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Effect of Integrated Weed Management Practices on Weed Parameters in Direct Seeded Aerobic Rice

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ABSTRACT: Weeds are the major constraints in aerobic rice cultivation, which offer stronger competition for essential growth factors. The weeds like *Echinocloacolona* and *E. crus-galli* affect the crop majorly. The yield loss may result in complete failure for crop. Even after development of several weed management strategies, no single method had proven fully effective. But the integrated approach that combines the advantages of various method can reduce the weed menace in aerobic rice cultivation. Different integrated weed management treatments were evaluated at Wetland farm, Department of Agronomy, TNAU, Coimbatore, to find the best performing integrated management practice during summer (March-July) 2022. Results showed that grassy weeds dominated in the aerobic rice field followed by broad leaved weeds. The integrated treatment, application of pyrazosulfuron ethyl (30g a.i./ha) as pre-emergence (3 DAS)*fb* bispyribac sodium (40g a.i./ha) as early post-emergence (12 DAS)*fb* one mechanical weeding (45 DAS) recorded higher weed control with decreased weed density (21.3/m^2) and weed dry weight (15.55 g/m^2)and the higher weed control efficiency (92.5%) at 60 DAS and was on par with the application of pendimethalin (1kg a.i./ha) as pre-emergence (3 DAS) *fb* two hand weeding (25 and 45 DAS).

Keywords: Aerobic rice, Bispyribac sodium, Pyrazosulfuron ethyl, Weed Control Efficiency, Weed Control index, Weed Persistence index.

INTRODUCTION

Aerobic rice production is a newly evolved concept to get higher yields with less water. In comparison with cultivation of lowland transplanted rice, the aerobic rice saves nearly half of water by reducing the water requirements for land preparation and nursery raising and also due to absence of standing water. According to Castaneda *et al.,* (2002), compared to lowland rice, water requirements in aerobic rice were 50per cent lower (470 mm—650 mm) and witnessed an increment of 64–88per cent in water productivity and a reduction in labor use by 55per cent. The reduction is also witnessed in seed rate, transplanting costs and labor wages (Kumar *et al.*, 2020).

In aerobic rice fields, the crop and weeds emerge together and weeds have comparative growth advantage. They compete for all the essential growth factors like light, space, nutrients and water. Weed competition is too severe that even within a single crop life cycle there may be three generations or flushes of weeds competing with them (Nagargade *et al.*, 2018). The yield of aerobic rice will reduce to a greater extent if left un-weeded. The extent of loss in yields due to improper weed management ranges between 62.2 to 91.7 per cent (Sunil, 2018). The weed competition may rise up to the extent that rice crop will get killed and no grain yield can be obtained (Bhullar *et al.*, 2016). This loss in yield can be overcome by efficient and integrated weed management practices. There are different methods of weed management, of which some are proven effective, some are economical and some others time saving.

Hand weeding is the primitive method of weed management that stands best even today. Though hand weeding is considered as a standard, in direct-seeded aerobic rice it is time and labor consuming. Also, hand weeding is at least five times more cost intense than herbicides, especially under limited and expensive labour situations (Rao *et al.*, 2017). Mechanical weeding helps in easy weeding than manual method, but it is confined to inter-row weeds, leaving the intra-row unattended. Singh *et al.* (2016) reported that in comparison with weed free condition, there was a reduction of 14-27 per cent rice grain yield in the plots treated with pendimethalin *fb* bispyribac sodium, which was due to the weeds that escaped herbicide applications, indicating the emerging ability of weeds even after chemical spray. Hence, studies have been made to evaluate the integrated approach of weed management. Munnoli *et al.* (2018) reported that higher growth and yield of aerobic rice in integrated weed management can be achieved by early control of initial flush of weeds by pre-emergence or early post-emergence and subsequent control of further weed growth by either manual or some herbicide application, that ensures necessary weed free conditions for better crop growth. Present study was taken up with different weed management methods like manual, mechanical and chemical methods, that are put together in different combinations and evaluated for efficient integrated weed management practice in aerobic rice.

MATERIALS AND METHODS

Field experiment was carriedout at Wetland Farms, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during *Summer* (March-June) 2022. The soil of the experimental field was neutral in reaction (pH:7.7), low in available N (238.3 kg/ha) and medium in available P (12.1 kg/ha) and high in available K (408.7 kg/ha). The experiment was laid in randomised block design, with nine treatments replicated thrice. The treatment details are furnished in Table 1. The different herbicides used in the experimental study were pendimethalin, pyrazosulfuron ethyl and bispyribac-sodium. The mechanical weeding was carried out using rotary weeder. The treatment of pendimethalin with two hand weeding was taken as standard check for comparision of other integrated weed management treatments.

