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Herbicides Performance in Management of Weeds in Transplanted Basmati Rice (*Oryza sativa*)

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ABSTRACT

The aim of the study was to evaluate the performance of pre- and post-emergence herbicides to control weeds and their effect on growth and yield of rice established by transplanting in **kharif** season of 2020 at research farm of Lovely Professional University. The experiment was laid out in randomized block design with nine treatments. The study revealed that hand weeding followed by bensulfuron methyl reduced weed dry weight by 90-97% compared to non-treated weedy plots. On the other hand, bispyribac sodium reduced the density of grassy weeds, whereas bensulfuron methyl reduced the density of sedges and broad-leaf weeds. Maximum number of panicles, filled grains, panicle length and 1000-grain weight were observed under hand weeding followed by Bensulfuron methyl. Bensulfuron methyl @ 55 g a.i./ha achieved yield (5764 kg/ha) close to those of the weed-free treatments (5914 kg/ha). Among the herbicide treatments, application of bispyribac sodium @ 35 g a.i./ha produced low grain yield similar to the non-treated crop (3853 kg/ha). The results suggested that bensulfuron methyl was the most effective pre-emergence herbicide in puddled transplanting system.

Key words : Bensulfuron methyl, broad-leaf weeds, grasses, pre-emergence herbicides, post-emergence herbicides, sedges

INTRODUCTION

Rice (*Oryza sativa* L.) is the main cereal of the world and two-third of the Asian people receive their daily calories from rice. Rice is the hub of food security of the global population. In India, total cultivated area of rice is 43 m ha with production of 112 million tonnes and productivity of 4.3 tonnes/ha (Nadir *et al.,* 2017). Leading rice producing states are West Bengal, Uttar Pradesh, Punjab, Odisha, Andhra Pradesh, Bihar and Chhattisgarh. India is 2nd largest producer of rice followed by China. In both area and production, West Bengal is at the top followed by Uttar Pradesh. Weeds are a major problem in rice. On an average, 40 to 60% yield losses in rice are due to weed completion. Water and labour scarcity threaten the sustainability of the traditional rice production system in Asia. In South and South-east Asia, the major rice establishment method is manual transplanting of seedlings into flooded soil. Flooded transplanted rice has the benefit of controlling the weeds because of standing water, which is known to suppress the germination of weeds that need oxygen to germinate. At present, the major obstacle in rice yield is infestation of weeds. The transplanted rice is mainly infested by different types of weeds : *Echinochloa crusgalli, Echinochloa colonum, Cyperus rotundus, Cyperus difforium* and *Eleusine indica*. Infestation of weeds in transplanted rice not only results in low level of yield but also in poor quality product. Uncontrolled weeds cause reduction in 76% yield in transplanted condition. In hand weeding, due to unavailability of labour, the farmers fail to remove weeds at early stage due to morphological similarity between grassy weed and rice seedlings. Therefore, timely weed control at early stage is necessary for attaining desired level of productivity (Venkatesh, 2016). The final decision about weed control measure will depend upon its effectiveness and economics. Labour scarcity and increasing labour costs in weeding of rice under moist conditions are the last choices of agricultural labours which have given momentum to the use of herbicides for weed management. Transplanted rice suffers from

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complex weed flora. 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. Proper weed management is considered one of the most important pre-requisites in transplanted systems to ensure high yield. Hence, judicious weed management in rice is a critical factor. Keeping this in view, a field experiment was conducted to evaluate the efficacy of different pre- and post-emergence herbicides in transplanted rice at different doses (Simma *et al.,* 2017). The general objective of this research was to find out the suitable herbicide for effective weed control and to compare the efficacy of pre- and post-emergence herbicides with hand weeding in transplanted basmati rice.

MATERIALS AND METHODS

The trial was conducted in the farm of School of Agriculture, Lovely Professional University Phagwara, Punjab having sandy loam soil. The experimental site enjoyed subtropical type of weather conditions with cool winter, hot summer and a distinct rainy season with annual rainfall of 711 mm. The rest water demand was supplied by irrigation. The trial comprised nine treatments (Table 1) in a randomized block design with three replications. Experimental material used for study was Pusa basmati 1121.

