 DAS), pendimethalin 1000 g/ha fb manual weeding (25-30 DAS), bispyribac 25 g/ha + chlorimuron 20 g/ha + metsulfuron methyl 4 g/ha (20 DAS), cono/rotary weeding (15, 30 and 45 DAS), weed free and weedy check were evaluated for yield attributes and yield of direct seeded rice at Palampur during kharif 2013, 2014 and 2015. Most of the herbicidal treatments were as effective as weed free in reducing the density of Echinochloa colona, Digitaria sanguinalis, Panicum dichotomiflorum, Commelina benghalensis, Aeschynomene indica and total weed count. Herbicidal treatments significantly increased plant height, effective panicles, panicle length, grains/panicle. Grain yield was negatively associated with count of E. colona, D. sanguinalis, P. dichotomiflorum and total weed count and positively associated with effective tillers and grains/ panicle. Pendimethalin 1000 g/ha (0-2 DAS) fb bispyribac 25g/ha (20 DAS) fb manual weeding (45 DAS) behaving statistically alike with oxadiargyl fb bispyribac, pendimethalin fb bispyribac, bispyribac, pyrazosulfuron fb bispyribac and weed free resulted in significantly higher grain yield of rice over other treatments. With every 1 weed/m2 increase in density, the grain yield of dry seeded rice was expected to fall by 15.1 kg/ha. Un-controlled growth of weeds reduced the grain yield of rice by 67.1%.**

Index Terms- direct seeded rice, herbicide combinations, weeds, yield attributes, yield.

INTRODUCTION

Rice is cultivated under various ecosystems, viz., transplanted, puddle sown, semi-dry, dry or rainfed or aerobic situations1. Dry seeded rice has many advantages viz., saving in labour, fast and easier, timely sowing, less drudgery, less water use, low cost of production, higher yield, more profit, less methane emissions and maintenance of soil structure. However, weed infestation and competition are severe under dry seeding as compared to puddle seeded rice because of the simultaneous emergence of both rice crop and weeds. Direct seeded rice is invaded by a complex plurispecific weed flora, composed of grasses, sedges and broad-leaved weeds2-4. Uncontrolled growth of weeds reduces yield of direct seeded rice by 96 to 100%5. Hence, developing an effective weed management module has been a challenge for widespread adoption of direct seeded rice cultivation. Manual removal of weeds is labour intensive, less cost effective, troublesome, back breaking and does not ensure weed removal at critical stage of crop-weed competition. Use of pre emergence herbicides has been found effective in early stage, but the later flushes of weeds require manual removal at 25 to 35 DAS which increases the cost of production. The scarce in labour under such circumstances endangers the successful cultivation of direct seeded rice. Post-emergence bispyribac has been recommended as an effective alternative3&6 if weed problem is more severe and appears in flushes. In order to optimize weed control efficacy and minimize the application costs, sequential application of pre and post-emergence herbicides7, formulated or tank mix herbicide mixtures8 as well as integrating herbicides with manual or mechanical means9-10 has to be the rule rather than the exception. Therefore, the present investigation was carried out to evaluate herbicide combinations for effective management of complex weed flora in direct seeded rice.

MATERIALS AND METHODS

A field experiment was conducted at Palampur during the three consecutive kharif seasons of 2013

