Indian Journal of Weed Science **44**(3): 176–180, 2012

Effect of stale seedbed method and weed management on growth and yield of irrigated direct-seeded rice

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Received: 12 April 2012; Revised: 4 August 2012

ABSTRACT

A field experiment was conducted at Agricultural Research Farm of Banaras Hindu University, Varanasi to study the effect of methods of rice establishment and weed management practices in irrigated direct seeded rice. Treatment comprised of three crop establishment methods, *viz.* dry seeding after land preparation using stale seed bed method by shallow ploughing or by glyphosate 1 kg/ha, puddled wet seeded in main plot and five weed control measures in subplot, *viz.* weedy, hand weeding at 15 and 30 DAS, pendimethalin 1 kg/ha pre emergence followed by 2,4-D EE 500 g/ha at 30 DAS, butachlor 1 kg/ha pre-emergence followed by 2,4-D 500 g/ha, fenoxaprop-p-ethyl with safener 56 g/ha 15 DAS followed by ethoxy sulfuron 18 g/ha at 20 DAS in a split plot design replicated thrice. Crop establishment methods did not influence rice growth and yield components, and yield. Irrespective of method of establishment, hand weeding twice was found to be superior in managing weeds in DSR than all sequentially applied herbicide treatments.

Key words: Chemical control, DSR, Irrigated, Stale seedbed, Weed management

Rice in the Indo Gangetic plains is raised by two principal rice methods of establishment, *viz.* transplanting and direct seeding. Due to certain constraints associated with transplanted rice like water (Bhuiyan *et al*. 1995) and labour shortage, deterioration of soil physical properties and environmental pollution (Balasubramanian and Hill 2002), emphasis is now being given on direct-seeded-rice cultivation which provides opportunities for system intensification and diversification (Mazid *et al*. 2002). A major impediment in the successful cultivation of direct-seeded rice (DSR) in tropical countries is heavy infestation of weeds which often range from 50-91% (Paradkar *et al.* 1997) 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. Further, nature of weed flora infesting direct-seeded rice also changes over years and it increased infestation of weedy rice in DSR of South Asian countries.

Stale or false seedbed technique is preventive method of weed management.This technique involves the soil preparation of a seedbed to promote germination of weeds, a number of days or weeks before the actual sowing or planting of the crop, thus depleting the seed bank in the surface layer of soil and reducing subsequent emergence of weeds (Rao *et al.* 2007). Following emergence, weeds are killed either by a non selective herbicide or by shallow tillage prior to the sowing of rice. Stale seedbed can also be implemented by submergence of rice field after 7 and 14 days of weed emergence (Sindhu *et al.* 2010). Singh *et al.* (2009) reported 53% lower weed density in dry–DSR after stale seedbed than without this practice. The initial seedbed preparation is then followed by destruction of the emerging weed seedlings with minimal soil disturbance (Mohler 2001). The control of emerging weed seedlings is mostly done with herbicides (Oliver *et al.* 1993). The present study was undertaken with main objective to find out the feasibility of using the option of stale seedbed during direct-seeding method of rice establishment and subsequent management of weeds by herbicides.

