



Bio-efficacy of herbicides on weeds in direct-seeded rice in Konkan region of India

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ABSTRACT

Rice cultivation by direct seeding is viewed as both cost and labor-saving practice and becoming popular alternative to transplanting. Weeds are a more serious problem in DSR than in transplanted rice. The field experimental is conducted to evaluate the bio-efficacy of pre and post-emergence herbicides, hand-weeding on weed control, yield components, yield and their economic feasibility for cost effective weed control in direct seeded rice. The experiment was laid out in randomized block design with three replications and seven treatments, viz. Pre-emergence oxadiargyl 80% WP @ 100 g/ha, Pre-emergence oxadiargyl 80% WP @ 100 g/ha fb HW at 30 DAS, oxadiargyl 80% WP (PE) @ 100 g/ha fb Post-emergence bispyribac- Na @ 25 g/ha at 25 DAS, Pre-emergence oxadiargyl 80% WP @ 100 g/ha fb Post-emergence metasulfuron- methyl + chlorimuron – ethyl @ 4 g/ha at 25 DAS, Pre-emergence oxadiargyl 80% WP @ 100 g/ha fb Post-emergence carfentrazone ethyl 40% @ 25 g/ha at 25 DAS. Weed density under weedy check (WC) situation showed that monocot weeds (grasses and sedges) were more pre-dominant wherein grasses and sedges constituted 74.80% and 11.48%, respectively, BLWs 14.20% of total weed density at 60 DAS of crop. Amongst the herbicide treatments, application of Oxadiargyl (PE) @ 100 g/ha fb HW at 30 DAS recorded significantly lowest number of weeds/m², dry weight/m². The highest grain yield (4.02 t/ha) and benefit cost (1.48) were recorded with the pre-emergence application of Oxadiargyl (PE) @ 100 g/ha fb HW at 30 DAS.

Key words: Direct Seeded Rice, Pre- and post-emergence herbicides, Sequential application, Weed density

Rice is an important food crop extensively grown in Konkan. This is widely planted manually by transplanting 20 to 30-days-old seedlings into puddled soil. However, transplanting is becoming increasingly challenging due to unavailability and the high cost of labour and energy, restricted supply of irrigation water, and decline of soil quality (Chauhan, 2012). Konkan region is narrow coastal lowland, gets about 2072-3800 mm annual average rainfall. A major traditional agricultural crop includes rice, millets pulses among the field crops. Rice is an important food crop extensively grown in Konkan, which is widely planted manually by transplanting 20 to 30-days-old seedlings into puddled soil. Rice cultivation by direct-seeding

is viewed as both a cost and labor-saving practice and becoming a popular alternative to transplanting. Weeds are a more serious problem in DSR than in transplanted rice. Weeds should be controlled before they start to compete with rice. Minimize weed seed production and seed recruitment in soil. Weed should be removed or controlled before they set seeds. Ninety per cent loss in grain yield due to weeds in direct-seeded rice was reported by Zahoor *et al.* (2014). However, it is very difficult to control the complex weed flora observed in DSR with application of single pre- or post-emergence herbicide (Mahajan *et al.*, 2013). Thus, effective weed management during early stages of crop growth promises for accomplishment of higher yields. Although manual weeding is effective, it is costly, tedious and time consuming. Due to the morphological similarity, it is often difficult to distinguish some grassy weeds from rice at early stages and sometimes deficit or excessive soil moisture may not permit efficient weeding. The scarcity of man power at critical period of weed infestation is an important hurdle for timely weeding in rice. Relying on

Based on research work carried on during 2019 to 2021 at A.R.S., Repoli.

