Indian Journal of Weed Science **48**(4):369–371, 2016
DOI: 10.5958/0974-8164.2016.00096.4

Herbicide combinations for weed control in direct-seeded rice

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Received: 20 October 2016; Revised: 1 December 2016

ABSTRACT

A field experiment was conducted during *Kharif* season of 2012 and 2013 at College farm, Professor Jayashankar Telangana State Agriculture University, Rajendranagar, Hyderabad to assess the bioefficacy of different herbicides and their integration with cultural methods to control weeds and relative influence on profitability in direct dry-seeded rice cultivation. Integrated weed management (pendimethalin *fb* bispyribac-sodium followed by manual weeding at 45 days after sowing) gave highest net returns with higher B:C ratio during both the years of study. Among cultural methods, three hand weedings (weed free condition) and three mechanical weedings recorded lower weed biomass and higher weed control efficiency.

Key words: Direct-seeded rice, Herbicides, Herbicide combinations, Weed biomass, Weeds

Direct dry-seeding of rice has potential for attaining better water and other resources utilization. Heavy weed infestation and shifts in weed population are major constraints in the sustainability of direct dry-seeded rice (dry-DSR). An appropriate weed management strategy has always been a major focus and key element to make dry-DSR a success. Such a strategy is of utmost significance to improve rice yield, quality and to minimize production costs as well. Traditionally, weeds are controlled through cultural/chemical methods. Manual weeding, though effective is getting increasingly impractical due to labour scarcity, rising wages and its dependence on weather conditions. Moreover, allowing weeds to reach sufficient size to be pulled out and the presence of perennial weeds that fragment/break on pulling are other related concerns (Rao *et al*. 2007). Thus, herbicide usage seems essential for weed management in dry-DSR. Although dry-DSR has been under practice in many regions of the world, yet its adoption has been limited by the unavailability of a successful local weed control strategy. The present study was designed to assess the bio-efficacy and economics of sole and sequential application of pre and post-emergence herbicides and their integration with manual/mechanical weeding for selective and season-long weed management in dry-DSR in Southern Telangana Zone of Telangana State.

MATERIALS AND METHODS

Field experiment was conducted at college farm, Rajendranagar, Hyderabad during *Kharif* season of 2012 and 2013. Hyderabad is situated at 17^0 19' N latitude, 78^0 28' E longitude 542 m above mean sea level. The total rainfall was770.5 mm and 658.9 mm during 2012 and 2013, respectively. The soil of the experimental site was clay loam with P^H 7.85 and electrical conductivity of 0.21 ds/m. The soil was low in organic carbon (0.52%). The experiment was laid out in randomized block design with three replications. The net plot size was 5 x 4 m. Seeds of rice *cv*. '*MTU-1010*' were sown during the first week of August using a seed rate of 75 kg/ha by maintaining 22.5 cm distance between crop rows on a non-flooded, non-puddled aerobic soil. Fertilizer dose of 150-60-60 Kg N, P_2O_5 and K_2O was applied. Fertilizers used were urea (46% N), superphosphate (16% P_2O_5) and muriate of potash (60% K_2O), entire phosphorus, ½ of potash and 1/3 of nitrogen were applied at the time of sowing. The remaining 2/3rd nitrogen was applied in two splits at tillering and panicle initiation and remaining potash was applied at panicle initiation, respectively.

Herbicides pendimethalin, oxadiargyl, pyrazosulfuron were applied as pre-emergence and these were followed by bispyribac-sodium as post-emergence. In addition, bispyribac-sodium was applied as post-emergence in combination with chlorimuron-ethyl + metsulfuron-methyl. Weedy check and weed free treatments were maintained for comparison. Spray volume was calibrated using water prior to treatment application. Herbicides were applied using a knapsack sprayer fitted with flood jet nozzle. Plant protection measures for insect pests and diseases and for iron deficiency were taken to grow healthy crop.

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Data on weed density and biomass was recorded at 60 DAS by two randomly selected quadrats (50 x 50 cm) from each experimental unit. Data on rice yield attributes was recorded from 15 randomly selected plants from each plot and averaged. Weed data were square root transformed before statistical analysis. The data were analyzed according to RBD by standard ANOVA at $P < 0.05$ level of significance.

RESULTS AND DISCUSSION

Weed density and weed biomass

Weed flora of the experimental site was comprised of *Trianthema portulacastrum*, *Digera arvensis*, *Echinochloa colonum*, *Echinochloa crus-galli*, *Dactylactenium aegyptium*, *Dinebra arabica*, *Cyperus rotundus* and *Cynodon dactylon*. All the treatments significantly suppressed weed density as compared to control.