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MATERIALS AND METHODS

A field experiment was conducted during wet season of 2009 and 2010 at Agricultural Research Farm, Institute of Agricultural Sciences, Varanasi, Uttar Pradesh The soil of the experimental field was sandy clay loam in texture having pH 7.5, organic carbon 0.40%, available nitrogen 284 kg/ha, available phosphorus 16.9 kg/ha, available potassium 140 kg/ha. Treatment comprised of three crop establishment methods, *viz.* dry-seeded after using stale seedbed method by shallow ploughing (ii) by glyphosate 1 kg/ha (iii) rice wet seeded after puddling in main plot and five weed control measures in sub plot, *viz.* weedy, hand weeding (15 and 30 DAS), pendimethalin 1 kg/ha pre-emergence followed by 2,4-D 500 g/ha at 30 DAS, butachlor 1 kg/ha pre-emergence followed by 2,4-D 500 g/ha, fenoxaprop-p-ethyl with safener 56 g/ha 15 DAS+ ethoxysulfuron 18 g/ha at 20 DAS in a split plot design, replicated thrice. In stale seedbed treatment to facilitate weed emergence, water was applied in first week of June 2009 and 2010, and the first flush of weeds was controlled by application of glyphosate 1 kg/ha or by shallow tillage as per the treatment. Rice cultivar '*BPT-5204*' was sown by the help of zero till ferti-cum seed drill on 20 and 19th June 2009 and 2010, respectively. In two main plots, *i.e.* stale seed bed method by shallow ploughing or by glyphosate 1 kg/ha, rice seeds were drill seeded and overnight water soaked rice seeds were sown using drum seeder in puddled wet seeded treatment. A uniform dose of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O were applied in the form of urea, diamonium phosphate and muriate of potash in each experimental plot. One third of nitrogen and full dose of phosphorus and potassium were applied as basal dose and remaining amount of nitrogen was applied in two equal splits at tillering and panicle initiation stages. Herbicides were applied as pre- and post-emergence as per the treatment with the help of under arm lever operated knapsack sprayer, fitted with flat fan nozzle with water as a carrier at 200 liter/ha.

Weed density and weed biomass were recorded at 60 days after sowing. Observations on weed density and weed biomass were recorded randomly from three places in each plot using 0.25/m^2 quadrate. The data recorded on weeds were subjected to square root transformation $(\times+0.5)^{1/2}$ homogeneity of variance. Biometrical observations on growth attributes, yield attributes and yields were also recorded. At 60 day stage of crop growth, dry matter accumulation was recorded on the basis of per meter row length whereas number of tillers and leaf area was recorded using 0.25/m^2 quadrate. Ten random plant samples were taken from each quadrate and the average leaf area/pant was determined by Systronics Leaf Area Meter 211. Leaf area was then converted to per m^2 using number of tillers/m^2. Weed competition index (%) was calculated by formula given by Gill and Vijaykumar (1966) and B: C ratio was calculated using formula, gross return/ total cost of cultivation.

RESULTS AND DISCUSSION

The major weed flora infesting crop field were: *Cynodon dactylon* (9.25%), *Echinochloa colona* (24.5%), *Echinochloa crusgalli* (14.2%), *Leptochloa chinensis* among grasses; *Commelina benghalensis* (4.54%), *Physalis minima, Phyllanthus fraternus* (13.9%), *Euphorbia hirta, Trianthema monogyna Chorchorus olitorius* (6.8%), *Eclipta alba* (2.1%) among broad-leaved weeds; *Cyperus iria* (13.2%), *Cyperus difformis* and *Fimbristylis miliaceae* among sedges.

Weed growth

The results revealed that the narrow-leaved weeds other than sedges were more in numbers as compared to broad-leaved weeds during both the years (Table 1 and 2). Crop establishment method did not show significant variations in weed density except in total weed density in second year. The wet-seeded rice recorded lesser weed density in comparison to dry-seeded rice using stale seed-bed with glyphosate 1 kg/ha and shallow tillage during both the years. Amongst herbicidal management, fenoxaprop–p-ethyl 56 g/ha followed by ethoxysulfuron 18g/ha significantly reduced total weed density in comparison to butachlor 1 kg/ha followed by 2,4-D 0.5 kg/ha and it was at par with pendimethalin 1 kg/ha followed by 2,4-D 0.5 kg/ha. Similar finding were also observed in case of total weed biomass during second year. In the first year, the fenoxaprop-p-ethyl 56 g/ha followed by ethoxysulfuron 18 g/ha was significantly superior to all the herbicidal treatment. It was also observed that fenoxaprop -p-ethyl followed by ethoxysulfuron significantly reduced population and biomass of *Echinochloa colona* compared to other herbicidal treatment during both the years except weed density during second year of experimentation. Butachlor 1 kg/ha followed by 2,4-D 0.5 kg/ha was not effective in reducing weed population and biomass in comparison to other herbicidal treatment.

