The Andhra Agric. J 59(1): 10-16, 2012

Weed Management in Aerobic Rice (*Oryza sativa* L.) Under South Gujarat Conditions

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ABSTRACT

Increasing water scarcity, there is a need to develop alternative systems that require less water. "Aerobic rice" is a new concept of growing rice. It is high-yielding rice grown in non-puddled, aerobic soils under irrigation and high external inputs. To make aerobic rice successful, new varieties and management practices must be developed. In this study it was determined how different herbicide like, butachlor, pendimethalin, pretilachlor, 2, 4-D (Ethyl ester) and aniloguard were responded to aerobic rice (*Oryza sativa* L.) with regards to growth and yield as well as on weed spectrum. Hand weeding at 20, 40 and 60 DAS (T_{12}) showed significant response to almost all the growth and yield attributes *viz*., plant height, number of tillers plant^{-1}, number of panicles m^{-2} and number of grains panicle^{-1}, ultimate result was reflect in the highest grain (43.83 q ha^{-1}) and straw (57.49 q ha^{-1}) yields of rice crop. Further, application of any herbicide supplement with one hand weeding was found most effective to reduce weed population.

Key words : Aniloguard, Butachlor, 2, 4-D (Ethyl ester),Pendimethalin, Pretilachlor, Rice, Weed management. , .

Rice (*Oryza sativa* L.) is one of the staple food crops of approximately half of the world population. The rice grain is termed as the Global grain. It is the most important crop of the country and second most important crop of the world. It is a prime need of time to maximize the production of rice for ever increasing population where weeds pose serious problems being naturally hardy, competitive and self sown plants. In India, rice production is strongly associated with rainfall distribution. The coefficient of rainfall variability is very high in the country between regions and within the season from place to place leading to drought during the vegetative and reproductive phase of the crop. A significant portion of the irrigated rice area suffers from intermittent water storage. The water crisis is threatening the sustainability of the irrigated rice system and food security. A fundamentally different approach is to grow rice like and upland crop, such as wheat, on non flooded aerobic soils, there by eliminating puddling under standing water, Aerobic rice is targeted to more favorable environments where land is flat or terraced and soil can be frequently brought to near field capacity by rainfall or supplementary irrigation. (Reddy and Ramulu, 2008)

Direct-seeded rice (*Oryza sativa* L.) is becoming popular as it is cheaper alternative to transplanting. But crop weed competition in this system is more severe, reducing the yield by 20-95% (Gogoi, 1995). Manual weeding is expensive, laborious and time consuming as well as difficult in early stage of crop growth. Use of pre-emergence herbicides has been found effective in early stage, but the second flush of weeds at 25-30 days after sowing (DAS) becomes problematic. Hence integrated weed management practice is the only effective alternative (Singh and Tripathi 2007). The current average yield of rice in India is 2.57 tonnes ha^{-1}. Which is much lower then the productivity of neighboring rice growing countries like China (5.51 tonnes ha^{-1}), Indonesia (4.32 tonnes ha^{-1}) and Thailand (3.11 tonnes ha^{-1}) and also that of world average of 4.32 tonnes ha^{-1} (Anon., 1991). In this context the present studies was under taken to evaluate the "Weed Management in Aerobic Rice (*Oryza sativa* L.) under south Gujarat Condition".

MATERIAL AND METHODS

A field experiment was conducted during *summer* 2008, at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari

Table 1. Weed population as influenced by various weed management treatments in summer aerobic rice crop

