



RESEARCH NOTE

Influence of alternative pre- and post-emergent herbicides on weeds and yield of direct-seeded rice

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ABSTRACT

A field experiment was conducted at Research Farm, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during *Kharif* 2020 to evaluate the influence of pre- and post-emergence herbicides on weeds and yield of direct-seeded rice. The experiment was laid out in factorial randomized block design with three replications. The treatments evaluated in the study include: pre-emergence application of (PE) pendimethalin 1.0 kg/ha, pyrazosulfuron-ethyl 20 g/ha PE, pretilachlor 600 g/ha PE, pretilachlor + pyrazosulfuron ethyl 615 PE g/ha, post-emergence application (PoE) of bispyribac-sodium 25 g/ha PoE at 25 DAS, penoxsulam + cyhalofop-butyl 135 g/ha PoE at 25 DAS, triafamone + ethoxysulfuron 66.5 g/ha PoE at 25 DAS along with un-weeded control. Major weeds observed were: *Echinochloa* spp., *Dactyloctenium aegyptium*, *Cynodon dactylon*, *Caesulia axillaris*, *Cyperus* spp. and *Phyllanthus niruri*. Pretilachlor + pyrazosulfuron-ethyl 615 g/ha PE recorded significantly lower weed density and dry biomass at harvest with maximum weed control efficiency (87.10 %), higher grain yield, net returns and benefit: cost ratio (1.99). Amongst, post-emergent herbicides, triafamone + ethoxysulfuron 66.5 g/ha PoE at 25 DAS recorded minimum weed density, weed biomass with highest weed control efficiency (82.61%) at harvest, higher rice grain yield, net returns and benefit cost ratio (2.02).

Keywords: Direct-seeded rice, Pretilachlor + pyrazosulfuron-ethyl, Triafamone + ethoxysulfuron, Weed control efficiency, Weed management

Rice is one of the most important staple food crops in the world and more than half of the world's population is dependent on it. It plays a pivotal role in Indian economy. The unavailability of agricultural labourers has become a major problem for transplanting of rice in India (Rao *et al.* 2020). Rice transplantation, which required a large number of labourers, is delayed due to a shortage of labours, and the economics of transplanted rice is under risk (Yadav *et al.* 2011). Concurrently, the high cost of irrigation water and the need of human labour for seedbed preparation, puddling, and transplanting operations reduces the profit margin of transplanted rice production (Rao *et al.* 2017). In addition, the long turn-around time combined with the

unpredictable monsoon results in delayed sowing of succeeding crops (Maity and Mukherjee 2011). Direct-seeding of rice provide opportunity for better mechanization and it mature 7-10 days earlier than transplanted crop. Other benefits of direct-seeded rice include faster and easier planting, improvement of soil health, higher tolerance to water deficit and often higher profit in areas with an assured water supply (Rao *et al.* 2007). Despite its many advantages, direct-seeded rice (DSR) has a number of production challenges, the most serious of which is severe weed infestation (Rao *et al.* 2007, Chauhan 2012). Weeds can reduce rice yield by 40 to 100 per cent in direct-seeded rice (Rao *et al.* 2007). Uncontrolled weeds decrease yield by 61% in wet DSR and 96 per cent in dry DSR. (Rathika *et al.* 2020). Herbicides are considered an alternative/supplement to hand weeding. Use of herbicides has now become an important component of weed management in direct-seeded rice. The use of herbicides gives selective and effective control of weeds and allows the crop to emerge in a relatively weed free environment. However, the use of a single herbicide does not provide effective and season-long weed control and may result in shifts to tolerant weed

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species. Bispyribac-sodium for example, controls *Echinochloa colona*. but does not provide effective control of *Leptochloa chinensis*. and *Dactyloctenium aegyptium* (Chauhan and Abugho 2012). Application of herbicides in sequence (pre-emergence followed by post-emergence) or a mixture of two or more broad-spectrum herbicides along with other cultural practices provides a season-long effective weed control and good yield in DSR (Maity and Mukherjee 2008, Mahajan and Chauhan 2013). Therefore, this study was conducted with an objective to evaluate the efficacy of pre- and post-emergence herbicides in DSR and identify most effective and economical option for successful weed management in DSR.

