INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

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RELATIVE EFFICACY OF DIFFERENT HERBICIDES FOR WEED CONTROL IN AEROBIC RICE (*Oryza sativa* L.)

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ABSTRACT
A field trial was conducted during *kharif* 2010 at Main Research Station, Hebbal, University of Agricultural Sciences, Bangalore to evaluate relative efficacy of different herbicides for weed control in aerobic rice. The major weed flora observed in the experimental field was *Echinochloa colonum, Digitaria marginata, Chloris barbata, Cynadon dactylon, Ageratum conyzoides, Commelina benghalensis, Spilanthus acmella, Mollugo disticha, Celosia argentia, Parthenium hysterophorus* and *Cyperus rotundus*. Among different herbicide treatments pre emergent application of bensulfuron methyl @ 60 g + pretilachlor @ 600 g a.i ha^{-1} recorded significantly higher productive tillers per hill (21.32), panicle weight (2.81 g), thousand grain weight (21.80 g), filled spikelets per panicle (88.23), weed control efficiency (91.37), grain yield (4100 kg ha^{-1}), straw yield (4961 kg ha^{-1}) and lower total weed density and dry weight (72 No.m^{-2} and 3.65 g 0.25 m^{-2}, respectively), followed by two hand weedings at 20 and 40 DAS and oxyfluorfen @ 90 g a.i. ha^{-1} as pre-emergent spray followed by 2, 4-DEE as post emergent spray @ 500 g a.i. ha^{-1} at 25 DAS which were on par with each other. Whereas, Un weeded check registered significantly lower productive tillers per hill (6.13), panicle weight (1.70 g), thousand grain weight (19.02 g), filled spikelets per panicle (40.50), grain yield (339 kg ha^{-1}), straw yield (462 kg ha^{-1}) and higher total weed density and dry weight (253 No.m^{-2} and 42.30 g 0.25 m^{-2}, respectively) with a weed index of 91.7 per cent.

KEY WORDS: Aerobic rice, pre emergent, post emergent, weed index.

INTRODUCTION

Aerobic rice refers to growing of rice varieties in non-puddled and non-flooded condition. Aerobic rice is a new method of cultivating rice that requires less water than low land rice. It entails the growing of rice in aerobic soil, with the use of external inputs such as supplementary irrigation, fertilizers besides aiming at high yields. In this method, land is brought to fine tilth under dry condition, the seeds are dibbled in definite row proportion with wider spacing and soil moisture regime is maintained almost around field capacity. With this method about 60 to 70 per cent of irrigation water is observed to be saved (Shanmuganathan, 2006). Weed infestation and competition is more severe in direct seeded aerobic rice as compared to transplanted rice, because of the reasons *viz.*, land is exposed during initial crop growth stages, aerobic soil conditions, dry tillage practices and alternate wetting and drying make the conditions more conducive for germination and growth of weeds. Direct seeded aerobic rice is highly infested with grasses, broad leaved weeds and sedges. Unlike transplanted rice early and timely weed control is essential in aerobic rice; otherwise the yield loss is to an extent of 82.00 per cent due to crop weed competition (Thimme Gowda, 2006). Among the agronomic requirements to improve the yield levels of aerobic rice timely weed control plays an important role. Traditional method of weed management practices are widely adopted for control of weeds in aerobic rice. These practices are tedious, time consuming, labour intensive, costly and not possible to practice over an extensive area. Further, due to labour scarcity and high labour wages as a result of rapid industrialization and urbanization, traditional weed management practices are being impracticable. Herbicide usage for control of weeds in crop lands has been proved successful in many advanced countries and is now gaining importance in Indian agriculture. Chemical weed control is more economical, less time consuming, less expensive and provides early weed control and crop establishes in a weed free environment. Several herbicides are available in the market and some new herbicides are continuously being introduced. But information on their usage under field conditions, suitability for aerobic rice and their concentrations for effective weed control of weeds is scarce. In view of the above facts, a field experiment was conducted.

