International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 1985-1987

Received: 01-03-2019
Accepted: 03-04-2019

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Evaluation of new herbicide molecules for transplanted rice

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Abstract
Field experiment was conducted at Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore during *Kharif*, 2012 under All India Co-ordinated Rice Improvement Programme with an objective of evaluating new molecules of herbicides for chemical weed control in transplanted rice. The experiment was conducted in randomized block design with three replications with the variety CO 47. The treatments included were butachlor at 1.5 kg ai./ha applied at 5-7 DAT, flucetosulfuron 20 g a.i./ha at 2-3 DAT, flucetosulfuron 25 g a.i./ha at 2-3 DAT, penoxsulam + cyhalofop-butyl at 120 g a.i./ha applied at 15-20 DAT, penoxsulam + cyhalofop-butyl at 135 g a.i./ha applied at 15-20 DAT, bispyribacsodium at 35 g a.i./ha applied at 15-20 DAT, two hand weedings at 20 & 40 DAT and unweeded control. The results revealed that among the weed management practices, the lowest weed dry weight (10.47 g/m^2) was recorded with application of penoxsulam + cyhalofop-butyl at 135 g a.i./ha applied at 15-20 DAT which resulted in higher grain yield of 7642 kg ha^{-1} and was comparable with application of bispyribac sodium at 35 g a.i./ha applied at 15-20 DAT (7487 kg ha^{-1}). No phytotoxicity symptoms on rice was evinced on application of penoxsulam + cyhalofop-butyl at 120 and 135 g a.i./ha.

Keywords: Rice, weed management, herbicides, yield and economics

Introduction
Rice is one of the major cereal crop cultivated worldwide. In India, rice is cultivated throughout the year in one or the other part of the country and it is cultivated in diverse ecologies with a total area of 43.8 mha (Jagtap *et al*., 2012) [1]. It is the major food crop of Tamil Nadu and it is cultivated in an area of about 20 lakh hectares. Among the different factors influencing the crop yield, weeds are one of the important yield limiting factors and they are most severe and widespread biological constraints to rice production. As timely weed management is an important key factor in obtaining higher grain yield, herbicides play a vital role by providing timely and efficient control of weeds with less labour and time.

The predominant weed flora present under transplanted rice situation were *Echinochloa colona*, *Echinochloa crusgalli* under grasses, *Cyperus iria and Cyperus difformis* under sedges, *Eclipta alba* and *Marsilea quadrifoliata* under broad leaved weeds. Ramachandra (2010) [2] recorded the dominant weed species in transplanted rice as *Echinochloa crus-galli* (L.) and *E.colona* (L.) under grasses; *Cyperus difformis* (L.), *Cyperus iria* (L.) and *Cyperus rotundus* (L.) under sedges and *Eclipta alba* (L.) Hassak and *Ammania baccifera* (L.) among broad leaved weeds. Chinnusamy *et al*. (2000[3]) reported that maintaining a weed free period up to 45 DAS was essential to augment the yield of medium duration rice. Pal *et al*. (2009) [4] found that hand weeding on 20 and 40 DAT recorded the highest grain yield of 5.08 t ha^{-1} in Gangetic alluvial soil. Application of Bispyribac Sodium 10% SC @ 20 g a.i. ha^{-1} kept the weed density and dry weight below the economic threshold level and increased the grain yield in rice (Rajib Das *et al*., 2015) [5].

Penoxsulam, a triazolopyrimidine sulfonamide rice herbicide, controls *Echinochloa* spp., annual sedges and many broadleaved weeds. It is an early post-emergence herbicide absorbed mainly via leaves and secondarily via roots. It is a new acetolactate synthase (ALS) inhibitor herbicide for post-emergence control of annual grasses, sedges and broad leaved weeds in rice culture (Jabusch and Tjeerdema, 2005) [6]. Yadav *et al*., (2010) [7] reported that penoxsulam at 25 g/ha as pre-emergence (3 DAT) and 22.5 g/ha as post emergence (10-12 DAT) application provided satisfactory control of all types of weeds consequently resulting in grain yield of transplanted rice similar to weed free plot. Ramesha *et al*., (2017) [8] reported that application of penoxsulam 83.3 ml/ha controlled all types of weeds and increased the grain yield of rice.