A field experiment was conducted during *Kharif* season of 2020 at Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu under irrigated conditions. The soil of the experimental field was sandy clay loam in texture with slightly alkaline in reaction (pH 7.75), low in organic carbon (4.68 g/kg) and available nitrogen (247.5 kg/ha) but medium in available phosphorus (14.05 kg/ha) and potassium (128.50 kg/ha). The experiment was laid out in factorial randomized block design with two factor and three replications. The first factor consisted of pre-emergence application (PE) of herbicides, *viz.* pendimethalin 1.0 kg/ha; pyrazosulfuron-ethyl 20 g/ha; pretilachlor 600 g/ha; pretilachlor + pyrazosulfuron-ethyl 615 g/ha and un-weeded control and second factor consist of post-emergence application (PoE) of herbicides *viz.* bispyribac-sodium 25 g/ha at 25 days after sowing (DAS); penoxsulam + cyhalofop-butyl 135 g/ha at 25 DAS, triafamone + ethoxysulfuron 66.5 g/ha at 25 DAS.

Rice crop variety '*Basmati-370*' was sown on 15th June 2020, with a row to row spacing of 20 cm.

The crop was harvested on 3rd November 2020. The recommended dose of NPK (30:20:10 kg/ha) was applied as per package of practices of the university. Irrigation was applied at regular intervals in rice as per need. The pre-emergence application of herbicides was done applied on the next day of sowing and post emergence herbicides were applied at 25 DAS. Observations on weeds were recorded at 30, 60, 90 DAS and at harvest. In each plot, grasses, broad-leaved weeds and sedges were counted from 2 randomly selected places using a 0.5 × 0.5 m quadrat. Weed count was expressed as weed density (no./m²) and subjected to square-root transformation to normalize their distribution. The weeds removed from the selected areas were dried at 65 °C to obtain constant weight and the weight was expressed weed biomass (g/m²). Weed control efficiency (WCE) was calculated by using the formulae suggested by Mishra and Mishra (1997). The crop was harvested from a net plot of from the individual plot, sun dried for 5-6 days and was subsequently threshed and cleaned. The grain thus obtained, were weighed and expressed in tons/hectare. Harvest index was calculated by dividing the economic yield to the biological yield as per the formula given by Nichiporovich (1967). The benefit-cost ratio (B:C) was calculated by dividing the gross income by the cost of cultivation. Data collected during the study were statistically analysed by using the technique of analysis of variance.

The most dominating weed species found throughout the crop growth period in experimental plots were: *Echinochloa* species., *Dactyloctenium aegyptium* and *Cynodon dactylon* amongst grassy weeds; *Caesulia axillaries* amongst broad-leaved weeds, *Cyperus* species, amongst sedges. *Phyllanthus niruri*, was also observed in experimental field during crop season.

Table 1. Effect of pre- and post-emergence herbicides on total weed density (no./m²) in direct-seeded rice

Treatment	30 DAS	60 DAS	90 DAS	At harvest
<i>Factor -A: Pre-emergence herbicides</i>				
Pendimethalin 1.0 kg/ha	5.72 (31.72)	5.05 (24.47)	4.87 (22.75)	4.68 (20.87)
Pyrazosulfuron ethyl 20 g/ha	7.04 (48.51)	6.80 (45.22)	6.76 (44.73)	6.52 (41.46)
Pretilachlor 600 g/ha	6.53 (41.60)	5.86 (33.33)	5.75 (32.06)	5.64 (30.80)
Pretilachlor + pyrazosulfuron ethyl 615 g/ha	5.00 (23.98)	4.03 (15.25)	3.85 (13.86)	3.70 (12.67)
Un-weeded control	7.47 (54.78)	8.60 (72.91)	8.64 (73.72)	8.79 (76.33)
LSD (p=0.05)	0.22	0.33	0.35	0.25
<i>Factor – B: Post-emergence herbicides</i>				
Bispyribac-sodium 25 g/ha 25 DAS	6.32 (38.98)	5.98 (34.72)	5.88 (33.55)	5.93 (34.12)
Penoxsulam + cyhalofop – butyl 135 g/ha 25 DAS	6.36 (39.39)	5.03 (24.30)	4.85 (22.52)	4.69 (20.99)
Triafamone + ethoxysulfuron 66.5 g/ha 25 DAS	6.29 (38.60)	4.42 (18.55)	4.25 (17.04)	4.07 (15.55)
Un-weeded control	6.43 (40.33)	8.83 (77.03)	8.94 (78.94)	8.78 (76.04)
LSD (p=0.05)	NS	0.30	0.31	0.22

