Indian Journal of Weed Science (2023) **55**(2): 157–161
http://dx.doi.org/10.5958/0974-8164.2023.00028.X

RESEARCH ARTICLE

Weed dynamics and productivity of transplanted aromatic rice as influenced by pre- and post-emergence herbicides in lower Gangetic alluvial zone

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Received: 18 August 2022 | Revised: 6 March 2023 | Accepted: 9 March 2023

ABSTRACT

A field experiment was conducted during *Kharif* seasons of 2018 and 2019 at Instructional Farm, Jaguli Bidhan, Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, with an objective to identify the best weed management practice in transplanted scented rice. The field experiment was laidout in a randomized block design replicated thrice with twelve treatments. It can be concluded that hand weeding at 20 and 40 days after transplanting (DAT) recorded significantly lower total weed density, total weed biomass, higher weed control efficiency and also higher grain yield, straw yield, and harvest index which were statistically at par with pre-emergence application (PE) of pretilachlor 1.5 kg/ha at 2 DAT followed by (*fb*) post-emergence application (PoE) of bispyribac-sodium at 25.0 g/ha at 20 DAT. Thus, it can be used as the better option for managing weeds and achieving higher productivity by the growers of the locally popular scented transplanted Gobindabhog rice variety in the new lower Gangetic alluvial zone of West Bengal.

Keywords: Aromatic rice, Bispyribac-sodium, Herbicides, Pretilachlor, Weed management, Weed control efficiency

INTRODUCTION

Rice (*Oryza sativa* L.) occupies a pivotal place in Indian agriculture as it is the staple food for more than 70% of the population. With the growing demand for rice, both at the global and national level, the required rice production in India by 2030 is estimated to be 138 million tons. Thus, rice production in India, need to grow by 17% from the current level of 118 million tons in 2020 to reach 138 million tons by 2030 (Chakraborty and Priya 2023). In West Bengal, the production of geographical indication (GI) tag Gobindabhog is about 90 thousand tonnes to 1.0 lakh tonnes/ha over 45 thousand hectares area of land with the potential productivity of 3.0 t/ha. Weeds have become an important production constraint in transplanted rice, and failure to control weeds results in lower crop yields with rice yield losses of may up to 40% (Maity and Mukherjee 2008; Pandey and Bhandari 2009; Rao *et al.* 2017). The weed flora emerges in several flushes during the crop growth period and the weed competition during the early growth is more damaging for rice (Rao *et al.* 2007). Because of the morphological similarities, transplanting of *E. crus-galli* with rice seedlings is very common resulting in 48-71% yield losses (Yu and Liu 1986; Rao and Moody 1987, 1988). In West Bengal under the new alluvial zone, the yield loss of rice due to weed was 37.02% and 23.12% in grain and straw, respectively (Mondal *et al.* 2015). However, the effective control of the weeds had increased the grain yield by 85.5% (Mukherjee and Singh 2005). Hand weeding is commonly used as it is very effective but it is not only laborious but also expensive and accounts for about 25% of the total labour force used which amounts to about 900–1200-man hours/ha (Nadeem *et al.* 2008, Nag and Dutt 1979). Thus, proper management of weeds in the crop field, in time, to reduce the crop-weed competition is difficult due to a sharp increase in the wages and unavailability of labour due to industrialization and urbanization in the community. In view of this, chemical weed control is becoming more popular. Several pre-emergence herbicides are available for controlling weeds, and the need for post-emergence herbicide is often realized to combat weeds emerging during later stages of crop growth. Among the post-emergence herbicides, bispyribac-sodium is a systemic herbicide absorbed by roots and leave and inhibits the enzyme acetoacetate synthase in susceptible weed plants (Pathak *et al.* 2011).

