Madras Agric. J., 105 (4-6): 161-164, June 2018

Integrated Weed Management in Aerobic Rice

Sourabh Munnoli*, D. Rajakumar, C. Chinnusamy and N. Thavaprakaash
Department of Agronomy
Tamil Nadu Agricultural University, Coimbatore - 641 003

Field experiment was conducted at the Wetlands Farm of Department of Farm Management, Tamil Nadu Agricultural University to find an effective integrated weed management strategy for the control of complex weed flora of aerobic rice. Pre emergence (PE) application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + Early post emergence (EPOE) application of bispyribac sodium (25 g ha^{-1}) on 20 DAS significantly lowered weed density and dry weight. This sequential application of pendimethalin and bispyribac sodium recorded 61.11 per cent increased yield over weedy check. The net return was higher in PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (`35,973 ha^{-1}). Mean while growing intercrops as living mulch showed promising results for using it as a component of integrated weed management practice.

Key words: Aerobic rice, Integrated weed management, Mulching, Sequential application of herbicides

Rice is an important staple food crop of the world. In India, it plays a vital role in meeting the nutritional demand of the nation. It is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 44.6 M ha with a production of 132 MT of rice and average productivity of 2.96 t ha^{-1}.The per capita water availability fell off from 5300 m^3 year^{-1} in 1953 to 2500 m^3 year^{-1} in 1990 and expected to further shrink to 1500 m^3 year^{-1} by 2025 signifying that irrigation water has been turned out to be scanty. Aerobic rice cultivation stands unique for it is sown and established in non-puddled, non-flooded fields which add to water productivity by reducing the seepage, percolation and evaporation. One of the major constraints which limit the yield of aerobic rice is that this crop suffers severely from weed infestations. In wetland ecosystem, rice has a 2-3 week 'head start' over weeds which complement the rice crop in competing weeds that have not emerged yet at transplanting. The continuous inundated water that exists after transplanting suppresses the emergence and growth of most weed flora effectively. Among all the rice growing eco systems, greatest weed pressure and competition occurs in aerobic rice system. Because, dry tillage and alternate wetting and drying conditions are favorable for germination and growth of weeds. Almost double the weed density and weed biomass was observed in aerobic rice field when compared to conventional transplanted condition (Mahajan *et al.,* 2011). Weeds are one of the main constraints in aerobic rice cultivation. Yield loss from 50 to 100 per cent has been reported due to weeds in aerobic rice (Mishra and Singh 2008). With this background, to find an effective integrated weed management practices an objective to find a cost effective weed management strategy for aerobic rice.

*Corresponding author's email: sourabh.ssm@gmail.com.

Material and Methods

The field experiment was conducted at Wetland Farms of Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore during *Kharif* 2017. The farm is geographically located at 11°N latitude and 77°E longitude and at an altitude of 426.7 m above mean sea level. Coimbatore is located in the Western agro climatic zone of Tamil Nadu. The soil of the experimental field was neutral in reaction (pH: 7.1), low in available N (215.1 kg ha^{-1}) and high in available P (13.5 kg ha^{-1}) and K (487.0 kg ha^{-1}). The experiment was laid out in randomized block design with twelve treatments in three replications. Treatment details are as follows,

T_1	-	PE Pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS
T_2	-	EPOE Bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS
T_3	-	EPOE Chlorimuron ethyl + Metsulfuron methyl (4 g ha^{-1}) on 2-3 leaf stage of weeds
T_4	-	PE Pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE Bispyribac (25 g ha^{-1}) on 20 DAS
T_5	-	Daincha intercropping (1:1) + Spreading on 30 DAS
T_6	-	Cowpea intercropping (1:1) + Spreading on 30 DAS
T_7	-	Coir pith mulching @ 5 tons ha^{-1} on 3 DAS
T_8	-	Shredded coconut waste mulching @ 5 tons ha^{-1} on 3 DAS
T_9	-	Mechanical weeding on 20 and 40 DAS
T_{10}	-	Hand weeding on 20 and 40 DAS
T_{11}	-	Mechanical weeding on 20 DAS + HW on 40 DAS
T_{12}	-	Weedy check