Crop growth

Growth attributes, *viz.* dry matter, numbers of tillers/ m^2 and leaf area index recorded at 60 DAS (Table 3) revealed that during first year, variations in these attributes due to crop establishment methods was non significant, however, in the second year, number of tillers/m^2 and leaf area index varied significantly, stale seedbed method by glyphosate 1 kg/ha recorded more number of tillers and higher leaf area index in comparison to shallow tillage. All the herbicidal treatments resulted in statistically similar variations in growth attributes. Hand weeding twice had significantly better performance of all the growth attributing characters in comparison to rest of the treatment. Weedy recorded the minimum value of growth attributes during both the years of experimentation.

Table 1. **Effect of rice establishment method and weed management treatments on weed density at 60 DAS**

Treatment	Broad-leaved weed		Sedges		*E. colonum*		*E. crusgalli*		Other narrow-leaved weed		Total	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Rice establishment												
Dry-seeded after stale bed	5.4	8.4	2.5	7.5	11.7	17.2	3.3	8.9	7.7	7.8	14.8	23.8
using shallow tillage	(52.2)	(92.8)	(11.7)	(74.9)	(249.6)	(368.3)	(20.5)	(99.2)	(83.5)	(79.7)	(334.1)	(714.9)
Dry-seeded after stale bed	4.1	8.7	2.6	6.6	15.3	18.61	2.1	8.5	8.7	7.5	17.1	24.3
using glyphosate	(30.1)	(98.1)	(14.1)	(54.1)	(340.3)	(435.5)	(10.4)	(93.1)	(98.4)	(70.1)	(389.6)	(750.9)
Wet seeded rice	6.7	8.8	6.0	6.8	12.4	16.1	3.5	8.8	8.0	7.7	17.0	22.8
	(70.1)	(97.9)	(53.1)	(61.1)	(218.9)	(332.5)	(26.1)	(100.0)	(85.9)	(76.0)	(367.7)	(667.5)
LSD (P=0.05)	NS	NS	2.4	NS	NS	1.49	NS	NS	NS	NS	NS	1.7
Weed management												
Butachlor + 2,4–D	2.1	9.2	3.8	7.1	20.3	20.9	3.6	9.5	14.5	8.4	21.8	27.3
	(9.8)	(87.1)	(25.3)	(52.0)	(476.0)	(447.1)	(28.0)	(91.1)	(213.3)	(73.8)	(539.1)	(751.1)
Pendimethalin+ 2,4–D	4.0	9.6	4.6	7.6	17.2	19.9	3.5	9.8	8.4	8.9	19.6	27.0
	(19.6)	(94.2)	(41.3)	(58.7)	(335.6)	(404.4)	(20.4)	(97.3)	(73.8)	(80.9)	(416.9)	(735.6)
Fenoxaprop-p-ethyl +	9.8	9.3	4.8	7.7	7.4	19.3	1.7	9.7	6.4	7.8	14.8	26.0
ethoxysulfuron	(108.9)	(89.3)	(28.3)	(61.3)	(98.7)	(379.6)	(6.7)	(95.6)	(42.7)	(61.3)	(238.7)	(687.1)
HW at 15 and 30 DAS	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.71
Weedy	10.2	14.4	4.7	11.9	20.1	25.6	5.3	14.2	10.7	12.6	24.5	37.1
	(115.1)	(210.7)	(36.0)	(144.9)	(437.8)	(662.7)	(40.0)	(203.1)	(116.4)	(160.4)	(624.4)	(1381.8)
LSD (P=0.05)	2.80	1.34	NS	1.17	6.41	1.66	NS	1.21	1.58	1.41	5.75	1.23

Original figures in parentheses were subjected to square root transformation before statistical analysis