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MATERIALS AND METHODS

A field experiment was conducted during *Kharif* seasons of 2018-19 and 2019-20 at Instructional Farm, Jaguli under Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal (22p 93'N latitude, $88^0$53' E longitude, 9.75 m above mean sea level) to identify best weed management practices in transplanted aromatic rice (*Oryza sativa* L.) variety Gobindabhog in lower Gangetic alluvial zone in lower gangetic alluvial zone of West Bengal. Soil at the experimental site (0-15 cm depth) was clayey loam in texture containing 24.5% sand, 37.4% silt and 42.1% clay with 7.21 pH and 0.58% organic carbon (OC) with medium in available N, P and K contents were 187.5, 38.2 and 201.9 kg/ha, respectively. The average annual rainfall is about 1396 mm; of which 70–80% comes from south-west monsoon with its onset in the region during second week of June. The maximum temperature during experimentation ranged between from 30.3°C to 34.2°C and minimum temperature prevailed between 14°C to 23.2°C. The maximum and minimum relative humidity ranged between 93.4 to 97.3% and 52.8 to 82.2%, respectively. The experiment was laid down in randomized block design with three replications and twelve treatments, *viz*. post-emergence application (PoE) of bispyribac-sodium 25.0 g/ha at 20 days after transplanting (DAT), bispyribac-sodium 40.0 g/ha PoE (20DAT), pre-emergence application (PE) of pretilachlor 1.0 kg/ha at 2 DAT, pretilachlor 1.5 kg/ha PE (2 DAT), pretilachlor 1.0 kg/ha PE (2 DAT)followed by (*fb*) bispyribac-sodium 25.0 g/ha PoE (20 DAT), pretilachlor 1.5 kg /ha PE (2 DAT) *fb* bispyribac-sodium 40.0 g/ha PoE (20 DAT), 2, 4-D ethyl ester 0.850 kg/ha PoE (20 DAT), penoxulam22.5 g/ha PoE (20 DAT), butachlor 1.5 kg/ ha PE (2 DAT), hand weeding twice at 20 DAT and 40 DAT, butachlor1.5 kg/ha PE (2 DAT) *fb* hand weeding at 30 DAT and weedy check. The seedlings of rice var. 'Gobindabhog' were transplanted at 20 (row to row) × 20 cm (plant to plant) spacing in the plots of size 5 × 4 m. The experimental field was ploughed twice with disc harrow and tractor-drawn cultivator followed by puddling with rotavator and later levelled uniformly. Twenty-four days old seedlings were transplanted at a spacing of 20 × 20 cm with 2-3 seedlings per hill. The recommended dose of nitrogen, phosphorus and potassium at 40, 20 and 20 kg/ha in the form of urea, single super phosphate and Muriate of Potash, respectively was applied. Nitrogen was applied in three equal splits at transplanting, maximum tillering stage and at panicle initiation. In this experiment, phosphorous was applied as basal dose at the time of transplanting and potassium was applied in two equal splits at transplanting and panicle initiation stage. The water level was maintained initially at two cm depth till the establishment of seedlings. Later on, water level was maintained at 5 ± 2 cm depth up to physiological maturity and then gradually reduced and drained off fifteen days before the harvest of the crop. All the herbicides were applied using 500 litres of water/ha by spraying uniformly in the experimental plots as per treatments with the help of power operated knapsack sprayer. The density of grasses, sedges and broad-leaved weeds was calculated by placing randomly the quadrat (0.25/m^2 area) at four places and the density (no./m^2) was estimated. Weed species within the area of quadrat were counted and collected and air dried in hot air oven maintained at 70 to 75ºC temperature for recording weed biomass. The data obtained from the field experiment were subjected to statistical analysis wherever the treatment differences were significant F test and critical differences were worked out at 5% probability level and the values were furnished. Weed index (WI) was calculated based on the grain yield obtained from different treatments using the formula.

$$\text{WI (\%)} = \frac{X-Y}{X}$$

Where, WI =Weed index, X = Grain yield from minimum competition plot and

Y = Grain yield from treatment for which weed index has to be worked out

$$\text{Weed control efficiency (\%)} = \frac{(WDM_c - WDM_t)}{WDM_c} \times 100$$

where, WDM_c= Weed biomass in control plot and WDM_t = Weed biomass in the treated plot.

