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Studies on chemical weed control in aerobic rice (*Oryza sativa* L.)

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Aerobic rice production system is gaining importance for increased productivity and reduced water usage and is expected to occupy 10-15 per cent of the total area in India. The major constrains to get higher yield in aerobic rice is weed infestation which cause around 80-90 per cent reduction in grain yield. Manual removal of weeds is suppose to be easy and ecofriendly but highly labour intensive, tedious, back breaking and does not ensure weed removal at critical stages due to non-availability of labours. Hence, there is a need to develop alternative practices for controlling the associated weeds. In such conditions herbicides offer most practical and cost effective means of reducing weed competitions. Therefore, to study the efficacy of some pre-emergence herbicides on aerobic rice the present investigation was under taken.

The experiment was conducted during *kharif* season of 2005, at Agriculture College, V.C. Farm, Mandya. The soil was sandy loam in texture and slightly acidic in reaction (6.76) with low available nitrogen, medium available phosphorus and potassium. The organic carbon content was medium (0.39 %). Rasi (IET-1444) a popular medium duration variety was sown in mid August with a spacing of 25 x 25 cm. There were included twelve treatments consisted of three doses, each of butachlor (0.75, 1.00 and 1.25 Kg a. i. ha^{-1}), pyrazosulfuron ethyl (20, 25 and 30 g *a.i.* ha^{-1}) and clomozone + 2,4-DEE (0.75, 1.00 and 1.25 litre ha^{-1}), two hand weeding at 20 and 45 DAS, two inter cultivation at 20 and 45 DAS and weedy check were laid out in Randomized Complete Block Design (RCBD) with three replications. Pre-emergence application of herbicides was done at one day after sowing. Irrespective of the treatments one intercultural operation was given at 45 DAS. The data was subjected to square root transformation using the formula $\sqrt{x+0.5}$ and the statistical analysis was done.

The major weed flora observed in experimental plots were: *Digetaria sanguinalis, Cynodon dactylon, Panicum repens* and *Dactyloctenium aegyptium*. The narrow leaved weeds (NLW) were, *Aegeratum conyzoids, Commelina benghalensis, Euphorbia hirta and Tridax procumbens. Phyllanthus niruri and Celosia argentia* were broad leaved weeds (BLW) and *Cyperus rotundus* and *Cyperus iria* were sedges.

Hand weeding at 20 and 45 DAS excelled with a lowest weed population of weeds (43.67 m^{-2}) and dry weight of weeds (3.42 g 0.25 m^{-2}) among the various treatments. It was at par with clomozone + 2,4-DEE @ 1.25 litre ha^{-1} and pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1} for controlling NLW and with pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1} for controlling BLW. Among the various herbicides, lowest weed population (48 m^{-2}) and dry weight of weeds (3.94 g 0.25 m^{-2}) were observed with pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1} followed by clomozone + 2,4-DEE @ 1.25 litre ha^{-1}. The highest weed population (366.33 m^{-2}) and dry weight of weeds (43.11 g 0.25 m^{-2}) were observed with unweeded check. The weed control efficiency was higher with hand weeding (92.07 %) and pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1} (90.86 %).

Hand weeding at 20 and 45 DAS recorded significantly taller plant height and higher dry matter production (72.53 cm and 66.25 g $hill^{-1}$, respectively) among the various treatments. It was statistically on par with herbicide treatment pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1} (71.53 cm and 65.37 g $hill^{-1}$). Sharma *et al*. 2004 and Moorthy 2002 also reported similar results in direct seeded rice. Unwedded check registered significantly least plant height and dry matter production (52.33cm and 16.58 g $hill^{-1}$) as a consequence of severe competition of rice plant with weeds for available resources.

The yield attributing parameters *viz*, number of effective tillers per hill, panicle length, filled grains per panicle and 1000 grain weight were found significantly higher with two hand weeding at 20 and 45 DAS (20, 23.67 cm, 132.73 and 24.93 g, respectively) and was remaining statistically at par with pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1}. The increase in yield attributing parameters in above mentioned treatments was mainly due to better crop growth. In general higher doses of various herbicides expressed higher growth and yield attributing characters as compared to their lower doses due to their higher weed control efficiency except clomozone + 2,4-DEE (Table 2).

All the weed control treatments registered significantly higher yield than weedy check The highest grain and straw yield among the treatments was recorded under hand weeding at 20 and 45 DAS

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(5.07 t ha^{-1} and 5.53 t ha^{-1}). It was on par with pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1}. The results are in good agreement with like, Budhar *et al*. (1991), Moorthy (1997b) and Moorthy (2002). Unwedded check recorded 82.84 and 82.60 per cent reduction in grain yield and 75.91 and 75.69 per cent reduction in straw yield as compared to hand weeding at 20 and 45 DAS and pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1}, respectively. This was due to less number of effective tillers per hill, panicle length, filled grains per panicle and 1000 grain weight. Greater competitions offered by weeds throughout crop growth period suppressed the crop, severely affecting plant height and dry matter production per hill led to the poor yield components and thus lower grain yield.