Table 1: Integrated weed management treatments and their details.

Treatments	Dose	Time of application(DAS)
T_1 –PE Pendimethalin 30 EC *fb* two hand weeding	1 kg a.i./ha	3 *fb* 25 *fb* 45
T_2–PE Pyrazosulfuron ethyl 10 WP *fb* two handweeding	30g a.i./ha	3 *fb* 25 *fb* 45
T_3–PE Pyrazosulfuron ethyl 10 WP *fb* two mechanical weeding	30g a.i./ha	3 *fb* 25 *fb* 45
T_4–EPoEBispyribac sodium 10 SC *fb* one hand weeding	40g a.i./ha	12 *fb* 45
T_5 – EPoEBispyribac sodium 10 SC *fb* one mechanical weeding	40g a.i./ha	12 *fb* 45
T_6–PE Pyrazosulfuron ethyl 10 WP *fb*EPoEBispyribac sodium 10 SC *fb* one mechanical weeding	30g a.i./ha *fb*40g a.i./ha	3 *fb* 12 *fb* 45
T_7 – Two Hand weeding	-	25 *fb* 45
T_8 – Two Mechanical weeding	-	25 *fb* 45
T_9 – Control (Weedy check)	-	Full crop period

PE-pre-emergence; EPoE-early post-emergence; EC-emulsifiable concentrate; SC-soluble concentrate; WP-wet table powder; fb-followed by; a.i./ha-active ingredient per hectare.

Rice variety CO-53 was used in the experiment. The field was ploughed thoroughly and fine tilth was obtained to facilitate easy sowing. The gross plot size was 5m × 3m and net plot was 4.6m × 2.6m. Sowing was done manually on March second week with the seed rate of 75kg/ha, spacing of 20cm × 10cm and was irrigated immediately. Recommended dose of fertilisers (150:50:50 kg/ha of N, P and K) was given in split doses, along with basal micro-nutrient application of Zinc sulphate (25 kg/ha) and iron sulphate (25 kg/ha). The pre-emergence and early post-emergence herbicides were sprayed at 3 DAS and 12 DAS, respectively. Hand weeding and mechanical weeding operations were carried out as per the treatment schedule on 25 DAS and 45 DAS.

Weed density and weed biomass of grasses and broadleaved weeds were recorded separately using $0.25m^2$ quadrat. The quadrat was placed in four random spots within each plot and weed count and weed biomass were taken for per square meter area. The observations were recorded at 30, 60 and 90 DAS. The weed samples were sun dried and oven dried for 24-48 hours at 65°C and weed dry matter was recorded.

Weed control efficiency, weed control index and weed persistence index for all the treatments were calculated using the formula (Mani *et al.*, 1973; Misra and Tosh, 1979; Mishra and Misra, 1997).

Weed Control Efficiency

$$= \frac{\text{WD Control plot (no./m}^2\text{) - WD Treated plot (no./m}^2\text{)}}{\text{WD Control (no./m}^2\text{)}}$$

Weed Control Index

$$= \frac{\text{WDM Control plot (g/m}^2\text{)} - \text{WDM Treated plot (g/m}^2\text{)}}{\text{WD}_\text{M}\text{ Control (g/m}^2\text{)}}$$

Weed Persistence Index

$$= \frac{\text{WD Control plot}}{\text{WD Treated plot}} \times \frac{\text{WD}_\text{M}\text{ Treated plot}}{\text{WD}_\text{M}\text{ Control plot}}$$

Where, WD = Weed density, WD_M = Weed dry matter

The weed data were statistically analysed according to the procedure given by Gomez and Gomez (1984) to find the significant difference (at five per cent probability level) and superior among the nine treatments. The data on weed density and weed dry matter is subjected to square root transformation ($\sqrt{x+0.5}$).

RESULTS AND DISCUSSION

Composition of weed flora in experimental field. Being sown in upland condition and receiving alternate wetting and drying method of irrigation, in the absence of standing water, aerobic rice recorded several species of weeds, that included mainly grasses and broadleaved weeds (Table 2). Weeds clearly showed periodicity of germination, as several weeds were seen after a month of sowing and few weeds made their presence even at flowering stage of crop. But the diversity of weed flora was restricted, as the experimental field was subjected to puddling in previous crop, which was also reasonable for absence of sedge weeds during entire period of crop growth (Munnoli *et al.*, 2018).

Table 2: Composition of weed flora in experimental field.