Table 1. Composition of different treatments

Treatments	Compositions
T_1	Bispyribac sodium10 SC @ 15 g a.i./ha
T_2	Bispyribac sodium10 SC @ 25 g a.i./ha
T_3	Bispyribac sodium10 SC @ 35 g a.i./ha
T_4	Azimsulfuron 50 DF @ 30 g a.i./ha
T_5	Azimsulfuron 50 DF @ 35 g a.i./ha
T_6	Bensulfuron methyl @ 50 g a.i./ha
T_7	Bensulfuron methyl @ 55 g a.i./ha
T_8	Weed free (HW)
T_9	Control
Total treatments	9

The recommended dose of fertilizer used was 43 kg N, 25 kg P_2O_5 and 25 kg K_2O/ha. As the SSP and MOP both were less mobile in the soil, so they were applied in the single dose as a basal application during the last ploughing, but urea was applied in the split doses due to high mobility in the soil and plants (at 21 and 42 DAT). The spacing followed in rice crop was 20 cm × 15 cm. Weeds, being wild in nature, gave tough competition to the basmati rice as *Echinochloa crusgalli, Echinochloa colona, Chloris barbata, Panicum* sp., and *Cynodon dactylon* etc. The weed infestation was recorded at 20, 40, 80 DAT and at harvesting stage and the weed density was counted by quadrate 0.25 sq. m which was placed randomly five times in the plot and then weeds counted for different species. The weed density was recorded 60 DAS and just before the harvest to avoid any biasness (Jaswal *et al.,* 2017). The sun-dried weeds were put in the brown colour paper bag and kept in the oven at 60°C for two days to get dry weight of the weeds. The data were transformed and expressed in g/m^2. The data were analyzed by analysis of variance and treatments were tested by f-test. The square root formation was used to count the weed data i. e. √x+0.5.

RESULTS AND DISCUSSION

Incidentally, the weed flora recorded at the experimental site was mainly consisted of grasses, sedges and broad-leaf weeds. The major weed species were : grasses– *Echinochloa crusgalli* (Swank), *Echinochloa colonum* (Barnyard grass), *Ischaemum rugosum* (Wrinkle grass); sedges– *Cyperus iria* (Chatri wala dila), *Cyperus rotundus* (Nut grass), *Cyperus difformis* (Dila motha) and *Cyperus compressus* (Motha). Broad-leaf weeds were *Eclipta alba* (Jalbhan grass), *Eleo charis atropuea* (Ghueen), *Euphorbia hirta* (Dhodhak) and *Ludwigia axillaris* (Gharilla).

The density of weeds in Basmati rice was recorded at 20, 40 and 80 days after transplanting (DAT) and at harvest. A noticeable variation was observed in case of weed density of grasses under different treatments at different durations. The data presented in Table 2 indicate that at 20 DAT, all treatments showed same result because at 20 DAT, there was no herbicidal spray, and no hand weeding was done. At 40 DAT, hand weeding (T_4) showed comparable result to herbicide application in which density of grass weeds was 4.5 m^2. The maximum number of grassy weeds was recorded under T_9 (Control) which was followed by T_4 (Azimsulfuron @ 30 g a.i./ha; Manisankar *et al.*, 2021). All

Table 2. Effect of pre- and post-emergence herbicides on weed density (number/m^2) at different durations