to 2015 to evolve effective combinations of herbicides against weed complex in direct seeded upland rice. Ten treatments viz. bispyribac 25 g/ha (20 DAS), pendimethalin 1000 g/ha (pre) fb bispyribac 25 g/ha (25 DAS), oxadiargyl 100 g/ha (pre) fb bispyribac 25 g/ha (25 DAS), pyrazosulfuron 20 g/ha (pre) fb bispyribac 25 g/ha (25 DAS), pendimethalin 1000 g/ha (pre) fb bispyribac 25 g/ha (20 DAS) fb manual weeding (45 DAS), pendimethalin 1000 g/ha (pre) fb manual weeding (25-30 DAS), bispyribac 25 g/ha + chlorimuron 20 g/ha + metsulfuron methyl 4 g/ha (20 DAS), cono/rotary weeding (15, 30 and 45 DAS), weed free (hand weeding 15, 30, 45 and 60 DAS) and weedy check were tested in randomized block design with three replications. The experimental soil was silty clay loam in texture, acidic in reaction (pH 5.6), medium in available nitrogen, phosphorus and high in available potassium. Rice variety HPR 1156 was sown on 01 June 2013, 20 May 2014 and 25 May 2015 keeping row to row spacing of 25 cm (80 kg seed/ha). The crop was fertilized with 90 kg N, 40 kg P2O5 and 40 kg K2O/ha through urea, single super phosphate and muriate of potash, respectively. The required quantity of half N and whole P2O5 and 40 kg K2O was drilled at sowing. The remaining half N was band placed at panicle initiation stage. Herbicides were applied with power sprayer using 600 L water per hectare. The rest of the management practices were in accordance with the recommended package of practices. Data on weed population were recorded at 70-75 DAT rice. Yield attributes were recorded at harvest. The crop was harvested on 22 October 2013, 28 October 2014 and 24 October 2015. The net plot grain yield was converted to kg/ha.

The data obtained were subjected to statistical analysis by analysis of variance (ANOVA) for the randomized block design to test the significance of the overall differences among the treatments by the "F" test and conclusion was drawn at 5% probability level. Standard error of mean was calculated in each case. When the 'F' value from analysis of variance tables was found significant, the critical difference (C.D.) was computed to test the significance of the difference between the two treatments.

RESULTS AND DISCUSSION

Effect on weeds

The major weeds of the experimental field were Echinochloa colona (38.7, 45.1, 69.5% & 51.3%), Digitaria sanguinalis (0.0, 39.5, 10.2 & 24.6%), Panicum dichotomiflorum (40.8, 12.6, 13.0 & 17.1%), Aeschynomene indica (4.8, 1.4, 3.9 & 2.5%) and Commelina benghalensis (15.7, 1.4, 3.9 & 4.4% during 2013, 2014, 2015 and combined of all the three years, respectively in the unweeded check).

Weed control treatments resulted in significant variation in the count of E. colona during all the three years (Table 1). Weed control treatments brought about significant reduction in the count of E. colona over weedy check in all the three years. Most herbicidal treatments were as effective as weed free in reducing density of E. colona and were superior to cono/rotary weeding. The superiority of bispyribac3&6, pendimethalin, oxadiargyl7, pyrazosulfuron and chlorimuron and herbicide combinations vis-à-vis sequential application of herbicides7,8&11 in controlling E. colona has been reported by several workers. Weed control treatments caused significant variation in the count of D. sanguinalis during all the three years. However, it had sporadic population during 2013. All the treatments were significantly superior to weedy check in reducing its population. Population of the weed was completely eliminated under pendimethalin fb bispyribac, oxadiargyl fb bispyribac, pyrazosulfum fb bispyribac, pendimethalin fb bispyribac fb manual weeding and weed free, all of which were significantly superior to cono/rotary weeding. Kaur and Singh7 also reported superiority of pendimethalin and pendimethalin fb bispyribac in controlling D. sanguinalis. Weed control treatments brought about significant variation also in the count of P. dichotomiflorum during all the three years. Pendimethalin fb bispyribac, oxadiargyl fb bispyribac, pyrazosulfuron fb bispyribac, pendimethalin fb bispyribac fb manual weeding, bispyribac + chlorimuron + metsulfuron methyl and were free resulted in significantly lower density of P. dichotomiflorum as compared to weedy check in all the three years. Cono/rotary weeding could not significantly curtail the population of P. dichotomiflorum over the unweeded check during 2013 and 2015. Weed control treatments encountered significant variation in the count of C. benghalensis and A. indica (Table 2). All treatments were significantly superior to weedy check in reducing the

population of these weeds. All herbicidal treatments except pendimethalin fb hand weeding gave comparable control of these weeds as weed free.

Owing to species-wise reduction in the population of weeds, all the weed control treatments except mechanical weeding (cono/rotary weeder) resulted in significantly lower total weed count. The superiority of herbicidal treatments in curtailing weed population has been presented in several scientific papers 2,5,11-13.

