

Effect of Weed Management Practices on Complex Weed Flora and Soil Microflora in Aerobic Rice under Rainfed Condition of Bihar

Birendra Kumar¹, Sunil Kumar², Rakesh Deo Ranjan^{3*} and C. S. Azad⁴

¹Department of Agronomy, Bihar Agricultural College, Sabour, Bhagalpur, Bihar 813 210, India.

²Soil Survey and Land Use Planning Scheme, Bihar Agricultural College, Sabour, Bhagalpu 813210, India.

³Department of Plant Physiology & Biochemistry, Bihar Agricultural College, Sabour, Bhagalpur 813210, India.

⁴Department of Plant Pathology, Bihar Agricultural College, Sabour, Bhagalpur 813210, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A Field experiment was conducted during the *Kharif* season of 2018 at Bihar Agricultural University, Sabour (Bihar) to evaluate the performance of different herbicides in aerobic rice (*Oryza sativa* L). Weed management had a positive influence on growth, yield attributes and yield of the aerobic rice. In experimental field, *Cyperus rotundus*, *Cyperus iria*, *Cyperus difformis*, *Cynodon dactylon*, *Eleusine indica*, *Fimbristylis miliacea*, *Echinochloa colona*, *Echinochloa crus-galli*, *Commelina benghalensis*, *Caesulia auxillaris*, *Lippia nodiflora*, *Amaranthus spinosus*, *Oxalis acetosella*, *Amaranthus viridis*, *Eclipta alba*, *Phyllanthus niruri* and *Monochoria vaginalis* were the dominant weed flora species. The results revealed that lowest weed population and weed dry weight were recorded in weed free situation which were significantly superior over rest of the herbicidal treatments. The maximum mean grain yield of aerobic rice (4.00 t/ha) was recorded by weed free which intern was statistically at par with the mean grain yield obtained from the herbicide

*Corresponding author: E-mail: rakeshdeoranj@rediffmail.com, rakeshdeoranj@rediff.com;

Pyrazosulfuron fb one hand weeding (3.92 t/ha) followed by Pyrazosulfuron fb Bispyribac (3.88 t/ha), Bispyribac sodium (3.83 t/ha), Pyrazosulfuron+Ethoxysulfuron (3.62 t/ha), Bispyribac sodium+Pyrazosulfuron (3.61 t/ha) and Halosulfuron + Azimsulfuron (3.50 t/ha). Significantly lowest mean grain yield of (1.90 t/ha) was obtained from weedy check plots. The highest weed control efficiency (100%) was recorded under the treatment weed free which was followed by Pyrazosulfuron fb one hand weeding (85.96%), Pyrazosulfuron fb Bispyribac (84.77%), Bispyribac sodium (83.09%). All microflora (*bacteria, fungi, actinomycetes*) were recorded maximum number under the treatment weedy check. There were halosulfuron causes some phytotoxic effects at early stage on rice crop. The highest gross return (Rs.70,000/ha) was obtained by weed free which was statistically at par with Pyrazosulfuron fb one hand weeding (Rs.68,600/ha), Pyrazosulfuron fb Bispyribac(Rs.67,900/ha), Bispyribac sodium (Rs.67,025/ha), Pyrazosulfuron+Ethoxysulfuron (Rs.63,350), Bispyribac sodium+Pyrazosulfuron (Rs.58,800/ha) and significantly superior over rest of the treatments. However, the highest net return (Rs. 37,323/ha) was recorded by the treatment Pyrazosulfuron fb Bispyribac sodium which was found superior over rest of the treatments. The highest B:C ratio (Rs.2.22) was recorded by Pyrazosulfuron fb Bispyribac which was statistically at par with Bispyribac sodium (Rs.2.20), Pyrazosulfuron fb one hand weeding (Rs.2.19), Pyrazosulfuron+Ethoxysulfuron (Rs.2.13) and Bispyribac sodium+Pyrazosulfuron (Rs.1.91) all these were significantly superior over rest of the treatments.

Keywords: Aerobic rice; economics; grain yield; herbicides; weed density.