S. No.	Treatments	20 DAT			40 DAT			80 DAT			At harvest		
		Grasses	BLW	Sedges	Grasses	BLW	Sedges	Grasses	BLW	Sedges	Grasses	BLW	Sedges
T_1	Bispyribacsodium10 SC @ 15 g a.i./ha	6.3 (39.4)	4.0 (16.2)	3.4 (11.5)	6.9 (47.2)	2.8 (7.5)	3.0 (8.9)	4.2 (18)	2.7 (7.2)	1.7 (2.5)	2.2 (4.6)	3 (8.9)	1.2 (1.1)
T_2	Bispyribac sodium10 SC @ 25 g a.i./ha	6.4 (41.7)	3.9 (15.9)	3.5 (12.0)	6.8 (46.4)	2.8 (7.6)	3.0 (7.6)	3.6 (13.1)	2.5 (6.2)	1.3 (1.6)	1.8 (3.0)	2.8 (8.0)	1.0 (0.4)
T_3	Bispyribac sodium 10 SC @ 35 g a.i./ha	6.3 (40.7)	3.8 (14.6)	3.7 (13.3)	6.9 (48.2)	2.9 (8.6)	2.3 (8.4)	3.7 (13.8)	1.8 (3.2)	1.7 (2.6)	2.2 (4.8)	2.9 (8.5)	1.3 (1.3)
T_4	Azimsulfuron 50 DF @ 30 g a.i./ha	6.4 (41.6)	3.8 (13.2)	3.4 (11.2)	7.8 (61.7)	2.9 (8.4)	2.3 (8.0)	5.5 (30.6)	2.6 (6.5)	1.6 (2.6)	3.2 (10.0)	2.5 (6.1)	1.3 (1.2)
T_5	Azimsulfuron 50 DF @ 35 g a.i./ha	6.3 (40.7)	3.8 (14.5)	3.6 (13.1)	6.7 (44.8)	2.6 (5.4)	2.3 (6.2)	5.8 (34.2)	2.3 (5.4)	1.5 (1.9)	3.0 (8.6)	2.3 (5.2)	0.9 (0.4)
T_6	Bensulfuron methyl @ 50 g a.i./ha	3.6 (12.3)	3.5 (12)	2.6 (7.0)	3.2 (9.8)	1.1 (0.8)	1.6 (5.4)	2.7 (7.2)	2.1 (4.4)	1.5 (2.1)	2.5 (6.4)	2.1 (4.4)	0.9 (0.6)
T_7	Bensulfuron methyl @ 55 g a.i./ha	3.4 (11.6)	3.2 (10.6)	2.3 (5.4)	2.9 (8.5)	0.8 (0.5)	1.3 (3.6)	2.4 (5.6)	2.0 (3.7)	1.1 (0.86)	2.3 (5.3)	2.0 (4.0)	0.7 (0.7)
T_8	Weed free (HW)	6.3 (40.3)	3.9 (15.6)	3.5 (12.2)	4.5 (20.4)	0.9 (0.)	1.3 (2.8)	1.3 (1.3)	0.7 (0)	0.8 (0.43)	0.7 (0)	2.7 (7.1)	2.6 (6.9)
T_9	Control	6.6 (43.3)	4.3 (18.9)	3.8 (14.3)	8.4 (70.8)	3.3 (10.8)	7.0 (9.8)	6.1 (36.5)	2.9 (8.6)	2.7 (7.4)	4.9 (24.1)	4.1 (16.7)	2.6 (6.9)
	S. Em±	1.08	0.25	0.12	0.45	0.23	0.41	0.1	0.52	0.36	0.35	0.45	0.10
	C. D. (P=0.05)	1.74	0.26	3.37	0.16	0.25	1.08	0.17	0.12	0.32	0.31	0.11	0.17
	C. V. (%)	17.9	4.13	10.49	1.58	6.77	25.7	2.60	3.58	11.10	7.16	2.38	8.54

treatments showed significantly better results over control. AT 80 DAT, number of grassy weeds varied from 1.3-6.1/m^2. Lowest number of grassy weeds (1.3/m^2) was observed in hand weeding followed by 2.4 and 2.7/m^2. Highest number of grasses (6.1/m^2) was recorded in control (T_9) followed by T_4 and T_5 (Azimsulfuron @ 30 and 35 g a.i./ha). All the treatments significantly decreased the density of weeds over control. At harvest, there was minimum density of weeds recorded. The number of grassy weeds was observed in T_8 (Hand weeding) followed by T_2 (Bispyribac sodium @ 25 g a.i./ha).

The highest number of grassy weeds (4.9) was recorded in control followed by T_4 and T_5 (Azimsulfuron @ 30 and 35 g a.i./ha) as 3.3 and 3.2/m^2. At 20 DAT, maximum number of sedges (3.8/m^2) was observed in control. All other treatments showed similar results. There was non-significant variation in density of sedges. At 40 DAT, the lowest density of sedges (1.3/m^2) was recorded in case of T_8 hand-weeding. The maximum number of sedges (7.0/m^2) was recorded in T_9 (control) followed by T_1 and T_2 (bispyribac sodium @ 15 and 25 g a.i./ha) but T_1 and T_2 showed superiority over control. Bispyribac sodium 10 SC was less effective in case of sedges control because it controlled only broad-leaf weeds and grasses. At 80 DAT, the lowest number of sedges (0.8/m^2) was observed in case of hand weeding followed by Azimsulfuron @ 30 g a.i./ ha. The maximum number of sedges (27/m^2) was recorded under control (Kumar, 2018). The best results were shown by hand weeding. The maximum number of sedges (7.0/m^2) was recorded in T_9 (control) followed by T_1 and T_2 (bispyribac sodium @ 15 and 25 g a.i./ha) but T_1 and T_2 showed superiority over control. Bispyribac sodium 10 SC was less effective in case of sedges control because it controlled only broad-leaf weeds and grasses. At 80 DAT, the lowest number of sedges (0.8/m^2) was observed in case of hand weeding which was at par with T_7 (1.1/ m^2) followed by Bensulfuron methyl @ 55 g a.i./ha. The maximum number of sedges (27/m^2) was recorded under control. At harvest, the density of sedges/m^2 was very less. The significant lowest number of sedges (0.7/m^2) was observed in Bensulfuron methyl @ 55 g and hand weeding. The maximum number of sedges (2.6/m^2) was observed in control. The symptoms like chlorotic patches on leaves, slow senescence, leaf necrosis and consistent morality at later stages of weed growth were recorded. These observations are in conformity with the findings of Biswas *et al.* (2020) who reported better efficacy of Azimsulfuron and Bensulfuron on sedges in transplanted rice. At 20 DAT, the broad-leaf weed density ranged from 32-4.3/m^2. The significant lowest density (3.2/m^2) was observed in T_7 (Bensulfuron methyl @ 55 g/ha) followed by T_6 (Bensulfuron methyl @ 50 g/ha). Pre-emergence application of Bensulfuron methyl reduced the density of broad-leaf weeds as compared to post-emergence, hand weeding and control. Maximum density (3.7/m^2) was observed in case of control.

