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Optimization of Nitrogen and Suitable Weed Management Practice for Aerobic Rice

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Field experiments were conducted at Wetland Farm of Tamil Nadu Agricultural University, Coimbatore during *late samba,* 2005-06 and *kuruvai*, 2006 to find out the optimum nitrogen level and effective weed management practice for aerobic rice cultivation. Three N levels (100, 125 and 150 kg N ha^{-1}) in main plots and five different weed management practices (Hand weeding twice, mechanical weeding twice, pre-emergence application of pendimethalin at 0.75 kg ha^{-1} + one hand weeding on 45 DAS, pretilachlor plus safener at 0.4 kg ha^{-1} + one hand weeding on 45 DAS and unweeded control) in sub plots were studied. Results revealed that application of 150 kg N ha^{-1} registered significantly higher number of tillers, panicles (349 and 235 m^{-2}), filled grains per panicle (104.7 and 76.3) 1000-grain weight (24.5 and 23.9) and grain yield (3424 and 2212 kg ha^{-1}) than 100 kg N ha^{-1} respectively during both the years. However, it was on par with 125 kg N ha^{-1} (3213 and 2036 kg ha^{-1} respectively). In weed management practices, pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45 DAS registered significantly lesser weed density, dry weight and higher weed control efficiency (WCE), followed by pretilachlor plus safener at 0.4 kg ha^{-1} followed by one hand weeding on 45 DAS. Hand weeding twice at 25 and 45 DAS was found to be superior in growth, yield attributes and grain yield of aerobic rice (3976 and 2349 kg ha^{-1}), closely followed by pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45 DAS.

Key words*:* Aerobic rice, N levels, weed management, weed control efficiency, yield

Increasing scarcity of fresh water for agriculture particularly for rice cultivation due to the demand of water to industries and other sectors, has threatens the sustainability of the irrigated rice ecosystem (Tuong and Bouman, 2003). In this context, aerobic rice cultivation offers an opportunity to produce rice with less water. In aerobic rice system, fields remain unsaturated throughout the season like an upland crop, such as wheat on non-flooded soils. This way of growing rice saves water by eliminating continuous seepage and percolation, land preparation and reducing evaporation (Bouman *et al.*, 2002). The yield of aerobic rice varied from 4.5 to 6.5 t ha^{-1}, which is about double that of traditional upland varieties and about 20-30 per cent lower than that of lowland (Wang *et al.,* 2002). Aerobic system of rice production saved irrigation water by more than half compared to flooded system and can possibly mitigate water scarcity in the future (Epino, 2004).

Nitrogen fertilization is the major agronomic practice that affects the yield and quality of rice crop, which requires as much as possible at early and mid tillering stages to maximize panicle numbers and during reproductive stage to produce more number of spikelets per panicle and percentage filled spikelets (Murty *et al.,* 1992). Since, the aerobic rice is a new method of rice cultivation and moreover the availability form of nitrogen is entirely differing from puddled paddy soil. So, optimization of nitrogen dose for aerobic rice is more important for higher grain yield. Apart from nitrogen, weeds infestation also poses a serious threat to aerobic rice. Under aerobic and upland rice, the crop is directly sown in non-puddled, non-flooded soil, weeds and rice germinate simultaneously resulted in severe weed pressure and competition than transplanted rice (Moody, 1996). Weeds are the greatest constraint to yield in upland or aerobic rice systems, resulting in yield losses between 30 and 98% (Oerke and Dehne, 2004). So weed menace is the serious problem encounter with aerobic rice production, which requires immediate attention. Considering the above facts, field experiments were conducted at Wetland Farm of Tamil Nadu Agricultural University, Coimbatore to find out the optimum nitrogen level and effective weed management practice for aerobic rice cultivation.

Materials and Methods

Field experiments were conducted during *late samba*, 2005-06 and *kuruvai* 2006 in split plot

