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RESEARCH ARTICLE

Management of jungle rice *(Echinochloa colona)* through herbicides in transplanted rice

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ABSTRACT

Field experiments were conducted to select suitable pre- and post-emergence herbicides for the control of *Echinochloa colonum* in rice. Treatments consisted of herbicide, *viz.* unweeded control, two hand weeding at 20 and 40 DAT/DAS, (PE) application of premixed pretilachlor 6% + bensulfuron-ethyl 0.6% GR 10 kg /ha at 3 DAT + hand weeding on 40 DAT/ DAS, (PE) application of pre-mixed pretilachlor 6% + pyrazosulfuron-ethyl 0.15% GR 10 kg/ha at 3 DAT + hand weeding on 40 DAT/DAS, (PE) application of pre-mixed pretilachlor 6% + bensulfuron-ethyl 0.6% GR 10 kg/ha at 3 DAT with PoE application of bispyribac-sodium 10% SC 200 mL/ha on 20 DAT, (PE) application of pre-mixed pretilachlor 6% + pyrazosulfuron-ethyl 0.15% GR 10 kg/ha at 3 DAT with PoE application of bispyribac-sodium 10% SC 200 mL/ha on 20 DAT. Significantly lesser weed density (66.4/m^2), dry weight (80.8 g/m^2) and higher weed control efficiency (82.9%) were recorded with PE application of premixed pretilachlor 6% + bensulfuron-methyl 10 kg/ha at 3 DAT + PoE application of herbicide bispyribac-sodium 10% SC 200 mL /ha on 20 DAT than other treatments at 45 DAT. Significantly higher dry matter production (6.10 t/ha), more number of productive tillers (382/m^2) and filled grain/panicle (173) higher grain yield of 5.68 t/ha, mean net returns (₹ 50475/ha) and benefit cost ratio of 2.52 were recorded in PE application of pre-mixed pretilachlor + bensulfuron-methyl 10 kg/ha on 3 DAT + PoE application of herbicide bispyribac-sodium 200 mL /ha on 20 DAT than other treatments. Thus, it could be concluded that PE application of pre-mixed pretilachlor + bensulfuron-methyl 10 kg/ha on 3 DAT + PoE application of herbicide bispyribac-sodium 200 mL/ha on 20 DAT controlled the *Echinochloa colona* effectively and produced higher productivity and profitability of rice in transplanted condition.

Keywords: Bensulfuron-methyl, Bispyribac-sodium, *Echinochloa colonum*, Pretilachlor, Pyrazosulfuron-ethyl

INTRODUCTION

Jungle rice (*Echinochloa colonum*) belongs to the Gramineae family and is a type of wild annual grass, up to 60 cm tall, with reddish purple or green stem, ascending to erect without hairs and long narrow spiny leaves. It is widely distributed in India, Bangladesh, Cambodia, Nepal, Pakistan, Thailand and Vietnam. Its infestation is very common in various crops, such as rice, maize, vegetables and legume crops. It is very problematic weed in irrigated rice and complete crop failure has been observed because of this weed (Mahajan and Chauhan 2022). The menace due to weeds is higher as the weeds emerge before or simultaneously with the crop emergence and this in turn brings down the final grain yield. The losses of grain yield due to weeds in rice crop ranges from 20 to 60 per cent and 30 to 80 per cent in transplanted and direct-seeded rice, respectively (Gharde *et al*. 2018). In rice cultivation, the management of the weeds at early stage of crop emergence is the most important requisite for profitable rice production. Hand weeding is most effective traditional method of eradication of weeds. However, the prevailing labour in availability and escalated labour wages for agricultural operations make this operation uneconomic. Under this condition, chemical method of weed control is an effective, economical and time saving strategy to combat the weeds. Besides the cost-effective nature it requires only minimal labour, curtails weed competition and augments crop productivity.

