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Herbicides for weed management in dry direct-seeded rice

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ABSTRACT

A field experiment was conducted during the *Kharif* season of 2015 to 2017 for three years at Agricultural Research Station, Vadgaon Maval, Pune, Maharashtra to find out the efficacy of different weed control methods on dry direct-seeded rice and its economics. Pretilachlor 0.450 kg/ha as pre-emergence application (PE) at 2-3 days after sowing (DAS) followed by (*fb*) azimsulfuron 0.035 kg/ha as post-emergence application (PoE) at 25 DAS effectively managed weeds in dry-DSR and gave the higher grain yield (5.62 t/ha), net returns (` 82777/ha), higher B:C ratio (2.8) with lower weed index (2.78) and higher weed control efficiency (87.7%).

Rice (*Oryza sativa* L.) is a major food grain crop of the world and more than half of the population subsists on it (The Columbia Encyclopedia 2000). India is the second largest rice producing country in the world. The method of direct-seeding avoids the transplanting and puddling operations and is an attractive and sustainable alternative to traditional transplanting of rice. Dry direct-seeding of rice (dry-DSR) offers advantages such as faster and easier planting, reduced labour, earlier crop maturity by 7–10 days, more efficient water uses and higher tolerance of water deficit, less methane emission (Ladha *et al.* 2015) and often higher profit in areas with an assured water supply (Balasubramanian and Hill 2002).

A major impediment in the successful cultivation of dry-DSR in tropical countries is heavy infestation of weeds which causes rice grain yield losses that range from 50-91% (Paradkar *et al.* 1997, Rao *et al.* 2007, Chauhan and Johnson 2010, Rao and Ladha 2011) due to simultaneous emergence of weeds and crop and less availability of efficient selective herbicides for control of weeds during initial stages of crop weed competition. Hence, present study was carried out to evaluate the efficacy of different chemical and mechanical weed control methods and its economics in dry-DSR.

A field experiment was carried out during *Kharif* 2015, 2016 and 2017 for three years at Agricultural Research Station, Vadgaon Maval, Pune, Maharashtra. The experiment consisted of nine treatments comprising of unweeded check, weed free and weed control methods, *viz*. pendimethalin [1.0 kg/ha, pre-emergence application at 2-3 days after seeding (DAS)] followed by (*fb*) metsulfuron-methyl + chlorimuron-ethyl (0.004 kg/ha, post-emergence application (PoE) at 25 DAS), pretilachlor (0.450 kg/ha, PE at 2-3 DAS) *fb* metsulfuron-methyl + chlorimuron-ethyl (0.004 kg/ha, PoE at 25 DAS), oxyflourfen(0.150 kg/ha, PE at 2-3 DAS) *fb* metsulfuron-methyl + chlorimuron-ethyl (0.004 kg/ha, PoE at 25 DAS), pendimethalin (1.0 kg/ha, PE at 2-3 DAS) *fb* azimsulfuron (0.035 kg/ha, PoE at 25 DAS), pretilachlor EC (0.450 kg/ha, PE at 2-3 DAS) *fb* azimsulfuron (0.035 kg/ha, PoE at 25 DAS), oxyflourfen (0.150 kg/ha, PE at 2-3 DAS) *fb* azimsulfuron (0.035 kg/ha, PoE at 25 DAS) and hand weeding (25 and 45 DAS).

The experiment was laid out in a randomized block design with three replications. The rice variety '*Phule Samruddhi*' was sown at 22.5 cm distance during *Kharif* 2015, 2016 and 2017. The crop was raised with recommended package of practices. All the herbicides were sprayed by using water 500 l/ha with the help of sprayer fitted with flat fan nozzle. The weed samples were taken out as per treatment were oven dried for about one week and weed biomass was recorded. All the other recommended package of practices except weed control was followed to raise the direct dry seeded crop.

Effect on weeds

In the experimental plots dominant weed flora consisted of monocots as *Echinochloa colona* and *Cynodon dactylon* among grasses; *Cyperus iria* and *Cyperus defformis* among sedges while dicots like *Eclipta alba, Portulaca oleracea, Celosia argentea* and *Ludwigia parviflora* for three years.

Significantly the lowest weed bioamass and weed index with the highest weed control efficiency were recorded in the weed free treatment (**Table 1 and 2**). The second-best treatment was pretilachlor (0.450 kg/ha, PE at 2-3 DAS) *fb* azimsulfuron (0.035 kg/ha, PE at 25 DAS) having the lowest weed biomass (19.50 g/m^2) with higher weed control efficiency (87.7%) and lower weed index (2.78). The highest weed biomass was recorded in unweeded check. Similar result was close conformity of Singh *et al.* (2010).

