Madras Agric. J., 99 (7-9): 545-547, September 2012
https://doi.org/10.29321/MAJ.10.100135

Short Note

Performance of New Herbicides on Productivity and Profitability of Aerobic Rice

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Field experiment was conducted at Agricultural College and Research Institute, Madurai during *Rabi* 2010-2011 to study the performance of new herbicides on productivity and profitability of aerobic rice with twelve treatments in randomized block design. In this study, post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS provided a broad spectrum of weed control by significantly reducing weed density and dry weight at 60 DAS and resulted in significantly higher weed control efficiency. Post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS recorded significantly higher grain yield and straw yield. The economic evaluation of results indicated that post emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS registered higher gross return (Rs. 50915 ha^{-1}), net return (Rs. 28281 ha^{-1}) and B:C ratio (2.25).

Key words: Aerobic rice**,** weed density, dry weight, WCE, yield and economics

About 50 per cent of the world rice production area is affected by drought stress. When soil water content drops below saturation, yield losses occur, as rice is susceptible to drought (Bouman and Tuong, 2001). Aerobic rice is a new way of cultivating rice that requires less water than lowland rice. It entails the growing of rice in aerobic soil, with the use of external inputs such as supplementary irrigation and fertilizers and aiming at high yields (Wang *et al.,* 2002). Aerobic soil conditions and dry tillage practices, beside alternate wetting and drying conditions are conductive for germination and growth of highly competitive weeds, which cause grain yield loss of 50-91 per cent (Singh *et al.,* 2006). The labour requirement for weeding is a major impediment to the adoption of water saving aerobic rice and for increasing the productivity of traditional upland rice based cropping systems (Zhao *et al.,* 2006). Herbicides are considered to be an alternative / supplement to hand weeding (Singh *et al.,* 2006). In this background, this study was planned with the following objectives. To find out efficacy of new herbicides on weed control and growth and yield of aerobic rice.

Materials and Methods

Field experiment was conducted at Agricultural College and Research Institute, Madurai during *rabi* 2010-2011 on weed management in rice with twelve treatments in randomized block design (RBD) with three replications. The soil of the experimental field was sandy clay loam.The test variety was ADT 47. The weed management treatments imposed were Pre–emergence pyrazosulfuron alone (25 g ha^{-1}) on 3 DAS (T_1), Pre–emergence pretilachlor – S alone (750 ml ha^{-1}) on 3 DAS (T_2), Post–emergence cyhalofop butyl alone (90 ml ha^{-1}) on 25 DAS (T_3), Post–emergence fenoxaprop alone (60 ml ha^{-1}) on 30 DAS (T_4), Post–emergence mixture of cyhalofop butyl + (chlorimuron + metsulfuron) (90 ml + 20 g ha^{-1}) on 30 DAS (T_5), Post–emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) (60 ml + 20 g ha^{-1}) on 30 DAS (T_6), Post–emergence azimsulfuron alone (35 g ha^{-1}) on 20 DAS (T_7), Post– emergence bispyribac sodium alone (25 ml ha^{-1}) on 20 DAS (T_8), Post–emergence mixture of fenoxaprop + ethoxysulfuron (60 ml + 15 g ha^{-1}) on 30 DAS (T_9), Sequence application of pre–emergence oxyfluorfen and post–emergence 2, 4-D (300 ml + 500 g ha^{-1}) on 30 DAS (T_{10}), Two hand weeding at 15 and 35 DAS (T_{11}) and Unweeded control (T_{12}). The observations on weeds and crop yield were recorded and statistically analysed. The weed density and DMP were subjected to square root transformation. The economics were worked out for treatment plots.

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Results and Discussion

Weed flora

The weed flora observed in the experimental field during the course of study consisted of grasses, sedges and broad leaved weeds. The predominant category of weed was broad leaved weeds followed by grasses and sedges. The weed flora mainly consisted of *Echinochloa colonum, Panicum javanicum, Chloris barbata, Dactyloctenium aegyptium* and *Panicum repens* under grasses, *Cyperus iria* under sedges and *Cleome viscosa, Corchorus olitorius, Euphorbia hirta, Merremia emarginata, Portulaca oleracea* and *Trianthema protulacastrum* under broad leaved weeds.