Although several ready-mix pre-emergence herbicides are available with high phytotoxicity on weeds, its potentiality against weeds needs to be ascertained through field experimentations. On other hand, the continuous use of similar type herbicides results in developments of resistance, leads to shift in weed flora orienting towards the weed species which are sparse in rice ecosystem. Different types of newer molecules of pre-emergence and post-emergence herbicides are available, bensulfuron methyl and pyrazosulfuron ethyl under systemic pre-emergence herbicidal group and the bispyribac sodium of post-emergence category, for managing of

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weeds in rice crop. The sequential application of pre-mixed pre-emergence herbicides followed by post-emergence herbicides could be more effective in the control of wider spectrum of weeds of rice (Parameswari and Srinivas (2017). Keeping in this view, field experiments were conducted to study the effect of PE and PoE herbicides on control of *Echinochloa colonum* under transplanted rice.

MATERIALS AND METHODS

A field experiment was conducted at Experimental Farm, School of Agriculture, Bharath Institute of Higher Education and Research, Selaiyur, Tamil Nadu, India during *Kharif* (rainy season) 2022 and 2023 to study the management of *Echinochloa colonum* through herbicides in transplanted rice. The study area has mean annual rainfall of about 1500 mm, majority of which was received during North-East Monsoon. The climate of the region is characterized by a tropical climate with a hot dry period (March-May), and extended wet period from November to February. The soil of the experimental field was moderately drained, clayey loam texture soil and soil is medium available in nitrogen (201.39 kg ha), high available in phosphorus (20.57 kg ha) and potassium (280.53 kg ha) with a pH of 7.4.

The experiment was laid out in a RBD (randomized block design) with three replications. Treatments consisted of herbicide, *viz*. unweeded control, two hand weeding at 20 and 40 DAT/DAS, (PE) application of pre-mixed pretilachlor 6% + bensulfuron-ethyl 0.6% GR 10 kg/ha at 3 DAT + hand weeding on 40 DAT/DAS, (PE) application of pre-mixed pretilachlor 6% + pyrazosulfuron-ethyl 0.15% GR10 kg/ha at 3 DAT + hand weeding on 40 DAT/ DAS, (PE) application of pre-mixed pretilachlor 6% + bensulfuron-ethyl 0.6% GR 10 kg /ha at 3 DAT with PoE application of bispyribac-sodium 10% SC 200 mL/ha on 20 DAT, (PE) application of pre-mixed pretilachlor 6% + pyrazosulfuron-ethyl 0.15% GR10 kg/ha at 3 DAT with PoE application of bispyribac-sodium 10% SC 200 mL/ha on 20 DAT. Rice variety '*CO 51*' was used for this study. The plot size of experiment was 5 × 4 m. Recommended seed rate (40 kg/ha) was used for nursery were treated with carbendazim 2 g/kg of seeds and soaked in water for 10 hrs and 15 × 10 cm spacing is adopted for transplant the seedlings. Twenty days old nursery was used in transplanting. A fertilizer dose of 120 : 40: 40 NPK kg/ha was adopted for the experiment. Full dose of phosphorous and half dose of nitrogen and potassium were applied as basal. The remaining half dose of nitrogen and potassium were applied into two splits during maximum tillering and panicle primordium initiation (PPI) stage. Nitrogen, phosphorous and potassium were supplied through urea, single super phosphate, and muriate of potash respectively. As per the treatment schedule, required quantity of herbicides was sprayed. The pre-emergence and post-emergence herbicide were sprayed with high volume Knapsack sprayer fitted with flood jet nozzle using 500 liters of water ha^{-1}. Pre-emergence herbicide pretilachlor 6% + bensulfuron methyl 0.6% GR and pretilachlor 6% + pyrazosulfuron-ethyl 0.15 % GR was sprayed on 3 DAT and post-emergence herbicides bispyribac sodium was sprayed on 20 DAT. A thin film of water was maintained at the time of both liquid and granular herbicide application. Observation on yield attributing characters, grain yield of rice, weed density, weed dry weight were recorded. The number of tillers were counted in the five hills earmarked at random and the mean value was recorded as number/hill. The number of panicles/m^2 was conducted from the sample hills at the time of harvest and the mean value were recorded. The panicles were randomly chosen for recording number of filled grains/panicle. The differentiation of well filled and chaffy grains was made by pressing the grain with fingers and they are counted and recorded. Weed population was recorded by using four quadrants of 0.25/m^2 area placed at random in each of the net plot area and computed to total weeds/m^2. Prior to transplanting the weed species present in the unweeded plots were identified and grouped in to grasses, sedges and broad-leaved weeds. Weed control efficiency was worked out at 45 DAS during both years and expressed as the percentage. The gross and net income/ha for each treatment was worked out based on the prevailing market rates. The net income was calculated by deducting the cost of cultivation from the gross return. Return/rupee invested was worked out by dividing the gross return by the cost of cultivation. All recorded data were analyzed statistically as per the method suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Effect on weeds