1. INTRODUCTION

Rice production cost in the subtropics areas are subject to rapidly changing basic parameters induced by changing in climate, limiting resources, high labour cost and increasing prices of bio-fuel and renewable resources. Aerobic rice growing system is gaining importance for increasing productivity and reduced cost of production in Bihar. India is the world's second largest producer of rice after china, accounting 20% of world rice production. In Bihar, total area under this crop is 31.59 lakhs ha, producing 61.55 lakhs metric tons and with average productivity of 1948 kg/ha (Statistics- Department of Agriculture. Govt. of Bihar, 2018-19 [1]).

Aerobic rice grows well in nonpuddled and nonsaturated soils with water content of 70% to 100% of water holding capacity throughout a growing season [2]. Aerobic rice can save as much as 50% of irrigation water in comparison with lowland rice. Savings are also from land preparation, no transplanting costs, seed costs, time saving and labor costs. Aerobic rice emits 80-85 % lesser methane gas into the atmosphere thus keeping the environment safe. Weeds are endemic in rice crop and a constant problem in rice production because of their dynamic nature. Despite modern management practices aimed at weed elimination, weeds continues to be a ubiquitous and recurrent threat for crop production due to its ability to shift in response to management practices and environmental conditions, because of the diversity and plasticity of weed communities, weed management should

include diverse approaches. However, aerobic systems are subject to much higher weed pressure than conventionally puddle transplanted rice. Aerobic rice is a potential water wise rice production system, but high weed infestation has threatened its sustainability, which demands an efficient and cost-effective weed management technique. Herbicide products were applied singly or as tank-mix or in sequence to evaluate their efficacy in aerobic rice. In aerobic rice weeds cause yield loss to an extent of 50-100% in order to overcome this problem an appropriate weed management practices are required [3].

Therefore, timely weed control at early stage is imperative for realizing desired level of productivity from aerobic rice. The use of herbicides offers selective and economic control of weeds right from the beginning, giving crop an advantage of good establish and competitive superiority. A number of pre-emergence and post-emergence herbicides have been recommended for the control of early and late flushes of weeds in aerobic rice field. These herbicides are specific and are effective against narrow range of weed species. The intensive use of such herbicides year after year has resulted in herbicide resistance problems and consequently, management of weeds is becoming increasingly more difficult and complex [4]. Moreover, continuous use of these herbicides leads to a shift of weed flora from grassy to non grassy broadleaf weeds and annual sedges. Thus, it would be desirable to use alternative herbicides that may provide wide spectrum of weed control. Manual weeding is often difficult due to

inadequate supply of laborers in time, higher cost and non workable condition of the field. In such situation, use of herbicides is an obvious choice. Proper weed management is considered to be one of the most important prerequisites to ensure satisfactory yield of aerobic rice. Jayadeva et al. [5] revealed that the integrated weed management has got the potential to reduce herbicide use and to provide a robust and sustainable weed management. Therefore, for designing a sustainable weed management strategy for aerobic rice, it is a prerequisite to assess the simultaneous effect of different herbicides application. Keeping these in view, an attempt was made to know most suitable herbicides and manual weeding combinations to provide a comprehensive integrated weed management system for aerobic rice in rainfed areas of Bihar.

2. MATERIALS AND METHODS

Field experiment was conducted during rainy seasons (*kharif*) of 2018 at Bihar Agricultural University, Sabour, Bihar (25° 04' N Latitude, 87° 04' E Longitude and 37.19 meter above mean sea levels). The treatments were arranged in a randomized block design with three replications. The experiment comprised 14 (Fourteen) weed management treatments viz., Pyrazosulfuron @ 20 g/ha as pre-emergence, Pendimethalin @1.0 l/ha as pre-emergence, Penoxsulam@22.5 g/ha as pre-emergence, Pretilachlor+Bensulfuron methyl@500+60 g/ha as pre-emergence, Pyrazosulfuron@ 20 g/ha as pre-emergence fb Fenoxaprop-P-ethyl@ 60 g/ha as post-emergence, Pyrazosulfuron+Ethoxysulfuron@ 20+20 g/ha as post-emergence, Bispyribac + Pyrazosulfuron@ 20 + 15 g/ha as post-emergence, 2,4-DEE@750 g/ha as post-emergence, Halosulfuron + Azimsulfuron@37.5+20 g/ha as post-emergence, Bispyribac@25 g/ha as post-emergence, Pyrazosulfuron @ 25 g/ha as pre-emergence fb one hand weeding, Pyrazosulfuron @20 g/ha as pre-emergence fb Bispyribac@20 g/ha as post-emergence, Weedy check, Weed free.

