Indian Journal of Weed Science **48**(3): 254–258, 2016
DOI: 10.5958/0974-8164.2016.00062.9

Sole and combined application of herbicides on composite weed flora of transplanted rice

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Received: 28 July 2016; Revised: 18 September 2016

ABSTRACT

Field experiments were conducted during *Kharif* (wet) seasons of 2014 and 2015 at Agricultural Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal, with rice variety '*MTU-7029'* to study the effect of sole and combined application of different herbicides on growth of composite weed flora and productivity of wet season transplanted rice. Eleven treatments were assigned in a randomized block design with three replications. *Echinochloa colona* and *Paspalum distichium* among the grasses; *Cyperus iria*, among the sedges and *Ludwigia parviflora* among the broad-leaved weeds were predominant throughout the cropping period. Azimsulfuron at 35 + 2, 4-D at 500 g/ha at 25 DAT effectively controlled the complex weed flora recorded at 50 DAT which was statistically at par with pretilachlor at 750 g + pyrazosulfuron-ethyl at 25 g/ha at 3 DAT. Weed competition reduced the grain yield of rice to the tune of 33-35%. Lower values of weed density, total weed dry weight and higher values of weed control efficiency and yield of rice were registered with combined application of azimsulfuron at 35 g + 2, 4-D at 500 g/ha at 25 DAT and it was followed by pretilachlor at 750 g + pyrazosulfuron-ethyl at 25 g/ha at 3 DAT. These treatments could be recommended for managing complex weed flora and obtaining higher yield of transplanted *Kharif* (wet) rice in the lateritic belt of West Bengal, India.

Key words: Azimsulfuron, Combined application, Pretilachlor, Pyrazosulfuron-ethyl, Transplanted rice, Weed management

Rice is main staple food crop of world providing food security and livelihood for millions of rural population living in tropical and sub-tropical regions of Asia. India is the second largest producer among the rice growing countries but its productivity is very low with 2.98 t/ha, while the world average is 4.25 t/ha (IRRI 2011). To sustain self-sufficiency in food and to meet future food requirements, greater emphasis should be given for increasing rice production. One of the important reasons for low riceproductivity is the infestation of weeds. Rice is generally cultivated in Eastern India by conventional transplanting. Transplanted rice is infested by heterogeneous type of weed flora which causes yield reduction by about 33-45% (Manhas *et al*. 2012 and Duary *et al*. 2015b). Manual weeding is the common practice of weed management in transplanted rice. But it is difficult, highly labour intensive and time consuming. Herbicides appear to hold a great promise in dealing with effective, timely and economic weed suppression in wet season (*Kharif)* transplanted rice. In recent past, several pre- and post-emergence herbicides have been recommended for controlling weeds in transplanted rice. However, single application of one herbicide has seldom been found effective against complex weed flora throughout the critical period of competition. Combined application of herbicides is emerging out as very effective tool to tackle the problem of complex weeds in transplanted rice. Therefore, the present experiment was undertaken to assess the effect of different herbicides either applied alone or in combination on complex weed flora and productivity of transplanted rice.

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MATERIALS AND METHODS

A field experiment was conducted on the lateritic soil of Agricultural Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal, during wet season of 2014 and 2015. The experimental field is situated at about 23^0392 N latitude and 87^0422 E longitude with an average altitude of 58.9 m above the mean sea level. The soil of the experimental field was sandy loam in texture with acidic in reaction (pH 6.1), low in organic C (0.39%) and available N (142.4 kg/ha), high in available P (32.13 kg/ha) and medium in available K (129.77 kg/ha). The experiment comprising of eleven treatments was laid out in randomized block design with three replications. The treatments were as follows: Pretilachlor at 750 g/ha at

