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Effect of herbicides on weed dynamics in transplanted rice (*Oryza sativa* L.) in Eastern U.P., India

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ABSTRACT

A field experiment was conducted at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, UP, India during *kharif*-2017 and 2018 to evaluate effect of herbicides on weed population and weed dry weight in transplanted rice in eastern UP. There were ten treatments in the combination of herbicides in varying doses, arranged in a randomized block design with three replications. Among dominant weed flora narrow leaf weeds like *Cynodon dactylon, Echinochloa colona* and *Echinochloa crusgalli*, sedges like *Cyperus rotundus, Cyperus iria* and *Fimbristylis miliacea* and broad-leaved weeds like *Eclipta alba* and *Caesulia axillaris* were recorded in the time of experimentation. Combined application of Bispyribac-Na 9.1% @ 24.57 g ha^{-1} + Metsulfuran methyl 1.2% @ 3.24 g ha^{-1} + Chlorimuron ethyl 1.2% SC @ 3.24 g ha^{-1} was recorded minimum weeds density and weeds dry weight and maximum weed control efficiency after weed free treatment at all the crop growth stage 30, 60 and 90 days after transplanting.

Key words : *Transplanted rice, Weed density, Bispyribac-Na, Metsulfuron-methyl*

Introduction

Rice (*Oryza sativa* L.) is one of the important food crops in India as it is a staple food of more than 65% of its population. Its accounts for about 17.28% of total food grain production and 18.49% of total cereals production in the country, contributing 20-25% of the agricultural GDP (Singh, 2011). In India, rice crop occupies an area of about 43.78 million hectares with total production of 118.41 million tonnes and productivity 2705 kg ha^{-1} during 2019-20. Uttar Pradesh is one of India's most important rice-growing states, where rice is grown on an area of 6.84 million hectares with 15.52 million tons of production and 2790 kg of productivity per hectare (Directorate of Economics and Statistics, DAC & FW, GOI, 2019-20).

Weeds are major problem limiting the growth and yield of rice. Transplanted rice faces diverse types of weed flora, consisting of grasses, broad-leaved weeds and sedges. They usually grow faster than rice and absorb nutrient and available water earlier than the rice and suppress rice growth. Effective control of weeds had increased the grain yield by 85.5% (Mukherjee and Singh, 2005). Single application of herbicide may provide effective control of weeds, but continuous use of such herbicides leads to the evolution of weeds resistant to several herbicides. Persistence of the herbicides in the field is only up to 30 DAT (Chauhan *et al.*, 2012). So, single

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application of pre and post emergence herbicide is ineffective in controlling the weed flora in transplanted rice ecosystem. Under such situations, application of herbicide either as mixture or in sequence may be useful for broad spectrum weed control in transplanted rice. Keeping this in view, a field experiment was carried out to evaluate the effect of herbicide applied in combination as well as in sequence for managing complex weed flora in transplanted rice.

Materials and Methods

The experiment was conducted at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University. The soil of the experimental site was sandy clay loam, homogeneous in fertility status and moderately fertile being low in available nitrogen (192.3 kg ha^{-1}), medium in available phosphorus (21.5 kg ha^{-1}) and potassium (219.9 kg ha^{-1}) respectively.Varanasi belongs to sub-tropical climate zone and the coldest months of the years are between the last week of December to first week of January. Average annual rainfall received in the region was about 647.4 mm in 2017 and 78.1 mm in 2018, which was recorded in the months of June-September. Rice *var*. 'Sarju-52' (30 days old seedling) was transplanted at a spacing of 20 × 15 cm apart on July 25 and 23 during 2017 and 2018, respectively. Recommended dose of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} was applied to the crop. Half of the recommended dose of nitrogen and full dose of recommended phosphorus and potassium were applied as basal dose. Rest half of the nitrogen was applied at the time of top dressing in two equal split at 25 and 55 DAT. The trial was laid-out in randomized block design to assigning the different herbicidal effect for weed management in transplanted rice crop during 2017 and 2018 respectively. The treatments of the experiment were, T_1: Bispyribac-Na 9.1 % (18.2 g ha^{-1}) + metsulfuron-methyl 1.2 % (2.4 g ha^{-1}) + chlorimuron ethyl 1.2 % (2.4 g ha^{-1}); T_2: Bispyribac-Na 9.1 % (22.75 g ha^{-1}) + metsulfuron-methyl 1.2 % (3 g ha^{-1}) + chlorimuron ethyl 1.2 % (3 g ha^{-1}); T_3: Bispyribac-Na 9.1 % (24.57 g ha^{-1}) + metsulfuron-methyl 1.2 % (3.24 g ha^{-1}) + chlorimuron ethyl 1.2 % (3.24 g ha^{-1}); T_4: Bispyribac-Na 10 % (25 g ha^{-1}); T_5: Metsulfuron-methyl 20 % (4 g ha^{-1}); T_6: Chlorimuron-ethyl 25 % (6 g ha^{-1}); T_7: Metsulfuron-methyl 10 % + chlorimuron-ethyl 10 % (4 g ha^{-1}); T_8: Penoxsulam 21.7 % (22.5 g ha^{-1}); T_9: Weedy check and T_{10}: Weed Free.