Different weed control treatments significantly influenced the weed biomass in dry-DSR. Significantly, lower weed biomass was observed with all treatments compared to control in both the years and highest weed biomass in weedy check (170.2 g/ m^2) indicating the essentiality of weed control in dry-DSR. Significantly, lowest weed biomass (12.5 g/m^2) was observed with weed free treatment wherein hand weeding was done at 20, 40 and 60 DAS followed by three mechanical weedings (31.5 g/m^2). Among different treatments, pendimethalin *fb* bispyribac-sodium *fb* manual weeding recorded significantly lowest weed biomass during both the years, indicating the importance of integrated weed management for effectively managing the weeds (Table 2). Similar results were obtained by Singh *et al.* (2011). The treatments pendimethalin *fb* bispyribac-sodium bispyribac-sodium + (chlorimuron-ethyl + metsul-furon-methyl) and pendimethalin *fb* manual weeding recorded weed biomass, which was at par with each other (85.6, 89.5 and 84.6 g/m^2, respectively).

Sequential application of oxadiargyl *fb* bispyribac-sodium and pyrazosulfuron-ethyl *fb* bispyribac-sodium recorded weed biomass (71.8 g and 69.7 g/m^2, respectively). Sole application of bispyribac-sodium could not control weeds effectively resulting in higher weed biomass (109.5 g/ m^2) compared to other sequential application of herbicides and integrated weed management practices during 2012 and 2013.

Grain yield

Significantly lowest rice grain yield (1.06 t/ha) was recorded under weedy check. Highest grain yield was under weed free condition (3.95 t/ha), which was at par with pendimethalin *fb* bispyribac-sodium *fb* manual weeding (3.67 t/ha) and three mechanical weedings (3.72 t/ha) and all these three treatments were significantly superior in recording higher grain yield compared to all the other herbicide treatments during 2012 and 13. Walia *et al.* (2008) also observed that it was difficult to raise weed free DSR with the application of only one herbicide (Table 2).

Among the treatments, pyrazosulfuron-ethyl *fb* bispyribac-sodium recorded a grain yield (3.02 t/ha) that was at par with oxadiargyl *fb* bispyribac-sodium (2.81 t/ha), which differed significantly from bispyribac-sodium + (chlorimuron-ethyl + metsulfuron-methyl 2.53 t/ha) and pendimethalin *fb* manual weeding (2.63 t/ha). All these treatments recorded significantly superior grain yield than sole application of bispyribac-sodium (1.85 t/ha) in both the years. Pendimethalin (PE) *fb* bispyribac-sodium

Table 1. Weed biomass (60 DAS) and weed control efficiency of dry-DSR as influenced by different weed management practices

Treatment	WCE (%)		Weed biomass (g/m^2)	
	2012	2013	2012	2013
Bispyribac-Na (25 g/ha) 20 DAS (3-4 leaf stage)	35.7	35.7	10.51 (109.5)	11.4 (129.2)
Pendimethalin *fb* bispyribac-Na (1000 *fb* 25 g/ha) 0-2 *fb* 25	49.7	49.7	9.30 (85.6)	10.1 (101.0)
Oxadiargyl *fb* bispyribac-Na (100 /25 g/ha) 0-2 *fb* 25	57.8	57.8	8.53 (71.8)	9.2 (84.7)
Pyrazosulfuron *fb* bispyribac-Na (20/25 g/ha) 0-3 *fb* 25	59.1	59.1	8.40 (69.7)	9.1 (82.2)
Pendimethalin *fb* bispyribac-Na *fb* manual weeding (1000 *fb* 25 g/ha) 0-2 *fb* 20 DAS (3-4 leaf stage) *fb* 45 DAS	73.4	73.4	6.79 (45.2)	7.37 (53.3)
Pendimethalin *fb* manual weeding (1000 g/ha) 0-2 *fb* 25-30 DAS	50.3	50.3	9.25 (84.6)	10.04 (100)
Bispyribac + (chlorimuron + metsulfuron) (20 + 4 g/ha) 20 DAS	47.4	47.4	9.51 (89.5)	10.3 (105.6)
Three mechanical weedings (cono / rotary weeder) 20, 40 and 60 DAS	81.5	81.5	5.69 (31.5)	6.17 (37.2)
Weed free (HW at 20, 40 and 60 DAS)	92.7	92.7	3.67 (12.5)	3.97(14.8)
Weedy check	-	-	13.08 (170.2)	14.2 (200.8)
LSD (P=0.05)			0.56	0.61

Data are square root transformed and values in parentheses are original values; DAS - days after sowing; Spray volume: 500 l/ha for PRE and 375 L/ha for POST herbicides; *fb* - followed by

Table 2. Yield attributes and grain yield of dry-DSR as influenced by different weed control treatments