The weed dry weight at 60 DAT was minimum (2.8 g) in hand weeded plots followed by

Table 3. Effect of pre- and post-emergence herbicides on weed dry weight and weed control efficiency

S. No.	Treatments	Weed dry weight (g/m^2)		Weed control efficiency (%)	
		60 DAT	At harvest	60 DAT	At harvest
T_1	Bispyribacsodium 10 SC @ 15 g a.i./ha	3.4 (11.4)	3.7(13.8)	84.3	92.0
T_2	Bispyribac sodium 10 SC @ 25 g a.i./ha	3.3 (10.6)	3.5(12.3)	85.4	92.8
T_3	Bispyribac sodium 10 SC @ 35 g a.i./ha	3.5 (12.4)	3.7 (13.4)	83.7	93.8
T_4	Azimsulfuron 50 DF @ 30 g a.i./ha	5.8 (34.0)	7.5 (56.8)	55.6	74.0
T_5	Azimsulfuron 50 DF @ 35 g a.i./ha	5.8 (33.3)	7.2 (52.8)	56.5	75.8
T_6	Bensulfuron methyl @ 50 g a.i./ha	5.7 (32.3)	4.7(21.7)	56.6	90.0
T_7	Bensulfuron methyl @ 55 g a.i./ha	5.6 (31)	4.6(20.9)	59.5	90.3
T_8	Weed free (HW)	2.8 (7.6)	2.6 (6.3)	90.0	97.0
T_9	Control	8.7 (76.7)	14.7 (21.9)	0	0
	S. Em±	0.29	0.76	0.41	0.86
	C. D. (P=0.05)	0.91	0.14	1.08	1.55
	C. V. (%)	1.06	1.47	1.03	1.17

Figures in parentheses are original values as observation, while without parentheses are transformed ($\sqrt{x}$+0.5) values.

Bispyribac sodium @ 25 g a.i./ha (3.3 g) and maximum weed dry weight (8.7 g/m^2) was recorded in weedy plots presented (Table 3). At harvest, the minimum weed dry weight was recorded in hand-weeding (2.6 g) followed by Bispyribac sodium @ 25 g a.i./ha. The maximum weed dry weight (14.7 g) was recorded under control. The above results indicated that weed biomass at 60 DAT and at harvest was significantly higher in non-weeded control treatment. In contrast, hand weeding twice recorded lowest weed biomass than rest of the herbicide among the tested herbicides. Bispyribac sodium 10 SC @ 15, 25 and 35 g applied at 22 DAT was most effective to check the growth of weeds and resulted lower weed dry weight due to high weed control efficiency. Weed control efficiency (WCE) was calculated to measure the effectiveness of any weed control treatment to eradicate weeds. Significantly highest (90%) weed control efficiency at 60 DAT was noted in hand-weeded plots followed by bispyribac sodium @ 25 g a.i./ha with 85.4% WCE. The lowest WCE was (54.4%) recorded with Azimsulfuron @ 35 g a.i./ha. At harvest, the maximum WCE (97%) was noted under hand-weeded plots followed by Bispyribac sodium @ 30 g a.i./ha (93.8%). Pre-emergence herbicide Bensulfuron methyl also showed comparable WCE (90.3%). The lowest weed control efficiency (74%) was recorded in Azimsulfuron treated plots. Manual weeding showed 97% efficiency as it completely knocked out weeds. Bispyribac sodium was second effective treatment regarding efficiency. This result was supported by Saha *et al.* (2021).