The aerobic rice variety "Sahbhagidhan" was sown at 20 cm apart in rows in the first week of June. The crop was fertilized with 80, 40, 20 kg/ha of N, P₂O₅ and K₂O respectively. In rice, half recommended dose of N (40 kg/ha) and full dose of P₂O₅ and K₂O was applied at sowing while the remaining nitrogen (40 kg/ha) was applied in two splits dose, half at active tillering and the rest half at panicle initiation stage. All the

others recommended agronomic and plant protection measures were adopted to raise the rice crop. Pre-emergence and Post-emergence herbicides were applied in saturated soil moisture as per the protocol of application time, using knapsack sprayer fitted with flat fan nozzle at spray volume of 500 l/ha. In the plots under weed free (hand weeding), weeds were removed manually by using khurpi. The experimental soil was sandy-loam in texture with pH 7.0. The organic carbon, electrical conductivity, available nitrogen, phosphorus and potash were 0.59%, 0.101 ds/m, 276.1, 17.07 and 289.65 kg/ha, respectively. The rainfall received during the crop season was 750 mm. Data on weed density, weed dry weight and weed control efficiency were recorded at different stages after rice sowing with the help of a quadrat (0.5 m x 0.5 m) at 3 places and then converted into per m². Weeds were cut at ground level, washed with tap water. The biomass was determined after drying the samples in an oven at 70°C for 72 hrs. Crop was manually harvested during last week of October. Weed control efficiency (WCE) was calculated as per the standard formula:

$$\text{WCE \%} = \frac{\text{dry weight of weeds in weedy check plots} - \text{dry weight of weeds in treated plots}}{\text{dry weight of weeds in weedy check plots}} \times 100.$$

Grain yield of rice along with other yield attributing characters like effective panicles/m², grains/panicle and test weight were recorded at harvest. Grain yield was converted to t ha⁻¹ at 14% moisture content. Cost of cultivation and gross return were calculated on the basis of prevailing market prices of different inputs and outputs, respectively.

3. RESULTS AND DISCUSSION

3.1 Weed Flora, Weed Density, Weed Dry Weight and Weed Control Efficiency

The most predominant weed species present in the experimental site were *Cynodon dactylon* (L) Pers., *Cyperus rotundus* (L.), *Cyperus iria* (L.), *Cyperus difformis* (L.), *Digitaria sanguinalis* (L.), *Fimbristylis miliacea* (L) Vaha., *Eclipta alba* (L.), *Echinochloa colona* (L). link., *Echinochloa crus-galli* (L) P. Beauv., *Eleusine indica* (L.), *Phyllanthus niruri* (L.), *Euphorbia hirta* (L.), *Amaranthus viridis* (L.), *Oxalis acetosella* (L) and *Commelina benghalensis* (L). The combination of grasses, sedges and broad leaf weeds in weedy check plot were 18, 30 and 52% respectively. The results are in conformity with

the findings of Anwar et al. [6]. Emergence of broad leaf weeds was noticed earlier than of sedges and grasses. Weed community in the aerobic rice is generally dominated by broadleaf weeds followed by sedges and grasses were reported by Jayadeva et al. [5] and Sunil et al. [7].