Table 1. Effect of herbicides on weed density, dry weight, grain, straw yield and economics of aerobic rice

Treatment	*Weed density (No. m)$^{-2}$ Grass	Sedge	BLW	*Totalweed density (No. m)$_{-2}$	WCE(%)	*Weed dry matterproduction(kgha)$^{-1}$ Grass	Sedge	BLW	*Totalweed DMP (kg ha)$_{-1}$	Grainyield (kg ha)$_{-1}$	Strawyield (kg ha)$_{-1}$	Totalcost (Rs ha)$_{-1}$	Grossreturn (Rs ha)$_{-1}$	Netreturn(Rsha)$_{-1}$	B:C ratio
T_1 - Pre–emergence pyrazosulfuron alone on 3 DAS	7.31 (53.00)	3.81 (14.00)	3.98 (15.35)	9.10 (82.35)	70.26	13.17 (173)	3.94 (15)	6.67 (44)	15.24 (232)	3795	5105	21958	31015	9687	1.45
T_2 - Pre–emergence pretilachlor – S alone on 3 DAS	7.33 (59.33)	4.06 (16.00)	4.38 (18.67)	9.72 (94.00)	66.05	13.43 (180)	4.30 (18)	8.57 (73)	16.49 (271)	3743	5085	22421	30615	8194	1.37
T_3 - Post–emergence cyhalofop butyl alone on 25 DAS	6.47 (41.33)	4.00 (15.49)	3.89 (14.62)	8.48 (71.44)	74.20	12.31 (151)	4.06 (16)	6.52 (42)	14.48 (209)	3860	5126	21465	31513	10048	1.47
T_4 - Post–emergence fenoxaprop alone on 30 DAS	5.46 (29.36)	4.10 (16.33)	4.14 (16.67)	7.92 (62.36)	77.48	8.69 (75)	4.41 (19)	6.74 (45)	11.81 (139)	4065	5376	22133	33176	11042	1.50
T_5 - Post–emergence mixture of cyhalofop butyl + (chlorimuron + metsulfuron) on 30 DAS	5.85 (33.67)	3.44 (11.33)	3.72 (13.33)	7.67 (58.33)	78.93	9.08 (82)	2.92 (8)	5.70 (32)	11.06 (122)	4118	5570	21878	33670	11792	1.54
T - Post–emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS	4.06 (16.00)	1.22 (1.00)	1.22 (1.00)	4.30 (18.00)	93.50	6.52 (42)	1.87 (3)	2.92 (8)	7.30 (53)	4345	5719	21754	35447	13693	1.63
T - Post–emergence azimsulfuron alone on 20 DAS	5.08 (25.33)	1.87 (3.00)	3.34 (10.67)	6.28 (39.00)	85.92	8.22 (67)	2.12 (4)	5.05 (25)	9.80 (96)	5153	6441	22758	41868	19110	4
T - Post–emergence bispyribac sodium alone on 20 DAS	4.81 (22.67)	0.71 (0.00)	2.20 (4.33)	5.24 (27.00)	90.25	8.09 (65)	0.71 (0)	4.84 (23)	9.40 (88)	5805	7140	21516	47108	25592	9
T - Post–emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS	4.74 (22.00)	1.68 (2.33)	1.78 (2.67)	5.24 (27.00)	90.25	7.97 (63)	2.12 (4)	4.53 (20)	9.33 (87)	6278	7659	22633	50915	28281	5
T_{10}- Pre–emergence oxyfluorfen and post emergence 2, 4-D on 30 DAS	4.38 (18.67)	0.71 (0.00)	1.47 (1.67)	4.56 (20.34)	92.66	7.84 (61)	0.71 (0)	4.30 (18)	8.93 (79)	4262	5615	22033	34773	12739	1.58
T_{11}- Two hand weeding at 15 and 35 DAS	5.37 (28.33)	3.54 (12.00)	2.97 (8.33)	7.01 (48.66)	82.43	8.51 (72)	3.08 (9)	4.95 (24)	10.25 (105)	4508	5799	26258	36710	10451	1.40
T_{12}- Unweeded control	11.14 (123.67)	7.19 (51.24)	10.12 (102.00)	16.66 (276.91)	-	21.94 (481)	9.62 (92)	21.53 (463)	32.20 (1036)	2105	3714	21258	17645	-3614	0.83

*Data subjected to square root transformation; Values in parentheses are original

Weed growth

Grass density was significantly reduced by post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS (T_6) significantly to 16.0 m$_2$. This was followed by sequential application of pre-emergence oxyfluorfen and post-emergence 2, 4-D on 30 DAS (T_{10}) and post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9) with grass density of 18.67 and 22.00 m$_{-2}$, respectively. But, treatment T_9 was comparable with post -emergence bispyribac sodium alone on 20 DAS (T_8). Sedge weed density was zero in post-emergence application of bispyribac sodium alone on 20 DAS (T_8) as well as sequence application of pre-emergence oxyfluorfen and post-emergence 2, 4-D on 30 DAS (T_{10}). This was followed by post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS (T_6) and post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9) which recorded sedge weed density of 1.00 and 2.33 m$_{-2}$, respectively.