Weed counts had been measured at 30, 60 and 90 DAT. A weed count for estimating weed density was recorded with the help of a quadrate (50 × 50 cm) placed randomly at two spots in each plot. Weeds have been counted and grouped into grasses, sedges, and broad-leaved weeds and expressed as number per square metre. Weed species counted in each quadrate were cut at ground stage and separated into grasses, broad-leaved and sedges weeds groups at 30, 60 and 90 DAT. Weeds have been washed with the help of tap water to dispose of soil and undesirable particles adhering to them, and then sun-dried accompanied by way of oven drying at 70^0C for 48 hours in oven until constant weight was achieved. The total weed dry weight was obtained by summing the weight of these each individual group of weeds and expressed as g square meter. Weed control efficiency (WCE) at different stages was calculated using formula given by Tripathy and Mishra (1971).

$$\text{Weed control efficiency (\%)} = \frac{DWC - DWT}{DWC} \times 100$$

Where,

DWT = Dry weight of weeds (g m^{-2}) in weed control plot

DWC = Dry weight of weeds (g m^{-2}) in treated plot

Weed index was calculated by the formula as suggested by Gill and Kumar, (1969).

$$\text{Weed index} = \frac{Xc - Yt}{Xc} \times 100$$

Where,

Xc= Grain yield from weed free treatment

Yt= Grain yield from treatment for which weed index to be worked out

Results and Discussion

The data revealed that during 2017 and 2018 herbicides showed positive weed control and produced significantly higher paddy yield compared to control. The field were infested with *Cynodon dactylon, Echinochloa colona* and *Echinochloa crusgalli* among grasses, *Eclipta alba* and *Caesulia axillaris* among broad-leaved weeds and *Cyperus rotundus, Cyperus iria* and *Fimbristylis miliacea* in sedges during both the year of experiment. All the weed control treatments resulted significant reduction in total weed density (Table 1) and dry matter accumulation (Table 2) in comparison to weedy check.

Effect of herbicides on weed density

The results of year 2017 and 2018 mean data showed that minimum grassy weed, broad leaves weed and sedges were recorded with application of bispyribac-Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron-ethyl 1.2 % SC @ 24.57 + 3.24 + 3.24 g ha^{-1} respectively at 20 days after transplanting at all the crop growth stages *i.e.* 30, 60 and 90 DAT followed by treatments bispyribac-Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron-ethyl 1.2 % SC @ 22.75 + 3 + 3 g ha^{-1}, respectively and bispyribac-Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron-ethyl 1.2 % SC @ 18.2 + 2.4 + 2.4 g ha^{-1} respectively, during both the years of experiment. Whereas in comparison of the entire weeds grassy weed recorded higher as compare to sedges and broad leaves weed at 30 DAS than 60 and 90 DAS. Among weed control practices, post-emergence application of bispyribac-Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron-ethyl 1.2 % SC w/v @ (24.57+3.24+3.24 g ha^{-1}) become most effective in decreasing density of weeds. The better efficacy of this treatment because of blended impact of chemical, which can be responsible grater control of narrow and broad leaved weed at all the crop growth stages during both the year of experimentation. Similar results also reported by Menon *et al.* (2017), Kaur *et al.* (2017).