3 DAT, pyrazosulfuron-ethyl at 25 g/ha at 3 DAT, azimsulfuron at 35 g/ha at 20 DAT, 2,4-D (Na-salt) at 500 g/ha at 35 DAT, ethoxysulfuron at 15 g/ha at 20 DAT, fenoxaprop-p-ethyl at 60 g/ha at 20 DAT, pretilachlor at 750 g/ha + pyrazosulfuron-ethyl at 25 g/ha at 3 DAT, azimsulfuron at 35 g/ha + 2,4-D (Na-salt) at 500 g/ha at 25 DAT, ethoxysulfuron at 15 g/ha + fenoxaprop-p-ethyl at 60 g/ha at 20 DAT, hand weeding twice at 20 and 40 DAT and unweeded control. The rice variety '*Swarna'* (*MTU-7029*) was used in the study and manual transplanting was done keeping a spacing of 20 × 10 cm. The recommended dose of fertilizers, *viz.* 80 kg N, 40 kg P_2O_5 and 40 kg K_2O /ha were applied through urea, DAP and MOP, respectively. One third quantity of nitrogen and full amount of phosphorus and potassium were applied in each plot as basal during the final land preparation. Rest two third quantity of N was applied in two splits as top dressing *i.e.* one third of nitrogen was top dressed at active tillering stage and rest one third of nitrogen was top dressed at panicle-initiation. All the herbicides alone or in combination were applied uniformly as per treatment with the help of knapsack sprayer fitted with flat fan nozzle using a spray volume of 500 L/ha. The recommended agronomic practices and plant protection measures were adopted to raise the crop. Species-wise weed density and biomass were recorded at 50 DAT by placing a quadrate of 50 x 50 cm from the marked sampling area of 1.0 m^2 in each plot. These were subjected to square root transformation to normalize their distribution. Weed control efficiency (%) was computed using the dry weight of different weed species. Weed Index (WI) was worked out using the formula as suggested by Gill and Vijayakumar (1969). Grain and straw yield of rice along with other yield-attributing characters like number of panicles/m^2, grains/panicle and test weight were also recorded at harvest.

RESULTS AND DISCUSSION

Weed flora

The experimental field comprised of weed species *Echinochloa colona, Digitaria sanguinalis, Paspalum distichium, Ludwigia parviflora, Marselia quadrifolia, Alternanthera sessilis, Eclipta alba, Commelina nudiflora, Cyperus iria* and *Fimbristylis miliacea* during both the years of study. In addition to these ten weed species, *Sphenoclea zeylanica* was observed during 2015. However, *Echinochloa colona, Digitaria sanguinalis* among the grasses; *Cyperus iria* among the sedges, and *Ludwigia parviflora* among the broad-leaved weeds were predominant throughout the cropping period (Table 1). Similar weed flora in transplanted rice has been reported by Duary (2014), Duary *et al.* (2015a and 2015b) and Teja *et al.* (2015).

Effect on weeds

The density and dry weight of different weed species were significantly reduced by herbicidal treatments and manual weeding in both the years of study. Significantly, the highest density and dry weight of all the weed species at 50 DAT were recorded in unweeded check. The lowest density as well as dry weight of the weed species was recorded with hand weeding twice at 20 and 40 DAT during both the years. Among the herbicidal treatments, application of ethoxysulfuron at 15 g + fenoxaprop-p-ethyl at 60 g/ha at 20 DAT significantly reduced the number of *Echinochloa colona* and *Paspalum distichium* at 50 DAT which was statistically at par with the combined application of azimsulfuron at 35 g + 2, 4-D at 500 g/ha and fenoxaprop-p-ethyl at 60 g/ ha during both the years. Similar trend was observed in case of dry weight of *Echinochloa colona* and *Paspalum distichium* at 50 DAT (Table 1 and 2). No *Ludwigia parviflora* was registered in treatment with combined application of azimsulfuron at 35 g + 2,4-D at 500 g/ha and it was closely followed by treatments of pretilachlor at 750 g + pyrazosulfuron-ethyl at 25 g/ha and ethoxysulfuron at 15 g + fenoxaprop-p-ethyl at 60 g/ha at 25 DAT. There were significant variations among the treatments with respect to the density of *Cyperus iria*. Combined application of azimsulfuron at 35g + 2,4-D at 500 g /ha effectively controlled *Cyperus iria* and recorded the lowest number as well as dry weight at 50 DAT but it was statistically at par with treatments of pretilachlor at 750 g + pyrazosulfuron-ethyl at 25 g/ha and ethoxysulfuron at 15 g + fenoxaprop-p-ethyl at 60 g/ha at 25 DAT. Among all the herbicides, azimsulfuron at 35 g + 2, 4-D at 500 g/ha registered the lowest number of other weeds (*Digitaria sanguinalis, Marselia quadrifolia, Alternanthera sessilis, Eclipta alba, Commelina nudiflora,* and *Fimbristylis miliacea*) during both the years at 50 DAT, which was at par with pretilachlor at 750 g + pyrazosulfuron-ethyl at 25 g/ha (Table 1). Similar trend was observed in case of dry weight of other weeds species present in the experimental field recorded at 50 DAT. All the treatments were significantly superior to unweeded control in reducing the density and dry weight of total weeds. During both the years of 2014 and 2015, combined application of azimsulfuron at 35 g/ha + 2,4-D at 500 g/ha registered the lower number and dry weight of