Commonly, grasses and sedges are the most dominant weeds in transplanted rice cultivation. Predominant grassy weeds present in the transplanted rice field were *Echinochloa colonum* and *Echinochloa crus-galli* and the dominant sedge was *Cyperus difformis* and the dominant broad-leaved weeds were *Ammania baccifera* and *Marselia*

quadrifolia found in the experimental field in both the seasons. Weed density and weed dry weight recorded at 45 DAT revealed that significantly lesser mean weed density of 66/m^2 and weed dry weight of 80.77 g/m^2 recorded with PE application of premixed pretilachlor 6% + bensulfuron methyl 0.6% GR 10 kg /ha on 3 DAT + PoE application of herbicide bispyribac-sodium 10% SC 200 mL/ha on 20 DAT, which was comparable with PE application of pre-mixed pretilachlor 6% + pyrazosulfuron-ethyl0.15% GR10 kg /ha on 3 DAT/ 7 DAS + PoE application of bispyribac sodium 10% SC 200 mL/ha on 20 DAT/ DAS (67.03/m^2 an+d 81.46 g/m^2). Considerable reduction in germination of *Echinochloa colonum* under sequential application of pretilachlor 6% + bensulfuron-methyl 0.6% GR 10 kg/ha and bispyribac-sodium 10% SC 200 mL/ha was the reason behind lesser weed density and dry weight also It might be due to the new pre-emergence herbicides under sulfonylurea group which would have suppress the density of weed flora at the early stages of crop itself and sequential application pre-emergence followed by post-emergence herbicide control broad spectrum of weeds in rice crop especially grasses which had grown along with rice crop seedlings in same hill and closer similarity of rice as documented by Jayadeva *et al.* (2019).

Higher mean weed control efficiency of 82.98% was registered in PE application of pre-mixed pretilachlor 6% + bensulfuron-methyl 0.6% GR 10 kg/ha on 3 DAT + PoE application of herbicide bispyribac-sodium 10% SC 200 mL /ha on 20 DAT and it was on par with PE application of pre-mixed pretilachlor 6% + pyrazosulfuron-ethyl 0.15% GR10 kg/ha on 3 DAT/ 7 DAS + PoE application of bispyribac-sodium 10% SC 200 mL/ha on 20 DAT/ DAS (82.22%) than other herbicide combination. Pretilachlor is the commonly used pre-emergence herbicide for management of all weed species in rice. However, continuous adoption of rice based intensive cropping sequences with indiscriminate scheduling of fertilizer nutrient and irrigation regimes favour luxurious weed growth and enhanced the bulk accumulation of weeds seed reserve in soil profile which offer menace to the succeeding crops. Hence, the combined applications of different group of herbicides having ideal compatibility and synergetic effect as premixed or tank mixed applications. Moreover, the weeds that emerge at later periods are also to be contained with effective and economical post-emergence herbicidal applications. Through effective suppression of weeds with the above premixed pre-emergence herbicidal combination at early stages of crop growth and the post-emergence

Table 1. Influence of weed management practices on total weed density, dry matter production (DMP), weed control efficiency at 45 DAS, growth parameters of rice (pooled data of two seasons)