MATERIALS & METHODS

The field investigation was undertaken at Main Research Station, Hebbal, University of Agricultural Sciences, Bangalore during *Kharif* 2010. The soil of the experimental site was sandy loamy in texture and pH was normal (6.5). The soil was medium in available nitrogen (490 kg ha^{-1}), available phosphorus (24 kg ha^{-1}) and available potassium

(146 kg ha^{-1}). The organic carbon content was medium (0.75 %). A popular medium duration variety MAS-946-1 was sown in June with a spacing of 30 cm X 30 cm. Experiment included twelve treatments consisted of T_1= pyrazosulfuron ethyl @ 25 g a.i. ha^{-1} as PE (pre-emergent spray) at 3 DAS (Days after sowing), T_2= pretilachlor + safener @ 300 g a.i. ha^{-1} as PE at 3 DAS, T_3= Oxadiargyl @ 80 g a.i. ha^{-1} as PE at 3 DAS, T_4= bensulfuron methyl @ 60g+ Pretilachlor @ 600 g a.i. ha^{-1} as PE at 3 DAS, T_5=butachlor 750 g a.i. ha^{-1} as PE at 3 DAS, T_6= cyhalofop butyl @ 100 g a.i. ha^{-1} + Ethoxysulfuron @ 60 g a.i. ha^{-1} as POE (post emergent spray) at 20 DAS, T_7=chlorimuron ethyl + metsulfuron methyl @ 4 g a.i. ha^{-1} as POE at 20 DAS, T_8=oxyfluorfen @ 90 g a.i. ha^{-1} as PE at 3 DAS + 2, 4-DEE as POE at @ 500 g a.i. ha^{-1} at 25 DAS, T_9= pyrazosulfuron ethyl @ 25 g a.i. ha^{-1} as PE at 3 DAS +chlorimuron ethyl + metsulfuron methyl @ 4 g a.i. ha^{-1} as POE at 30 DAS, T_{10}=passing of cycle hoe 3 times at 15, 30, & 45 DAS, T_{11}= two hand weedings at 20 and 40 DAS and T_{12}= Unweeded check were laid out in Randomized Complete Block Design (RCBD) with three replications. The experimental data collected on growth and yield components of crop and weed growth parameters was subjected to Fisher's method of "Analysis of Variance" (ANOVA) as outlined by Panse and Sukhatme (1967). Wherever, F- test was significant an appropriate value of critical difference (C.D.) was worked out for comparison among the treatment means, otherwise, against C.D. values NS (Non significant) was indicated. The results were presented and discussed at a probability level of five per cent. Correlation matrix was worked out between the various characters and grain yield (Gomez and Gomez, 1984). Since the data on weed count and weed dry weight were not normally distributed, the data were subjected to square root and logarithmic transformation using the formulae $\sqrt{x+1}$ and Log X+2 and the statistical analysis was done.

$$\text{Weed control efficiency} = \frac{\text{Dry matter production of weeds in unweeded plot – dry matter production of weeds in treated plot}}{\text{Dry matter production of weeds in unweeded plot}} \times 100$$

$$\text{Weed index} = \frac{\text{Yield from hand weeded plot – yield from treatment plot}}{\text{Yield from hand weeded plot}} \times 100$$

RESULTS & DISCUSSION

The various observations made on weeds and crop namely weed density, dry weight of weeds, weed index and weed control efficiency besides yield and yield parameters and correlation studies of aerobic rice as influenced by various treatments are presented in Table 1, 2 & 3.