Table 1. Effect of treatments on density of different weed species in transplanted rice at 50 DAT

Treatment	*Echinochloa colona*		*Paspalum distichum*		*Ludwigia parviflora*		*Cyperus iria*		Others		Total	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Pretilachlor at 750 g/ha at 3 DAT	2.86 (7.7)	2.55 (6.0)	2.61 (6.3)	2.68 (6.7)	2.27 (4.7)	2.48 (5.7)	2.20 (4.3)	2.27 (4.7)	5.28 (27.3)	5.67 (31.7)	7.13 (50.3)	7.43 (54.7)
Pyrazosulfuron-ethyl at 25 g/ha at 3 DAT	2.74 (7.0)	2.48 (5.7)	2.80 (7.3)	2.68 (6.7)	2.04 (3.7)	2.42 (5.3)	2.04 (3.7)	1.87 (3.0)	4.14 (16.7)	5.02 (24.7)	6.23 (38.3)	6.77 (45.3)
Azimsulfuron at 35 g/ha at 20 DAT	2.12 (4.0)	1.78 (2.7)	1.87 (3.0)	1.68 (2.3)	1.68 (2.3)	1.35 (1.3)	1.87 (3.0)	1.78 (2.7)	2.86 (7.7)	2.97 (8.3)	4.53 (20.0)	4.22 (17.3)
2,4-D (Na-salt) at 500 g/ha at 35 DAT	3.34 (10.7)	2.92 (8.0)	3.44 (11.3)	3.24 (10.0)	2.20 (4.3)	1.78 (2.7)	2.48 (5.7)	2.80 (7.3)	5.08 (25.3)	5.28 (27.3)	7.60 (57.3)	7.47 (55.3)
Ethoxysulfuron at 15 g/ha at 20 DAT	3.03 (8.7)	2.61 (6.3)	2.97 (8.3)	2.68 (6.7)	2.04 (3.7)	1.87 (3.0)	1.96 (3.3)	2.04 (3.7)	3.89 (14.7)	4.45 (19.3)	6.26 (38.7)	6.28 (39.0)
Fenoxaprop-p-ethyl at 60 g/ha at 20 DAT	1.58 (2.0)	1.22 (1.0)	1.35 (1.3)	1.47 (1.7)	2.97 (8.3)	3.29 (10.3)	2.86 (7.7)	2.97 (8.3)	5.93 (34.7)	6.57 (42.7)	7.38 (54.0)	8.03 (64.0)
Pretilachlor at 750g/ha + pyrazosulfuron-ethyl at 25 g/ha at 3 DAT	1.96 (3.3)	1.78 (2.7)	1.35 (1.3)	1.58 (2.0)	1.08 (0.7)	0.91 (0.3)	1.22 (1.0)	1.35 (1.3)	1.96 (3.3)	2.27 (4.7)	3.19 (9.7)	3.39 (11.0)
Azimsulfuron at 35 g/ha + 2,4-D (Na-salt) at 500 g/ha at 25 DAT	1.68 (2.3)	1.35 (1.3)	1.22 (1.0)	1.35 (1.3)	0.71 (0)	0.71 (0)	1.08 (0.7)	1.22 (1.0)	1.47 (1.7)	1.87 (3.0)	2.48 (5.7)	2.68 (6.7)
Ethoxysulfuron at 15 g/ha + fenoxaprop-p-ethyl at 60 g/ha at 20 DAT	1.47 (1.7)	0.91 (0.3)	1.08 (0.7)	1.22 (1.0)	1.08 (0.7)	1.22 (1.0)	1.22 (1.0)	1.47 (1.7)	2.20 (4.3)	2.48 (5.7)	2.97 (8.3)	3.19 (9.7)
Hand weeding twice at 20 and 40 DAT	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)
Unweeded control	3.58 (12.3)	3.19 (9.7)	3.44 (11.3)	3.39 (11.0)	3.19 (9.7)	3.14 (9.3)	2.97 (8.3)	3.29 (10.3)	6.57 (42.7)	7.25 (52.0)	9.21 (84.3)	9.64 (92.3)
LSD (P=0.05)	0.36	0.32	0.24	0.26	0.28	0.23	0.29	0.27	0.55	0.63	0.75	0.72

