Short communication

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Efficacy of herbicides for weed control in aerobic rice

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In the 21st century along with population pressure, the scarcity of agricultural land, water and shortage of labour maintained pressure for a shift towards direct seeding methods in rice cultivation (Mortimer *et al.* 2005). Aerobic rice systems, wherein the crop is established through direct seeding in non-puddled, non-flooded fields, are among the most promising approaches for saving water (Bhushan *et al.* 2007). Weeds pose a serious threat to the direct seeded aerobic rice by competing for nutrients, light, space and moisture throughout the growing season (Hussain *et al.* 2008). Samar Singh *et al.* (2008a) reported that in aerobic direct seeded rice, loss of grain yield due to weed competition ranged from 38 to 92%. Therefore, the present investigation was undertaken to find out the efficacy of new generation herbicides for broad-spectrum weed control over traditional recommended herbicide in aerobic rice.

Field experiment was conducted at Agricultural College and Research Institute, Madurai during *Rabi* 2010-2011. The investigation was carried out on weed management in aerobic rice with 12 treatments under randomized block design (RBD) with three replications. The test variety of rice was '*ADT 47*'. The weed management treatments imposed were pre-emergence pyrazosulfuron alone (25 g/ha) on 3 DAS (T_1), pre-emergence pretilachlor-S alone (750 ml/ha) on 3 DAS (T_2), post-emergence cyhalofop butyl alone (90 ml/ha) on 25 DAS (T_3), post-emergence fenoxaprop alone (60 ml/ha) on 30 DAS (T_4), post-emergence mixture of cyhalofop butyl + (chlorimuron + metsulfuron) (90 ml + 20 g/ha) on 30 DAS (T_5), post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) (60 ml + 20 g/ha) on 30 DAS (T_6), post-emergence azimsulfuron alone (35 g/ha) on 20 DAS (T_7), post-emergence bispyribac sodium alone (25 ml/ha) on 20 DAS (T_8), post-emergence mixture of fenoxaprop + ethoxysulfuron (60 ml + 15 g/ha) on 30 DAS (T_9), sequence application of pre-emergence oxyfluorfen and post-emergence 2,4-D (300 ml + 500 g/ha) 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 dry matter production (DMP) were subjected to square root transformation.

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Weed flora

The predominant category of weed was broad leaved weeds followed by grasses and sedges. The weed flora mainly consisted of *Echinochloa colona, 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.

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 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 grass density of 18.7 and 22.0/m^2, respectively. But treatment T_9 was comparable with post-emergence bispyribac sodium alone on 20 DAS (T_8).

Sedge weed density was not found 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 1.0 and 2.3/m^2, respectively.

Broad leaved weed (BLW) density 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. Hand weeding twice recorded grass, sedge and BLW density of 28.3, 12.0 and 8.3/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 weed control efficiency (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 fenoxaprop ethyl at 50 g/ha could be used as post-emergence spray for the control of grassy weeds (Samar Singh *et al.* 2008b). Another result with metsulfuron-methyl + chlorimuron-ethyl at 4 g/ha provided excellent control of broad leaved weeds and sedges (Singh and Tewari 2005). However, Purshotam Singh *et al.* (2007) recorded highest weed control efficiency with

Table 1. Effect of new herbicides on weed density, dry weight at 60 DAS and grain yield of aerobic rice

Treatment	*Weed density (no./m^2)				WCE (%)	*Weed dry matter production (kg/ha)				Grain yield (kg/ha)
	Grasses	Sedges	BLWs	Total		Grasses	Sedges	BLWs	Total	
T_1- Pre-emergence pyrazosulfuron alone on 3 DAS	7.31 (53)	3.81 (14)	3.98 (15)	9.10 (82)	70.2	13.17 (173)	3.94 (15)	6.67 (44)	15.24 (232)	3795
T_2- Pre-emergence pretilachlor-S alone on 3 DAS	7.33 (59)	4.06 (16)	4.38 (18)	9.72 (94)	66.0	13.43 (180)	4.30 (18)	8.57 (73)	16.49 (271)	3743
T_3- Post-emergence cyhalofop butyl alone on 25 DAS	6.47 (41)	4.00 (15)	3.89 (14)	8.48 (71)	74.2	12.31 (151)	4.06 (16)	6.52 (42)	14.48 (209)	3860
T_4- Post-emergence penoxapropalonen 30 DAS	5.46 (29)	4.10 (16)	4.14 (16)	7.92 (62)	77.4	8.69 (75)	4.41 (19)	6.74 (45)	11.81 (139)	4065
T_5- Post-emergence mixture of cyhalofopbutyl+chlorimuron + metsulfuron) on 30 DAS	5.85 (34)	3.44 (11)	3.72 (13)	7.67 (58)	78.9	9.08 (82)	2.92 (8)	5.70 (32)	11.06 (122)	4118
T_6- Post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS	4.06 (16)	1.22 (1)	1.22 (1)	4.30 (18)	93.5	6.52 (42)	1.87 (3)	2.92 (8)	7.30 (53)	4345
T_7- Post-emergence azimsulfuron alone on 20DAS	5.08 (25)	1.87 (3)	3.34 (10)	6.28 (39)	85.9	8.22 (67)	2.12 (4)	5.05 (25)	9.80 (96)	5153
T_8- Post-emergence bispyribac sodium alone on 20 DAS	4.81 (22)	0.71 (0)	2.20 (4)	5.24 (27)	90.2	8.09 (65)	0.71 (0)	4.84 (23)	9.40 (88)	5805
T_9- Post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS	4.74 (22)	1.68 (2)	1.78 (2)	5.24 (27)	90.2	7.97 (63)	2.12 (4)	4.53 (20)	9.33 (87)	6278
T_{10}–Pre-emergence oxyfluorfen and post-emergence 2, 4-D on 30 DAS	4.38 (19)	0.71 (0)	1.47 (1)	4.56 (20)	92.6	7.84 (61)	0.71 (0)	4.30 (18)	8.93 (79)	4262
T_{11}-Two hand weeding at 15 and 35 DAS	5.37 (28)	3.54 (12)	2.97 (8)	7.01 (48)	82.4	8.51 (72)	3.08 (9)	4.95 (24)	10.25 (105)	4508
T_{12}-Unweeded control	11.14 (124)	7.19 (51)	10.12 (102)	16.66 (276)	-	21.94 (481)	9.62 (92)	21.53 (463)	32.20 (1036)	2105
LSD (P=0.05)	0.19	0.09	0.11	0.25		0.340	0.10	0.21	0.42	357