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herbicides may be the best choice of labour saving technology for timely weed control. On the other side, farmers are also looking forward for the selective herbicides application as pre as well as post-emergence to obtain cost effective management of broad spectrum weeds right from the initial stages compared to hand weeding. However, increased consciousness about the chemical pollution of soil and water has widened the scope for exploring the advantage of low dose herbicides such as oxadiargyl 80% WP (PE) @ 100 g/ha, bispyribac- Na @ 25 g/ha, metsulfuron-methyl + chlorimuron – ethyl @ 4 g/ha, carfentrazone ethyl 40% @ 25 g/ha, which are very effective against wide range of weeds. In cognizance of the above facts, the present investigation was carried out.

MATERIALS AND METHODS

The field experiment was conducted during *Kharif* seasons of 2019, 2020 and 2021, at Agricultural Research Station, Repoli, Raigad, Maharashtra. The soil of the experimental site was medium black soils of Konkan with soil pH was 6.5. It was low in available nitrogen and phosphorus and high in potassium. The experiment was laid-out in a randomized block design with three replications and seven treatments, viz. pre-emergence oxadiargyl 80% WP @ 100 g/ha, pre-emergence oxadiargyl 80% WP @ 100 g/ha *fb* HW at 30 DAS, oxadiargyl 80% WP (PE) @ 100 g/ha *fb* post emergence bispyribac- Na @ 25 g/ha at 25 DAS, pre-emergence oxadiargyl 80% WP @ 100 g/ha *fb* post emergence metasulfuron- methyl + chlorimuron – ethyl @ 4 g/ha at 25 DAS, pre-emergence oxadiargyl 80% WP @ 100 g/ha *fb* post emergence carfentrazone ethyl 40% @ 25 g/ha at 25 DAS. All herbicides were applied in 500 liter of water/ha. These weed control treatments were compared with hand weeding twice at 20, and 40 DAS weed-free check, and weedy-check.

Karjat -5 variety of rice was sown by using line markers at 20 cm row spacing. The crop was fertilized with 100:50:50 kg/ha of N, P₂O₅ and K₂O, respectively. Half dose of N and full dose of P₂O₅ and K₂O were applied at sowing and remaining dose of N was applied in two split doses at tillering and panicle initiation. Herbicides were applied with manually operated knapsack sprayer fitted with flat fan nozzle. In hand weeding, weeds were removed manually. Data on weed density and dry weight were recorded after 20, 40 and 60 days after sowing in each plot in four quadrats (25 × 25 cm²). Weeds were counted in three categories i.e. (grasses, broad leaved weed, and sedges) were removed for recording dry weight of weeds. Weed samples were sun-dried before oven drying at 70 °C until a constant weight was attained. Data on weeds were subjected to square-root transformation ($\sqrt{x} + 0.5$) before statistical analysis. Yield and yield attributes of rice were recorded at

crop harvest. Weed control efficiency was calculated based on weed dry weight.

$$\text{Weed control efficiency (WCE)} = \frac{(\text{WDC} - \text{WDT})}{\text{WDC}} \times 100$$

Where, WDC is the biomass of weeds in weedy plots, WDT is the dry weight of weeds in treated plots.

All the data were analyzed as per the experimental design, and the least significant values at 5% level of significance were calculated to compare treatment means for determining significant differences.

RESULTS AND DISCUSSION

Weed flora

On an average, a weed density of 278/m² was recorded in the weedy-check plot. The major grassy weeds observed in the direct-seeded rice experimental plot were *Echinochloa colona* and *Echinochloa crus-galli* and *Ischane globosa* while, *Cyperus iria* and *Cyperus difformis* were the dominant weeds among sedges and broad-leaved weeds viz., *Eclipta alba* (L.), *Commelina diffusa*. Weed density under weedy-check (WC) situation showed that monocot weeds (grasses and sedges) were more pre-dominant wherein grasses and sedges constituted 74.8% and 11.5%, respectively, however, BLWs 14.2% of total weed density at 60 DAS of crop.