Cyhalofop-butyl, an aryloxyphenoxypropionate rice herbicide, controls many grassy weeds including *Echinochloa* spp. and *Leptochloa chinensis*. Combination products containing penoxsulam + cyhalofop-butyl can increase rice productivity in direct-seeded, water-seeded and transplanted rice production systems. Each herbicide has a different mode of action, so their application is an effective means to manage *Echinochloa* spp. Penoxsulam+cyhalofop-butyl mixtures provided excellent weed control and with no injury to rice (Lap *et al*., 2013) [9].

According to Mukherjee and Singh (2005) [10], the yield losses due to uncontrolled weed growth in lowland rice ranges from 12 to 81 per cent. Suitable weed control measures have to be adopted to reduce weed competition and to increase the rice yield. With this view, the present investigation was conducted with an objective of evaluating new molecules of herbicides for chemical weed control in transplanted rice.

Materials and methods

The experiment was conducted at Paddy Breeding station, TNAU, Coimbatore during *Kharif*, 2012. The soil of the experimental site was clay loam in texture with low available N (252 kg ha^{-1}), medium in available P (18 kg ha^{-1}), and high in available K (540 kg ha^{-1}). The experiment was conducted in randomized blocks design with three replications with the variety CO 47. The treatments included were T_1 - butachlor at 1.5 kg ai./ha applied at 5-7 DAT, T_2 - flucetosulfuron 20 g a.i./ha at 2-3 DAT, T_3 - flucetosulfuron 25 g a.i./ha at 2-3 DAT, T_4 - penoxsulam + cyhalofop-butyl at 120 g a.i./ha at 15-20 DAT, T_5 - penoxsulam + cyhalofop-butyl at 135 g a.i./ha at 15-20 DAT, T_6 - bispyribac sodium at 35 g a.i./ha at 15-20 DAT, T_7 - two hand weedings at 20 & 40 DAT and T_8 unweeded control. Observations on weed population, weed dry weight, yield parameters and yield of rice were recorded. The data collected were subjected to statistical analysis in Randomized Block Design following the method of Gomez and Gomez (1984) [11]. Data on density of weeds showed high variation and hence they were subjected to square root transformation ($\sqrt{X} + 0.5$) and analyzed statistically. Critical difference was worked out at five per cent probability level whenever the treatment differences were found significant (F test) and the values were furnished.

Results and Discussion

Weed population and dry weight

Among the treatments, lower population of grasses, sedges and broad leaved weeds were recorded with application of penoxsulam + cyhalofop-butyl at 135 g a.i./ha at 15- 20 DAT followed by two hand weedings at 20 and 40 DAT. The highest weed control efficiency (92.1%) was recorded with the application of penoxsulam + cyhalofop-butyl at 135 g a.i./ha at 15- 20 DAT. It was followed by two hand weedings at 20 and 40 DAT (91.1%) (Table.1). This might be attributed to broad spectrum control of weeds by the combined action of penoxsulam and cyhalofop-butyl, which reduced the population of major grasses, sedges and broad leaved weeds.

Among the different weed control practices, the lowest weed dry weight (10.47 g/m^2) was recorded with application of penoxsulam + cyhalofop-butyl at 135 g a.i./ha. Application of penoxsulam + cyhalofop-butyl at 120 and 135 g a.i./ha did not record any phytotoxicity symptoms on rice. Similar results are also reported by Lap *et al*. (2013) [9].

Table 1: Effect of treatments on weed population (No./m^2) at 10 Days after Herbicide Application and weed dry weight (g/m^2) at flowering.