RESULTS AND DISCUSSION

Effect on weeds

The predominant weed flora observed in the experimental site was among grasses: *Echinochloa colona, Echinochloa crus-galli, Cynodon dactylon;* sedges: *Cyperus iria*, *Cyperus difformis*, *Fimbristylis miliacea*, and broad-leaved weeds: *Marsilea quadrifoliata*, *Ludwigia parviflora*, *Ammania baccifera,* and *Alternanthera philoxeroides.* At 30, 60 and 90 DAT, hand weeding twice at 20 and 40 DAT recorded significantly lower weed density and biomass; higher WCE and lower WI than all other the treatments (**Table 1**). The highest weed density and biomass was observed in weedy check (control). Among the herbicide treatments, pretilachlor 1.5 kg/ ha as PE (2DAT) *fb* bispyribac-sodium 25.0 g/ha as PoE (20 DAT) recorded lowest weed density and biomass, higher WCE and lower WI. This might be due to the higher efficacy of pre-emergence herbicide followed by post-mergence herbicide which resulted in lower weed biomass. The results are in conformity with Uma *et al.* (2014), Saha (2006), Sharma *et al.* (2007), Singh (2015), Manjunatha *et al.* (2013). The weed density increased with the advancement of time due to emergence of more flushes of weeds in later stages of crop growth due to weather and agronomic practices (Chauhan and Seth 2013). The minimum weed control efficiency of 64.11% and 54.18% at 60 DAT and 90 DAT, respectively was observed with bispyribac-sodium 25.0 g/ha POE (20 DAT) and the highest weed control efficiency of 86.59% and 74.35% was obtained with hand weeding twice at 20 and 40 DAT, respectively. This might be due to the complete removal of weeds at 20 DAT as it prevents weed regeneration during the period under consideration (Sharma *et al.* 2007).

Effect on crop

At 30, 60 and 90 DAT the best value of plant height, number of tillers, crop dry matter production was recorded with twice hand weeding at 20 and 40 DAT followed by pretilachlor 1.5 kg/ha as PE (2 DAT) *fb* bispyribac-sodium 25.0 g/ha as PoE. The minimum plant, height, number of tillers, crop dry matter production was recorded with weedy check. Among herbicides tested, pretilachlor 1.5 kg/ha PE (2 DAT) *fb* bispyribac-sodium 25.0 g/ha PoE (20 DAT) recorded higher plant height, tillers, crop dry matter production. This might be due to suppression of weed growth by an effective pre-emergence herbicide followed by post-emergence herbicides resulting in better access of resources to growth to rice plants. Pretilachlor 1.5 kg/ha PE (2 DAT) *fb* bispyribac-sodium 25.0 g/ha and hand weeding twice at 20 and 40 DAT recorded highest number of panicles per square metre, panicle length (cm), test weight, grain yield (t/ha), straw yield (t/ha) and harvest index (%). The timely and effective control of weeds with integrated use of pre and post-emergence herbicides resulted in increased yield attributes, which ultimately reflected on grain yield (Deepthi Kiran and Subramanyam 2010). These results are in conformity with Mishra and Singh (2007), Pal and Banerjee (2007), Singh and Paikra (2014) and Uma *et al.* (2014). Minimum yield and yield attributes were recorded with weedy control due to severe weed competition by uncontrolled weed growth (Patra *et*

Table 1. Effect of weed management treatments on weed density, weed biomass, weed control efficiency, weed index (pooled data of 2 years)