Effect on crop

Weed control treatments brought about significant variation in rice plant height (Table 3) in all the three years. Owing to effective control of weeds particularly at the critical stage of crop growth, all the treatments were significantly superior to weedy check in increasing plant height of rice. Kaur and Singh7 also reported significant increase in rice plant height with pendimethalin/oxadiargy/pyrazosulfuron fb bispyribac. Similarly all treatments were significantly superior to weedy check in producing longer panicles, the sink or platform for more grains. The consequence of having longer panicles was reflected in more number of grains/panicle. All the herbicidal treatments had more number of grains or spikelets/panicle. Kaur and Singh7 also reported significantly higher number of grains with the sequential application of herbicides. Weed control treatments significantly influenced number of effective tillers. Weed control treatments resulted in significantly higher number of effective tillers over weedy check due to effective removal of weed competition. Increase in the number of effective tillers with the removal of competition with the sequential application of herbicides have been reported in several scientific communications 3,7 &11.

Rice grain yield was negatively associated with the count of E. colona (r= -0.738*, -0.869**, -0.947** and -0.888**, during 2013, 2014, 2015 and combined of all three years, respectively; *significant at 5% level of significance and **significant at 1% level of significance), D. sanguinalis (r= -0.886**, -0.861** and -0.923** during 2014, 2015 and combined of the three years), P. dichotomiflorum (r= -0.604, -0.714*, -0.728* and -0.735*), A. indica (r= - 0.640*, -0.852**, -0.939** and -0.912**), C. benghalensis (r= - 0.728*, -0.863**, -0.882** and -0.883**) and total weed count (r= -0.789**, -0.871**, -0.952** and -0.898**) showing their high competitiveness in direct seeded rice. The grain yield was found to be positively correlated with plant height (r= -0.849*, -0.836**, -0.973** and -0.654**), panicle length (r= -0.943*, -0.951**, -0.926** and -0.977**), effective tillers (r= -0.801*, -0.801**, -0.954** and -0.892**) and spikelets/panicle (r= -0.692*, -0.921**, -0.971** and -0.958**). Weed control treatments resulted in significant variation in grain yield of rice (Table 3). Pendimethalin 1000 g/ha (0-2 DAS) fb bispyribac 25g/ha (20 DAS) fb manual weeding (45 DAS) behaving statistically alike with oxadiargyl fb bispyribac, pendimethalin fb bispyribac, bispyribac, pyrazosulfuron fb bispyribac and weed free during 2013 and 2015 resulted in significantly higher grain yield of direct seeded rice over other treatments. The higher grain yield under these treatments was owed to superior weed control. These findings are in line with those of 2-3,5-6,9-14. Weeds in unweeded check reduced the grain yield of rice by 67.1% over pendimethalin fb bispyribac fb manual weeding.

The linear relationship between weed count (x) and grain yield (Y) of direct seeded rice is given here as under,

$Y = 2847 - 15.1x$ $(R2 = 0.807)$……..(i)

The equation (i) explains that 80.7% of variation in grain yield of maize due to weed dry weight could be explained by the regression equation. With every 1 weed/m2 increase in density, the grain yield of dry seeded rice was expected to fall by 15.1 kg/ha.

It may be conclusively inferred from the present investigation that pendimethalin 1000 g/ha (0-2 DAS) fb bispyribac 25g/ha (20 DAS) fb manual weeding (45 DAS) followed by oxadiargyl 100 g/ha fb bispyribac 25 g/ha, pendimethalin 1000 g/ha fb bispyribac 25 g/ha, and pyrazosulfuron 20 g/ha fb bispyribac 25 g/ha can be the better alternatives to manual weeding under the mid hills conditions of Himachal Pradesh.