Effect of herbicides on weed dry matter accumulation

All weed management treatments resulted in lower weed dry weight than the weedy check (Table 2). Application of bispyribac-Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron-ethyl 1.2 % SC @ 24.57 + 3.24 + 3.24 g ha^{-1}, respectively at 20 days after transplanting at all the crop growth stages 30, 60 and 90 DAT, which was significantly superior over all the other treatments with respect to minimizing weed dry weight followed by treatments bispyribac-Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron-ethyl 1.2 % SC @ 22.75 + 3 + 3 g ha^{-1} respectively and bispyribac-Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron-ethyl 1.2 % SC @ 18.2 + 2.4 + 2.4 g ha^{-1} respectively, at different stages of observation during both the years of experiment. Due to this result, bispyribac and metsulfuron-methyl were found to be effective

Table 1. Effect of herbicides on weed density in transplanted rice (pooled data 2017 & 2018).

Treatment	30 DAS				60 DAS				90 DAS			
	Grassy	Broad leaves	Sedges	Total	Grassy	Broad leaves	Sedges	Total	Grassy	Broad leaves	Sedges	Total
T_1	6.84 (46.35)	4.20(17.11)	6.14(37.18)	10.06(100.63)	8.20(66.66)	4.05(15.91)	6.59(42.88)	11.22(125.44)	6.68(44.16)	4.03(15.76)	5.75(32.58)	9.64(92.50)
T_2	6.10 (36.65)	3.34(10.64)	5.29(27.48)	8.68(74.77)	7.56(56.59)	3.31(10.44)	5.79(33.08)	10.03(100.11)	5.92(34.53)	3.13(9.29)	4.84(22.88)	8.20(66.69)
T_3	4.85 (23.05)	2.38(5.18)	4.29(17.88)	6.83(46.10)	6.29(39.03)	2.36(5.08)	4.89(23.38)	8.24(67.48)	4.41(18.93)	2.15(4.13)	3.69(13.08)	6.05(36.13)
T_4	7.11 (50.05)	4.48(19.58)	6.44(41.01)	10.54(110.63)	8.40(70.03)	4.35(18.38)	6.86(46.58)	11.64(134.98)	6.95(47.83)	4.33(18.23)	6.08(36.51)	10.15(102.56)
T_5	7.49 (55.65)	4.88(23.31)	6.85(46.48)	11.22(125.43)	8.73(75.63)	4.75(22.11)	7.26(52.18)	12.26(149.91)	7.34(53.43)	4.63(20.96)	6.51(41.88)	10.81(116.26)
T_6	7.91 (62.05)	5.30(27.58)	7.31(52.88)	11.96(142.50)	9.08(82.03)	5.18(26.38)	7.69(58.58)	12.94(166.98)	7.77(59.83)	5.07(25.23)	6.98(48.28)	11.57(133.33)
T_7	7.32 (53.05)	4.71(21.68)	6.66(43.88)	10.91(118.60)	8.57(73.03)	4.57(20.38)	7.08(49.58)	11.98(142.98)	7.16(50.83)	4.44(19.23)	6.31(39.28)	10.48(109.33)
T_8	7.67 (58.35)	5.06(25.11)	7.05(49.18)	11.54(132.63)	8.88(78.36)	4.94(23.91)	7.44(54.88)	12.56(157.14)	7.53(56.13)	4.82(22.76)	6.71(44.58)	11.13(123.46)
T_9	10.37 (107.05)	7.51(55.91)	9.92(97.88)	16.17(260.83)	11.42(130.03)	7.40(54.21)	10.35(106.58)	17.07(290.81)	10.39(107.51)	7.49(55.56)	9.89(97.28)	16.15(260.34)
T_{10}	0.71 (0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
SEm±	0.73	0.77	0.70	1.17	0.70	0.62	0.61	1.05	0.79	0.67	0.75	1.31
CD (P=0.05)	2.21	2.03	2.10	3.51	2.09	1.85	1.83	3.16	2.37	2.02	2.24	3.92