Broad leaved weed density (BLW) was significantly reduced by post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS (T_6) to 1.00 m^{-2}. This was followed by sequence application of pre-emergence oxyfluorfen and post-emergence 2, 4 -D on 30 DAS (T_{10}) and post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9) with BLW of 1.67 and 2.67 m$_{-2}$, respectively.Unweeded control (T_{12}) recorded higher sedge weed density of 51.24 and 63.28 m$_{-2}$ at 60 and 90 DAS, respectively.

Post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS (T_6) significantly lowered the total weed density to 18.00 m$_{-2}$. This was followed by sequence application of pre-emergence oxyfluorfen and post-emergence 2, 4 -D on 30 DAS (T_{10}) and post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9). But post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9) was comparable with post -emergence bispyribac sodium alone on 20 DAS (T_8). Post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS (T_6) significantly increased the WCE. It might be due to the use of mixture of herbicides which showed broad spectrum control of weeds. This is evident from earlier result that lower grass weed density and dry weight were obtained by

fenoxaprop-p-ethyl 6.9 % EC from 47.44 to 60.38 g ha^{-1} (Mallick *et al.,* 2009). Another result with metsulfuron-methyl + chlorimuron-ethyl at 4 g ha^{-1} provided excellent control of broad-leaved weeds and sedges (Singh and Tewari, 2005).

Post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS (T_6) provided a broad spectrum of weed control by significantly reducing the dry weight of grass, sedge, BLW and total weeds at 60 DAS. This weed management practice (T_6) was followed by sequential application of pre-emergence oxyfluorfen and post-emergence 2, 4-D on 30 DAS (T_{10}) and post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9). These treatments were found to be superior compared to farmers' practice of hand weeding twice and test chemical of pre-emergence application of pretilachlor (Table 1).

Grain and straw yields

The economic yield in the single usage of herbicide treatments were found superior to farmers' practices of hand weeding twice and test chemical pre-emergence application of pretilachlor alone. Post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9) recorded significantly higher grain and as straw yield (Table 1). The treatment post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9) recorded additional grain yield of 1770, 1933 and 2535 kg ha^{-1} compared to farmers practice, post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS (T_6) and pre-emergence application of pretilachlor alone. This showed the superiority of the treatment T_9 over all other common weed management practices of direct seeded rice. It might be due to the broad spectrum weed control, reduced weed growth and higher weed control efficiency at early stage crop weed competition caused by the mixture of herbicides. Similar results were also noticed with fenoxoprop at 0.06 kg ha^{-1} mixed with ethoxysulfuron at 0.015 kg ha^{-1} as post emergence produced significantly higher grain yield (Tiwari *et al.,* 2010).

Economics

The economic evaluation of results indicated that post emergence mixture of fenoxaprop + ethoxy sulfuron on 30 DAS (T_9) registered higher gross return (Rs. 50915 ha^{-1}), net return (Rs. 28281 ha^{-1}) and B:C ratio (2.25) (Table 1). This promising weed management treatment (T_9) recorded additional gross return of Rs. 14205 ha^{-1} and net return of Rs. 17830 ha^{-1} compared to farmers' practice of hand weeding twice. This was achieved by way of effective, long term and timely broad spectrum control of weeds by these mixtures of herbicides which prevented the crop weed competition. As a result more uptake of nutrients and more crop growth resulting in higher grain yield were obtained in the above promising weed management practices. This was followed by post-emergence bispyribac sodium alone on 20 DAS (T_8) and post-emergence azimsulfuron alone on 20 DAS (T_7). Similarly, this treatment (T_9) recorded additional gross return of Rs. 20300 ha^{-1} and net return of Rs. 20087 ha^{-1} compared to recommend pretilachlor –S alone (T_2). Because in the later treatment (T_2) only one chemical i.e. pretilachlor –S was used as pre emergence on 0-5 DAS without any follow up chemical or weeding. The farmers' practice of hand weeding twice registered higher cost of cultivation (Rs. 26258 ha^{-1}) and lower net return (Rs. 20758 ha^{-1}) as well as B:C ratio (1.79) which was probably due to higher labour cost involved for hand weeding twice. This is in line with Saha *et al.* (2005) who stated hand weeding as cost prohibitive method. It is concluded that post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9) in aerobic rice is the appropriate weed management practice to control broad spectrum of weeds and to achieve higher productivity and economic returns in rice.

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Received: February 24, 2012; Accepted: May 25, 2012