Treatment	Total weed density (no./m^2)	Weed dry weight (g/m^2)	WCE (%)
Unweeded control	(180.9)13.95	(1051.4)32.92	-
Two hand weeding (HW) on 20 and 40 DAT/ DAS	(78.3)9.35	(117.7)11.34	73.42
Premixed pretilachlor + bensulfuron-ethyl 10 kg/ha PE on 3 DAT / 7 DAS + HW on 40 DAT/DAS	(71.2)8.94	(100.0)10.49	78.50
Premixed pretilachlor + pyrazosulfuron-ethyl PE 10 kg/ha on 3 DAT/ 7 DAS + HW on 40 DAT/DAS	(86.0)9.77	(148.6)12.68	67.76
Premixed pretilachlor + bensulfuron-methyl PE 10 kg/ha on 3 DAT/ 7 DAS + PoE bispyribac-sodium 200 ml/ha on 20 DAT/DAS	(66.3)8.64	(80.8)9.48	82.98
Premixed pretilachlor + pyrazosulfuron-ethyl PE 10 kg/ha on 3 DAT /7 DAS + PoE bispyribac-sodium 200 ml/ha on 20 DAT/DAS	(67.0)8.68	(81.5)9.52	82.21
LSD (p=0.05)	1.9	1.2	-

Figures in parentheses are square root $\sqrt{(x+0.5)}$ transformed values

Table 2. Influence of weed management practices on growth parameters, productive tillers, filled grain/panicle of rice (pooled data of two seasons)

Treatment	Plant height (cm)	DMP (t/ha)	Productive tillers	Filled grain/ panicle
Unweeded control	55.95	4645	238	108
Two hand weeding (HW) on 20 and 40 DAT/ DAS	65.77	5270	306	145
Premixed pretilachlor + bensulfuron-ethyl 10 kg/ha PE on 3 DAT / 7 DAS + HW on 40 DAT/DAS	70.86	5597	337	156
Premixed pretilachlor + pyrazosulfuron-ethyl PE 10 kg/ha on 3 DAT/ 7 DAS + HW on 40 DAT/DAS	60.82	4956	273	120
Premixed pretilachlor + bensulfuron-methyl PE 10 kg/ha on 3 DAT/ 7 DAS + PoE bispyribac-sodium 200 ml/ha on 20 DAT/DAS	78.11	6101	383	173
Premixed pretilachlor + pyrazosulfuron-ethyl PE 10 kg/ha on 3 DAT /7 DAS + PoE bispyribac-sodium 200 ml/ha on 20 DAT/DAS	76.13	5924	372	170
LSD (p=0.05)	2.3	0.09	2.2	

herbicidal applications in later stage might have effectively minimizes weed population, nutrient removal, dry matter production and in turn resulted in enhanced weed control efficiency. The results were in corroboration with the results documented by Palani *et al*. (2020). The lowest weed control efficiency was observed in hand weeding on 20 and 40 DAT because of hand weeding is a cultural approach to control weeds and also *Echinochloa colonum* young plant resemble rice, which makes hand weeding difficult early stage. This was the reason behind lesser weed control efficiency.

Effect on crop growth, yield attributes and yield

Growth and yield characters of rice has significantly influenced by weed management treatments. PE application of pre-mixed pretilachlor 6% + bensulfuron-methyl 0.6% GR 10 kg /ha on 3 DAT + PoE application of herbicide bispyribac-sodium 10% SC 200 mL/ha on 20 DAT produced significantly taller plants, highest DMP, productive tillers, filled grain/panicle than other herbicidal treatments. However, this was on par with PE application of pre-mixed pretilachlor 6% + pyrazosulfuron-ethyl 0.15% GR 10 kg/ha on 3 DAT/ 7 DAS + PoE application of bispyribac-sodium 10% SC 200 mL /ha on 20 DAT/DAS. Planting a younger seedling with optimal growing conditions is responsible for accelerated growth rate in plants as these make possible to complete more phyllochrons before entering into their reproductive phase. Completion of more phyllochrons at early seedlings stage resulted in more number of tillers and effective tillers per hill and plant height of rice under different combination of herbicides showed comparable with each other. This is mainly because of reduced weed competition during early stages of crop growth with the simultaneous increase in the uptake of nutrients by the crop which favoured taller plants, increase assimilation surface which enhanced the crop growth characters and better control of weeds under this treatment would have favoured increased source sink relationship which resulted in more yield attributing characters (Ankit *et al.* 2018 and Yadav *et al.* 2017). Control plot produced significantly treatments, mainly due to higher weed competition.