Treatment	Productive tillers (no./m^2)		No. of filled grains/ panicle		1000-seed weight (g)		Grain yield (t/ha)	
	2012	2013	2012	2013	2012	2013	2012	2013
Bispyribac-Na (25 g/ha) 20 DAS (3-4 leaf stage)	240	301.0	48	62.4	18.0	19.1	1.85	2.29
Pendimethalin *fb* bispyribac-Na (1000 *fb* 25 g/ha) 0-2 *fb* 25	270	341.0	53	67.1	19.0	19.2	2.47	3.11
Oxadiargyl *fb* bispyribac-Na (100 /25 g/ha) 0-2 *fb* 25	275	336.0	55	68.5	19.0	19.8	2.81	3.44
Pyrazosulfuron *fb* bispyribac-Na (20/25 g/ha) 0-3 *fb* 25	282	357.0	56	69.9	20.0	20.1	3.02	3.81
Pendimethalin *fb* bispyribac-Na *fb* manual weeding (1000 *fb* 25 g/ha) 0-2 *fb* 20 DAS (3-4 leaf stage) *fb* 45 DAS	305	381.0	56	69.2	21.0	20.5	3.67	4.54
Pendimethalin *fb* manual weeding (1000 g/ha) 0-2 *fb* 25-30 DAS	271	333.0	55	66.8	19.5	19.5	2.63	3.21
Bispyribac + (chlorimuron + metsulfuron) (20 + 4 g/ha) 20 DAS	269	336.0	54	68.1	19.3	19.3	2.53	3.18
Three mechanical weedings (cono / rotary weeder) 20, 40 and 60 DAS	315	394.0	56	70.2	20.2	20.2	3.72	4.64
Weed free (HW at 20, 40 and 60 DAS)	320	405.0	58	72.8	21.0	20.6	3.95	4.98
Weedy check	175	241.0	32	41.6	15.5	18.7	1.06	1.54
LSD (P=0.05)	13.0	22.0	5.0	6.1	2.2	1.2	0.35	0.34

DAS (Days after sowing); Spray volume: 500 l/ha for PRE and 375 l/ha for POST herbicides; *fb* followed by

Table 3. Economics of different weed control treatments in dry-DSR cultivation

Treatment	Cost of cultivation (x10^3 `/ha)		Gross returns (x10^3 `/ha)		Net returns (x10^3 `/ha)		B:C ratio	
	2012	2013	2012	2013	2012	2013	2012	2013
Bispyribac-Na (25 g/ha) 20 DAS (3-4 leaf stage)	13.95	18.75	22.20	27.49	8.25	8.74	1.59	1.5
Pendimethalin *fb* bispyribac-Na (1000 *fb* 25 g/ha) 0-2 *fb* 25	15.72	20.53	29.70	37.38	13.97	16.85	1.89	1.8
Oxadiargyl *fb* bispyribac-Na (100 /25 g/ha) 0-2 *fb* 25	15.57	20.37	33.78	41.29	18.21	20.92	2.17	2.0
Pyrazosulfuron *fb* bispyribac-Na (20/25 g/ha) 0-3 *fb* 25	15.67	20.47	36.24	45.78	20.57	25.31	2.31	2.3
Pendimethalin *fb* bispyribac-Na *fb* manual weeding (1000 *fb* 25 g/ha) 0-2 *fb* 20 DAS (3-4 leaf stage) *fb* 45 DAS	17.42	22.23	41.70	54.49	24.27	32.27	2.39	2.5
Pendimethalin *fb* manual weeding (1000 g/ha) 0-2 *fb* 25-30 DAS	18.87	23.68	31.62	38.5	12.74	14.89	1.68	1.6
Bispyribac + (chlorimuron + metsulfuron) (20 + 4 g/ha) 20 DAS	15.87	20.67	30.36	38.21	14.49	17.54	1.91	1.9
Three mechanical weedings (cono / rotary weeder) 20, 40 and 60 DAS	17.70	22.50	38.70	55.69	28.53	33.19	2.18	2.5
Weed free (HW at 20, 40 and 60 DAS)	25.90	30.70	43.80	59.78	27.70	29.08	1.69	2.0
Weedy check	12.00	16.80	12.72	18.49	0.72	1.69	1.06	1.0
LSD (P=0.05)	-	-	-	-	2.72	3.15	-	-

DAS (Days after sowing); Spray volume: 500 l/ha for PRE and 375 l/ha for POST herbicides; *fb* followed by

and oxadiargyl (PE) *fb* bispyribac-sodium recorded grain yield which were at par with each other indicating the efficacy of sequential application of pre- and post-emergence herbicides in effective weed control and realizing higher yield in paddy. These results were in conformity with the findings of Mahajan and Timsina (2011).

Economics

Highest gross returns (` 59,784/ha) were realized due to maintenance of weed free situation at 20, 40 and 60 DAS followed by three mechanical weedings (and pendimethalin *fb* bispyribac *fb* manual weeding). However, higher cost of cultivation in weed free resulted in lower net returns (` 29084) and BC ratio (2.0). Pre-emergence application of pendime-thalin *fb* bispyribac *fb* manual weeding gave reasonably good B:C ratio (2.3 and 2.5) in both the years and it was at par with three mechanical weedings. Though three mechanical weedings were effective in dry-DSR (2.2 and 2.5), the impending problem of labour scarcity and non-availability in time may prohibit farmers relying on it. Oxadiargyl *fb* bispyribac and pyrazosulfuron *fb* bispyribac also performed better, registering a B:C ratio of 2.0 each (Table 3).

It was concluded that pre-emergence application of pendimethalin *fb* bispyribac-sodium along with one manual weeding at 45 DAS may be recommended for efficient weed management, realizing higher grain yield and good profit in dry-DSR cultivation.

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