Weed density and weed dry weight were higher at 60 (DAS). This was perhaps due to death of some of the weeds like *Cyperus difformis*, *Echinochloa crus-galli*, *Marsilea quadrifoliata* and *Commelina benghalensis* and the shading effect of crop plant on short nature weeds. At both the stages of observation unweedy check recorded significantly higher weed population and weed dry weight than any other treatment (Table.1). Weed free plots were recorded the minimum weed population and dry weight and the highest weed control efficiency at 60 DAS. Among the herbicidal treatments, application of Pyrazosulfuron fb one hand weeding followed by Pyrazosulfuron fb Bispyribac, Bispyribac sodium, Pyrazosulfuron+Ethoxysulfuron, Bispyribac sodium+Pyrazosulfuron and Halosulfuron + Azimsulfuron obtained lowest weed dry weight/m², weed density/m² and highest weed control efficiency%. The highest weed control efficiency (100%) was recorded under the treatment weed free which was followed by Pyrazosulfuron fb one hand weeding (85.96%), Pyrazosulfuron fb Bispyribac (84.77%), Bispyribac sodium (83.09%). The reduction of weed density and dry weight may be attributed to broad spectrum and season long weed control properties exhibited by the herbicide mixture or sequential application. Unweeded control plots recorded the highest weed density and dry weight and lowest weed control efficiency. This was mainly due to better control of weeds growth even upto harvest resulting in lower dry weight of weeds. The results are in conformity with the findings of Singh et al. [8].

3.2 Yield and Yield Attributes

All the weed control treatment combinations significantly reduced the weeds flora as compared to weedy check and single use of herbicide and recorded higher grain yield of rice. Pyrazosulfuron fb one hand weeding (3.92 t/ha) followed by Pyrazosulfuron fb Bispyribac (3.88 t/ha), Bispyribac sodium (3.83 t/ha), Pyrazosulfuron+Ethoxysulfuron (3.62 t/ha), Bispyribac sodium+Pyrazosulfuron (3.61 t/ha) and Halosulfuron + Azimsulfuron (3.50 t/ha) recorded higher grain yield as well as recorded

higher yield attributing characters like productive panicles per m², panicle length, filled grains per panicle and 1000-grain weight. Better weed control facilitated the crop for better absorption of nutrients, more sun light, less weeds-crop competition, space and air in weed free plots. The increased grain yield in these treatments were owing to reduced weed density, weed dry weight and better weed control efficiency and higher panicles/unit area conformity with Singh et al. [8] (Table 1). Rao and Singh [9] also reported that increased grain yield by herbicide mixture and sequential herbicide application respectively. The minimum yield and yield attributes were received in weedy check plots, the result of severe weed competition by the uncontrolled weed growth. There was little phytotoxic effect of halosulfuron methyl herbicide at initial stages applied in aerobic rice crop.

3.3 Economics and Soil Microflora

Among weed control measures, the highest gross return (Rs.70,000/ha) was obtained by weed free which was statistically at par with Pyrazosulfuron fb one hand weeding (Rs.68,600/ha), Pyrazosulfuron fb Bispyribac (Rs.67,900/ha), Bispyribac sodium (Rs.67,025/ha), Pyrazosulfuron+Ethoxysulfuron (Rs.63,350), Bispyribac sodium+Pyrazosulfuron (Rs.58,800/ha) and significantly superior over rest of the treatments. However, the highest net return (Rs. 37,323/ha) was recorded by the treatment Pyrazosulfuron fb Bispyribac sodium which was found superior over rest of the treatments. The highest B:C ratio (Rs.2.22) was recorded by Pyrazosulfuron fb Bispyribac which was statistically at par with Bispyribac sodium (Rs.2.20), Pyrazosulfuron fb one hand weeding (Rs.2.19), Pyrazosulfuron+Ethoxysulfuron (Rs.2.13) and Bispyribac sodium+Pyrazosulfuron (Rs.1.91), all these were significantly superior over rest of the treatments (Table. 3). This could be due to high weed control efficiency and higher grain yield obtained owing to application of effective herbicide dose and combinations. Thus application of all above herbicides proved more effective in checking the weed population and their growth and increasing the grain yield in aerobic rice. When herbicides were replaced by manual weeding, gross income increased but net benefit decreased because of high cost involvement in manual weeding. Even a combined early and post-emergence application generated more net benefit as compared to manual weeding. Consequently, manual weeding is less remunerative compared to herbicidal