Treatments	Weed population (m^{-2})								
	At 30 DAS			At 60 DAS			At harvest		
	Monocot	Dicot	Total	Monocot	Dicot	Total	Monocot	Dicot	Total
W_1 : Butachlor @ 1.25 kg ha^{-1} as pre-emergence	3.61 (12.10)	2.26 (4.15)	5.87 (16.25)	3.61 (11.89)	3.34 (11.18)	7.02 (23.07)	4.45 (19.92)	4.36 (18.38)	8.81 (38.30)
W_2 : Pendimethalin @ 1.00 kg ha^{-1} as pre-emergence	3.70 (12.70)	2.28 (4.24)	5.98 (16.94)	3.70 (19.15)	2.48 (6.14)	7.01 (25.29)	5.30 (28.19)	3.38 (11.43)	8.68 (39.62)
W_3 : Pretilachlor @ 0.75 kg ha^{-1} as pre-emergence	3.64 (12.30)	2.20 (3.90)	5.84 (16.20)	3.64 (11.33)	2.87 (8.24)	6.33 (19.57)	4.51 (20.48)	3.80 (14.41)	8.31 (34.95)
W_4 : Aniloguard @ 0.5 kg ha^{-1} as pre-emergence	3.74 (13.10)	2.57 (5.66)	6.31 (18.76)	3.74 (18.34)	3.15 (9.91)	7.47 (28.25)	5.02 (25.21)	4.31 (18.56)	9.33 (43.77)
W_5 : 2, 4-D (Ethyl ester) @ 1.00 kg ha^{-1} as post-emergence at 20 to 25 DAS	3.82 (13.70)	2.65 (6.09)	6.47 (19.79)	3.82 (21.30)	3.49 (12.15)	8.19 (33.45)	5.55 (30.78)	4.36 (19.25)	9.91 (50.03)
W_6 : W_1 + Hand weeding at 40 DAS	2.90 (7.50)	1.83 (2.37)	4.73 (9.87)	2.90 (3.42)	1.13 (1.28)	3.17 (4.70)	3.39 (11.52)	3.21 (10.29)	6.60 (21.81)
W_7 : W_2 + Hand weeding at 40 DAS	3.68 (12.60)	1.97 (2.90)	5.65 (15.50)	3.68 (6.28)	1.55 (2.39)	3.82 (8.67)	3.52 (12.37)	2.00 (4.01)	5.52 (16.38)
W_8 : W_3 + Hand weeding at 40 DAS	3.04 (8.30)	1.67 (1.80)	4.71 (10.09)	3.04 (6.12)	1.15 (1.32)	3.77 (7.44)	3.42 (11.71)	3.16 (9.98)	6.58 (21.69)
W_9 : W_4 + Hand weeding at 40 DAS	3.77 (13.30)	2.34 (4.49)	6.11 (17.80)	3.77 (8.98)	1.76 (3.10)	4.91 (13.08)	3.63 (13.18)	2.32 (5.37)	5.95 (18.55)
W_{10} : W_5 + Hand weeding at 40 DAS	3.79 (13.40)	2.79 (6.80)	6.58 (20.20)	3.79 (8.16)	2.03 (4.13)	4.77 (12.29)	4.19 (17.64)	3.19 (10.16)	7.38 (27.80)
W_{11}: Un weeded control	6.29 (38.60)	4.46 (18.92)	10.75 (57.52)	6.29 (42.56)	5.49 (30.19)	11.96 (72.75)	6.88 (47.40)	5.90 (34.76)	12.78 (82.16)
W_{12} : Weed free condition by hand weeding at 20, 40 and 60 DAS	2.73 (6.49)	1.71 (1.92)	4.44 (8.41)	2.73 (2.88)	1.06 (1.13)	2.59 (4.01)	3.18 (10.23)	1.91 (3.67)	5.09 (13.90)
S. Em. ±	1.10	0.45	1.34	1.20	0.67	1.60	1.56	1.11	2.56
C.D. at 5 %	3.24	1.31	3.94	3.52	1.95	4.69	4.57	3.25	7.50
C.V. %	13.98	14.70	12.27	15.53	15.16	13.17	13.04	14.37	13.02

Note: Data in parenthesis indicate actual value and those outside are $\sqrt{X+1}$ transformed values

Table 2 . Dryweight of weed, weed control efficiency and weed index as influenced by various weed management treatments in summer aerobic rice crop