Tallest plants of Basmati rice were recorded in hand-weeding plots at 20, 40 and 60 DAT (45.3, 94.4 and 145 cm), whereas shortest plants were recorded in control at 20, 40 and 60 DAT (39.4, 76.6 and 103.1 cm). The highest number of effective tillers at 20, 40 and 60 DAT was found (6.3, 16.6 and 34.6) in hand-weeded plots. Control at 20, 40 and 60 DAT (3.6, 16.6 and 27) produced lowest number of tillers (Mangaraj *et al.,* 2022). The highest number of panicles/plant (48.3) was obtained in hand-weeded plots and minimum number of panicles/plant was (41) noted in control. The maximum number of filled grains/panicle (114.3) was observed in hand-weeded plots followed by Bensulfuron methyl @ 25 g a.i./ha (103.6) and minimum in control plots (65).

Table 4. Effect of pre- and post-emergence herbicides on growth and yield parameters of basmati rice

S. No.	Treatments	Plant height (cm)	Tillers (No.)	No. of panicles/ plant	Filled grains/ panicle	Panicle length (cm)	Panicle weight (g)	1000-grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
T_1	Bispyribacsodium10 SC @ 15 g a.i./ha	104	30.6	46.6	77.3	20.3	2.2	21.6	3683.3	5313	40.6
T_2	Bispyribac sodium 10 SC @ 25 g a.i./ha	110	32.0	47.0	84.0	22.8	2.3	23.3	4194.0	5572	42.9
T_3	Bispyribac sodium 10 SC @ 35 g a.i./ha	107	30.3	45.3	77.3	21.2	2.2	22.2	3853.0	5674	40.3
T_4	Azimsulfuron 50 DF @ 30 g a.i./ha	111	31.0	45.3	82.6	20.3	2.6	26.4	4738.3	5891	44.5
T_5	Azimsulfuron 50 DF @ 35 g a.i./ha	113	32.6	46.3	86.0	21.1	2.7	27.4	4824.3	6155	42.9
T_6	Bensulfuron methyl @ 50 g a.i./ha	120	30.6	46.6	95.6	21.9	2.7	27.8	5695.0	6175	47.5
T_7	Bensulfuron methyl @ 55 g a.i./ha	122	32.6	46.1	103.6	22.7	2.9	29.2	5764.0	6280	48.2
T_8	Weed free (HW)	145	34.6	48.3	114.3	25.8	3.2	32.0	5914.0	6327	38.6
T_9	Control	102	27.0	41.0	65.0	18.6	1.8	20.8	2667.6	4278	0.305
	S. Em±	0.66	6.37	0.47	4.53	0.36	0.21	2.08	4082.9	4707	0.924
	C. D. (P=0.05)	1.36	1.03	1.15	3.56	NS	0.24	2.14	118.3	114.8	1.24
	C. V. (%)	0.74	1.97	1.50	2.43	2.49	5.61	5.54	1.55	1.23	1.20

Highest panicle length was recorded in hand-weeded plots (25.8 cm) followed by Bispyribac sodium @ 25 g a.i./ha and maximum in control (1.8 g). The maximum 1000-grain weight (32 g) was found in hand-weeded plots which showed superiority over all other treatments and minimum 1000-grain weight (20.8 g) in control (Singh *et al.*, 2016). Highest grain yield (5914 kg/ha) was obtained in hand-weeded plots followed by Bensulfuron methyl @ 55 g (5764 kg/ha) and minimum in control (2667 kg/ha) followed by Bispyribac sodium @ 20 g a.i./ha (3683 kg/ha). The maximum straw yield 6327.3 kg/ha was recorded in hand-weeded plots followed by Bensulfuron methyl @ 55 g a.i./ha and minimum in control (4278 kg/ha). Growth and yield were highest in manual weeding (Table 4). In case of herbicides, the phytotoxic symptoms like yellowing of leaves, necrosis on margins of the leaf seen and the chlorophyll content decreased which were responsible for photosynthesis. Decrease in the chlorophyll content directly affected the photosynthesis and the growth parameters. This resulted in low yield in herbicidal treated plots as compared to hand weeding. The minimum yield was obtained under control. The similar results were reported by Hameed *et al.* (2019).

CONCLUSION

It was concluded that in order to obtain the optimum rice grain yield in transplanted rice system, growers may use two hand weedings at 20 and 40 DAT as per the availability of labours, or the pre-emergence herbicide Bensulfuron methyl @ 55 g/ha in order to control the wide spectrum of weed. Bensulfuron methyl gave comparable results to hand-weeding. However, there is need for further investigation on this aspect.

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