Data was subjected to square root transformation ($\sqrt{x+1}$). Original values are in parentheses; DAS: days after seeding

Effect on weeds

All the pre-emergence herbicides treatments showed significant effect weed density and biomass at 30, 60, 90 DAS and at harvest (Table 1 and 2). Among the pre-emergence herbicides pretilachlor + pyrazosulfuron-ethyl 615 g/ha recorded significantly lowest total weed density, biomass and highest weed control efficiency at 30 DAS and 60 DAS than other herbicides treatment and highest weed density and biomass were recorded in un-weeded control. The post-emergence herbicides treatments failed to show any significant impact on density and biomass of total weeds at 30 DAS. Amongst post-emergence herbicides, triafamone + ethoxysulfuron 66.5 g/ha at 25 DAS treatments, recorded significantly lower density of total weed density, biomass and higher weed control efficiency than all other herbicides. Similar trend was recorded at 90 DAS and at harvest. This could be due to the broad-spectrum control of weeds provided by combined application of herbicides with different mode of action. These results are in conformity with Singh *et al.* (2018), who reported that combined application of tank-mix or ready-mix more effective than single herbicides. When these two ready-mix herbicides are applied to the field, the efficacy of these herbicides increases compared to their sole application with a significant inhibitory effect on weed flora in transplanted rice. This study results confirm findings of Raj *et al.* (2013), Deivasigamani (2016), and Menon *et al.* (2017).

Effect on rice yield

All the pre- and post-emergence herbicides caused significant effect on grain yield and straw yield of direct-seeded rice (Table 3). Among pre-

emergence herbicides, pretilachlor + pyrazosulfuron-ethyl 615 g/ha recorded highest yield which was found to be statistically at par with pendimethalin 1.0 kg/ha PE and significantly higher than pyrazosulfuron-ethyl 20 g/ha PE, pretilachlor 600 g/ha PE and un-weeded control. It might be due to lower weed biomass and higher weed control efficiency and better utilization of nutrient and growth factors which ultimately resulted in higher yield of direct-seeded rice confirming the findings of Mishra and Singh (2012). Amongst, post-emergence herbicides, triafamone + ethoxysulfuron 66.5 g/ha at 25 DAS recorded significantly higher yield which was statistically at par with penoxsulam + cyhalofop-butyl 135 g/ha at 25 DAS, whereas, lowest value was recorded with un-weeded control. Increase in yield attributes, *viz.* number of panicles/m², number of grains/panicles, 1000-grain weight resulted higher grain and straw yield which is attributed by reduced competition for moisture, space, light and nutrients between crop and weeds along with effective control of weeds by combination of post-emergence herbicides as reported by Dhanapal *et al.* (2018) and Ramesha *et al.* (2019).

Economics

The economic evaluation (Table 3) revealed that among the pre-emergence herbicides, pretilachlor + pyrazosulfuron ethyl 615 g/ha generated highest net returns (77379 Rs./ha) and B:C ratio (1.99) followed by pendimethalin 1.0 kg/ha PE. Among the post-emergence herbicide treatments, highest net returns of (76860 Rs./ha) and B:C ratio (2.02) was recorded with triafamone + ethoxysulfuron 66.5 g/ha at 25 DAS followed by penoxsulam + cyhalofop-butyl 135 g/ha at 25 and bispyribac-sodium 25 g/ha at 25 DAS.