Hand weeding required additional investment of Rs. 2500 ha^{-1}. for removing weeds. All the herbicidal treatments need lesser additional investment (Rs. 625 to 1062 ha^{-1}) depending upon the cost and rate of herbicide application. The maximum gross returns was (Rs. 31,203 ha^{-1}) hand weeding which was closely followed by of pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1} (Rs. 30,782 ha^{-1}). The net returns and benefit cost ratio was maximum with pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1} (Rs. 21,019 ha^{-1} and 2.15). The net returns and benefit cost ratio were quite lower (Rs. 10,940 $ha^{-1}$and 1.77) under two hand weeding at 20 and 45 DAS which indicated that it was less remunerative than most of the herbicidal weed control treatments, confirming the view of Singh and Govindra Singh (2001).

The above study concludes that hand weeding at 20 and 45 DAS found effective in control of weeds and recorded lower weed population and dry weight among various treatments. It was on par with herbicide treatment pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1}. The growth and yield attributing characters were recorded higher with hand weeding at 20 and 45 DAS howere, on par with pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1}. Hand weeding at 20 and 45 DAS recorded significantly higher grain yield and was at par with herbicide treatment pyrazosulfuron ethyl @ 30 g *a.i.* ha^{-1}.

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Table 1: Effect of weed control treatments on weed population, dry weight and weed control efficiency (WCE)

Treatments	Weed population (No. m^{-2}) at harvest				Weed dry weight (g 0.25 m^{-2}) at harvest				WCE (%)
	NLW	BLW	Sedges	Total weeds	Grasses	BLW	Sedges	Total weeds	
T_1	5.15 (26.33)	9.61 (92.00)	4.92 (23.67)	11.93 (142.00)	2.91 (8.00)	3.23 (10.00)	2.16 (4.16)	4.82 (22.16)	48.60
T_2	4.49 (20.00)	7.36 (54.33)	3.78 (14.00)	9.30 (88.33)	2.35 (5.00)	2.80 (7.40)	1.64 (2.10)	4.00 (14.59)	66.16
T_3	3.98 (12.67)	6.75 (45.00)	3.66 (13.00)	8.39 (70.67)	2.12 (4.00)	2.47 (5.83)	1.50 (1.75)	3.54 (11.58)	73.14
T_4	5.58 (31.00)	7.70 (59.00)	1.92 (3.33)	9.66 (93.33)	3.21 (9.80)	2.30 (4.80)	0.83 (0.19)	3.96 (14.79)	65.69
T_5	4.40 (19.00)	6.99 (48.67)	0.89 (0.33)	8.27 (68.00)	2.71 (6.83)	1.90 (3.10)	0.71 (0.00)	3.23 (9.93)	76.97
T_6	3.47 (11.67)	6.06 (36.33)	0.71 (0.00)	6.96 (48.00)	1.43 (1.54)	1.70 (2.40)	0.71 (0.00)	2.10 (3.94)	90.86
T_7	4.33 (19.33)	7.47 (55.67)	5.00 (24.67)	9.96 (99.67)	1.74 (2.67)	3.05 (8.83)	2.55 (6.00)	4.30 (17.50)	59.41
T_8	3.61 (13.33)	6.56 (43.00)	3.84 (14.33)	8.39 (70.66)	1.44 (1.63)	2.55 (6.00)	2.11 (3.95)	3.57 (11.58)	73.14
T_9	3.05 (9.33)	6.51 (42.33)	3.78 (13.67)	8.08 (65.33)	1.21 (1.00)	2.40 (5.33)	1.89 (3.07)	3.25 (9.40)	78.20
T_{10}	4.48 (19.67)	7.35 (54.00)	3.87 (14.67)	9.40 (88.34)	2.53 (5.93)	2.86 (7.73)	1.89 (3.07)	4.18 (16.73)	61.19
T_{11}	2.11 (4.00)	5.92 (34.67)	2.32 (5.00)	6.66 (43.67)	1.16 (0.87)	1.51 (1.80)	1.12 (0.75)	1.86 (3.42)	92.07
T_{12}	7.27 (53.33)	15.71 (247.33)	8.13 (65.67)	19.19 (366.33)	3.97 (15.33)	4.32 (18.17)	3.18 (9.61)	6.67 (43.11)	-
S.Em. ±	**0.454**	**0.389**	**0.190**	**0.507**	**0.127**	**0.161**	**0.113**	**0.177**	**-**
LSD (P=0.05)	**1.331**	**1.141**	**0.557**	**1.484**	**0.371**	**0.472**	**0.331**	**0.519**	