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Table 1. Effect of treatments on count (No/m2) of Echinochloa, Digitaria and Panicum in direct seeded rice

Treatment	*Dose (g/ha)*	*Time (DAS)*	*Echinochloa*			*Digitaria*			*Panicum*		
			2013	*2014*	*2015*	*2013*	*2014*	*2015*	*2013*	*2014*	*2015*
Bispyribac	*25*	*20*	1.9(2.5)	1.5(1.3)	1.9(2.5)	1.8(2.4)	1.2(0.44)	1.2(0.5)	3.9(14.0)	2.9 (7.4)	1.8(2.4)
Pendimethalin *fb* bispyribac	1000, 25	0-2, 25	2.9(7.6)	2.7(6.3)	2.4(4.6)	1.0(0.0)	1.0(0.0)	1.0(0.0)	2.5(5.0)	2.3(4.3)	2.2(3.9)
Oxadiargyl *fb* bispyribac	100, 25	0-2, 25	2.6(6.0)	2.5(5.3)	2.3(4.25)	1.0(0.0)	1.0(0.0)	1.0(0.0)	3.2(9.0)	3.1(8.6)	2.9(7.6)
Pyrazosulfum *fb* bispyribac	20, 25	0-3, 25	2.7(6.1)	2.4(4.8)	2.4(4.90)	1.0(0.0)	1.0(0.0)	1.0(0.0)	2.7(6.4)	2.6(5.8)	2.3(4.3)
Pendimethalin *fb* bispyribac	1000, 25	0-2, 20, 45	3.1(8.4)	2.0(3.0)	1.9(2.5)	1.7(2.0)	1.0(0.0)	1.0(0.0)	2.7(6.3)	2.6(5.7)	2.3(4.1)

fb manual weeding											
Pendimethalin *fb* manual weeding	1000	0-2, 25-30	2.5(6.2)	2.4(4.8)	1.4(1.10)	1.0(0.0)	2.1(3.41)	1.6(1.5)	1.6(1.6)	1.5(1.3)	1.4(1.0)
Bispyribac + (chlorimuron + metsulfuron methyl)	25+ 20+4	20	1.6(1.7)	1.8(2.1)	1.9(2.5)	1.0(0.0)	2.0(3.0)	2.0(2.9)	3.4(10.4)	3.6(2.1)	1.7(1.9)
Mechanical weeding (cono/rotary weeder)	-	15,30,45	3.5(10.9)	4.0(15.0)	3.3(10.0)	1.0(0.0)	3.2(9.24)	3.0(8.2)	3.9(14.4)	3.8(13.4)	3.5(11.0)
Weed free	-		1.7(2.0)	1.2(0.4)	1.2(0.51)	1.0(0.0)	1.0(0.0)	1.0(0.0)	2.9(7.3)	2.7(6.3)	2.3(4.3)
Weedy check	-		4.8(22.0)	9.5(89.4)	8.7(75.0)	1.0(0.0)	8.9(78.3)	3.5(11.0)	4.9(23.2)	5.1(25.0)	3.9(14.0)
SEm ±			0.5	0.4	0.4	0.1	0.2	0.2	0.4	0.4	0.3
LSD (P=0.05)			1.3	1.2	1.3	0.4	0.7	0.6	1.1	1.2	1.0

Values given in the parentheses are the original means; DAS= Days after sowing; fb= followed by

Table 2. Effect of treatments on count (No/m2) Commelina, Aeschynomene and combined of all weeds in direct seeded

Treatment	*Dose (g/ha)*	*Time (DAS)*	*Commelina*			*Aeschynomene*			Total weed count		
			2013	*2014*	*2015*	*2013*	*2014*	*2015*	2013	2014	2015
Bispyribac	*25*	*20*	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	4.5(18.9)	3.2(9.1)	2.5(5.4)
Pendimethalin *fb* bispyribac	1000, 25	0-2, 25	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	3.7(12.6)	3.4(10.6)	3.1(8.5)
Oxadiargyl *fb* bispyribac	100, 25	0-2, 25	1.0(0.0)	1.0(.0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	4.0(15.0)	3.9(13.9)	3.6(11.9)
Pyrazosulfum *fb* bispyribac	20, 25	0-3, 25	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	3.7(12.5)	3.4(10.6)	3.2(9.2)
Pendimethalin *fb* bispyribac *fb* manual weeding	1000, 25	0-2, 20, 45	1.0(0.0)	1..0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	4.2(16.7)	3.1(8.7)	2.8(6.6)
Pendimethalin *fb* manual weeding	1000	0-2, 25-30	1.7(1.8)	1.7(2.0)	1.7(1.8)	1.6(1.5)	1.0(0.0)	1.2(0.50)	3.5(11.1)	3.5(11.5)	2.6(5.9)
Bispyribac + (chlorimuron + metsulfuron methyl)	25+ 20+4	20	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	3.6(12.1)	2.9(7.2)	2.9(7.3)
Three mechanical weedings (cono/rotary weeder)	-	15, 30, 45	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.8(2.4)	1.0(0.0)	1.0(0.0)	5.4(27.7)	6.2(37.2)	5.5(29.2)
Weed free	-		2.5(5.3)	1.0(0.0)	1.0(0.0)	2.0(3.2)	1.0(0.0)	1.0(0.0)	4.3(17.8)	2.8(6.7)	2.4(4.8)
Weedy	-		3.2(8.9	1.9(2.8	2.3(4.2	2.7(6.7	1.9(2.8	2.2(3.7)	7.6(56.8	14.1(198.	10.4