Table 2. Effect of pre- and post-emergence herbicides on weed biomass (g/m²) and weed control efficiency (WCE) of direct-seeded rice

Treatment	30 DAS		60 DAS		90 DAS		At harvest	
	Weed biomass (g/m ²)	WCE (%)	Weed biomass (g/m ²)	WCE (%)	Weed biomass (g/m ²)	WCE (%)	Weed biomass (g/m ²)	WCE (%)
<i>Factor -A: Pre-emergence herbicides</i>								
Pendimethalin 1.0 kg/ha	2.94(7.6)	72.97	6.14(37)	76.11	7.35(53)	78.26	7.14(50)	78.99
Pyrazosulfuron-ethyl 20 g/ha	3.65(12.3)	56.42	8.22(66)	56.74	10.18(103)	57.89	9.88(97)	59.37
Pretilachlor 600 g/ha	3.35(10.2)	63.85	7.12(50)	67.68	8.65(74)	69.73	8.58(73)	69.46
Pretilachlor + pyrazosulfuron-ethyl 615 g/ha	2.38(4.7)	83.52	4.98(24)	84.50	5.82(33)	86.50	5.63(31)	87.10
Un-weeded control	5.41(28.3)	-	12.44(154)	-	15.65(244)	-	15.46(238)	-
LSD (p=0.05)	0.18	-	0.32	-	0.57	-	0.19	-
<i>Factor - B: Post-emergence herbicides</i>								
Bispyribac-sodium 25 g/ha 25 DAS	3.56(11.7)	5.81	6.83(46)	69.64	8.33(68)	71.38	8.11(65)	72.41
Penoxsulam + cyhalofop-butyl 135 g/ha 25 DAS	3.52(11.4)	8.07	6.39(40)	73.49	7.62(57)	76.11	7.42(54)	76.98
Triafamone + ethoxysulfuron 66.5 g/ha 25 DAS	3.46(11.0)	11.46	5.60(30)	79.80	6.68(44)	81.74	6.47(41)	82.61
Un-weeded control	3.66(12.4)	-	12.30(150)	-	15.49(239)	-	15.36(235)	-
LSD (p=0.05)	NS	-	0.29	-	0.51	-	0.17	-

Data was subjected to square root transformation ($\sqrt{x+1}$). Original values are in parentheses; DAS: days after seeding

Table 3. Effect of pre- and post-emergence herbicides on grain yield, straw yield, harvest index and economics of direct-seeded rice

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Cost of cultivation (x10 ³ Rs/ha)	Gross returns (x10 ³ Rs/ha)	Net returns (x10 ³ Rs/ha)	B:C Ratio
<i>Factor -A: Pre-emergence herbicides</i>							
Pendimethalin 1.0 kg/ha	2.28	4.09	35.70	37.78	111.21	73.43	1.94
Pyrazosulfuron-ethyl 20 g/ha	2.05	3.69	35.77	37.03	99.99	62.96	1.70
Pretilachlor 600 g/ha	2.17	3.87	35.98	37.08	105.72	68.64	1.85
Pretilachlor + pyrazosulfuron-ethyl 615 g/ha	2.39	4.15	36.38	38.74	116.12	77.38	1.99
Un-weeded control	1.66	3.12	34.97	35.65	81.11	45.46	1.27
LSD (p=0.05)	0.11	0.18	NS	-	-	-	-
<i>Factor -B: Post-emergence herbicides</i>							
Bispyribac-sodium 25 g/ha at 25 DAS	2.20	3.97	35.63	37.29	107.43	70.14	1.88
Penoxsulam + cyhalofop-butyl 135 g/ha 25 DAS	2.30	4.13	35.69	39.14	112.25	73.12	1.86
Triafamone + ethoxysulfuron 66.5 g/ha 25 DAS	2.36	4.16	36.15	37.95	114.81	76.86	2.02
Un-weeded control	1.57	2.87	35.57	34.65	76.83	42.18	1.21
LSD (p=0.05)	0.10	0.16	NS	-	-	-	-

Comparatively higher grain yield attained might be the reason for better net returns and B: C ratio among these treatments as compared to other treatments as observed by Mahajan and Chauhan (2013) and Kashid *et al.* (2016).

Conclusion

It is concluded that among the herbicide treatments evaluated to manage weeds and improve productivity of direct-seeded rice, economically, pretilachlor + pyrazosulfuron-ethyl 615 g/ha PE and triafamone + ethoxysulfuron 66.5 g/ha PoE at 25 DAS were observed to be most promising.

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