Effect on rice

The highest mean rice grain (5.78 t/ha) and straw yield (6.52 t/ha) were observed in the weed free treatment (**Table 3**). It was at par with pretilachlor (0.450 kg/ha PE at 2-3 DAS) *fb* azimsulfuron (0.035 kg/ha, PoE at 25 DAS) with equivalent grain yield (5.62 t/ha) and straw yield (6.35 t/ha). These results are in close conformity with Abraham *et al.* (2014)

Economics

Weed free recorded significantly highest gross returns (` 133330/ha) (**Table 4**) and was at par with pretilachlor (0.450 kg/ha, PE at 2-3 DAS) *fb* azimsulfuron (0.035 kg/ha, PoE at 25 DAS) having gross returns (` 129727/ha). Significantly highest net returns (` 82777/ha) was obtained with pretilachlor

Table 1. Weed density, weed biomass, weed control efficiency and mean weed indexin dry direct-seeded rice as affected by different treatments

Treatment	Weed density (no./m^2)				Weed biomass (g/m^2)				Weed control efficiency (%)				Weed index			
	2015	2016	2017	Pooled	2015	2016	2017	Pooled	2015	2016	2017	Pooled	2015	2016	2017	Pooled
Pendi. 1.0 kg/ha PE + mets. + chlor. WP 0.004 kg/ha PoE	28	33	21	27	43	50	34	42	74	71	76	73	22	25	24	24
Preti. 0.450 kg/ha PE + mets. + chlor. 0.004 kg/ha PoE	18	19	15	17	31	33	24	29	81	81	83	82	12	19	13	15
Oxyfl. 0.150 kg/ha PE + mets. + chlor. 0.004 kg/ha PoE	25	23	20	23	39	37	31	36	76	78	78	78	17	18	16	17
Pendi. 1.0 kg/ha PE + azim. 0.035 kg/ha PoE	26	25	22	24	43	40	34	39	74	77	76	76	21	19	22	21
Preti. 0.450 kg/ha PE + azim. 0.035 kg/ha PoE	14	13	12	13	21	20	17	19	87	88	88	88	4.7	1.1	2.5	2.8
Oxyf. 0.150 kg/ha PE + azim. 0.035 kg/ha PoE	21	20	19	20	35	32	27	31	79	81	81	80	14	16	16	15
Hand weeding (25 and 45 days after seeding)	33	31	25	30	57	54	45	52	65	68	68	67	27	24	27	26
Weed free	0	0	0	0	0	0	0	0	100	100	100	100	0	0	0	0
Unweeded check	99	104	86	96	163	171	143	159	0	0	0	0	74	76	75	75
LSD (p=0.05)	3.1	3.7	3.3	3.4	11.4	11.0	10.2	10.7	5.7	2.2	2.0	2.2				

Pendi = Pendimethalin; mets = Metsulfuron-methyl; chlor = Chlorimuron-ethyl; Preti = Pretilachlor ; Oxyfl = Oxyflourfen ; azim = Azimsulfuron

Table 2. Growth and yield attributes as affected by different treatments in dry direct-seeded rice

Treatment	Plant height (cm)				Number of tillers per plant			
	2015	2016	2017	Pooled	2015	2016	2017	Pooled
Pendimethalin 1.0 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl WP 0.004 kg/ha PoE	79.9	76.6	81.9	79.4	13	13	13	13
Pretilachlor 0.450 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl 0.004 kg/ha PoE	87.8	82.7	91.5	87.3	14	14	15	14
Oxyflourfen 0.150 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl 0.004 kg/ha PoE	85.3	84.1	90.8	86.7	14	15	14	14
Pendimethalin 1.0 kg/ha PE + azimsulfuron 0.035 kg /ha PoE	80.4	83.4	84.0	82.6	13	14	13	14
Pretilachlor 0.450 kg/ha PE + azimsulfuron 0.035 kg /ha PoE	91.9	90.6	91.9	91.5	18	19	19	19
Oxyflourfen 0.150 kg/ha PE + azimsulfuron 0.035 kg/ha PoE	87.7	86.3	90.9	88.3	14	14	14	14
Hand weeding (25 and 45 days after seeding)	74.5	78.0	78.3	76.9	12	12	12	12
Weed free	92.9	91.3	92.5	92.3	19	19	20	19
Unweeded check	63.2	56.2	64.7	61.3	5	4	5	5
LSD (p=0.05)	13.5	13.4	14.2	13.2	2.2	3.1	2.2	2.1

Treatment	Number of grains per panicle				Length of panicle (cm)			
	2015	2016	2017	Pooled	2015	2016	2017	Pooled
Pendimethalin 1.0 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl WP 0.004 kg/ha PoE	244	230	249	241	17.6	17.0	18.2	17.6
Pretilachlor 0.450 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl 0.004 kg/ha PoE	275	248	285	269	19.9	18.4	20.8	19.7
Oxyflourfen 0.150 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl 0.004 kg/ha PoE	260	252	276	263	18.8	18.7	20.2	19.2
Pendimethalin 1.0 kg/ha PE + azimsulfuron 0.035 kg /ha PoE	245	250	256	250	17.7	18.5	18.7	18.3
Pretilachlor 0.450 kg/ha PE + azimsulfuron 0.035 kg /ha PoE	297	306	319	307	21.5	22.6	23.3	22.5
Oxyflourfen 0.150 kg/ha PE + azimsulfuron 0.035 kg/ha PoE	268	259	277	268	19.4	19.2	20.2	19.6
Hand weeding (25 and 45 days after seeding)	227	234	238	233	16.5	17.3	17.4	17.1
Weed free	312	308	327	316	22.6	22.8	23.9	23.1
Unweeded check	81	71	83	78	11.1	10.0	11.1	10.7
LSD (p=0.05)	39.0	38.2	41.8	37.5	2.77	3.82	2.95	2.66