	Treatments	WCE (%)	Weed population/m^2 (10 Days after Herbicide Application)			Weed dry wt. (g/m^2) at flowering
			Grasses	Sedges	BLW	
T_1	Butachlor 1.5 kg/ha	75.8	3.53 (12.00)	1.22 (1.00)	1.95 (3.33)	33.33
T_2	Flucetosulfuron 20 g/ha	73.9	3.89 (14.67)	1.05 (0.67)	1.68 (2.33)	37.60
T_3	Flucetosulfuron 25 g/ha	82.7	3.08 (9.00)	1.00 (0.67)	1.56 (2.00)	34.80
T_4	Penoxsulam + Cyhalofop-butyl 120 g/ha	81.3	3.62 (12.67)	0.71 (0.00)	0.71 (0.00)	23.67
T_5	Penoxsulam + Cyhalofop-butyl 135 g/ha	92.1	2.26 (4.67)	0.71 (0.00)	1.05 (0.67)	10.47
T_6	Bispyribacsodium 35 g/ha	89.6	2.41 (5.33)	0.88 (0.33)	1.34 (1.33)	24.00
T_7	Two hand weedings (20 & 40 DAT)	91.1	2.54 (6.00)	0.71 (0.00)	0.71 (0.00)	20.07
T_8	Unweeded control	-	7.70 (59.00)	1.93 (3.33)	2.36 (5.33)	118.47
	SEd		0.27	0.23	0.25	1.65
	CD(P=0.05)		0.58	0.49	0.53	3.55

(Figures in parenthesis are original values)

Grain Yield

Application of penoxsulam + cyhalofop-butyl at 135 g a.i./ha recorded higher grain yield of 7642 kg/ha and was comparable with application of bispyribac sodium at 35 g a.i./ha (7487 kg/ha) and penoxsulam + cyhalofop-butyl at 120 g a.i./ha (7360 kg/ha). The treatment hand weeding twice recorded a grain yield of 7091 kg/ha (Table.2). The increased grain yield with application of penoxsulam + cyhalofop-butyl at 135 g a.i./ha might be attributed to efficient and broad spectrum control of grasses, sedges and broadleaved weeds. Similar results were also reported by Yadav *et al*., (2010) [7]

Table 2: Effect of treatments on yield and economics of rice

	Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Net return (Rs./ha)	B:C ratio
T_1	Butachlor 1.5 kg/ha	6755	8137	59,700	3.03
T_2	Flucetosulfuron 20 g/ha	6667	8031	57,051	2.84
T_3	Flucetosulfuron 25 g/ha	7056	8499	61,367	2.95
T_4	Penoxsulam + Cyhalofop-butyl 120 g/ha	7360	8866	67,460	3.30
T_5	Penoxsulam + Cyhalofop-butyl 135 g/ha	7642	9206	71,259	3.42
T_6	Bispyribacsodium 35 g/ha	7487	8542	67,826	3.24
T_7	Two hand weedings (20 & 40 DAT)	7091	9019	56,947	2.53
T_8	Unweeded control	5194	6257	40,183	2.43
	SEd	144	173		
	CD(P=0.05)	310	372		

Economics

The highest net return (Rs.71,259/ha) and B:C ratio (3.42) were recorded with application of penoxsulam + cyhalofop-butyl at 135 g a.i./ha at 15-20 DAT followed by application of bispyribacsodium at 35 g/ha at 15-20 DAT (Rs. 67,826/ha) (Table.2). Hand weeding twice recorded lower net return (Rs. 56,947/ha) and B:C ratio (2.53) which might be due to additional labour required for hand weeding compared to herbicide application.

Conclusion

The results revealed that among the different weed management practices, application of penoxsulam + cyhalofop-butyl at 135 g a.i./ha at 15-20 DAT effectively controlled the weed population and recorded higher grain yield of rice (7642kg ha^{-1}), net return (Rs.71,259/ha) and B:C ratio (3.42). Hand weeding twice recorded lower net return and B:C ratio.

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