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design with three replications. The experimental field was clay loam in texture, taxonomically known as *Typic Haplustalf*, neutral in pH (7.1) and the EC was 3.9 dSm^{-1}. The soil was low (203 kg ha^{-1}) in available N, medium (19.6 kg ha^{-1}) in available P and high (524 kg ha^{-1}) in available K. The main plot treatments were three N levels viz., 100, 125 and 150 kg N ha^{-1}. The sub plot treatments were weed management practices viz., hand weeding twice, mechanical weeding twice (25 and 45 days after sowing (DAS)), pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45 DAS, pre-emergence application of pretilachlor plus safener at 0.4 kg ha^{-1} followed by one hand weeding on 45 DAS. Non-replicated plots with unweeded control and weed free condition were also maintained. The field was thoroughly prepared by using disc plough, cultivator and rotavator. Rice variety PMK 3 was used as test crop. The seeds were treated with carbandazim at 2 g kg^{-1} of seeds and soaked in water for 12 hours. The soaked seeds were inoculated with Azospirillum at 20 g kg^{-1} of seeds and incubated for 10 hours. The pre germinated seeds were sown in rows 20 cm apart and 10 cm within rows. A common fertilizer dose of 50: 50 kg P and K ha^{-1} was adopted. The entire dose of P in the form of single super phosphate was applied as basal dose. Nitrogen as urea was applied as per the treatment schedule in four equal splits at 15 days after sowing, tillering, panicle initiation and flowering stages. Potassium as muriate of potash was applied along with nitrogen in four splits. Herbicide treatments were imposed third day after sowing. Long handled star type weeder was used in mechanical weeding. Observations on weed density and dry weight were recorded at 20 and 60 DAS. Growth, yield parameters and yield of aerobic rice were recorded. Square root transformation (x+0.5) was used to analyze the data on weeds. Weed control efficiency was worked out at 20 and 60 DAS. It is expressed as the percentage reduction in weed density due to weed management practices over control. It was worked by using weed density present in control and treated plots (Mani *et al*., 1973)

$$WCE = \frac{WPc - WPt}{WPc} \times 100$$

Where,

WPc - Weed density (No. /m^2) in control plot

WPt - Weed density (No. /m^2) in treated plot

Results and Discussion

Weed flora

The predominant weed flora found in the experimental field were *Cynodon dactylon, Echinochloa colonum, Dactyloctenium aegyptium* and *Chloris barbata* among the grasses, *Alternanthra pungens, Portulaca oleraceae, Cleome chelidoni, Parthenium hysterophorus, Eclipta alba* and *Tridax procumbens* among the broad leaved weeds. *Cyprus rotuntus* was the only sedge, constituted for the major portion of total weed density.

Weed density and dry weight

Weed density as well as weed dry weight in aerobic rice were not influenced by different nitrogen levels at all the stages of crop growth during both the years. Weed management practices significantly influenced the weed density and dry weight in different growth stages of aerobic rice. Pre-emergence application of pendimethalin at 0.75 kg ha^{-1} recorded significantly lesser weed density (21.9 and 22.5 No. m^{-2}) and dry weight (9.2 and 10.9 g m^{-2}) followed by pre-emergence application of pretilachlor plus safener at 0.4 kg ha^{-1} at 20 DAS respectively during 2005 and 2006 (Table 1). This might be due to the broad-spectrum control of variety of grasses and broad-leaved weeds by pre emergence application of pendimethalin in rice (Dhyani *et al.*, 2005). At 60 DAS, hand weeding twice at 25 and 45 DAS registered significantly lesser weed density (23.5 and 34.0 No. m^{-2}) and dry weight (19.1 and 26.7 g m^{-2}) respectively during both the years than unweeded control and mechanical weeding with long handled star type weeder twice at 25 and 45 DAS. However, hand weeding twice was comparable with pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45 DAS (weed density of 26.2 and 44.2 No. m^{-2} and weed dry weight of 21.0 and 25.2 g m^{-2} respectively) and pretilachlor plus safener at 0.4 kg ha^{-1} followed by one hand weeding on 45 DAS. Unweeded control produced significantly more number of weeds (136.9 and 133.3 No. m^{-2}) as well as dry weight of 112.1 and 81.5 g m^{-2} respectively during both the years.

Weed control efficiency (WCE)

Weed control efficiency varied with different weed management practices followed in aerobic rice. At 60 DAS, maximum WCE was noticed under hand weeding twice at 25 and 45 DAS (82.9 and 74.5 per cent), followed by pre-emergence application of pretilachlor plus safener at 0.4 kg ha^{-1} followed by one hand weeding on 45 DAS (82.7 and 68.7 per cent) and pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45

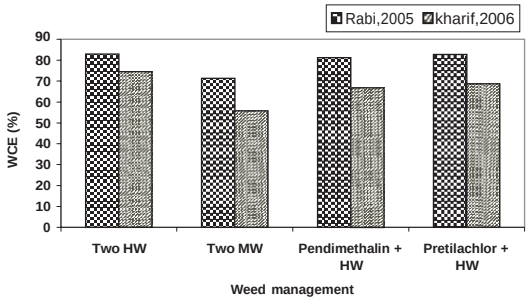

Fig 1. Effect of weed management practices on weed control efficiency at 60 DAS in aerobic rice

Table 1. Weed density, dry weight and weed control efficiency of aerobic rice under different N levels and weed management treatments