Effect on weeds

The predominant weed flora observed in the experimental field in association with the aerobic rice includes grasses like, *Echinochloa colonum, Digitaria marginata, Elusine indica, Chloris barbata, Cynadon dactylon and Dactyloctenium aegyptium*. Among broad leaved weeds *Ageratum conyzoides, Commelina benghalensis, Spilanthus acmella, Acanthospermum hispidum, Mollugo disticha, Phyllanthus niruri, Protulaca oleraceae, Cynotis axillaries, Stachytarpheta indica, Celosia argentia, Parthenium hysterophorus* and *Aeschynomene indica* and among sedges *Cyperus rotundus.* Similar weed species under direct seeded upland rice, aerobic rice were also reported by Mishra and Singh (2007), Moorthy and Sanjoy Saha (2002), Fayaz Ahmed Bahar and Govindra Singh (2004), Singh *et al.* (2005), Sunil (2010) and Sanjoy Saha *et al*. (2005). Weed control efficiency is a measure of the efficiency of weed control methods in restricting the weed growth. Among weed control treatments bensulfuron methyl @ 60 g + pretilachlor @ 600 g a.i. ha^{-1} as pre-emergent spray recorded higher weed control efficiency at harvest (91.37 %) which was followed by oxyfluorfen @ 90 g a.i. ha^{-1} as pre-emergent spray fb 2, 4-DEE as post emergent spray @ 500 g a.i. ha^{-1} at 25 DAS (90.14 %) and two hand weedings at 20 and 40 DAS (90.09%) compared to unweeded check. This was due to better control of weeds during crop growth period which results in lower total weed population and its dry weight. However, lower weed control efficiency among herbicide treatments was noticed with pre emergence application of butachlor at 750 g a.i. ha^{-1} (68.41 %) followed by chlorimuron ethyl + metsulfuron methyl @ 4 g a.i. ha^{-1} as post emergent spray at 20 DAS (72.34 %). The lower weed control efficiency was due to poor control of weeds as a result recorded higher weed population and their dry weight. The results are in conformity with findings of Sanjoy Saha (2009) and Singh *et al.* (2005). The weed population and total dry weight of weeds differed significantly due to different weed control treatments. Bensulfuron methyl @ 60 g + pretilachlor @ 600 g a.i ha^{-1} as pre-emergent spray recorded significantly lower grasses, broad leaved weeds, sedge population and their total dry weight (24.00, 31.33, 16.33 No. m^{-2} and 3.65 g 0.25 m^{-2}, at harvest, respectively) which was on par with two hand weedings at 20 and 40 DAS (32.70, 33.00,18.33 No. m^{-2} and 4.19g 0.25 m^{-2} at harvest, respectively) and oxyfluorfen @ 90 g a.i. ha^{-1} as pre-emergent spray fb 2, 4-DEE as post emergent spray @ 500 g a.i. ha^{-1} at 25 DAS (26.70, 38.00, 19.90 No. m^{-2} and 4.17 g 0.25 m^{-2}, at harvest, respectively).

ISSN 2229 – 6441

TABLE 1: Effect of weed control treatments on weed density, weed dry weight and weed control efficiency.

