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Chemical and non-chemical weed management effects on weed spectrum, yield and economics of direct-seeded rice in North-Western zone of Tamil Nadu

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ABSTRACT

Field experiments were conducted to study the chemical and non-chemical weed management on weed spectrum, yield and economics of direct-seeded rice (DSR) under lowland irrigated condition at Regional Research Station, Tamil Nadu Agricultural University, Paiyur, Tamil Nadu, India in wet and dry seasons of 2013-14 and 2014-15. The results revealed that application of pyrazosulfuron-ethyl 10% WP at 20 g/ha at 3 DAS *fb* mechanical weeding with cono-weeder at 25 DAS recorded higher weed control efficiency (WCE) of 94% and higher grain yield of 6.45 t/ha, gross income of ₹ 82669/-, net income of ₹ 48767/- with the benefit : cost ratio of 2.45. It recorded 56% higher grain yield over weedy check and 14% higher yield over pyrazosulfuron-ethyl. Hence, pre-emergence application (3 DAS) of pyrazosulfuron-ethyl 10% WP at 20 g/ha followed by mechanical (cono-weeder) at 25 DAS was effective for weed management in DSR.

INTRODUCTION

Weeds have been reported to reduce the yield by 50-60% in direct-seeded rice (Naresh *et al.* 2011). DSR is an eco-friendly water and energy (labour) saving technology under the present resources scarcity scenario (Mallikarjun *et al*. 2014 and Choudhary and Dixit 2018). To overcome the problems of human labours involved in nursery preparation and transplanting operations, researchers as well as farmers are looking at direct-wet seeding options for rice establishments. Direct-wet seeding of rice (WSR) through drum seeder offers the advantages of eliminates the nursery raising and transplanting operations, faster and easier planting, reduces labour requirement, hastens crop maturity and increase water use efficiency, thus 25% (250-300 man hours) of total human labour involved in rice cultivation were reduced making rice cultivation more profitable (Kachro and Bazaya 2011).

Rice crop sown through drum seeding technique by using sprouted seeds on puddled soil is associated with the problem of profuse growth heterogeneous weed flora. It becomes the biggest biological constraint because uncontrolled weeds in direct-seeded rice can reduce yields to the tune of 53% (Naresh *et al.* 2011) and losses were reported even up to 90% (Bhat *et al*. 2011). The yield loss due to weeds varied from 40 to 100% in direct-seeded rice (Choubey *et al*. 2001). The weed flora of WSR is entirely different from that of transplanted crop due to maintenance of saturation moisture at sowing and shallow depths of water up to 3 weeks after sowing. As weeds emerge almost at the same time as that of the crop in WSR and weed competition with rice crop is greater, hence weed management by herbicide is more crucial (Singh and Singh 2010). Hence, present investigation was carried out to study the chemical and non-chemical weed management to manage the weeds in direct WSR.

MATERIALS AND METHODS

Field experiments were conducted to study the effect of chemical and non- chemical weed control in direct (drum)-seeded rice under lowland irrigated condition at Regional Research Station, Tamil Nadu Agricultural University, Paiyur Tamil Nadu India in wet and dry seasons of 2013-14 and 2014-15, respectively in a randomized block design with three replications. The treatments constituted pre- and post-emergence application of pyrazosulfuron-ethyl 10% WP at 20 g/ha on 3 DAS and bispyribac sodium

10% EC 25 g/ha on 20 DAS, respectively and in combination with mechanical weeding (cono-weeder) at 10 and 25 DAS. Hand weeding at 15 and 30 DAS and in combination with mechanical weeding at 10 and 30 DAS along with weedy check. The eight row drum seeder (20 cm line spacing) was used.

The soil was sandy loam in texture with pH 8.1. The available N, P and K were 175, 25 and 235 kg/ha with organic carbon of 0.5%. The recommended fertilizer at 150: 50: 50 kg N, P and K/ha were applied as urea (46% N), single super phosphate (16% P) and muriate of potash (60% K). The full dose of phosphorus was applied as basal at the time of sowing. Nitrogen and potassium was applied in four equal splits, *viz*. basal, active tillering, panicle initiation and flowering stages. Pre-germinated seed of rice variety '*ADT 39*' at 25 k g/ha was used for direct seeding of rice. Pre- and post-emergence herbicides were applied with the help of a sand mixture and hand-operated knapsack sprayer fitted with flat-fan nozzle respectively and water as a carrier at 600 liters/ha for post-emergent herbicide application. Observations on weed population and weed dry matter were recorded with the help of a quadrate 1 × 1 m placed randomly at two spots in each plot at 30 and 60 DAS and expressed in number per meter square (no./m^2) and gram per meter square (g/m^2), respectively. The data was subjected to square root transformation ($\sqrt{x+1}$) to normalize their distribution and statistical analysis was done. Weed control efficiency (WCE) was calculated. Yield parameter like panicle (no./m^2), panicle length (cm), grains (no./panicle) and unfilled grains (no./panicle) were calculated from the individual plots and converted to kg per hectare.