Table 1. Effects of weed management practices on weed flora, yield attributes and yield in aerobic rice

Herbicides	Dose (g /ha)	Application time (DAS)	Weed density/m ² (60 DAS)	Weed biomass (g/m ²) (60 DAS)	WCE%	Plant height (cm)	Effective panicles/m ²	Panicle length (cm)	Filled grain per panicle	Test weight (g)	Yield (t/ha)	
T1	Pyrazosulfuron	20	Pre-em (0-3 DAS)	24.31	33.08	49.50	121.61	195.33	22.92	62.65	22.25	2.69
T2	Pendimethalin	1000	Pre-em (0-3 DAS)	23.45	31.45	51.29	122.67	197.67	23.15	63.68	22.39	2.81
T3	Penoxsulam	22.5	Pre-em (0-3 DAS)	26.74	35.20	44.46	121.05	193.67	22.28	61.67	21.73	2.62
T4	Pretilachlor+Bensulfuron methyl	500+60	Pre-em (0-3 DAS)	17.54	25.79	63.57	125.00	199.33	23.97	66.27	22.94	3.06
T5	Pyrazosulfuron fb Fenoxaprop-P-ethyl	20+60	Pre & Post-em (15DAS)	16.68	24.63	65.35	125.17	206.67	24.29	66.46	22.98	3.23
T6	Pyrazosulfuron+Ethoxysulfuron	20+20	Post-em (15DAS)	10.16	18.66	78.89	127.11	212.33	25.48	72.03	23.66	3.62
T7	Bispyribac + Pyrazosulfuron	20 + 15	Post-em (15-20 DAS)	15.36	22.41	68.09	125.73	208.67	24.40	67.35	23.12	3.32
T8	2,4-D EE	750	Post-em (30 DAS)	17.69	25.90	63.25	123.95	198.33	23.46	65.04	22.85	2.91
T9	Halosulfuron + Azimsulfuron	37.5+20	Post-em (15-20 DAS)	11.47	19.91	76.18	126.42	210.67	25.06	70.68	23.49	3.50
T10	Bispyribac	25	Post-em (15 DAS)	8.14	15.00	83.09	127.56	215.33	25.52	73.57	23.74	3.83
T11	Pyrazosulfuron fb one hand weeding	25	Pre-em (0-3 DAS) fb HW	6.76	11.47	85.96	128.43	219.33	26.44	74.33	24.05	3.92
T12	Pyrazosulfuron fb Bispyribac	20 fb 20	Pre-em (0-3 DAS) fb Post-em (25 DAS)	7.33	12.04	84.77	128.04	217.00	26.11	73.66	24.01	3.88
T13	Weedy check	-	-	48.14	69.37	-	113.70	176.00	21.65	50.02	21.72	1.90
T14	Weed free	-	-	0.71	0.71	100.00	129.00	222.67	26.78	75.01	24.10	4.00
	S. Em±			1.34	1.88	-	4.00	19.44	1.78	5.99	1.59	0.19
	LSD (0.05)			4.12	5.76	-	12.12	59.33	NS	18.29	NS	0.58

Table 2. Effects of weed management practices on microbial population in aerobic rice