Treatment	Total weed density (no./m^2)			Total weed biomass (g/ m^2)			Weed control efficiency (%)			Weed index (%)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	
Bispyribac-sodium 25.0 g/ha PoE (20 DAT)	4.75 (22.0)	7.45 (55.0)	9.66 (92.0)	3.04 (8.7)	3.97 (15.2)	4.74 (21.5)	68.37	64.11	54.18	40.30
Bispyribac-sodium 40.0 g/ha PoE (20 DAT)	3.04 (8.7)	5.31 (27.7)	7.51 (55.0)	2.06 (3.7)	3.22 (9.9)	4.07 (15.7)	86.45	76.79	66.50	16.06
Pretilachlor 1.0 kg/ha PE (2 DAT)	3.20 (9.7)	5.38 (28.4)	7.91 (61.3)	2.18 (4.2)	3.24 (10.0)	4.18 (16.5)	84.61	76.48	64.92	23.33
Pretilachlor 1.5 kg/ha PE (2 DAT)	2.88 (7.7)	5.27 (27.2)	7.31 (52.0)	2.05 (3.7)	3.18 (9.6)	4.02 (15.1)	86.60	77.39	67.72	10.91
Pretilachlor 1.0 kg/ha PE (2 DAT) *fb* bispyribac-sodium 40.0 g/ha PoE (20 DAT)	2.81 (7.4)	5.24 (27.0)	6.91 (46.6)	2.04 (3.6)	3.13 (9.2)	3.89 (14.1)	86.75	78.13	69.89	5.15
Pretilachlor 1.5 kg/ha PE (2 DAT) *fb* bispyribac-sodium 25.0 g/ha PoE (20 DAT)	2.37 (5.1)	4.43 (19.1)	5.97 (34.3)	1.88 (3.0)	2.67 (6.6)	3.69 (12.6)	89.02	84.41	73.09	1.82
2,4-D ethyl ester 0.850 kg/ha PoE (20 DAT)	3.31 (10.4)	5.65 (31.4)	8.51 (71.0)	2.28 (4.7)	3.34 (10.7)	4.33 (17.8)	83.00	74.94	62.18	30.91
Penoxsulam 22.5 g/ha PoE (20 DAT)	3.51 (11.7)	5.98 (35.2)	8.74 (75.0)	2.58 (6.1)	3.42 (11.2)	4.40 (18.4)	77.72	73.67	60.86	37.27
Butachlor 1.5 kg/ha PE (2 DAT)	3.31 (10.4)	5.47 (29.4)	8.00 (62.6)	2.24 (4.5)	3.24 (10.0)	4.25 (17.1)	83.65	76.48	63.62	26.97
Two hand weeding twice at 20 and 40 DAT	2.36 (5.0)	3.95 (15.1)	5.83 (32.6)	1.82 (2.8)	2.49 (5.7)	3.61 (12.0)	89.82	86.59	74.35	-
Butachlor 1.5 kg/ha as PE (2 DAT) *fb* hand weeding at 30 DAT	2.82 (7.4)	5.13 (25.8)	6.49 (40.6)	1.98 (3.4)	2.92 (8.0)	3.80 (13.5)	87.62	81.12	71.30	5.15
Weedy check	8.28 (77.1)	10.92 (130.6)	14.29 (218.9)	4.75 (27.6)	6.02 (42.5)	6.28 (47.7)	-	-	-	42.12
LSD (p=0.05)	0.46	0.52	0.63	0.19	0.31	0.38	-	-	-	-

*Figures in parentheses indicate original values; PE = pre-emergence; PoE = post-emergence; DAT = days after transplanting

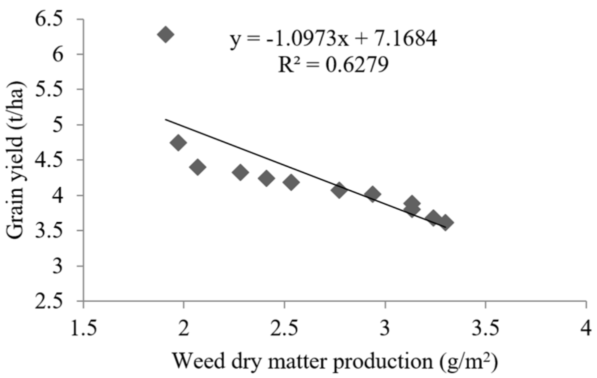
Table 2. Effect of weed management treatments on growth parameters of aromatic rice (pooled data of 2 years)