(HW - Hand weeding: MW - Mechanical weeding: DAS - Days after sowing: PE – Pre emergence: EPOE – Early post emergence)

Results and Discussion

Weed flora of the experimental field

Weed flora of the experimental field consisted of two and four species of grass and broad-leaved weeds, respectively. In the experimental field, sedges were not observed. *Echinochloa colona* and *Dinebra retroflexa* were the predominant grassy weeds and *Corchorus olitorius, Trianthema portulacastrum, Euphorbia microphylla* and *Hibiscus vitifolius* were the broad leaved weeds. Puddling operation is always having positive impact on the reduction of the weed seed bank. Lowland rice was the previous crop in the experimental field. Hence, the weed floral diversity was found to be limited and also accounted for absence of the sedges (Jha and Kewat, 2013 and Gajri *et al.* 1999).

Table 1. Influence of chemical and non chemical weed management practices on weed parameters of aerobic rice

	Treatments	Weed density (m^{-2})		Weed dry weight (g m^{-2})		WCE (%)	
		20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS
T_1	PE Pendimethalin + HW on 40 DAS	1.62 (02.13)	4.51 (19.82)	1.20 (00.94)	6.01 (35.60)	98.2	78.4
T_2	EPOE Bisyribac + HW on 40 DAS	9.45 (88.80)	4.68 (21.41)	7.31 (52.94)	6.38 (40.20)	-	75.7
T_3	EPOE Almix on 2-3 leaf stage of weeds	9.38 (87.57)	6.74 (44.93)	7.25 (52.09)	9.57 (91.10)	-	44.8
T_4	PE Pendimethalin + EPOE Bispyribac	1.55 (01.90)	3.03 (08.70)	1.24 (01.05)	3.55 (12.10)	98.0	92.7
T_5	Daincha intercropping (1:1) + Spreading on 30 DAS	6.75 (45.08)	7.16 (50.83)	3.33 (10.59)	10.14 (102.3)	80.1	38.0
T_6	Cowpea intercropping (1:1) + Spreading on 30 DAS	6.68 (44.17)	7.70 (58.83)	3.38 (10.94)	10.53 (110.3)	79.4	33.2
T_7	Coir pith mulching (5 tons ha^{-1}) on 3 DAS	9.45 (88.86)	11.95 (142.3)	7.07 (49.52)	12.79 (163.1)	6.9	1.2
T_8	Shredded coconut waste mulching (5 tons ha^{-1}) on 3 DAS	7.25 (52.05)	9.78 (95.22)	3.82 (14.06)	11.64 (135.1)	73.6	18.2
T_9	MW on 20 and 40 DAS	9.24 (84.93)	6.36 (39.92)	7.15 (50.61)	9.37 (87.30)	-	47.1
T_{10}	HW on 20 and 40 DAS	9.73 (94.22)	2.81 (07.41)	7.25 (52.03)	3.26 (10.10)	-	93.9
T_{11}	MW on 20 DAS + HW on 40 DAS	9.52 (90.17)	6.31 (39.36)	7.30 (52.76)	9.44 (88.70)	-	46.3
T_{12}	Weedy check	9.52 (90.13)	12.19 (148.08)	7.33 (53.20)	12.87 (165.1)	0.0	0.0
SEd		0.54	0.62	0.76	0.86		
CD (P=0.05)		1.11	1.28	1.58	1.74		

PE Pendimethalin - PE application of pendimethalin (1 kg ha^{-1}) on 3 DAS. HW- Hand weeding
EPOE Bispyribac - EPOE of bispyribac sodium (25 g ha^{-1}) on 20 DAS. MW - Mechanical weeding
EPOE Almix - EPOE of chlorimuron ethyl + metsulfuron methyl (25 g ha^{-1}). DAS - Days after sowing

(Figures in parenthesis are original values; data subjected to square root transformation ($\sqrt{x+0.5}$)

Weed density

There was a significant difference between various weed management practices on 20 DAS and lower weed density was observed in PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (1.90 m^{-2}) and PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (2.13 m^{-2}), which were on par with each other. *Daincha* intercropping (1:1) + spreading on 30 DAS (45.08 m^{-2}), cowpea intercropping (1:1) + spreading on 30 DAS (44.17 m^{-2}) and shredded coconut waste mulching (5 tons ha^{-1}) on 3 DAS (52.05 m^{-2}) were the subsequent comparable treatments (Table 1).