Herbicides	Dose (g/ha)	Application time (DAS)	Bacteria (10 ⁵ cfu g ⁻¹ soil)	Fungi (10 ⁵ cfu g ⁻¹ soil)	Actinomycetes (10 ⁵ cfu g ⁻¹ soil)
T1	Pyrazosulfuron	20	Pre-em (0-3 DAS)	82.02	72.14
T2	Pendimethalin	1000	Pre-em (0-3 DAS)	82.30	72.58
T3	Penoxsulam	22.5	Pre-em (0-3 DAS)	84.36	75.04
T4	Pretilachlor+Bensulfuron methyl	500+60	Pre-em (0-3 DAS)	84.67	75.33
T5	Pyrazosulfuron fb Fenoxaprop-P-ethyl	20+60	Pre & Post-em (15DAS)	95.01	78.55
T6	Pyrazosulfuron+Ethoxysulfuron	20+20	Post-em (15DAS)	79.87	68.78
T7	Bispyribac + Pyrazosulfuron	20 + 15	Post-em (15-20 DAS)	84.13	74.86
T8	2,4-D EE	750	Post-em (30 DAS)	83.96	71.35
T9	Halosulfuron + Azimsulfuron	37.5+20	Post-em (15-20 DAS)	84.65	72.56
T10	Bispyribac	25	Post-em (15 DAS)	80.54	69.24
T11	Pyrazosulfuron fb one hand weeding	25	Pre-em (0-3 DAS) fb HW	84.68	75.45
T12	Pyrazosulfuron fb Bispyribac	20 fb 20	Pre-em (0-3 DAS) fb Post-em (25 DAS)	82.36	72.71
T13	Weedy check	-	-	96.12	80.14
T14	Weed free	-	-	85.12	76.98
	S. Em±			8.14	2.46
	LSD (0.05)			24.86	7.51

Table 3. Effects of weed management practices on cost of cultivation, gross return, net return and benefit: cost ratio in aerobic rice

Herbicides	Dose (g /ha)	Application time (DAS)	Cost of cultivation (Rs.)	Gross return (Rs.)	Net return (Rs.)	B:C ratio (Rs.)	
T1	Pyrazosulfuron	20	Pre-em (0-3 DAS)	28725	47075	18350	1.64
T2	Pendimethalin	1000	Pre-em (0-3 DAS)	29352	49175	19823	1.68
T3	Penoxsulam	22.5	Pre-em (0-3 DAS)	29077	45850	16773	1.58
T4	Pretilachlor+Bensulfuron methyl	500+60	Pre-em (0-3 DAS)	30400	53550	23150	1.76
T5	Pyrazosulfuron fb Fenoxaprop-P-ethyl	20+60	Pre & Post-em (15DAS)	29976	56525	26549	1.89
T6	Pyrazosulfuron+Ethoxysulfuron	20+20	Post-em (15DAS)	29702	63350	33648	2.13
T7	Bispyribac + Pyrazosulfuron	20 + 15	Post-em (15-20 DAS)	30758	58800	28042	1.91
T8	2,4-D EE	750	Post-em (30 DAS)	28454	50925	22471	1.79
T9	Halosulfuron + Azimsulfuron	37.5+20	Post-em (15-20 DAS)	33470	61250	27780	1.83
T10	Bispyribac	25	Post-em (15 DAS)	30402	67025	36623	2.20
T11	Pyrazosulfuron fb one hand weeding	25	Pre-em (0-3 DAS) fb HW	31295	68600	37305	2.19
T12	Pyrazosulfuron fb Bispyribac	20 fb 20	Pre-em (0-3 DAS) fb Post-em (25 DAS)	30577	67900	37323	2.22
T13	Weedy check	-	-	28000	33250	5250	1.19
T14	Weed free	-	-	38560	70000	31440	1.82
	S. Em±			-	3312	3017	0.11
	LSD (0.05) CD (P=0.05)			-	10107	9109	0.34

control confirming the view by Mahajan et al. [10]. All microflora (*bacteria*, *fungi*, *actinomycetes*) were recorded maximum under the treatment weedy check. These weed management methods were found to be promising to control weeds in aerobic rice and would play an important role in areas where labour is too expensive and time is a constraint.

4. CONCLUSION

Based on these findings, it is concluded that weed free treatment, Pyrazosulfuron fb one hand weeding, Pyrazosulfuron fb Bispyribac, Bispyribac sodium, Pyrazosulfuron +Ethoxy sulfuron, Bispyribac sodium+Pyrazosulfuron and Halosulfuron + Azimsulfuron were the best among the treatments and it may effective control of a broad spectrum of weeds in aerobic rice. However, its application should be followed by a pre and post herbicide in future. There is also a possibility of reducing herbicide dosage through the integration of different weed management strategies. These six herbicides combinations may be recommended for controlling of predominant weeds flora in aerobic rice.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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