RESULTS AND DISCUSSION

Weed flora of the experimental field

The dominant weed flora of the experimental fields are *Echinochola colona* (L.) among the grasses, *Cyperus difformis* (L.) among the sedges and *Ammannia baccifera* (L.), *Bergia capensis* (L.), *Marsilia quadrifolia* (L.), *Eclipta alba* (L.) Hassk. among the broad-leaved weeds.

The total weed count was recorded at 30 and 60 DAS. The weed samples were dried and dry weight was recorded for individual treatments. Based on dry weight the WCE was worked out for all treatments **(Table 1)**.

Among the treatments, application of pyrazosulfuron-ethyl 10% WP at 20 g/ha at 3 DAS *fb* cono-weeding at 25 DAS recorded the lowest weed number of 113.3/m^2 to 168.6/m^2 and 101/ m^2 to 86/m^2 at 30 and 60 DAS during 2014 and 2015, respectively, which was significantly lower than the other treatments. This was followed by the cono-weeding on 10 and 25 DAS, which recorded the total weed count of 380.3 to 169.6/m^2 and 111 to 100/m^2 at 30 and 60 DAS during 2014 and 2015, respectively. The higher weed counts of 2169.6 and 1266 /m^2 and 1808 and 1049/m^2 at 30 and 60 DAS were recorded during 2014 and 2015, respectively in weedy check. Application of pyrazosulfuron-ethyl 10% WP at 20 g/ ha on 3 DAS *fb* cono-weeding on 25 DAS recorded higher WCE of 85.8 to 70.7% and 94 to 96.5% at 30 and 60 DAS during 2014 and 2015, respectively. Application of bispyribac-sodium 10% EC 25 g/ha recorded lower WCE of 53.8 to 8.7% and 64% at 30 and 60 DAS during 2014 and 2015, respectively. The weed density and weed dry weight data indicated the application of pyrazosulfuron-ethyl 10% WP 20 g/ha at3 DAS *fb* cono-weeding at 25 DAS effectively controlled the grasses and broad-leaved weeds and suppressed the sedges followed by cono-weeding. The cono-weeding incorporates the weeds in puddle soil and enriches the nutrient content of soil and supply the nutrient to the crop plants. This finding was also supported by Pal *et al.* (2012). Chopra and Chopra (2003) also found that pyrazosulfuron-ethyl at 20 and 25 g/ha significantly reduced weed density and total weed biomass of *Cyperus iria* (L.), *Echinochloa colona* (L.).

Among the weed control treatments, application of pyrazosulfuron-ethyl 10% WP 20 g/ha at 3 DAS *fb* cono-weeding at 25 DAS recorded the lowest weed dry weight of 9.03 to 29.49 g/m^2 and 4.2 to 12.5 g/m^2 at 30 and 60 DAS during 2014 and 2015, respectively, which was significantly superior over other treatments. This was followed by the cono-weeding on 10 and 25 DAS, which recorded the total weed dry weight of 13.74 to 38.34 g/m^2 and 9.4 to 19.9 g/m^2 at 30 and 60 DAS during 2014 and 2015, respectively. The higher weed dry weight of 63.93 to 100.76 g/m^2 and 61.2 to 360.7 g/m^2 at 30 and 60 DAS during 2014 and 2015, respectively were recorded in weedy check followed by application of bispyribac sodium 10% EC 25 g/ha at 20 DAS recorded higher weed dry weight of 29.49 to 91.91 and 32.1 to 74.6 g/m^2 at 30 and 60 DAS during 2014 and 2015, respectively. Application of pyrazosulfuron-ethyl at 15 g/ha was effective to lower the weed density and weed biomass and not having any phyto-toxicity to the rice plant (Angirs and Kumar 2005, Acharya and Bhattachrya 2013). Choudhary and Dixit (2018) indicated that adoption of pyrazosulfuron *fb* pretilachlor have effective control of wide spectrum weeds.