Treatments	Weed density (No. m^{-2}) #				Weed dry weight (g 0.25 m^{-2}) *				WCE
	Grasses	BLW	Sedges	Total	Grasses	BLW	Sedges	Total	
T_1	1.77 (57)	1.76 (56)	1.52 (31)	2.16 (144)	1.91 (2.70)	2.17 (4.70)	1.24 (0.53)	2.99 (7.93)	81.25
T_2	1.78 (58)	1.79 (60)	1.53 (32)	2.18 (150)	2.06 (3.30)	2.20 (4.75)	1.26 (0.60)	3.11 (8.65)	79.55
T_3	1.72 (50)	1.75 (54)	1.46 (27)	2.12 (131)	1.76 (2.10)	2.13 (6.30)	1.21 (0.46)	3.14 (8.86)	79.05
T_4	1.41 (24)	1.53 (32)	1.26 (16)	1.87 (72)	1.48 (1.20)	1.65 (2.20)	1.11 (0.25)	2.16 (3.65)	91.37
T_5	1.90 (78)	1.94 (85)	1.79 (60)	2.35 (223)	2.47 (5.20)	2.62 (7.10)	1.46 (1.16)	3.79(13.36)	68.41
T_6	1.83 (65)	1.89 (75)	1.64 (42)	2.26 (182)	2.14 (3.60)	2.29 (4.85)	1.33 (0.77)	3.20 (9.22)	78.20
T_7	1.85 (68)	1.91 (79)	1.79 (60)	2.32 (207)	2.29 (4.28)	2.50 (6.40)	1.42 (1.03)	3.56(11.70)	72.34
T_8	1.46 (27)	1.60 (38)	1.32 (19)	1.93 (84)	1.53 (1.35)	1.70 (2.50)	1.15 (0.32)	2.27(4.17)	90.14
T_9	1.68 (46)	1.73 (52)	1.45 (26)	2.10 (124)	1.61 (1.60)	1.73 (2.66)	1.19 (0.43)	2.39 (4.69)	88.91
T_{10}	1.88 (73)	1.88 (74)	1.74 (53)	2.31 (200)	2.02 (3.30)	2.41 (5.50)	1.39 (0.93)	3.28 (9.73)	76.99
T_{11}	1.53 (32)	1.54 (33)	1.30 (18)	1.93 (83)	1.51 (1.30)	1.69 (2.63)	1.12 (0.26)	2.28 (4.19)	90.09
T_{12}	1.95 (87)	1.96 (90)	1.89 (76)	2.41 (253)	4.70 (21.30)	3.61 (16.90)	2.23 (4.10)	6.58(42.30)	0.00
S. Em $\pm$	0.07	0.07	0.07	0.07	0.042	0.03	0.028	0.06	NA
CD @ 5 %	0.21	0.20	0.18	0.22	0.122	0.069	0.082	0.17	NA

Values in the parenthesis are original values, BLW: broad leaved weeds, # Sq root transformation, * Log transformation; NA**:** Not Analysed

TABLE 2: Effect of weed control treatments on yield parameters, grain yield, straw yield and weed index (WI) of aerobic rice.

Treatments	Productive tillers per hill	Panicle weight (g)	1000 grain weight (g)	Filled spikelets per Panicle	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	WI (%)
T_1	20.10	2.46	20.80	83.42	3436	4290	15.65
T_2	20.14	2.27	20.00	81.24	3279	4015	19.51
T_3	20.85	2.41	21.00	83.12	3529	4376	13.39
T_4	21.32	2.81	21.80	88.23	4100	4961	0.00
T_5	18.95	1.74	20.07	68.97	2421	3190	40.50
T_6	19.04	2.01	21.00	80.04	2907	3575	28.64
T_7	18.01	1.75	21.00	70.10	2506	3190	38.41
T_8	21.16	2.57	21.38	87.90	3876	4730	4.85
T_9	21.00	2.53	21.10	84.67	3696	4565	9.28
T_{10}	18.86	1.99	21.03	73.24	2660	3410	34.71
T_{11}	21.30	2.62	21.56	88.16	4074	4928	0.00
T_{12}	6.13	1.70	19.02	40.50	339	462	91.68
S. Em $\pm$	0.08	0.09	0.13	1.06	109	119	NA
CD @ 5 %	0.25	0.25	0.40	3.00	320	350	NA

NA=Not Analyzed

TABLE 3: Correlation Co-efficient (r) values on grain yield, yield components, Weed population and dry weight of aerobic rice as influenced by weed control treatments

Correlation coefficient (r)	Grain yield	Productive tillers per hill	Panicle weight	1000 grain weight	Filled spikelets per panicle	Total weed population	Total weed dry weight
Grain yield	1.00*	0.950*	0.860*	0.848*	0.989*	-0.906*	-0.948*