Sr. No.	Botanical name	Common name	Family
I.	**Grassy weeds**		
1.	*Echinocloacolona*	Jungle grass	Poaceae
2.	*Echinocloa crus-galli*	Barnyard grass	Poaceae
3.	*Dinebraretroflexa*	Viper grass	Poaceae
4.	*Chloris barbata*	Purpletopchloris	Poaceae
II.	**Broad-leaved weeds**		
1.	*Portulaca oleracea*	Common purslane	Portulacaceae
2.	*Corchorus olitorius*	Nalta jute	Malvaceae
3.	*Hibiscus vitifolius*	Grape leaved mallow	Malvaceae
4.	*Amaranthus viridis*	Slender amaranth, pigweed	Amaranthaceae

Weed density. Among the treatments, significant difference was recorded in weed densities in all the treated plots. At 30 DAS, the treatment application pendimethalin (1kg a.i./ha) as pre-emergence *fb* two hand weeding (T_1) recorded significant superiority in controlling weed density (10.7/m^2). This was on par with two hand weeding at 25^{th} and 45^{th} days (T_7) (11.0/m^2) andthe treatment of pyrazosulfuron ethyl (30ga.i./ha) as pre-emergence *fb* bispyribac sodium (40g a.i./ha) as early post-emergence *fb* one mechanical weeding (T_6) (12.3/m^2). The decreased weed density in these treatments indicated the efficient control of weeds with the pre-emergence application of pendimethalin and pyrazosulfuron ethyl at 3 DAS. Similar observations for pre-emergence application of herbicides were recorded by Awan *et al.* (2016); Singh *et al.* (2016). However, the control plot (T_9) without any weed control measure recorded the highest weed density of 266.0/m^2 (Table 3).

Table 3: Effect of integrated weed management practices on Weed density (No./m^2) and Weed dry matter (g/m^2)at 30, 60 and 90 DAS.

	Treatments	Total Weed Density (No./m^2)			Total Weed Dry matter (g/m^2)		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	PE Pendimethalin 1 kg a.i./ha *fb* two hand weeding at 25 and 45 DAS	3.3 (10.7)	4.6 (20.3)	4.8 (22.7)	1.49 (1.72)	4.18 (17.07)	5.41 (28.84)
T_2	PE Pyrazosulfuron ethyl 30 g a.i./ha *fb* two hand weeding at 25 and 45 DAS	3.5 (11.7)	5.0 (24.7)	5.8 (33.3)	1.52 (1.83)	4.37 (18.65)	6.38 (40.20)
T_3	PE Pyrazosulfuron ethyl 30 g a.i./ha*fb* two mechanical weeding at 25 and 45 DAS	5.0 (25.0)	6.7 (45.0)	7.1 (50.0)	2.24 (4.54)	6.06 (36.25)	7.72 (59.24)
T_4	EPoE Bispyribac sodium 40 g a.i./ha *fb* one hand weeding at 45 DAS	5.0 (24.7)	4.9 (23.3)	4.9 (24.0)	2.23 (4.48)	4.28 (17.81)	5.23 (26.88)
T_5	EPoE Bispyribac sodium 40 g a.i./ha *fb* one mechanical weeding at 45 DAS	5.1 (26.0)	6.4 (40.7)	5.9 (34.3)	2.23 (4.46)	5.83 (33.58)	6.70 (44.49)
T_6	PE Pyrazosulfuron ethyl 30 g a.i./ha *fb* EPoE Bispyribac sodium 40 g a.i./ha*fb* one mechanical weeding at 45 DAS	3.6 (12.3)	4.7 (21.3)	4.8 (23.0)	1.50 (1.76)	4.01 (15.55)	5.14 (25.96)
T_7	Two Hand weeding at 25 and 45 DAS	3.4 (11.0)	5.0 (24.7)	5.7 (31.7)	1.51 (1.80)	4.42 (19.16)	6.00 (35.60)
T_8	Two Mechanical weeding at 25 and 45 DAS	10.9 (118.7)	10.2 (104.0)	10.0 (100.0)	4.21 (17.28)	10.32 (106.23)	10.99 (120.30)
T_9	Control (Weedy check)	16.3 (266.0)	16.8 (282.7)	16.2 (261.0)	6.47 (41.40)	13.99 (195.90)	15.34 (236.26)
	SEd	0.3	0.4	0.5	0.15	0.37	0.46
	CD (P=0.05)	0.7	0.9	1.0	0.32	0.79	0.97

The total weed density at 60 DAS was significantly reduced in the treatment, pendimethalin (1kg a.i./ha) as pre-emergence *fb* two hand weeding (T_1) (20.3/m^2), that was comparable with pyrazosulfuron ethyl (30g a.i./ha) as pre-emergence *fb* bispyribac sodium (40g a.i./ha) as early post-emergence *fb* one mechanical weeding (T_6) (21.3/m^2), while unweeded control plot (T_9) recorded highest weed density (282.7/m^2). The decreased weed density was attributed to the sequential application of pre-emergence and early post-emergence herbicides in the former treatment. Similar findings were also recorded by Hemalatha and Singh (2018); Kumar *et al.*(2020).