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

metsulfuron-methyl 10% + chlorimuron-ethyl 10% (Almix) 8 g/ha.

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).

Visual phyto-toxicity on crop

Phyto-toxicity symptom was observed on aerobic rice at 10, 20 days after herbicide spraying and before harvest. The result on phyto-toxicity rating revealed that pre-emergence oxyfluorfen and post-emergence 2,4-D on 30 DAS (T_{10}) showed phyto-toxicity rating of 5 on 10 DAS and 4 on 20 DAS and no toxicity before harvest. This was reported earlier by Kathiresan and Manoharan (2002). All other herbicidal weed management treatments did not exhibit any phyto-toxicity symptoms at any stage of the aerobic rice (Table 2).

Economic yield

Grain yield was significantly improved by weed control treatments compared to unweeded control. Among

Table 2. Visual phyto-toxicity of aerobic rice at 10 and 20 DAS and before harvest

Treatment	Visual phytotoxicity					
	10 DAS	Rating	20 DAS	Rating	Before harvest	Rating
T_1-Pre-emergence pyrazosulfuron alone on 3 DAS	No injury, normal	0	No injury, normal	0	No injury, normal	0
T_2-Pre-emergence pretilachlor-S alone on 3 DAS	No injury, normal	0	No injury, normal	0	No injury, normal	0
T_3-Post-emergence cyhalofop butyl alone n 25 DAS	No injury, normal	0	No injury, normal	0	No injury, normal	0
T_4-Post-emergence penoxapropalonen 30 DAS	No injury, normal	0	No injury, normal	0	No injury, normal	0
T_5-Post-emergence mixture of cyhalofopbutyl+chlorimuron + metsulfuron) on 30 DAS	No injury, normal	0	No injury, normal	0	No injury, normal	0
T_6-Post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS	No injury, normal	0	No injury, normal	0	No injury, normal	0
T_7-Post-emergence azimsulfuron alone on 20DAS	No injury, normal	0	No injury, normal	0	No injury, normal	0
T_8-Post-emergence bispyribac sodium alone on 20 DAS	No injury, normal	0	No injury, normal	0	No injury, normal	0
T_9-Post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS	No injury, normal	0	No injury, normal	0	No injury, normal	0
T_{10}–Pre-emergence oxyfluorfen and post-emergence 2,4-D on 30 DAS	Injury more persistent, recovery doubtful	5	Moderate injury, recovery possible	4	No injury, normal	0
T_{11}-Two hand weeding at 15 and 35 DAS	-	-	-	-	-	-
T_{12}-Unweeded control	-	-	-	-	-	-

different treatments, post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9) recorded significantly higher grain yield of 6278 kg/ha. Fenoxaprop + ethoxysulfuron 50 +18 g/ha at 21 DAS were found effective in reducing the weeds and improving the yield (Samar Sing *et al.* 2008b). This was followed by post-emergence bispyribac sodium alone on 20 DAS (T_8), post-emergence azimsulfuron alone on 20 DAS (T_7). Unweeded control (T_{12}) recorded very low grain yield of 2105 kg/ha which was 4173 kg/ha lesser than best treatment of post emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9) (Table 1).

Fenoxaprop at 0.06 kg/ha mixed with ethoxysulfuron at 0.015 kg/ha as post-emergence showed the lowest weed dry matter, highest weed control efficiency and higher grain yield (Tiwari *et al.* 2010). Similar results of increased yield through effective weed control were also noticed with fenoxaprop-ethyl (Lourens *et al.* 1989) and ethoxysulfuron (Hussain *et al.* 2008).

The post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS (T_9) in aerobic rice was the appropriate weed management practice to control broad spectrum of weed species with minimum grass, sedge, broad-leaved weed and total weed density and their dry matter production and higher weed control efficiency to obtain higher productivity in aerobic rice.

SUMMARY

Field experiment was conducted at Agricultural College and Research Institute, Madurai during *Rabi* 2010-2011 to study the efficacy of new herbicides for controlling weeds in aerobic rice. Minimum grass, sedge, broad leaved weed and total weed density and their dry matter production and higher weed control efficiency were obtained in plots receiving post-emergence mixture of fenoxaprop + (chlorimuron + metsulfuron) on 30 DAS followed by sequential application of pre-emergence oxyfluorfen and post-emergence 2,4-D on 30 DAS and post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS. The result on phyto-toxicity rating revealed that pre-emergence oxyfluorfen and post-emergence 2,4-D on 30 DAS showed phyto-toxicity rating of 5 on 10 DAS and 4 on 20 DAS and no toxicity before harvest. Post-emergence mixture of fenoxaprop + ethoxysulfuron on 30 DAS recorded significantly higher grain yield of 6278 kg/ha.

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