Values in the parenthesis are original values

T_1: Butachlor @ 0.75 kg *a.i.* ha^{-1}
T_2: Butachlor @ 1.00 kg *a.i.* ha^{-1}
T_3: Butachlor @ 1.25 kg *a.i.* ha^{-1}
T_4: Pyrazosulfuron ethyl @ 20 g *a.i.* ha^{-1}
T_5: Pyrazosulfuron ethyl @ 25 g *a.i.*ha^{-1}
T_6: Pyrazosulfuron ethyl @ 30 g *a.i.*ha^{-1}
T_7: Clomozone + 2,4 - DEE (RM) @ 0.75 lit. ha^{-1}
T_8: Clomozone + 2,4 - DEE (RM) @ 1.00 lit. ha^{-1}
T_9: Clomozone + 2,4 - DEE (RM) @ 1.25 lit. ha^{-1}
T_{10}: Two IC at 20 & 45 DAS
T_{11}: Two HW at 20 & 45 DAS
T_{12}: Weedy check

BLW: Broad leaved weeds
NLW :Narrow leaved weeds
RM : Ready Mix
IC : Inter Cultivation
HW : Hand Weeding

Table 2: Effect of weed control treatments on growth, yield and yield parameters of aerobic rice

Treatments	Plant height (cm)	Dry matter (g hill^{-1})	No. of effective tillers hill^{-1}	Panicle length (cm)	Filled grains per panicle	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	56.97	37.40	10.33	18.57	95.47	22.33	2.76	3.71
T_2	62.90	48.01	15.60	20.50	111.40	23.17	3.37	4.16
T_3	64.27	52.50	16.80	20.90	116.53	23.83	3.75	4.49
T_4	59.20	40.89	13.33	18.60	98.20	23.17	2.95	3.86
T_5	65.43	52.63	15.47	20.00	110.87	23.97	3.81	4.61
T_6	71.53	65.37	19.30	23.30	132.27	24.83	5.00	5.47
T_7	62.33	42.19	13.13	19.17	104.73	23.23	2.96	3.79
T_8	67.10	56.62	17.40	21.00	117.80	24.17	4.16	4.90
T_9	66.93	52.31	16.57	20.80	113.80	24.00	3.81	4.56
T_{10}	60.50	45.79	15.13	19.57	113.07	22.33	3.23	4.07
T_{11}	72.53	66.25	20.00	23.67	132.73	24.93	5.07	5.53
T_{12}	52.33	16.58	4.67	16.33	54.47	21.30	0.87	1.33
S.Em. $\pm$	1.477	1.517	0.573	0.703	3.953	0.441	0.167	0.163
C.D.= P=0.05) at 5%	4.332	4.451	1.680	2.062	11.594	1.299	0.489	0.478

T_1: Butachlor @ 0.75 kg *a.i.* ha^{-1} T_2: Butachlor @ 1.00 kg *a.i.* ha^{-1}

T_3: Butachlor @ 1.25 kg *a.i.* ha^{-1} T_4: Pyrazosulfuron ethyl @ 20 g *a.i.* ha^{-1} BLW: Broad leaved weeds

T_5: Pyrazosulfuron ethyl @ 25 g *a.i.*ha^{-1} T_6: Pyrazosulfuron ethyl @ 30 g *a.i.*ha^{-1} NLW :Narrow leaved weeds

T_7: Clomozone + 2,4 - DEE (RM) @ 0.75 lit. ha^{-1} T_8: Clomozone + 2,4 - DEE (RM) @ 1.00 lit. ha^{-1} RM : Ready Mix

T_9: Clomozone + 2,4 - DEE (RM) @ 1.25 lit. ha^{-1} T_{10}: Two IC at 20 & 45 DAS IC : Inter Cultivation

T_{11}: Two HW at 20 & 45 DAS T_{12}: Weedy check HW : Hand Weeding

Table 3: Economics of weed control treatments in aerobic rice

Treatments	Cost of weed control (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit: Cost ratio
	625	9388	17406	8018	0.85
	750	9513	21031	11518	1.21
T_3	875	9638	23319	13681	1.42
T_4	750	9513	18541	9028	0.95
T_5	875	9638	23721	14083	1.46
T_6	1000	9763	30782	21019	2.15
T_7	737	9500	18554	9054	0.95
T_8	900	9663	25820	18157	1.88
T_9	1062	9825	23691	13866	1.41
T_{10}	600	9363	20207	10844	1.16
T_{11}	2500	11263	31203	10940	1.77
T_{12}	-	8763	5583	-3180	-0.36