Weed density

Data pertaining to the weed density and dry biomass at 20 and 60 DAS are presented in Table 1. It was observed that all the weed-control treatments reduced the weed density significantly compared to WC. The highest weed density was recorded in WC attributable to uncontrolled weed growth. Weed-free check recorded significantly lower total weed density at 20 and 60 DAS of crop. In case of herbicides treatments, at 20 DAS application of all herbicidal treatments recorded significantly lower weed density as compared to weedy-check treatment. However, application of oxadiargyl (PE) @ 100 g/ha *fb* HW at 30 DAS (T₂) treatment resulted in significantly lower weed density of grassy, sedges and broad-leaf weeds at 60 DAS compared to other weed control treatments. Among the sequential herbicide treatments, application of oxadiargyl (PE) @ 100 g/ha *fb* metsulfuron- methyl + chlorimuron – ethyl @ 4 g/ha at 25DAS (T₄) registered a significantly lower density of grassy, sedges and broadleaf weeds at 60 DAS as compared to other sequential herbicide treatments.

Dry biomass is the way of expressing weed dominance in plot. Biomass provides information about the accumulation of growth. The dry biomass of grasses, broad-leaf and sedges was lower with application of oxadiargyl 80 % WP (PE) @ 100 g/ha *fb* HW at 30DAS (T₂) treatment com-

Table 1. Effect of different herbicides on weed density and dry weight of weeds and weed control efficiency (%) in direct seeded rice

Treatments	(mean data of 3 years)															
	No. of weeds / m ²						Total No. of weeds / m ²									
	Grasses		BLW		Sedges		Grasses		BLW		Sedges					
	20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS				
T ₀ -Oxadiargyl (PE)@ 100 g/ha	5.28 (27.56)	6.86 (46.67)	3.18 (9.78)	4.26 (17.78)	3.29 (10.67)	4.05 (16.00)	6.96 (48.0)	8.99 (80.45)	1.75 (1.83)	2.73 (7.00)	1.13 (0.53)	1.63 (2.17)	1.88 (3.05)	3.61 (12.57)	65.10	57.68
T ₁ - Oxadiargyl (PE)@ 100 g/ha/ <i>fb</i> HW at 30DAS	5.28 (27.56)	2.65 (6.67)	3.16 (9.78)	4.89 (20.44)	3.25 (10.22)	2.12 (4.00)	6.92 (47.56)	4.01 (15.56)	1.75 (1.991)	1.22 (1.00)	1.12 (0.65)	1.02 (0.54)	1.92 (3.21)	1.72 (2.47)	65.30	91.70
T ₂ - Oxadiargyl (PE)/ <i>fb</i> Bispyribac - Na @ 25 g/ha at 25DAS	5.14 (26.22)	4.53 (20.44)	3.16 (9.78)	3.51 (12.00)	3.16 (9.78)	3.33 (10.67)	6.76 (45.77)	6.60 (43.11)	1.71 (1.91)	2.01 (3.59)	1.10 (0.61)	1.39 (1.45)	1.91 (3.17)	2.79 (7.33)	66.56	75.52
T ₃ - Oxadiargyl (PE)/ <i>fb</i> Metsulfuron- methyl+ chlorimuron – ethyl @ 4 g/ha at 25DAS	5.01 (24.89)	4.93 (24.00)	3.12 (9.33)	3.03 (8.89)	3.16 (9.78)	2.90 (8.00)	6.65 (44.00)	6.43 (40.89)	1.68 (2.00)	1.87 (3.05)	1.10 (0.65)	1.25 (1.08)	1.98 (3.43)	2.50 (5.83)	67.85	80.37
T ₄ - Oxadiargyl (PE)/ <i>fb</i> carfentozone ethyl 40% @ 25 g/ha at 25DAS	5.20 (26.67)	4.90 (24.00)	3.23 (10.22)	3.38 (11.11)	3.14 (9.78)	3.32 (10.67)	6.84 (46.67)	6.75 (45.78)	1.73 (1.79)	2.01 (3.58)	1.10 (0.53)	1.39 (1.46)	1.86 (2.97)	2.75 (7.17)	65.99	75.86
T ₅ - Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	100.0	100.0
T ₆ Weedy check	9.70 (94.22)	11.32 (127.78)	4.85 (23.11)	5.93 (34.67)	4.41 (19.11)	5.41 (28.89)	11.69 (136.44)	13.85 (191.33)	3.03 (3.59)	4.43 (19.11)	1.65 (1.26)	2.10 (3.94)	2.61 (6.32)	5.49 (29.70)	0	0
SEM±	0.25	0.27	0.13	0.12	0.16	0.12	0.27	0.26	0.07	0.10	0.03	0.05	0.05	0.10	-	-
CD (P= 0.05)	0.77	0.83	0.41	0.38	0.48	0.37	0.83	0.80	0.20	0.31	0.09	0.15	0.17	0.31	-	-