Figures in parentheses are the original values. The data was transformed to $\sqrt{x+0.5}$ before analysis

Table 2. Effect of treatments on dry weight of different weed species in transplanted rice at 50 DAT

Treatment	*Echinochloa colona*		*Paspalum distichium*		*Ludwigia parviflora*		*Cyperus iria*		Others		Total	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Pretilachlor at 750 g/ha at 3 DAT	3.03 (8.69)	2.71 (6.85)	2.63 (6.42)	2.70 (6.77)	2.49 (5.72)	2.73 (6.96)	2.11 (3.94)	2.17 (4.19)	3.54 (12.03)	3.88 (14.58)	6.11 (36.80)	6.31 (39.35)
Pyrazosulfuron-ethyl at 25 g/ha at 3 DAT	2.80 (7.33)	2.53 (5.92)	2.56 (6.07)	2.45 (5.53)	2.04 (3.66)	2.42 (5.34)	1.81 (2.77)	1.67 (2.29)	2.54 (5.95)	3.28 (10.27)	5.13 (25.77)	5.46 (29.34)
Azimsulfuron at 35 g/ha at 20 DAT	1.98 (3.42)	1.64 (2.18)	1.67 (2.28)	1.50 (1.75)	1.70 (2.38)	1.37 (1.39)	1.66 (2.24)	1.57 (1.98)	1.77 (2.63)	2.00 (3.51)	3.67 (12.94)	3.36 (10.79)
2,4-D (Na-salt) at 500 g/ha at 35 DAT	3.48 (11.59)	3.03 (8.69)	3.55 (12.09)	3.37 (10.86)	2.32 (4.89)	1.87 (3.00)	2.38 (5.17)	2.68 (6.69)	3.54 (12.06)	3.80 (13.91)	6.80 (45.79)	6.61 (43.15)
Ethoxysulfuron at 15 g/ha at 20 DAT	2.94 (8.14)	2.51 (5.81)	2.89 (7.85)	2.61 (6.29)	2.15 (4.11)	1.95 (3.32)	1.79 (2.70)	1.86 (2.97)	2.51 (5.80)	2.93 (8.11)	5.39 (28.60)	5.20 (26.50)
Fenoxaprop-p-ethyl at 60 g/ha at 20 DAT	1.51 (1.77)	1.18 (0.89)	1.27 (1.12)	1.39 (1.43)	3.29 (10.35)	3.47(1 1.52)	2.89 (7.86)	3.01 (8.53)	3.92 (14.83)	4.34 (18.36)	6.04 (35.94)	6.42 (40.73)
Pretilachlor at 750g/ha + pyrazosulfuron-ethyl at 25 g/ha at 3 DAT	1.61 (2.09)	1.57 (1.96)	1.25 (1.07)	1.42 (1.52)	1.09 (0.69)	0.91 (0.33)	1.10 (0.72)	1.22 (0.99)	1.15 (0.82)	1.42 (1.52)	2.43 (5.38)	2.61 (6.32)
Azimsulfuron at 35 g/ha + 2,4-D (Na-salt) at 500 g/ha at 25 DAT	1.41 (1.50)	1.15 (0.82)	1.12 (0.75)	1.21 (0.97)	0.71 (0)	0.71 (0)	0.96 (0.42)	1.06 (0.61)	0.82 (0.18)	1.23 (1.02)	1.83 (2.85)	1.98 (3.42)
Ethoxysulfuron at 15 g/ha + fenoxaprop-p-ethyl at 60 g/ha at 20 DAT	1.28 (1.15)	0.89 (0.29)	1.02 (0.55)	1.16 (0.84)	1.06 (0.63)	1.19 (0.91)	1.05 (0.60)	1.21 (0.95)	1.23 (1.02)	1.46 (1.62)	2.11 (3.94)	2.26 (4.61)
Hand weeding twice at 20 and 40 DAT	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)
Unweeded control	3.78 (13.77)	3.41 (11.13)	3.57 (12.21)	3.51 (11.80)	3.58 (12.33)	3.52 (11.90)	3.03 (8.66)	3.45 (11.40)	4.75 (22.02)	5.55 (30.28)	8.34 (68.98)	8.77 (76.50)
LSD (P=0.05)	0.31	0.29	0.34	0.31	0.29	0.22	0.25	0.27	0.22	0.25	0.61	0.69