* Significant at 5 per cent probability level, n = 36

The reduced grasses, broad leaved weeds, sedges and their total dry weight in these treatments was due to effective control of the weeds at all stages of crop growth period resulted in lower weed population and their total dry weight. Whereas, significantly higher population of grasses, broad leaved weeds, sedges and their total dry weight was registered with unweeded check (84.00, 90.33, 76.00 No. m^{-2} and 42.30 g 0.25 m^{-2}, at harvest, respectively) is due to no control of weeds. The results are in conformity with findings of Dubey *et al.* (2005), Sanjoy Saha (2005 & 2009) and Singh *et al.* (2005). Higher weed control efficiency and lower weed index was recorded with application of bensulfuron methyl @ 60g+ pretilachlor @ 600 g a.i. ha^{-1} as pre-emergent spray at 3 DAS followed by two hand weedings at 20 and 40 DAS and oxyfluorfen @ 90 g a.i. ha^{-1} as pre-emergent spray at 3 DAS + 2, 4-DEE as post emergent spray at @ 500 g a.i. ha^{-1} at 25 DAS (T_8) which were on par with each other. This was mainly due to better control of weeds even upto harvest resulting in lower weed density and dry weight of weeds. The results are in conformity with findings of Singh *et al.* (2005).

Effect on growth and yield

Grain and straw yield differed significantly due to different weed control treatments (Table 2). In the present investigation yield loss recorded due to crop weed competition is to an extent of 91.70 per cent as indicated by weed index value. Weed control treatments registered significantly higher grain and straw yield than unweeded check. The higher grain and straw yield was recorded with application of bensulfuron methyl @ 60g+ pretilachlor @ 600 g a.i. ha^{-1} as pre-emergence spray at 3 DAS (4100 and 4961 kg ha^{-1}, respectively) which was on par with two hand weedings at 20 and 40 DAS (4074 and 4928 kg ha^{-1}, respectively) and oxyfluorfen @ 90 g a.i. ha^{-1} as pre-emergence spray at 3 DAS + 2, 4-DEE as post emergent spray at @ 500 g a.i. ha^{-1} at 25 DAS (3876 and 4730 kg ha^{-1}, respectively). The higher grain and straw yield in these treatments is mainly due to better control of weeds and higher weed control efficiency during early stage of crop growth which resulted in effective utilization of resources such as nutrients, moisture, space and light resulted in better expression of yield component viz., number of productive tillers per hill (21.32, 21.30 and 21.16 respectively), number of filled spikelets per panicle (88.23, 88.16 and 87.90, respectively), panicle weight (2.81, 2.62 and 2.57 g, respectively) and test weight (21.80, 21.56 and 21.38 g respectively). Whereas, lower grain and yield was recorded with unweeded check (339 and 462 kg ha^{-1}) owing to severe crop weed competition which resulted in reduction in the expression of yield components such as productive tillers per hill (6.13), panicle weight (1.70 g), thousand grain weight (19.02 g), filled spikelets per panicle (40.50). These results are in conformity with the findings of Dubey *et al.* (2005),

Sanjoy Saha (2005 & 2009), Singh *et al*. (2005) and Sunil. (2011).

Correlation studies

There was a significant positive correlation (r values) between grain yield and productive tillers, panicle weight, 1000 grain weight, filled spikelet's per panicle. But there was negative correlation (r values) between total weed population and total weed dry weight (Table 3). Thus bensulfuron methyl @ 60g+ Pretilachlor @ 600 g a.i. ha^{-1} as pre-emergent spray at 3 DAS may be recommended for controlling the weeds in aerobic rice Sunil. (2011).

CONCLUSION

The above study indicates pre-emergence application of bensulfuron methyl @ 60g + pretilachlor @ 600 g a.i. ha^{-1} as or application of oxyfluorfen @ 90 g a.i. ha^{-1} as pre-emergent spray + 2, 4-DEE as post emergent spray @ 500 g a.i. ha^{-1} at 25 DAS resulted in similar grain and straw yield as that of hand weeding and significantly superior over unweeded control thereby reducing the dependence of human labour for hand weeding, especially in the era of urbanization and industrialization.

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