(Figures in parentheses are original values, which were subjected to square root transformation ($\sqrt{x + 0.5}$) before statistical analysis)

pared with weedy-check at 60 DAS and at harvest stages of crop (Table 1). A sequential herbicide treatment, application of oxadiargyl (PE) @ 100 g/ha *fb* metsulfuron- methyl + chlorimuron – ethyl @ 4 g/ha at 25 DAS (T₄) registered significantly lower density of sedges and broad-leaf weeds at 60. This might be due to weeds stop growing after herbicide application and exhibits stunting, inter venial chlorosis and gradual death of the weed so that weed density and dry weight of weeds decreases resulted in reduced competition of crop. Singh *et al.* (2016) who reported initial effectiveness of pre-emergence herbicides, such as pendimethalin and oxadiargyl alone but their performance declined at 45 DAS. Singh *et al.* (2005) emphasized the importance of the sequential application of pendimethalin as pre-emergence and chlorimuron + metsulfuron as post-emergence in realizing reduced grass population. These results conformed with the findings of Yogananda *et al.* (2017), Hemalatha *et al.* (2017), Ramana Murthy *et al.* (2012) and Rajkhowa *et al.* (2005), Sangram Singh *et al.* (2022).

Weed control efficiency

Among herbicidal treatments T₂ (oxadiargyl (PE) @ 100 g/ha *fb* HW at 30 DAS) recorded the maximum weed control efficiency. Among sequential herbicide treatments, application of Oxadiargyl 80% WP (PE) @ 100 g/ha *fb* Metsulfuron- methyl + chlorimuron – ethyl @ 4 g/ha at 25 DAS (T₄) recorded highest weed control efficiency (Table 1). The highest weed control efficiency might be attributed to successive application of 2 herbicides at an interval of 25 days resulting in a reduction in total weed biomass which was comparable to weed free. These results are in agreement with Walia *et al.* (2012) and Dahiphale *et al.* (2015).

Effect of different herbicides on growth, yield attributes and yield of rice

All weed control treatments showed significantly higher values of growth and yield attributes compared to weedy control (Table 2) mainly due to effective suppression of weeds that resulted in improved uptake of inputs like nutrients, light, moisture and other resources by crop. The weed-free check treatment (T₆) recorded significantly superior growth and yield attributes as compared to other treatments including weedy-check. The herbicide treatments increased the plant height (94.44) and yield attributing parameters of rice like number of tillers (481.06 m²), number of effective tillers

Table 2. Effect of different herbicide on, growth, yield attributes and yield of Direct Seeded Rice