Figures in parentheses are the original values. The data was transformed to $\sqrt{x+0.5}$ before analysis

total weeds which was statistically at par with pretilachlor at 750 g + pyrazosulfuron-ethyl at 25 g/ha and ethoxysulfuron at 15 g + fenoxaprop-p-ethyl at 60 g/ha at 25 DAT (Table 1 and 2). Weed control efficiency (WCE) with respect to different weed species was higher with hand weeding treatment during both years of study (Fig. 1 and 2). Among the herbicidal treatments combined application of azimsulfuron at 35 g + 2,4-D at 500 g/ha applied at 25 DAT resulted into higher weed control efficiency against different weed species but it was closely followed by the treatment of pretilachlor at 750 g + pyrazosulfuron-ethyl at 25 g/ha. The lower value of weed index was recorded with the combined application of azimsulfuron at 35 g + 2,4-D at 500 g/ha and pretilachlor at 750 g + pyrazosulfuron-ethyl at 25 g/ha (Fig. 3). Similar results were reported by Jayadeva *et al.* (2009), Kumar *et al.* (2014), Duary *et al.* (2015b) and Teja *et al.* (2015).

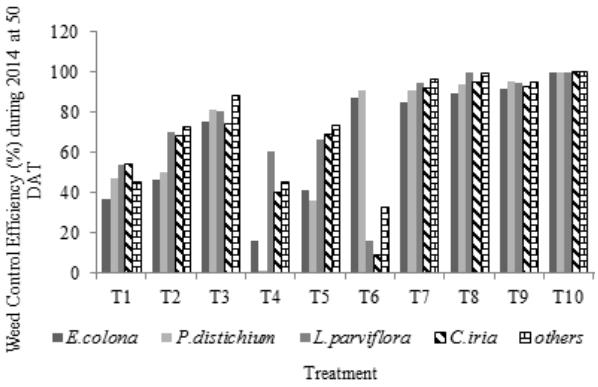

Fig. 1. Effect of treatments on weed control efficiency of different weed species in transplanted rice during 2014 at 50 DAT

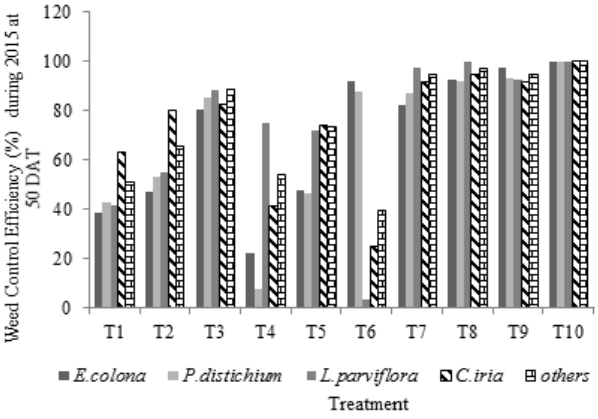

Fig. 2. Effect of treatments on weed control efficiency of different weed species in transplanted rice during 2015 at 50 DAT

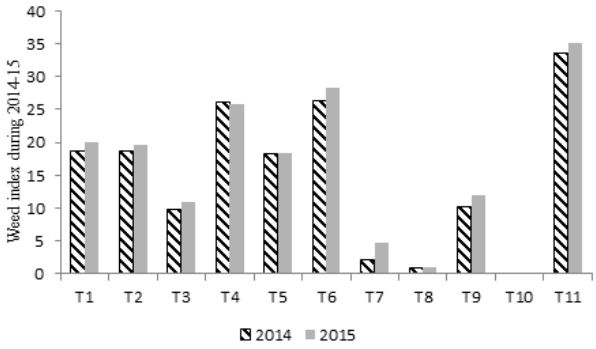

Fig. 3. Effect of treatments on weed index of transplanted rice during 2014 and 2015