At 90 DAS, the treatment of pendimethalin (1kg a.i./ha) as pre-emergence *fb* two hand weeding (T_1) recorded significantly lower weed density (22.7/m^2) and was followed by the application of pyrazosulfuron ethyl (30g a.i./ha) as pre-emergence *fb* bispyribac sodium (40g a.i./ha) as early post-emergence *fb* one mechanical weeding (T_6) (23.0/m^2) and application of early post-emergence bispyribac sodium (40g a.i./ha) *fb* one hand weeding (T_4) (24.0/m^2). The weed control with decreased weed densities reflected the benefit of integration of early post-emergence application of bispyribac sodium that either followed pre-emergence application of pyrazosulfuron ethyl or as alone *fb* one hand weeding (Rana *et al.*, 2016; Patil *et al.*, 2020; Kumari *et al.*, 2016). The control of multiple flushes of weeds that germinate periodically was reason for better reduction in weed density.

Weed dry matter. During early stage of crop growth, at 30 DAS, the treatments that combined the pre-emergence application of either pendimethalin (1kg a.i./ha) or pyrazosulfuron ethyl (30g a.i./ha) with hand weeding or early post-emergence spray of bispyribac sodium (40g a.i./ha)achieved significantly lower weed dry matter than other treatments. The weed dry matter in pendimethalin (1kg a.i./ha) applied as pre-emergence herbicide *fb* two hand weeding (T_1) was 1.72g/m^2, that was comparable with other two treatments, *viz.*, pyrazosulfuron ethyl (30g a.i./ha) as pre-emergence that followed bispyribac sodium (40g a.i./ha) as early post-emergence*fb* one mechanical weeding (T_6) (1.76 g/m^2) and two hand weeding (T_7) (1.80g/m^2). The results were in accordance with Saravanane *et al.* (2016), where the pre-emergence herbicides have effectively controlled the initial flush of weeds by suppressing the germination and also by killing the emerging weeds.

The treatment with pyrazosulfuron ethyl (30g a.i./ha) as pre-emergence *fb* bispyribac sodium (40g a.i./ha) as early post-emergence *fb* one mechanical weeding (T_6) achieved significantly lower values for weed dry weight (15.55g/m^2) at 60 DAS and was on par with pendimethalin (1kg a.i./ha) as pre-emergence *fb* two hand weeding (17.07g/m^2) and bispyribac sodium (40g a.i./ha) as early post-emergence *fb* one hand weeding (T_4) (17.81g/m^2). The results were in accordance with Sar and Duary(2022). The highest weed dry weight was recorded in control plot (T_9) without any treatment application (195.90g/m^2). The weed dry weight reduction is clearly due to the efficient control of weeds by the application of early-post emergence bispyribac sodium(Kumar *et al.*, 2013; Singh *et al.*, 2016). The similar trend of observation was noticed at 90 DAS, where pyrazosulfuron ethyl (30g a.i./ha) as pre-emergence *fb* bispyribac sodium (40g a.i./ha) as early post-emergence *fb* one mechanical weeding (T_6)recorded significantly lower values for weed dry weight (25.96g/m^2). But the highest weed dry matter was seen in control (T_9) (un-weeded check) (236.26g/m^2).

Table 4: Effect of integrated weed management practices on Weed Control Efficiency (%), Weed Control Index & Weed Persistence Index at 30, 60 and 90 DAS.