Treatments	*Rabi* 2005-06						*Kharif* 2006					
	Weed density (No. m^{-2})		Weed dry weight (g m^{-2})		WCE %		Weed density (No. m^{-2})		Weed dry weight (g m^{-2})		WCE %	
N levels (kg/ha)	20	60	20	60	20	60	60	60	60	60	20	60
	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS
N_1: 100	7.31	6.50	4.83	5.84	-	-	7.2	7.7	5.18	6.06	-	-
	(56.7)	(48.3)	(24.5)	(38.9)			(56.7)	(62.8)	(29.2)	(38.5)		
N_2: 125	7.33	6.67	4.84	6.14	-	-	7.1	7.1	5.06	5.70		
	(57.5)	(51.2)	(24.8)	(43.0)			(54.7)	(53.7)	(27.6)	(34.4)	-	-
N_3: 150	7.37	6.51	4.94	5.90			7.5	8.1	5.23	6.44		
	(57.0)	(49.0)	(25.4)	(40.2)	-	-	(60.2)	(70.9)	(28.3)	(44.2)	-	-
CD(P=0.05)	NS	NS	NS	NS			NS	NS	NS	NS		
Weed Management												
W_1: Two HW	8.45	4.88	5.59	4.41			8.9	5.8	6.29	5.17		
	(70.9)	(23.5)	(30.7)	(19.1)	-	82.9	(78.8)	(34.0)	(39.5)	(26.7)	-	74.5
W_2: Two MW	9.05	6.12	5.99	5.70		71.3	8.7	7.7	6.17	5.87		
	(81.6)	(37.1)	(35.4)	(32.1)	-		(75.2)	(59.1)	(38.0)	(34.3)	-	55.7
W_3: Pendimethalin + HW	4.72	5.16	3.11	4.64	75.2	81.2	4.8	6.6	3.35	5.03	73.6	66.8
	(21.9)	(26.2)	(9.2)	(21.0)			(22.5)	(44.2)	(10.9)	(25.2)		
W_4: Pretilachlor +	5.34	4.93	3.54	4.45	67.6	82.7	5.0	6.4	3.51	5.26	71.1	68.7
safener + HW	(28.1)	(23.9)	(12.0)	(19.3)			(24.6)	(41.8)	(12.0)	(27.5)		
W_5: Unweeded	9.12	11.72	6.13	10.60			9.2	11.5	6.45	9.00		
	(82.9)	(136.9)	(37.1)	(112.1)	-	-	(85.0)	(133.3)	(41.6)	(81.5)	-	-
CD(P=0.05)	**0.28**	**0.30**	**0.12**	**0.25**			**0.87**	**0.76**	**0.54**	**0.61**	**-**	**-**

Interaction not significant, HW- Hand Weeding, MW- Mechanical Weeding; Square root transformation (x+0.5) Figures in parentheses are the original values

DAS (81.2 and 66.8 per cent) during late samba, 2005-06 and *kuruvai* 2006 respectively (Fig 1.). This was in accordance with the findings of Bahar and Govindra Singh, (2004) who reported that application of pendimethalin at 1.0 kg ha^{-1} was found to increase WCE in dry seeded rice. Mechanical weeding twice at 25 and 45 DAS produced the minimum WCE of 71.3 and 55.7 per cent respectively during both the years.

Tillers population

Tillers population of aerobic rice positively influenced by different levels of nitrogen as well as various weed management practices. Significantly higher tiller population (522 and 325 No. m^{-2}) was recorded with the application of 150 kg N ha^{-1} and it was on par with 125 kg N ha^{-1} (496 No. m^{-2}) respectively during both the years. Application of 100 kg N ha^{-1} produced minimum tiller population of 448 and 298 No. m^{-2} respectively during late samba, 2005-06 and *kuruvai* 2006 (Table 2). The usefulness of increased N application on tiller production was also observed by Singh *et al*. (2006).

Among the weed management practices, hand weeding twice at 25 and 45 DAS produced significantly higher number of tillers (462 and 331 No. m^{-2}) than other treatments and it was on par with pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45 DAS (444 and 328 No. m^{-2} respectively) during both the years. Mechanical weeding twice at 25 and 45 DAS and pre-emergence application of pretilachlor plus safener at 0.4 kg ha^{-1} followed by one hand weeding on 45 DAS were comparable in tiller production. Both the years, unweeded control produced the lowest tiller population (288 and 253 No.m^{-2} respectively). There was no significant interaction between nitrogen and weed management practices.