Table 2. **Effect of rice establishment method and weed management treatments on weed biomass at 60 DAS**

Treatment	Broad-leaved		Sedges		*E. colonum*		*E. crusgalli*		Total	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Rice establishment										
Dry-seeded after stale bed	3.9	7.2	1.7	6.1	9.0	9.6	6.4	8.3	13.4	15.9
using shallow tillage	(27.7)	(66.6)	(4.9)	(48.0)	(143.5)	(117.9)	(21.2)	(86.4)	(197.3)	(318.9)
Dry-seeded after stale bed	4.0	7.1	1.7	5.3	11.5	9.0	4.0	7.9	13.9	15.0
using glyphosate	(31.1)	(64.9)	(6.1)	(34.5)	(198.4)	(104.2)	(16.5)	(78.8)	(263.8)	(282.4)
Wet seeded rice	5.7	7.1	3.4	5.6	10.3	8.2	5.8	7.74	15.7	14.5
	(49.1)	(63.4)	(19.0)	(40.0)	(155.7)	(86.2)	(18.9)	(75.0)	(324.7)	(264.4)
LSD (P=0.05)	NS	NS	NS	0.32	NS	NS	NS	NS	NS	NS
Weed management										
Butachlor + 2,4–D	1.6	7.7	2.5	6.4	17.6	11.9	6.1	9.3	20.0	18.4
	(8.7)	(62.3)	(11.7)	(44.0)	(320.4)	(147.4)	(23.3)	(87.6)	(416.1)	(341.4)
Pendimethalin + 2,4 –D	4.7	9.0	2.3	6.0	11.7	9.5	8.2	9.3	17.6	17.3
	(29.5)	(82.0)	(8.6)	(39.2)	(176.6)	(91.7)	(34.4)	(89.8)	(360.0)	(302.7)
Fenoxaprop-p-ethyl +	8.2	8.1	3.3	6.6	4.9	8.6	1.6	9.5	11.6	16.8
ethoxysulfuron	(82.3)	(68.1)	(16.8)	(45.2)	(42.6)	(77.5)	(2.2)	(93.02)	(141.5)	(283.8)
HW at 15 and 30 DAS	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Weedy	7.5	10.4	2.6	8.6	16.4	13.9	10.7	11.2	28.0	22.6
	(59.4)	(112.5)	(12.8)	(75.8)	(289.8)	(197.1)	(34.0)	(129.9)	(396.0)	(515.3)
LSD (P=0.05)	2.89	1.66	NS	1.32	4.89	1.26	5.73	1.55	5.17	1.27

Original figures in parentheses were subjected to square root transformation before statistical analysis

Yield attributes and yield

The results revealed that number of grains/panicle and grain yield did not vary significantly due to rice establishment methods during both the years (Table 3), however, variation in yield attributing characters, *viz.* number of panicles/m^2 and 1000 grain weight was significant in second and first year, respectively. Glyphosate 1 kg/ha recorded significantly more numbers of panicles/m^2 in

Table 3. Effect of establishment method and weed management on growth, yield and weed competition index in direct-seeded rice