	Treatments	Weed control efficiency (%)			Weed control index			Weed persistence index		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	PE Pendimethalin 1 kg a.i./ha*fb* two hand weeding at 25 and 45 DAS	96.0	92.8	91.3	95.9	91.3	87.8	1.04	1.21	1.41
T_2	PE Pyrazosulfuron ethyl 30 g a.i./ha*fb* two hand weeding at 25 and 45 DAS	95.6	91.3	87.2	95.6	90.5	83.0	1.01	1.09	1.34
T_3	PE Pyrazosulfuron ethyl 30 g a.i./ha *fb* two mechanical weeding at 25 and 45 DAS	90.6	84.1	80.8	89.0	81.5	74.9	1.17	1.17	1.31
T_4	EPoE Bispyribac sodium 40 g a.i./ha*fb* one hand weeding at 45 DAS	90.7	91.7	90.8	89.2	90.9	88.6	1.17	1.10	1.24
T_5	EPoE Bispyribac sodium 40 g a.i./ha*fb* one mechanical weeding at 45 DAS	90.2	85.6	86.8	89.2	82.9	81.2	1.10	1.20	1.44
T_6	PE Pyrazosulfuron ethyl 30 g a.i./ha *fb* EPoE Bispyribac sodium 40 g a.i./ha *fb* one mechanical weeding at 45 DAS	95.4	92.5	91.2	95.8	92.1	89.0	0.91	1.06	1.25
T_7	Two Hand weeding at 25 and 45 DAS	95.9	91.3	87.9	95.7	90.2	84.9	1.04	1.12	1.25
T_8	Two Mechanical weeding at 25 and 45 DAS	55.4	63.2	61.7	58.3	45.8	49.1	0.93	1.48	1.33
T_9	Control (Weedy check)	-	-	-	-	-	-	1.00	1.00	1.00

Weed control efficiency. Weed control efficiency varied between the treatments. Among the treatments, pendimethalin (1kg a.i./ha) as pre-emergence *fb* two hand weeding (T_1) recorded highest per cent of weed control efficiency at 30, 60 and 90 DAS (96.0%, 92.8% and 91.3%, respectively). Similar recordings were also observed by Verma *et al.* (2017). The application of pyrazosulfuron ethyl (30g a.i./ha) as pre-emergence *fb* bispyribac sodium (40g a.i./ha) as early post-emergence *fb* one mechanical weeding (T_6) was recorded the next best treatment at 60 and 90 DAS (92.5% and 91.2%, respectively). This indicated the broad-spectrum and longer period control of weeds by sequential application of herbicides and integrated management of weeds combined with mechanical weeding. Similar observation was also noted by Pinjari *et al.* (2016) and Soujanya *et al.* (2020). Two times hand weeded plots (T_7)recorded better weed control efficiency at 30 DAS (95.9%), followed by the plots with sequential application of pyrazosulfuron ethyl, bispyribac sodium and mechanical weeding in order (T_6) (95.5%).

Weed control index. The weed control index was higher in the treatment of pyrazosulfuron ethyl (30g a.i./ha) as pre-emergence *fb* bispyribac sodium (40g a.i./ha) as early post-emergence *fb* one mechanical weeding (T_6), at 30, 60 and 90 DAS with values of 95.8, 92.1 and 89.0, respectively. This was followed by the treatment, pendimethalin (1kg a.i./ha) as pre-emergence *fb* two hand weeding (T_1) (95.9, 91.3 and 87.8, respectively). With these values, it was clear that the treatment of sequential application of herbicides with mechanical weeding had reduced the weed dry weight efficiently over the control plots (un-weeded check) Singh *et al.*(2018) also recorded similar observations. Among the treatments, two times mechanically weeded plots (T_8) recorded very low weed control index at all the observations.

Weed persistence index. Weed persistence index is a measure of persistence/resistance of the weeds that escaped the applied treatment, whose higher value indicates greater persistence and lower indicating less (Garko *et al.*, 2020).The treatment of pyrazosulfuron ethyl (30g a.i./ha) as pre-emergence *fb* bispyribac sodium (40g a.i./ha) as early post-emergence *fb* one mechanical weeding (T_6) had recorded lowest weed persistence values at 30 and 60 DAS (0.91 and 1.06, respectively) and at 90 DAS, the value was 1.25, which was similar to two hand weeding treatment. This indicated the lower persistence of weeds in these treatments. The results were in line with Mishra *et al.*(2016).

CONCLUSION

From the above results, it could be concluded that the treatment pyrazosulfuron ethyl (30g a.i./ha) as pre-emergence *fb* bispyribac sodium (40g a.i./ha) as early post-emergence *fb* one mechanical weeding (T_6)gave broader spectrum control of weeds and reduced the weed density and weed dry matter and was comparable with the standard check of pendimethalin (1kg a.i./ha) as pre-emergence *fb* two hand weeding (T_1), in terms of weed density and weed dry matter production.

FUTURE SCOPE

As weeds are the major constraints in agricultural crops and individual methods of weed control are not fully effective, integrated weed management approaches sounds better suitable under field conditions. Effectiveness of combining different herbicides with other weed managing strategies should be studied for cost effective integrated weed management practices.

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Conflict of interest. None.

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