Growth characteristics

Application of pyrazosulfuron-ethyl 10% WP at 20 g/ha at 3 DAS *fb* cono-weeding on 25 DAS recorded the higher plant height of 48.8 to 92.2 cm during 2014 and 2015, respectively. This was followed cono-weeding at 10 and 25 DAS, it recorded the plant height of 48.4 to 91.9 cm during 2014 and 2015, respectively. The lower plant heights of 46.7 to 87.7 cm were recorded in weedy check. This treatment also recorded the higher panicle length of 25.8 cm. The lower panicle length of 23.3 cm was recorded in weedy check **(Table 2)**.

Yield and yield attributes

Application of pyrazosulfuron-ethyl 10% WP at 20 g/ha on 3 DAS *fb* cono-weeding at 25 DAS recorded the higher panicles (440.6 and 493.7 no./ m^2), grains (167.2 and 183.1 no./panicle) and 1000 grain weight (16.2 and 16.9 g) during 2014 and 2015, respectively. This was followed by cono-weeding at 10 and 25 DAS and it recorded the panicle (410.3 and 477 no./m^2), grains (166.3 and 177 no./panicle) and 1000 grain weight (15.6 and 16.7 g) during 2014 and 2015, respectively. The minimum number of panicle (260.8 and 272 no./m^2), grains (120.5 and 146 no./panicle) and 1000 grain weight (14.9 and 15.9 g) during 2014 and 2015, respectively were recorded in weedy check (**Table 3**).

Application of pyrazosulfuron-ethyl at 20 g/ha at 3 DAS *fb* cono- weeding on 25 DAS recorded the higher grain yield of 6.25 and 6.38 t/ha during 2014 and 2015, respectively. This treatment recorded 69% higher grain yield over weedy check and 11% higher yield over pyrazosulfuron-ethyl at 20 g/ha. The cono-weeding at 10 and 25 DAS recorded the grain yield of 6.10 and 6.29 t/ha during 2014 and 2015,

Table 1. Effect of different weed control treatments on no. of weeds, weed dry weight and WCE in direct-seeded rice

Treatment	30 DAS						60 DAS					
	Total weed (no./m^2)		Total weed dry weight (g/m^2)		WCE (%)		Total weed (no./m^2)		Total weed dry weight (g/m^2)		WCE (%)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Pyrazosulfuron-ethyl 10% WP at 20 g/ha	26.2 (688)	25.1 (644)	4.7 (216)	4.5 (19.2)	66.2	64.3	26.7 (715)	18.0 (365)	9.4 (87.7)	7.6 (59.6)	12.9	83.0
Bispyribac-sodium 10% EC 25 g/ha	26.4 (698)	25.4 (644)	5.5 (29.5)	5.7 (31.2)	53.8	64.3	27.2 (737)	17.9 (412)	9.6 (91.9)	7.5 (74.6)	8.7	79.3
Cono-weeder on 10 and 25 DAS	19.5 (380)	10.6 (111)	3.8 (13.7)	3.2 (9.4)	78.5	93.8	13.1 (170)	10.0 (101)	6.3 (38.3)	4.4 (19.9)	61.9	94.5
Pyrazosulfuron-ethyl 20 g/ha *fb* bispyribac sodium 25 g/ha at 20 DAS	20.0 (400)	11.0 (120)	3.9 (14.4)	3.7 (12.5)	77.4	91.6	15.2 (230)	11.4 (129)	6.8 (45.9)	5.2 (27.5)	54.4	92.3
Pyrazosulfuron-ethyl at 20 g /ha *fb* Cono-weeder on 25 DAS	10.7 (113)	10.1 (102)	3.2 (9.0)	2.3 (4.2)	85.8	94.3	13.0 (169)	9.2 (86)	5.5 (29.5)	3.5 (12.5)	70.7	96.5
Cono-weeder on 10 DAS *fb* bispyribac-sodium 25 g/ha at 20 DAS	21.4 (457)	11.6 (133)	4.1 (16.3)	3.8 (13.7)	74.5	92.6	20.1 (402)	10.9 (127)	7.6 (56.6)	4.2 (19.1)	43.8	94.7
Hand weeding on 15 and 30 DAS	20.2 (408)	11.1 (121)	4.0 (15.3)	3.6 (12.1)	76.0	93.3	18.1 (328)	11.5 (132)	7.3 (52.9)	4.4 (19.9)	47.5	94.4
Hand weeding on 15 DAS *fb* cono-weeder on 25 DAS	22.5 (503)	13.3 (175)	4.6 (19.9)	4.2 (16.9)	68.8	90.3	23.7 (561)	11.4 (131)	9.1 (83.7)	5.5 (32.6)	16.9	90.9
Cono-weeder on 10 DAS *fb* hand weeding on 30 DAS	21.6 (466)	12.3 (150)	4.3 (17.6)	3.8 (13.7)	72.4	91.6	20.3 (412)	11.7 (136)	9.1 (82.9)	5.6 (36.4)	17.7	89.9
Weedy check	46.6 (2170)	42.5 (1808)	8.0 (63.9)	7.8 (61.2)	-	-	35.6 (1266)	32.3 (1049)	10.1 (100)	18.9 (361)	-	-
LSD (p=0.05)	3.59	3.5	0.66	0.59	-	-	2.55	7.2	1.13	2.7	-	-