On 40 DAS, PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS and hand weeding on 20 and 40 DAS were comparable with lower weed density (8.70 and 7.41 m^{-2}, respectively) and was followed by PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (19.82 m^{-2}) and EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS (21.41 m^{-2}). Lower weed density in both the herbicides applied treatment was due to sequential management of weeds by the application of EPOE application of bispyribac sodium after PE application of pendimethalin. Similar results were also reported by Walia *et al.* (2008) and Mahaja and Timsina (2011). However, higher weed density was observed under the treatments, weedy check (148.08 m^{-2}) and coir pith mulching (5 tons ha^{-1}) on 3 DAS (142.33 m^{-2}).

The treatment with 2 MW on 20 and 40 DAS and 1 MW on 20 DAS + 1 HW on 40 DAS recorded lesser weed density than other non-chemical weed management practices on 40 DAS suggesting their efficiency in managing weeds. But, the weeds that remained in the intra-row *i.e.*, in between plants were not removed in mechanically weeded plots. Also heavy rains during early crop growth may prevent mechanical weeding in clay soils (Rajakumar *et al.,* 2010). Similarly, there was not much variation among weed densities registered on 20 and 40 DAS in *daincha* and cowpea intercropping and spreading on 30 DAS. Though there were evidences for their effectiveness in managing weeds, the quantity required for spreading the ground cover might not have been sufficient to serve as physical barrier.

Higher weed density was observed under the treatments, weedy check (148.08 m^{-2}) and coir pith mulching (5 tons ha^{-1}) on 3 DAS (142.33 m^{-2}).

Weed dry weight

With regard to total weed dry weight on 20 DAS, PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (0.94 g m^{-2}) and PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (1.05 g m^{-2}) recorded lower weed dry weight which were found to be statistically significant. The treatments *viz*., *Daincha* intercropping (1:1) + spreading on 30 DAS (10.59 g m^{-2}), cowpea intercropping (1:1) + spreading on 30 DAS (10.94 g m^{-2}) and shredded coconut waste mulching (5 tons ha^{-1}) on 3 DAS (14.06 g m^{-2}) were comparable with respect to total weed dry weight (Table 1).

On 40th day of observation, the treatments, hand weeding on 20 and 40 DAS (10.10 g m^{-2}) and PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (12.10 g m^{-2}) were found to be comparable. Subsequently, PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (35.60 g m^{-2}) and EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS (40.20 g m^{-2}) were the next on par treatments. Effectiveness of these two treatments was mainly due to the timely PE application of pendimethalin at sufficient moisture level and its effect in controlling the weed seed germination effectively (Saravanane *et al.,* 2016). Higher total weed dry weight was recorded in weedy check (165.10 g m^{-2}) and coir pith mulching (5 tons ha^{-1}) on 3 DAS (163.10 g m^{-2}) than the rest of the treatments.

Table 2. Influence of chemical and non chemical weed management practices on yield, weed index and economics of aerobic rice

	Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Total cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1	PE Pendimethalin + HW on 40 DAS	4031	5512	37586	67458	29872	1.79
T_2	EPOE Bispyribac + HW on 40 DAS	3987	5389	37586	66596	29010	1.77
T_3	EPOE Almix on 2-3 leaf stage of weeds	3006	4589	28391	48841	20451	1.72
T_4	PE Pendimethalin + EPOE Bispyribac	4128	5697	33213	69186	35973	2.08
T_5	*Daincha* intercropping (1:1) + Spreading on 30 DAS	2576	3940	32876	43944	11068	1.34
T_6	Cowpea intercropping (1:1) + Spreading on 30 DAS	2426	3789	34376	41542	7166	1.21
T_7	Coir pith mulching (5 tons ha^{-1}) on 3 DAS	1840	2840	32616	33780	1164	1.04
T_8	Shredded coconut waste mulching (5 tons ha^{-1}) on 3 DAS	2212	3489	31876	37946	6070	1.19
T_9	MW on 20 and 40 DAS	2321	3612	37816	39718	1902	1.05
T_{10}	HW on 20 and 40 DAS	4298	5802	41216	71776	30560	1.74
T_{11}	MW on 20 DAS + HW on 40 DAS	3286	4700	39516	55404	21668	1.40
T_{12}	Weedy check	1812	2794	27616	28968	1352	1.05
	SEd	179	310	-	-	-	-
	CD (P=0.05)	371	643	-	-	-	-

PE - PE application of pendimethalin (1 kg ha^{-1}) on 3 DAS. HW- Hand weeding
EPOE Bis - EPOE of bispyribac sodium (25 g ha^{-1}) on 20 DAS. MW - Mechanical weeding
EPOE Almix - EPOE of chlorimuron ethyl + metsulfuron methyl (25 g ha^{-1}) DAS - Days after sowing

Weed control efficiency

Weed control efficiency (WCE) infers the magnitude of effective reduction of weeds by weed management treatments over unweeded control. This was highly influenced by different weed management treatments in the experiment conducted. It was observed that weed control efficiency on 20 DAS was higher (98.2 per cent) in PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS which was closely followed by PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (98.0 per cent). This might be due to greater reduction of grasses and BLW through early arrest of weed germination by pendimethalin and further regrowth as effectively checked by bispyribac sodium in PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) and hand weeding on 20 and 40 DAS, respectively. (Chauhan *et al.,* 2015). Among all the treatments imposed, coir pith mulching @ 5 tons ha^{-1} on 3 DAS (T_7) recorded the least weed control efficiency (6.9 per cent) (Table 1).

Weed control efficiency on 40 DAS showed that hand weeding on 20 and 40 DAS (T_{10}) recorded higher weed control efficiency (93.9 per cent) which was followed by PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (92.7 per cent). Among the non-chemical weed management practices, *daincha* and cowpea intercropping and spreading on 30 DAS recorded a weed control efficiency of 38.0 and 33.2 per cent respectively followed by shredded coconut waste mulching @ 5 tons ha^{-1} on 3 DAS (18.2 per cent). Coir pith mulching @ 5 tons ha^{-1} on 3 DAS registered a lower weed control efficiency of 1.2 per cent. The least weed control efficiency was observed in coir pith mulching @ 5 tons ha^{-1} on 3

DAS. Insufficient quantity and nature of coir pith that was washed away in irrigation water and wind lead to ineffective control of weeds during critical crop growth period leading to higher weed density and dry weight in coir pith mulching.

Grain yield

In the experiment conducted, along with the treatment hand weeding twice, chemical weed management practices recorded higher yields. Hand weeding on 20 and 40 DAS (4298 kg ha^{-1}), PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS (4128kg ha^{-1}), PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS (4031kg ha^{-1}), EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS (3987 kg ha^{-1}) recorded 61.11, 59.55 , 58.57 and 57.97 per cent more yield than weed check. Higher grain yield might be attributed to the weed free environment provided by early control of weeds by PE application of pendimethalin/EPOE application of bispyribac sodium and subsequent establishment of weed free condition either manually or by spraying chemicals in the respective treatments at later stage (Table 2).

The treatments, growing intercrops and spreading were performing better than coconut waste residue mulch. Intercrops being leguminous in nature might have created complimentary environment for crop growth apart from reducing the weed growth. Coir pith mulching @ 5 tons ha^{-1} on 3 DAS recorded substantially lower yield (1840 kg ha^{-1}). It was found that higher quantum of mulches was needed to significantly decrease weed emergence as compared to the present level of 5 tons ha^{-1}.