Treatment	Plant height (cm)			Tillers (no./m^2)			Dry matter production (g/m^2)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Bispyribac-sodium 25.0 g/ha PoE (20 DAT)	46.30	69.66	91.01	195.56	237.29	270.68	114.93	223.40	489.40
Bispyribac-sodium 40.0 g/ha PoE (20 DAT)	51.33	72.23	98.21	205.26	247.29	279.42	134.71	289.27	593.00
Pretilachlor 1.0 kg/ha PE (2 DAT)	50.31	71.80	95.90	203.41	245.52	276.51	128.21	281.52	579.51
Pretilachlor 1.5 kg/ha PE (2 DAT)	50.74	72.51	99.43	207.36	249.56	285.17	147.34	310.71	619.24
Pretilachlor 1.0 kg/ha PE (2 DAT) *fb* bispyribac-sodium 40.0 g/ha PoE (20 DAT)	52.21	73.23	102.10	208.46	251.13	289.35	158.43	348.61	660.68
Pretilachlor 1.5 kg/ha PE (2 DAT) *fb* bispyribac-sodium 25.0 g/ha PoE (20 DAT)	58.20	73.49	110.95	213.36	245.40	295.49	173.99	380.41	698.57
2,4-D ethyl ester 0.850 kg/ha PoE (20 DAT)	49.54	72.75	93.79	201.11	243.49	272.51	116.82	229.05	514.74
Penoxsulam 22.5 g/ha PoE (20 DAT)	47.51	69.79	92.34	198.22	240.07	271.67	114.93	228.53	491.94
Butachlor 1.5 kg/ha PE (2 DAT)	50.00	71.21	94.80	202.50	244.31	275.47	115.28	232.29	528.31
Two hand weeding (HW) twice at 20 and 40 DAT	61.23	82.25	121.17	216.71	251.39	302.37	210.65	436.59	773.07
Butachlor 1.5 kg/ha as PE (2 DAT) *fb* HW at 30 DAT	55.01	73.2	106.91	211.18	252.47	290.19	163.43	357.85	646.51
Weedy check	43.50	65.83	87.20	194.50	236.63	268.42	103.17	203.03	455.09
LSD (p=0.05)	2.94	4.45	5.84	0.29	1.29	0.11	10.36	16.60	27.85

Table 3. Effect of weed management treatments on yield and yield attributes of aromatic rice (pooled data of 2 years)

Treatment	No of Panicles/ m^2	Panicle length (cm)	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Bispyribac-sodium 25.0 g/ha PoE (20 DAT)	281.66	23.77	10.12	1.97	4.10
Bispyribac-sodium 40.0 g/ha PoE (20 DAT)	307.33	25.00	10.60	2.77	5.76
Pretilachlor 1.0 kg/ha PE (2 DAT)	305.00	24.76	10.50	2.53	5.47
Pretilachlor 1.5 kg/ha PE (2 DAT)	313.66	25.26	10.72	2.94	6.05
Pretilachlor1.0kg/ha PE (2 DAT) *fb* bispyribac-sodium 40.0 g/ha PoE (20 DAT)	320.00	25.83	10.83	3.13	6.45
Pretilachlor1.5 kg/ha PE (2 DAT) *fb* bispyribac-sodium 25.0 g/ha PoE (20 DAT)	337.60	26.50	11.26	3.24	6.63
2,4-D ethyl ester 0.850 kg/ha PoE (20 DAT)	297.66	24.33	10.32	2.28	4.79
Penoxsulam 22.5 g/ha PoE (20 DAT)	283.33	24.00	10.24	2.07	4.36
Butachlor 1.5 kg/ha PE (2 DAT)	299.00	24.63	10.36	2.41	5.25
Two hand weeding twice at 20 and 40 DAT	370.00	26.66	11.39	3.30	6.65
Butachlor 1.5 kg/ha as PE (2 DAT) *fb* hand weeding at 30 DAT	328.33	26.23	11.13	3.13	6.41
Weedy check	272.33	23.16	10.08	1.91	4.01
LSD (p=0.05)	33.95	1.72	0.38	0.31	0.37

Figure 1. The linear regression between grain yield and weed dry matter production in transplanted aromatic rice during 2018-19 and 2019-2020



al. 2006). Grain yield with hand weeding twice is appreciably higher due to efficient weed control but it is time-consuming, laborious, presently too costly, and non-availability of labourers at peak agricultural operations. Hence, though grain yield recorded with twice hand weeding was appreciably good due to efficient weed control but it cannot be recommended for large scale. These results are in conformity with Mishra and Singh (2007) and Pal and Banerjee (2007). A significantly negative correlation (R^2=0.627) was observed between grain yield and weed dry matter production (**Figure 1**).

Conclusion

It can be concluded that hand weeding twice at 20 and 40 DAT was statistically at par with pretilachlor 1.5 kg/ha PE (2 DAT) *fb* bispyribac-sodium 25.0 g/ha as PoE (20 DAT) in attaining significantly higher grain yield, straw yield and harvest index by managing weeds effectively. Hence, they are the better options for the growers of the locally popular scented transplanted Gobindabhog variety of rice in the new alluvium lower Gangetic zone of West Bengal.

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