Treatment	No. of tillers/m² at 60 DAS		Leaf area index at 60 DAS		No. of panicles/m²		No. of grains /panicle		1000-grain weight (g)		Grain yield (x10³ ₹/ha)		Weed competition index (%)		B: C ratio	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Rice establishment																
Dry-seeded after stale bed using shallow tillage	148.1	75.8	1.6	1.0	357	276	111.7	94.7	12.5	9.6	2.66	2.61	25.8	39.8	1.97	2.65
Dry-seeded after stale bed using glyphosate	154.8	82.8	1.9	1.2	401	329	114.6	88.3	12.7	10.8	2.74	2.63	26.6	41.5	1.95	2.44
Wet seeded rice	112.7	82.8	1.4	1.2	352	313	100.3	86.3	10.3	9.73	2.29	2.63	33.6	33.9	2.01	2.35
LSD(P=0.05)	NS	4.17	NS	0.11	NS	22.7	NS	NS	1.48	NS	NS	NS	NS	NS	-	-
Weed management																
Butachlor + 2,4–D	88.9	67.2	1.0	0.7	292	234	102.4	78.1	10.4	8.49	2.25	2.69	37.1	36.8	2.16	1.99
Pendimethalin + 2,4–D	170.7	64.7	2.1	0.7	356	236	108.1	77.7	11..2	9.78	2.72	2.37	24.2	43.8	2.52	1.75
Fenoxaprop-p-ethyl + ethoxysulfuron	145.8	60.0	1.8	0.7	410	295	117.0	88.3	12.2	9.34	2.91	2.63	19.1	37.9	2.90	1.92
HW at 15 & 30 DAS	207.3	179.7	2.4	3.45	577	564	118.3	134.1	13.4	13.8	3.60	4.28	0.0	0.0	3.32	3.40
Weedy	80.0	30.4	0.9	0.8	216	121	98.6	70.6	11.5	8.33	1.32	1.12	62.9	73.5	1.48	0.82
LSD(P=0.05)	71.3	13.4	0.9	1.2	159	38.7	NS	9.7	1.8	1.0	0.4	365	10.6	8.27	-	-

Table 4. Interaction between establishment methods and weed management on grain yield (t/ha) of direct-seeded rice in 2009

Weed management	Establishment method: Dry-seeded using stale seedbed with Shallow tillage	Establishment method: Dry-seeded using stale seedbed with Glyphosate 1 kg/ha	Establishment method: Wet-seeded rice
Butachlor + 2,4–D	2.09	2501	2.16
Pendimethalin + 2,4–D	2.96	3280	1.91
Fenoxaprop-p-ethyl + ethoxysulfuron	3.59	3340	2.27
HW at 15 and 30 DAS	3.36	3493	3.47
Weedy	1.28	1081	1.61
LSD(P=0.05)			
Weed management treatment at the same crop establishment			0.76
Crop establishment at same or different weed management			0.81

comparison to shallow tillage whereas in case of 1000 grain weight it was statistically similar to shallow tillage. Fenoxaprop-p-ethyl 56 g/ha followed by ethoxysulfuron 18g/ha recorded higher values of yield attributes in comparison to weedy and it was as at par with butachlor 1 kg/ha and pendimethalin 1 kg/ha followed by 2,4-D 0.5 kg/ha. Rice grain yield with fenoxaprop-p-ethyl 56 g/ha *fb* ethoxysulfuron 18 g/ha was significantly higher than weedy check and it was at par with all the other herbicidal treatment in second year. In first year, it was significantly superior to butachlor 1 kg/ha *fb* 2,4-D 0.5 kg/ha and statistically similar to pendimethalin 1 kg/ha *fb* 2,4-D 0.5 kg/ha. Weed competition index was higher in the first year with butachlor 1 kg/ha and in second year the differences in weed competition index were not significantly different among herbicide treatments. Among herbicide sequential application of fenaxaprop-p-ethyl 56 g/ha *fb* ethoxysulfuron 18 g/ha had higher benefit: cost ratio than other herbicidal treatment in first year whereas in second year butachlor 1 kg/ha followed by 2,4-D 0.5 kg/ha had higher benefit: cost ratio. Hand weeding twice recorded the highest benefit: cost ratio during both the years.

Interaction effect

Interaction effect between crop establishment method and weed management in first year revealed that stale seedbed by shallow tillage in combination with fenoxaprop-p-ethyl 56 g/ha *fb* ethoxysulfuron 18 g/ha had the highest grain yield and it was significantly superior to all the crop establishment method under butachlor 1 kg/ha *fb* 2,4-D 0.5 kg/ha and weedy treatments (Table 4). The same treatment was significantly at par with combination of crop establishment method under hand weeding twice.

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