Yield attributes

Various nitrogen levels and weed management practices showed significant difference on yield attributes of aerobic rice. Among the nitrogen levels, application of 150 kg N ha^{-1} registered significantly higher number of panicles (349 and 235 No. m^{-2}), filled grains per panicle (104.7 and 76.3) and 1000-grain weight (24.5 and 23.9 g) than other levels respectively during both the years, mainly because of increased N supply at distinct physiological phases which would have supported better assimilation of photosynthates and in turn better yield attributes. Lower number of panicles, filled grains and test weight were obtained under 100 kg N ha^{-1} application (Table 2). Hand weeding twice at 25 and 45 DAS registered significantly higher number of panicles (356 and 236 No. m^{-2}), filled grains per panicle (88.9 and 75.7) and 1000-grain

Table 2. Growth, yield components and grain yield of aerobic rice under different N levels and weed management practices

Treatments	*Rabi* 2005-06					*Kharif* 2006				
	Tillers m-2	Panicles m-2	Filled grains panicle^{-1}	1000 grain weight (g)	Grain yield (kg ha^{-1})	Tillers m^{-2}	Panicles m^{-2}	Filled grains panicle^{-1}	1000 grain weight (g)	Grain yield (kg ha^{-1})
Nitrogen levels (kg ha^{-1})										
N1: 100	448	298	102.2	24.3	3104	292	202	67.3	23.6	1861
N2: 125	496	326	104.4	24.8	3213	308	220	72.5	23.8	2036
N3: 150	522	349	104.7	24.5	3424	325	235	76.3	23.9	2212
CD (P = 0.05)	33	20	NS	NS	220	25	13	5.9	NS	253
Weed management										
W1: Two HW	462	356	88.9	25.4	3976	331	236	75.7	23.7	2349
W2: Two MW	422	324	83.4	24.6	3408	312	217	70.5	23.6	2053
W3: Pendimethalin + HW	444	344	85.9	24.1	3842	328	237	75.4	23.8	2374
W4: Pretilachlor + HW	429	328	84.6	25.2	3514	316	220	72.5	24.1	2155
W5: Unweeded	288	129	52.1	25.1	1495	253	183	65.9	23.6	1250
CD(P=0.05)	**25**	**25**	**5.6**	**NS**	**184**	**16**	**11**	**5.1**	**NS**	**193**

Interaction not significant, HW- Hand Weeding, MW- Mechanical Weeding;

weight (25.4 and 23.7 g) followed by pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45 DAS (344 and 237 No. m^{-2}), filled grains per panicle (85.9 and 75.4) and 1000-grain weight (24.1 and 23.8 g) during *late samba* 2005 and *kuruvai* 2006 respectively. Unweeded control recorded significantly lower yield attributes of aerobic rice. Interaction of nitrogen and weed management was not significant.

Grain yield

Grain yield of aerobic rice significantly influenced by both nitrogen levels and weed management treatments. Among the nitrogen levels, application of 150 kg N ha^{-1} recorded significantly higher grain yield (3424 and 2212 kg ha^{-1}) than 100 kg N ha^{-1} (3104 and 1861 kg ha^{-1}) respectively during *late samba*, 2005 and *kuruvai*, 2006 (Table 2). However, it was on par with 125 kg N ha^{-1} (3213 and 2036 kg ha^{-1} respectively). Availability of adequate quantity of nitrogen during critical stages of plant growth might have resulted in better growth characters and yield components and finally on the yield of aerobic rice. These results are in accordance with the findings of Bouman *et al* (2002) who reported that higher level of nitrogen at 150 kg N ha^{-1} recorded higher grain yield of aerobic rice.

Hand weeding twice at 25 and 45 DAS was found to be superior in obtaining higher grain yield of aerobic rice (3976 and 2349 kg ha^{-1}) over mechanical weeding twice at 25 and 45 DAS (3408 and 2053 kg ha^{-1}), pretilachlor plus safener at 0.4 kg ha^{-1} followed by one hand weeding on 45 DAS (3514 and 2155 kg ha^{-1}) and unweeded control (1495 and 1250 kg ha^{-1}) respectively during both the years. However, pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45 DAS (3842 and 2374 kg ha^{-1}) was found to be on par with hand weeding twice at 25 and 45 DAS. Control of weeds by herbicides during early stages of rice resulted in lesser competition to the crop for moisture, nutrients and sunlight that influenced the crop to grow better as evidenced in increased plant growth and yield attributes and yield (Singh *et al*.,2005).Between the herbicides, pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45 DAS showed significantly higher grain yield than pretilachlor plus safener at 0.4 kg ha^{-1} followed by one hand weeding on 45 DAS. The lowest grain yield was obtained under unweeded control during both the years. The interaction effect between nitrogen levels and weed management was not significant. Considering the labour scarcity and cost of labour as well as statistically comparable with hand weeding twice, pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45 DAS could be recommended as viable practice in aerobic rice.

Thus, application of nitrogen at 125 kg N ha^{-1} found to be an optimum dose for higher productivity of aerobic rice. Pre-emergence application of pendimethalin at 0.75 kg ha^{-1} followed by one hand weeding on 45 DAS could be a suitable weed management practice for higher weed control efficiency and grain yield of aerobic rice.

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