Table 4. Grain and straw yields as affected by different treatments in dry direct-seeded rice

Treatment	Grain yield (t/ha)				Straw yield (t/ha)			
	2015	2016	2017	Pooled	2015	2016	2017	Pooled
Pendimethalin1.0 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl WP 0.004 kg/ha PoE	4.42	4.25	4.55	4.40	4.91	4.85	5.18	4.98
Pretilachlor 0.450 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl 0.004 kg/ha PoE	4.99	4.59	5.19	4.92	5.55	5.22	5.92	5.56
Oxyflourfen 0.150 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl 0.004 kg/ha PoE	4.72	4.67	5.04	4.81	5.14	5.31	5.75	5.40
Pendimethalin 1.0 kg/ha PE + azimsulfuron 0.035 kg/ha PoE	4.45	4.63	4.66	4.58	4.94	5.26	5.31	5.17
Pretilachlor 0.450 kg/ha PE + azimsulfuron 0.035 kg/ha PoE	5.38	5.66	5.82	5.62	5.99	6.45	6.62	6.35
Oxyflourfen 0.150 kg/ha PE + azimsulfuron 0.035 kg/ha PoE	4.86	4.79	5.05	4.90	5.40	5.47	5.76	5.54
Hand weeding (25 and 45 days after seeding)	4.12	4.33	4.35	4.27	4.58	4.92	4.95	4.82
Weed free	5.67	5.70	5.97	5.78	6.29	6.49	6.79	6.52
Unweeded check	1.47	1.31	1.50	1.43	1.59	1.45	1.66	1.57
LSD (p=0.05)	0.70	0.71	0.77	0.69	0.78	0.86	0.91	0.81

Table 4. Economics of dry direct-seeded rice cultivation as affected by different treatments

Treatment	Mean gross returns (x10^3 `/ha)				Net Returns (x10^3 `/ha)				B:C ratio			
	2015	2016	2017	Pooled	2015	2016	2017	Pooled	2015	2016	2017	Pooled
Pendimethalin1.0 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl WP 0.004 kg/ha PoE	98.77	99.65	106.54	101.65	51.21	52.28	59.17	54.22	2.1	2.1	2.2	2.1
Pretilachlor 0.450 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl 0.004 kg/ha PoE	111.65	107.53	121.65	113.61	66.20	62.39	76.51	68.37	2.5	2.4	2.7	2.5
Oxyflourfen 0.150 kg/ha PE + metsulfuron-methyl + chlorimuron-ethyl 0.004 kg/ha PoE	105.22	109.35	118.14	110.90	59.24	63.12	71.90	64.76	2.3	2.4	2.6	2.4
Pendimethalin 1.0 kg/ha PE + azimsulfuron 0.035 kg/ha PoE	99.40	108.41	109.25	105.68	51.61	58.60	59.44	56.55	2.1	2.2	2.2	2.1
Pretilachlor 0.450 kg/ha PE + azimsulfuron 0.035 kg/ha PoE	120.34	132.58	136.25	129.72	74.65	84.99	88.67	82.77	2.6	2.8	2.9	2.8
Oxyflourfen 0.150 kg/ha PE + azimsulfuron 0.035 kg/ha PoE	108.53	112.34	118.23	113.04	62.32	63.67	69.56	65.18	2.3	2.3	2.4	2.4
Hand weeding (25 and 45 days after seeding)	92.17	101.44	101.88	98.50	42.11	51.80	52.66	48.86	1.8	2.0	2.1	2.0
Weed free	126.62	133.57	139.79	133.33	73.83	80.78	85.73	80.11	2.4	2.5	2.6	2.5
Unweeded check	32.76	30.55	35.11	32.81	-10.58	-12.78	-8.22	-10.53	0.8	0.7	0.8	0.8
LSD (p=0.05)	15.81	16.83	17.99	13.01	15.81	16.83	17.99	13.01				

(0.450 kg/ha, PE at 2-3 DAS) *fb* azimsulfuron (0.035 kg/ha, PoE at 25 DAS) which was at par with the weed free treatment (` 80117/ha). The highest B:C ratio (2.8) was observed with pretilachlor (0.450 kg/ha, PE at 2-3 DAS) *fb* azimsulfuron (0.035 kg/ha, PoE at 25 DAS) (**Table 4**).

The gram was dibbled immediately after harvest of experimental rice plot to observe the effect of different treatments on succeeding crop. The herbicides applied to the rice crop did not affect the germination of the succeeding crop gram.

On the basis of this study, it can be concluded that in drilled dry-seeded rice, effective management of weeds with higher economical returns may be obtained with pre-emergence application of pretilachlor at 0.450 kg/ha at 2-3 days after sowing followed by post-emergence application of azimsulfuron at 0.035 kg/ha at 25 days after sowing.

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