check			)	)	)	)	)		)	3)	(107.9)
SEm ±	-		0.2	-	-	0.1	-	-	0.3	0.4	0.1
LSD (P=0.05)	-		0.5	-	-	0.3	-	-	0.9	1.2	1.3

Values given in the parentheses are the original means DAS= after sowing fb= followed by

Table 3. Effect of treatments on plant height, yield attributes and grain yield of direct seeded rice

Treatment	Dose (g/ha)	Time (DAS)	Plant height (cm)			panicle Length (cm)			Effective tillers/m^2			Spikelets/panicle			Grain yield (t/ha)		
			2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Bispyribac	*25*	*20*	90.8	94.1	93.0	20.6	21.3	20.3	235.6	244.4	232.0	15.2	15.4	14.2	2793	2677	2610
Pendimethalin *fb* bispyribac	1000, 25	0-2, 25	92.0	93.6	93.0	20.3	21.2	20.4	231.2	237.6	236.0	15.3	15.7	14.6	3025	2799	2681
Oxadiargyl *fb* bispyribac	100, 25	0-2, 25	89.5	92.1	93.1	20.7	21.8	19.9	234.0	240.4	236.8	13.2	15.3	15.6	3089	3068	2615
Pyrazosulfum *fb* bispyribac	20, 25	0-3, 25	91.2	93.1	93.2	20.4	20.6	19.4	238.0	244.8	219.2	13.1	14.6	13.7	2795	2806	2310
Pendimethalin *fb* bispyribac *fb* manual weeding	1000, 25	0-2, 20, 45	88.0	93.6	93.9	21.3	21.7	21.2	230.4	228.8	237.2	10.3	16.7	16.2	3147	3384	2789
Pendimethalin *fb* manual weeding	1000	0-2, 25-30	86.4	89.4	91.2	18.7	19.7	19.6	231.2	232.4	229.2	10.6	10.8	12.9	1960	2207	2390
Bispyribac + (chlorimuron + metsulfuron methyl)	25+20+4	20	88.5	91.1	90.6	19.5	21.4	20.7	235.6	236.4	237.6	11.4	14.4	13.7	2650	2600	2317
Three mechanical weedings (cono/rotary weeder)	-	15, 30, 45	89.9	92.2	90.4	19.0	19.8	19.5	234.0	235.6	230.0	10.9	11.4	13.5	2230	2404	2210
Weed free	-	-	90.5	88.4	92.3	20.9	21.2	20.9	235.6	242.4	222.4	11.3	15.0	14.3	2799	2810	2425
Weedy check	-	-	78.8	82.7	83.0	17.7	17.0	16.4	174.4	188.4	160.4	8.0	8.7	7.5	1116	1077	873
SEm ±	-	-	2.1	1.6	0.8	0.2	0.2	0.2	4.0	5.2	4.8	0.5	0.4	0.3	125	106	78.0
LSD (P=0.05)	-	-	6.2	4.8	5.2	0.7	0.5	0.6	12.0	16.0	14.6	1.5	1.0	1.0	371	314	250

Values given in the parentheses are the original means, DAS= after sowing, fb= followed by