Economics

The highest cost of cultivation was registered with hand weeding on 20 and 40 DAS (` 41216 $ha^{-1}$) and was followed by mechanical weeding on 20 DAS + Hand weeding on 40 DAS ($T_{11}$) (` 39516 ha^{-1}). A proportion of 33.0 per cent of cost of cultivation expenses was directed to hand weeding operations. Timely availability of labours may also alter the per cent contribution of weeding operation in total cost of cultivation. Chemical weeding showed 24 per cent lesser capital requirement for controlling the weeds in aerobic rice. This was mainly due to the low man power that was required for the chemical weeding. In spite of higher cost of cultivation, hand weeding on 20 and 40 DAS recorded higher gross returns (` 71776 $ha^{-1}$) that was followed by PE application of pendimethalin (1.0 kg $ha^{-1}$) on 3 DAS + EPOE of bispyribac sodium (25 g $ha^{-1}$) on 20 DAS (` 69186 ha^{-1}). This was mainly attributed to the higher biological yield recorded in those treatments (Table 2).

The net return was higher in PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE of bispyribac sodium (25 g ha^{-1}) on 20 DAS (` 35973 ha^{-1}). This was mainly due to lower cost of cultivation and higher gross returns (Singh *et al.*, 2016). The B:C ratio was higher (2.08) in PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS followed by 1.79 in PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + HW on 40 DAS and 1.77 in EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS + HW on 40 DAS.

Conclusion

It can be concluded that PE application of pendimethalin (1.0 kg ha^{-1}) on 3 DAS + EPOE application of bispyribac sodium (25 g ha^{-1}) on 20 DAS was effective and economically viable in managing the weeds under aerobic rice system.

References

Chauhan, B.S, T.H. Awan, S.B., Abugho and G. Evengelista. 2015. Effect of Crop establishment methods and Weed control treatments on Weed management and Rice yield. *Filed Crops Res.,* **172**: 72-84.

Gajri, P.R., K.S. Gill, R. Singh and B.S. Gill. 1999. Effect of pre-planting tillage on crop yields and weed biomass in a rice-wheat system on a sandy loam soil in Punjab. *Soil & Tillage Res.,* **52**: 83-89.

Jha. A and M.L. Kewat. 2013. Weed composition and seed bank as affected by different tillage and crop establishment techniques in rice–wheat system. *Indian J. Weed Sci.* **45(1)**: 19–24.

Mahajan, G., B. Chauhan, and M. Gill. 2011. Optimal nitrogen fertilization timing and rate in dry-seeded rice in northwest India. *Agron. J.,* **103(6)**: 1676-1682.

Mahajan.G. and J. Timsina. 2011. Effect of nitrogen rates and weed control methods on weeds abundance and yield of direct-seeded rice. *Archives of Agronomy and Soil Science*. **57:3**: 239-250.

Mishra, J., and V. Singh. 2008. Integrated weed management in dry-seeded irrigated rice (*Oryza sativa* L.). *Indian J. Agron., **53***(**4**): 299-305.

Rajakumar, D., E. Subramanian, N. Maragatham and G. Thiyagarajan. 2010. Integrated weed and nitrogen management in aerobic rice. **In** Proceedings National conference on challenges in weed management in agro-ecosystems, present status and future strategies. Tamil Nadu Agricultural University, Coimbatore. 278.

Saravanane, P., S. Mala and V. Chellamuthu. 2016. Integrated Weed Management in Aerobic rice. *Indian J. Weed Sci.* **48(2)**: 152-154.

Singh, V., M. L. Jat, Z. A., Ganie, B.S., Chauhan, and R.K., Gupta. 2016. Herbicide options for effective weed management in dry direct-seeded rice under scented rice-wheat rotation of western Indo-Gangetic Plains. *Crop Protection.* **81**: 168-176.

Walia, U.S., M.S. Bhullar, S. Nayyar and S.S. Walia. 2008. Control of complex weed flora of dry-seeded rice (*Oryza sativa* L.) with pre and post-emergence herbicides. *Indian J. Weed Sci.* **40(3)**: 161-164.

Received : June 03, 2018; Revised : June 24, 2018; Accepted : June 28, 2018