T_1; Bispyribac Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron ethyl 1.2 % SC w/v (18.2+2.4+2.4a.i g ha^{-1}), **T_2**: Bispyribac Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron ethyl 1.2 % SC w/v (22.75+3+3 a.i g ha^{-1}), **T_3**: Bispyribac Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron ethyl 1.2 % SC w/v (24.57+3.24+3.24 a.i g ha^{-1}), **T_4**: Bispyribac Na 10 % SC(25 a.i g ha^{-1}), **T_5**: Metsulfuron-methyl 20 % WG (4 a.i g ha^{-1}), **T_6**: Chlorimuron-ethyl 25 % SC WP (6 a.i g ha^{-1}), **T_7**: Metsulfuron-methyl 10% + chlorimuron-ethyl 10% WP (4 a.i g ha^{-1}), **T_8**: Penoxsulam 21.7% SC (22.5 a.i g ha^{-1}), **T_9**: Weedy check and **T_{10}**: Weed Free

Table 2. Effect of herbicides on weed dry matter accumulation in transplanted rice (pooled data 2017 & 2018).

Treatment	30 DAS				60 DAS				90 DAS			
	Grassy	Broad leaves	Sedges	Total	Grassy	Broad leaves	Sedges	Total	Grassy	Broad leaves	Sedges	Total
T_1	6.74(45.08)	4.11 (16.69)	5.12 (25.76)	9.38(87.54)	6.81 (46.04)	3.25 (10.16)	5.73 (32.43)	9.44(88.63)	4.35 (18.55)	2.45 (5.65)	5.40 (28.92)	7.32(53.11)
T_2	6.40(40.61)	2.68(6.80)	3.81 (14.17)	7.88(61.59)	6.10 (36.92)	2.84 (7.71)	4.50 (20.10)	8.08(64.73)	3.46 (11.83)	2.08 (3.89)	4.00 (15.74)	5.65(31.46)
T_3	6.02 (36.10)	1.98 (3.51)	3.29 (10.49)	7.11 (50.10)	5.40 (28.79)	2.23 (4.52)	3.68 (13.23)	6.86(46.54)	2.98 (8.73)	1.85 (2.97)	3.33 (10.86)	4.80(22.55)
T_4	7.37 (54.15)	4.62 (20.96)	6.21 (38.19)	10.67 (113.30)	7.41 (54.53)	4.30 (18.08)	6.24 (38.57)	10.57(111.18)	5.06 (25.25)	3.73 (13.47)	6.16 (37.63)	8.77(76.34)
T_5	8.24 (67.53)	5.92 (34.60)	7.76 (59.76)	12.74 (161.89)	8.66 (74.51)	6.35 (39.93)	7.91 (62.12)	13.31(176.55)	6.71 (44.65)	5.56 (30.50)	7.53 (56.36)	11.49(131.51)
T_6	9.21 (84.37)	7.02 (48.92)	8.28 (68.13)	14.21 (201.43)	9.19 (84.02)	7.79 (60.23)	9.02 (80.91)	15.02(225.16)	7.37 (53.88)	6.64 (43.65)	8.55 (72.71)	13.07(170.25)
T_7	7.78 (60.07)	5.34 (28.04)	6.89 (47.09)	11.65(135.20)	7.99(63.40)	5.53 (30.28)	6.94 (47.72)	11.91(141.40)	6.14 (37.25)	4.58 (20.61)	6.69 (44.43)	10.14 (102.29)
T_8	8.79 (76.81)	6.51 (41.96)	8.11 (65.32)	13.59 (184.09)	8.99 (80.37)	7.34 (53.46)	8.50 (71.85)	14.36(205.69)	7.09 (49.87)	6.04 (36.04)	8.08 (64.88)	12.30(150.80)
T_9	9.62 (92.28)	7.50 (55.88)	8.63 (74.06)	14.92 (222.22)	10.86 (117.56)	8.05 (64.37)	9.24 (84.95)	16.35(266.88)	8.83 (77.52)	6.83 (46.23)	8.83 (77.49)	14.20 (201.24)
T_{10}	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
SEm±	0.40	0.80	0.77	0.89	0.62	0.63	0.78	1.18	0.66	0.54	0.88	0.96
CD (P=0.05)	1.21	2.40	2.31	2.68	1.85	1.89	2.35	3.53	1.98	1.61	2.65	2.88