Effect on crop

All the weed management treatments registered significantly higher values of yield and yield attributes like number of panicles, number of grains per panicle and test weight of transplanted rice over the unweeded control. The highest number of panicles/ $m^2$and number of grains/panicle were recorded with hand weeding twice at 20 and 40 DAT during both the years. But among the other treatments, combined application of azimsulfuron at 35 g + 2, 4-D at 500 g/ ha registered the highest number of panicles/m^2 and number of grains/panicle, which was statistically at par with pretilachlor at 750 g + pyrazosulfuron-ethyl at 25 g/ha during both the years of study (Table 3). Test weight did not vary significantly among the treatments. Weed competition in unweeded control plot resulted in 33-36% reduction in grain yield of transplanted *Kharif* rice. Similar yield reduction in wet season rice due to weed competition in the lateritic belt of West Bengal was also reported by Duary (2014), Duary *et al.* (2015a) and Teja *et al.* (2015). During both the years, the highest grain yield was recorded under hand weeding twice at 20 and 40 DAT treatment but it was statistically at par with azimsulfuron at 35 g + 2,4-D at 500 g/ha and pretilachlor at 750g + pyrazosulfuron-ethyl at 25 g/ ha, azimsulfuron at 35 g/ha at 20 DAT (Table 3). Effective and timely weed management under these treatments reduced the density as well as dry weight of weeds consequently resulting into increased number of panicles/m^2, number of grains/panicle and finally the yield. The results were in conformity with the findings of Jayadeva *et al.* (2009), Kumar *et al.* (2014), Shyam and Singh (2015), Duary *et al.* (2015b) and Teja *et al.* (2015). Similar trend was observed in case of straw yield of transplanted rice. Unweeded control registered the lowest grain and straw yield during both years of study.

Table 3. Effect of treatments on yield attributes, yield and economics of transplanted rice

Treatment	No of panicles/m^2		No. of grains/ panicle		Test weight (g)		Grain yield (t/ha)		Straw yield (t/ha)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Pretilachlor at 750 g/ha at 3 DAT	219	214	123	128	19.8	20.5	4.24	4.33	4.97	4.98
Pyrazosulfuron-ethyl at 25 g/ha at 3 DAT	217	218	127	124	19.5	20.2	4.23	4.35	4.95	4.98
Azimsulfuron at 35 g/ha at 20 DAT	241	243	138	141	20.5	20.9	4.70	4.82	5.29	5.36
2,4-D (Na-salt) at 500 g/ha at 35 DAT	189	192	108	108	20.0	19.6	3.85	4.01	4.62	4.56
Ethoxysulfuron at 15 g/ha at 20 DAT	219	221	122	125	20.5	20.3	4.26	4.42	4.97	4.96
Fenoxaprop-p-ethyl at 60 g/ha at 20 DAT	194	187	110	107	19.8	19.5	3.83	3.88	4.60	4.58
Pretilachlor at 750 g/ha + pyrazosulfuron-ethyl at 25 g/ha at 3 DAT	261	265	149	155	20.6	21.2	5.09	5.15	5.62	5.72
Azimsulfuron at 35 g/ha + 2,4-D (Na-salt) at 500 g/ha at 25 DAT	270	276	157	164	20.8	21.4	5.16	5.36	5.67	5.76
Ethoxysulfuron at 15 g/ha + fenoxaprop-p-ethyl at 60 g/ha at 20 DAT	231	232	134	138	20.2	20.3	4.68	4.76	5.28	5.31
Hand weeding twice at 20 and 40 DAT	270	281	160	166	20.9	21.2	5.21	5.41	5.69	5.81
Unweeded control	164	156	95	89	19.3	19.4	3.46	3.51	4.25	4.18
LSD (P=0.05)	21	18	10	12	NS	NS	0.36	0.32	0.32	0.36

Based on present investigation, it was inferred that combined application of azimsulfuron at 35 g + 2, 4-D at 500 g/ha at 25 DAT or pretilachlor at 750 g + pyrazosulfuron-ethyl at 25 g/ha at 3 DAT were very effective against the composite weed flora and registered higher yield of transplanted *Kharif* (wet) rice and this outcome could be very useful for the farmers of the lateritic belt of West Bengal.

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