Figures in parentheses are original values (analysis by $(\sqrt{x+1})$ transformations)

Table 2. Effect of different weed control treatments on growth characters of direct-seeded rice

Treatment	Plant height (cm)						Panicle length (cm)		Unfilled grain (no./panicle)	
	60 DAS		90 DAS		At harvest					
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Pyrazosulfuron-ethyl at 20 g/ha	49.9	46.8	73.5	64.9	75.9	89.9	21.4	23.9	21.0	33.7
Bispyribac-sodium 25 g/ha	48.6	46.7	73.5	65.5	75.0	90.3	21.3	23.9	22.8	35.2
Cono-weeder on 10 and 25 DAS	53.3	48.4	77.2	69.3	78.3	91.9	22.4	24.7	16.1	23.9
Pyrazosulfuron-ethyl 20 g/ha *fb* bispyribac-sodium 25 g/ha at 20 DAS	51.2	47.2	77.3	67.2	73.8	91.5	21.4	23.4	16.0	28.2
Pyrazosulfuron-ethyl at 20 g/ha *fb* Cono-weeder on 25 DAS	54.1	48.8	78.3	70.9	79.3	92.2	22.6	25.8	16.6	22.7
Cono weeder on 10 DAS *fb* bispyribac-sodium 25 g/ha at 20 DAS	51.7	47.3	71.6	70.3	73.5	89.1	21.5	23.8	22.2	32.8
Hand weeding on 15 and 30 DAS	51.7	48.2	71.7	68.8	72.0	91.8	22.4	24.6	24.4	32.3
Hand weeding on 15 DAS *fb* cono-weeder on 25 DAS	50.2	47.1	73.8	69.2	75.6	89.6	22.1	23.7	18.8	33.4
Cono-weeder on 10 DAS *fb* hand weeding on 30 DAS	50.7	46.9	75.0	67.8	78.2	89.1	22.2	24.3	20.3	33.9
Weedy check	48.5	46.7	70.9	63.0	73.5	87.7	21.2	23.3	23.1	37.5
LSD(p=0.05)	4.0	2.3	5.5	6.6	5.4	3.2	1.1	1.9	5.9	9.2

Table 3. Effect of different weed control treatments on yield characters in direct-seeded rice