T_1; Bispyribac Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron ethyl 1.2 % SC w/v (18.2+2.4+2.4a.i g ha^{-1}), **T_2**: Bispyribac Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron ethyl 1.2 % SC w/v (22.75+3+3 a.i g ha^{-1}), **T_3**: Bispyribac Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron ethyl 1.2 % SC w/v (24.57+3.24+3.24 a.i g ha^{-1}), **T_4**: Bispyribac Na 10 % SC(25 a.i g ha^{-1}), **T_5**: Metsulfuron-methyl 20 % WG (4 a.i g ha^{-1}), **T_6**: Chlorimuron-ethyl 25 % SC WP (6 a.i g ha^{-1}), **T_7**: Metsulfuron-methyl 10% + chlorimuron-ethyl 10% WP (4 a.i g ha^{-1}), **T_8**: Penoxsulam 21.7% SC (22.5 a.i g ha^{-1}), **T_9**: Weedy check and **T_{10}**: Weed Free.

against most of the grassy weeds and also effective on broad-leaved weeds and sedge weeds. Similar results also reported by Negalur *et al.* (2017), Akter *et al.* (2018).

Effect of herbicides on Weed control efficiency and weed index

Weed control efficiency (WCE) varied significantly at 30, 60 and 90 days after transplanting under different weed control treatments (Table 3). Maximum weed control efficiency was recorded with post emergence application of bispyribac-Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron-ethyl 1.2 % SC @ 24.57 + 3.24 + 3.24 g ha^{-1}, while minimum in weedy check. However, maximum weed control efficiency was found with weed free at 30, 60 and 90 days after transplanting. The reason of better weed control efficiency could be due to higher dose and mixed application of herbicide which controlled first flush of grassy weeds, sedges and broad-leaved weeds. This may be attributed to least competition

Table 3. Effect of herbicides on weed control efficiency and weed index of total weed in transplanted rice.

Treatment	Weed Control Efficiency (%)			Weed Index (%)
	30 DAS	60 DAS	90 DAS	
T_1	60.60	66.75	73.64	12.89
T_2	72.29	75.77	84.39	11.16
T_3	77.35	82.55	88.76	7.41
T_4	48.94	58.35	62.11	17.63
T_5	26.99	33.80	34.62	26.25
T_6	9.16	15.59	15.40	23.85
T_7	39.09	46.98	49.18	28.30
T_8	17.02	22.85	25.07	32.44
T_9	0.00	0.00	0.00	43.73
T_{10}	100.00	100.00	100.00	0.00
SEm±	1.70	1.43	1.64	1.63
CD (P=0.05)	5.04	4.26	4.86	4.84

T_1; Bispyribac Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron ethyl 1.2 % SC w/v (18.2+2.4+2.4a.i g ha^{-1}), **T_2**: Bispyribac Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron ethyl 1.2 % SC w/v (22.75+3+3 a.i g ha^{-1}), **T_3**: Bispyribac Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron ethyl 1.2 % SC w/v (24.57+3.24+3.24 a.i g ha^{-1}), **T_4**: Bispyribac Na 10 % SC(25 a.i g ha^{-1}), **T_5**: Metsulfuron-methyl 20 % WG (4 a.i g ha^{-1}), **T_6**: Chlorimuron-ethyl 25 % SC WP (6 a.i g ha^{-1}), **T_7**: Metsulfuron-methyl 10% + chlorimuron-ethyl 10% WP (4 a.i g ha^{-1}), **T_8**: Penoxsulam 21.7% SC (22.5 a.i g ha^{-1}), **T_9**: Weedy check and **T_{10}**: Weed Free.

as a result of effective suppression of sedges and dicot weeds thereby enabling plant to exhibit full potential in a competition free environment as evident by higher WCE in the same treatments. Similar results have been reported by Sreelakshmi *et al.*, 2016; Mahbub *et al*., 2017**.** Weed index showed the relevance of weed management on comparative basis (Table 3). Minimum weed index was recorded under post emergence application of bispyribac-Na 9.1 % + metsulfuron-methyl 1.2 % + chlorimuron-ethyl 1.2 % SC @ 24.57 + 3.24 + 3.24 g ha^{-1}, among all weed control treatments while, maximum in weedy check (43.73 %). This is due to the fact that application of herbicides reduced the weed competition which enabled the rice plant for better utilization of nutrient and growth factors which ultimately resulted in higher grain yield.

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