Treatments	Growth, yield attributes and yield of rice							
	Plant height (cm)	No. of tillers/m ²	Effective tillers/m ²	Grain yield (t/ha)	Straw yield (t/ha)	Weed index	Net return over Input cost (₹)	Benefit-cost ratio on input cost
T ₁ : Oxadiargyl 80% WP (PE) @ 100 g/ha	86.56	368.33	209.44	2.84	3.39	34.25	9518	1.17
T ₂ : Oxadiargyl 80% WP (PE) @ 100 g/ha fb HW at 30 DAS	92.79	463.33	259.89	4.02	4.87	6.98	29974	1.48
T ₃ : Oxadiargyl 80% WP (PE) fb Bispyribac - Na @ 25 g/ha at 25DAS	89.11	433.33	240.22	3.56	4.22	17.74	22403	1.38
T ₄ : Oxadiargyl 80% WP (PE) fb Metsulfuron- methyl+ chlorimuron – ethyl @ 4 g/ha at 25 DAS	94.44	481.06	269.22	4.02	4.81	7.03	29826	1.48
T ₅ : Oxadiargyl (PE) fb carfentrozone ethyl 40% @ 25 g/ha at 25 DAS	89.71	447.22	248.67	3.66	4.35	15.43	25670	1.44
T ₆ : Weed free check (2HW at 20 & 40 DAS)	95.31	493.89	275.67	4.32	5.18	0.00	34215	1.52
T ₇ : weedy (control)	80.57	270.56	146.78	2.05	2.45	52.66	-2250	0.72
S Em±	0.95	3.72	2.81	0.07	0.08	-	-	-
C.D. at 5 %	2.92	11.45	8.67	0.21	0.26	-	-	-

(269.22 m²) were the highest with application of oxadiargyl (PE) @ 100 g/ha fb metsulfuron- methyl + chlorimuron – ethyl @ 4 g/ha at 25 DAS (T₄) which is at par with treatment T₂ where oxadiargyl (PE) @ 100 g/ha fb HW at 30 DAS was applied. This might be attributed to initial vigorous crop growth restricting the growth of weeds that has indirectly boosted the plants to record higher growth parameters and hence improved yield attributes and yield of rice.

Weed-free treatment (T₆) recorded significantly higher grain (4.32 t/ha) and straw yield (5.18 t/ha) of rice than the rest of the weed-control treatments owing to better control of weeds. Among herbicidal and sequential herbicidal treatments, significantly higher grain yield (4.02 t/ha) and straw yield (4.87 t/ha) were recorded with application of oxadiargyl (PE) @ 100 g/ha fb HW at 30DAS (T₂) as compared with other treatment where as it was at par with oxadiargyl 80% WP (PE) @ 100 g/ha fb metsulfuron-methyl + chlorimuron – ethyl @ 4 g/ha at 25 DAS (T₂) was applied. Significantly lower grain yield and straw yields were recorded with weedy-check (2.04 and 2.45 t/ha, respectively). The enhanced yields under these treatments were because of the elimination of weeds which helped in enhancing the availability of nutrients, space, sunlight and water resulting in better growth and development of crop plants. Similarly, among the herbicides a lower weed index (6.98) was recorded in treatment T₂ where in oxadiargyl 80% WP (PE) @ 100 g/ha fb HW at 30 DAS (T₂) followed by treatment T₄ (weed index 7.03) was recorded in which oxadiargyl 80% WP (PE) @ 100 g/ha fb metsulfuron- methyl + chlorimuron – ethyl @ 4 g/ha at 25 DAS was applied. These results conform with the findings of Walia *et al.* (2012) and Mahadkar *et al.* (2015).

Economics

Weed free condition recorded higher net profit on input cost (34215) and benefit cost ratio (1.52) as compared to other remaining treatments (Table 2). Among herbicide treatments, T₂ recorded high net profit (29974) and benefit-cost ratio (1.48) and treatment T₄ recorded net profit (29826) and benefit cost ratio (1.48). Whereas, the lower net returns were recorded in weedy treatment (-2250) as compared with other treatments. Similar results of higher net returns and B:C ratio in direct-seeded rice due to sequential application of herbicides were also reported by Pinjari *et al.* (2016) and Halder and Thakur (2023).

Based on three years of studies it is concluded that application of oxadiargyl (PE) @ 100 g/ha fb HW at 30 DAS and sequential application of herbicide oxadiargyl (PE) @ 100 g/ha fb Metsulfuron- methyl + chlorimuron – ethyl @ 4 g a.i/ ha at 25 DAS was found to be most effective in weed control as well as higher returns in direct-seeded rice during *kharif* season.

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