Grain yield and straw of rice was significantly varied with weed management practices. PE application of pre-mixed pretilachlor 6% + bensulfuron-methyl 0.6% GR 10 kg/ha on 3 DAT + PoE application of herbicide bispyribac-sodium 10% SC 200 mL/ha on 20 DAT recorded significantly higher mean grain yield over other treatments and it was on par with PE application of pre-mixed pretilachlor 6% + pyrazosulfuron-ethyl 0.15% GR 10 kg/ha on 3 DAT/ 7 DAS + PoE application of bispyribac-sodium 10% SC 200 mL/ha on 20 DAT/ DAS. This might be due to reduced weeds under sequential application of pre-emergence and post emergence herbicides applied plots resulted in competition free environment at the critical stages of crop favoured the crop to utilize the factors for crop growth and production and enhanced the well balanced source sink capacities and uniform stand of the crop due to application of pre and post emergence herbicides which attributed to the production of more DMP, productive tillers, filled grain/panicle compared to all other treatments and responsible for higher yield of rice. These were in accordance with the earlier findings of Teja *et al.* 2015.

Effect on economics

Economics of *Echinochloa colonum* weed management techniques in rice revealed that PE application of premixed pretilachlor 6% + bensulfuron-methyl 0.6% GR 10 kg/ha on 3 DAT + PoE application of herbicide bispyribac-sodium 10% SC 200 mL/ha on 20 DAT gave higher mean net returns and benefit cost ratio than other treatments and herbicide resulted in increased grain yield and reduced cost of weeding were reason behind higher net profit. Similar result has reported by Bhatt *et al.*

Table 3. Influence of weed management practices on grain yield, straw yield, return rupee invested (pooled data of two seasons)

Treatment	Grain yield (t/ha)			Straw yield (t/ha)			Net income ($x10^3$ Rs/ha)	Return/ rupee invested
	2022	2023	Pooled	2022	2023	Polled		
Unweeded control	2.76	2.14	2.45	4.68	3.44	4.06	8.95	1.32
Two hand weeding (HW) on 20 and 40 DAT/ DAS	5.33	3.85	4.59	8.64	6.59	7.62	34.16	2.0
Premixed pretilachlor + bensulfuron-ethyl 10 kg/ha PE on 3 DAT / 7 DAS + HW on 40 DAT/DAS	5.67	4.17	4.92	8.62	7.13	7.88	39.25	2.17
Premixed pretilachlor + pyrazosulfuron-ethyl PE 10 kg/ha on 3 DAT/ 7 DAS + HW on 40 DAT/DAS	4.88	3.40	4.14	7.86	5.79	6.83	29.00	1.89
Premixed pretilachlor + bensulfuron-methyl PE 10 kg/ha on 3 DAT/ 7 DAS + PoE bispyribac-sodium 200 ml/ha on 20 DAT/DAS	6.58	4.77	5.67	9.80	7.72	8.76	50.47	2.52
Premixed pretilachlor + pyrazosulfuron-ethyl PE 10 kg/ha on 3 DAT /7 DAS + PoE bispyribac-sodium 200 ml/ha on 20 DAT/DAS	6.33	4.58	5.46	9.95	7.61	8.78	48.14	2.47
LSD (p=0.05)			39					

(2017). Hand weeding on 20 and 40 DAS gave lesser net return mainly due to higher cost of manual weeding. Control plot recorded negative net returns in both the seasons due to higher weed competition led to lesser grain yield.

Thus, it can be concluded that PE application of pre-mixed pretilachlor 6% + bensulfuron-methyl 0.6% GR 10 kg/ha on 3 DAT + PoE application of herbicide bispyribac-sodium 10% SC 200 mL /ha on 20 DAT followed by PE application of pre-mixed pretilachlor 6% + pyrazosulfuron-ethyl0.15% GR 10 kg/ha on 3 DAT/ 7 DAS + PoE application of bispyribac- sodium 10% SC 200 mL/ha on 20 DAT/ DAS controlled the jungle rice *(Echinochloa colona)* effectively and produced higher profitability of rice in transplanted condition.

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