Treatment	Panicle (no./m^2)		Grain (no./panicle)		Test weight (g)		Grain yield (t/ha)		Straw yield (t/ha)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Pyrazosulfuron-ethyl at 20 g/ha	359.6	432.2	145.6	157.2	15.7	16.5	5.58	5.76	6.32	6.44
Bispyribac-sodium 25 g/ha	300.5	454.7	133.2	155.1	15.5	16.5	5.57	5.64	6.31	6.53
Cono-weeder on 10 and 25 DAS	410.3	477.3	166.3	177.4	15.6	16.7	6.10	6.29	6.91	7.31
Pyrazosulfuron-ethyl 20 g/ha *fb* bispyribac-sodium 25 g/ha at 20 DAS	398.1	457.3	163.2	166.0	15.8	16.6	5.94	5.89	6.74	6.71
Pyrazosulfuron-ethyl at 20 g/ha *fb* Cono-weeder on 25 DAS	440.6	493.7	167.2	183.1	16.2	16.9	6.25	6.38	7.28	7.48
Cono weeder on 10 DAS *fb* bispyribac-sodium 25 g/ha at 20 DAS	384.6	470.7	151.1	153.7	14.9	15.9	5.83	5.68	6.61	6.97
Hand weeding on 15 and 30 DAS	391.8	469.3	155.7	170.6	15.4	16.4	5.94	5.90	6.64	7.03
Hand weeding on 15 DAS *fb* cono-weeder on 25 DAS	376.3	424.2	147.3	165.1	15.8	16.7	5.75	5.81	6.53	6.58
Cono-weeder on 10 DAS *fb* hand weeding on 30 DAS	392.0	467.3	148.7	172.7	15.0	16.0	5.81	5.79	6.59	6.82
Weedy check	260.8	272.3	120.5	146.7	14.9	15.9	4.49	3.79	5.10	4.98
LSD(p=0.05)	59.54	46.6	21.70	25.8	0.9	1.0	0.34	0.37	0.38	0.46

Table 4. Effect of different weed control treatments on yield and economics of direct-seeded rice

Treatment	Grain yield (t/ha)			Straw yield (t/ha)			Gross income (x10^3 ₹/ha)			Net income (x10^3 ₹/ha)			B:C ratio		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Pyrazosulfuron-ethyl at 20 g/ha	5.58	5.76	5.67	6.32	6.44	6.37	72.49	75.49	73.99	40.46	43.46	41.96	2.26	2.36	2.31
Bispyribac-sodium 25 g/ha	5.57	5.64	5.60	6.32	6.53	6.42	72.40	74.21	73.30	39.44	41.26	40.35	2.19	2.25	2.23
Cono-weeder on 10 and 25 DAS	6.10	6.29	6.20	6.92	7.31	7.12	79.30	82.79	81.05	44.52	48.01	46.26	2.28	2.38	2.33
Pyrazosulfuron-ethyl 20 g/ha *fb* bispyribac-sodium 25 g/ha at 20 DAS	5.94	5.89	5.92	6.74	6.71	6.73	77.27	77.40	77.33	43.14	43.82	43.48	2.29	2.31	2.30
Pyrazosulfuron-ethyl at 20 g/ha *fb* Cono-weeder on 25 DAS	6.41	6.48	6.45	7.28	7.48	7.39	81.24	84.10	82.67	47.34	50.19	48.77	2.40	2.49	2.45
Cono-weeder on 10 DAS *fb* bispyribac-sodium 25 g/ha at 20 DAS	5.83	5.68	5.76	6.61	6.97	6.79	75.82	75.10	75.46	41.00	40.27	40.64	2.17	2.16	2.17
Hand weeding (HW) on 15 and 30 DAS	5.94	5.90	5.92	6.64	7.03	6.79	77.16	77.80	77.48	38.93	39.57	39.25	2.01	2.04	2.03
HW on 15 DAS *fb* cono-weeder on 25 DAS	5.75	5.81	5.78	6.53	6.58	6.57	74.78	76.30	75.54	38.28	39.79	39.03	2.04	2.09	2.07
Cono weeder on 10 DAS *fb* HW on 30 DAS	5.81	5.79	5.80	6.59	6.82	6.71	73.51	76.33	74.92	37.00	39.82	38.41	2.01	2.09	2.05
Weedy check	4489	3.79	4.14	5.10	4.99	5.04	58.36	50.41	54.39	27.33	19.30	23.32	1.87	1.62	1.75
LSD(p=0.05)	0.34	0.37	0.33	0.39	0.46	0.29	-	-	-	-	-	-	-	-	-

respectively. The lower grain and straw yield of 4.49 t/ha and 3.79 t/ha during 2014 and 2015, respectively was recorded in weedy check (**Table 3**).

Application of pyrazosulfuron-ethyl 10% WP at 20 g/ha on 3 DAS *fb* cono-weeding on 25 DAS recorded the higher gross income of ₹ 82669/ ha, net income of ₹ 48767/ha with the B:C ratio of 2.45. This was followed by the cono-weeding on 10 and 25 DAS, which recorded the gross income of ₹ 81046/ ha, net income of ₹ 46264/ha with the B:C ratio of 2.33. The lower gross income of ₹ 54387/ha, net income of ₹ 23316/ha with the B:C ratio of 1.75 were recorded in weedy check **(Table 4)**.

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