Treatments	Dryweight of weeds			Weed control efficiency (%)	Weed index (%)
	At 30 DAS ($g\ m^{-2}$)	At 60 DAS ($g\ m^{-2}$)	At harvest ($Kg\ ha^{-1}$)		
W_1 : Butachlor @ 1.25 kg ha^{-1} as pre-emergence	6.30	10.23	297.97	55.06	22.78
W_2 : Pendimethalin @ 1.00 kg ha^{-1} as pre-emergence	7.20	11.55	306.03	53.88	34.27
W_3 : Pretilachlor @ 0.75 kg ha^{-1} as pre-emergence	6.80	10.38	300.53	54.74	26.02
W_4 : Aniloguard @ 0.5 kg ha^{-1} as pre-emergence	7.30	12.23	313.00	52.45	33.68
W_5 : 2, 4-D (Ethyl ester) @ 1.00 kg ha^{-1} as post-emergence at 20 to 25 DAS	7.80	13.56	329.40	50.38	49.06
W_6 : W_1 + Hand weeding at 40 DAS	3.30	5.33	73.47	88.98	3.45
W_7 : W_2 + Hand weeding at 40 DAS	4.10	6.09	78.87	88.05	11.26
W_8 : W_3 + Hand weeding at 40 DAS	3.70	5.67	76.53	88.46	6.64
W_9 : W_4 + Hand weeding at 40 DAS	4.70	6.20	79.80	87.97	17.26
W_{10} : W_5 + Hand weeding at 40 DAS	4.80	7.86	104.43	84.25	20.31
W_{11}: Un weeded control	12.40	18.54	662.70	0.00	50.66
W_{12} : Weed free condition by hand weeding at 20, 40 and 60 DAS	2.70	4.03	43.40	93.42	0.00
S. Em. ±	0.48	0.78	14.62		
C.D. at 5 %	1.41	2.27	42.89		
C.V. %	14.46	14.43	11.40		

to study the "Weed management in aerobic rice (*Oryza sativa* L.) under South Gujarat conditions. The soil of the experimental field was clayey in texture, low in available nitrogen (250) and medium in available phosphorus (31.4), fairly rich in available potassium (348), slightly alkaline in reaction with 7.3 pH. Total twelve treatments combinations, viz., butachlor @ 1.25 kg ha^{-1} as pre-emergence (T_1), pendimethalin @ 1.00 kg ha^{-1} as pre-emergence (T_2), pretilachlor @ 0.75 kg ha^{-1} as pre-emergence (T_3), aniloguard @ 0.5 kg ha^{-1} as pre-emergence (T_4), 2, 4-D (Ethyl ester) @ 1.00 kg ha^{-1} as post-emergence at 20 to 25 DAS (T_5), T_1 + Hand weeding at 40 DAS (T_6), T_2 + Hand weeding at 40 DAS (T_7), T_3 + Hand weeding at 40 DAS (T_8), T_4 + Hand weeding at 40 DAS (T_9), T_5 + Hand weeding at 40 DAS (T_{10}), Un weeded control (T_{11}), Weed free condition by hand weeding at 20, 40 and 60 DAS (T_{12}), were evaluated in randomized block design with 3 replications. Herbicides were applied as spray using 600L of water ha^{-1}. Spraying was made by knapsack sprayer using flat fan nozzle. The rice seeds were drilled manually at 30 cm row distance on second week of January, 2008 and fertilize with 120-30-00 kg NPK ha^{-1}.

RESULT AND DISCUSSION

Effect on weed flora

The experimental field was infested by number of weed species comprising of monocot weeds viz., *Echinochloa crusgalli* (L.), *Echinochloa colunum* L., *Cynodon dactylon* (L.), *Eichhornia crassipes*, *Dactyloctenium agegyptium* and *Bracharia* spp. *major* dicot weeds viz., *Alternanthera sessilis, Digera arvensis*, *Euphorbia hirta* L. and *Physalis minima* L. were predominantly present during the course of experimentation.(Table 1)

Treatments, *viz.*, T_1 + Hand weeding at 40 DAS (T_6), T_2 + Hand weeding at 40 DAS (T_7), T_3 + Hand weeding at 40 DAS (T_8) and T_4 + Hand weeding at 40 DAS (T_9) found most effective with the lowest

Table 3. Growth and yield attributes as influenced by various weed management treatments in summer aerobic rice crop

Treatments	Plant height (cm)	No. of tillers plant^{-1}	Number of panicles m^{-2}	Length of panicle (cm)	Number of grains panicle^{-1}	Test weight (gm)
W_1 : Butachlor @ 1.25 kg ha^{-1} as pre-emergence	68.00	372.4	338.3	23.50	79.10	23.79
W_2 : Pendimethalin @ 1.00 kg ha^{-1} as pre-emergence	66.50	340.2	310.3	22.90	77.70	23.48
W_3 : Pretilachlor @ 0.75 kg ha^{-1} as pre-emergence	67.30	369.1	329.5	23.10	78.50	23.84
W_4 : Aniloguard @ 0.5 kg ha^{-1} as pre-emergence	66.10	337.3	305.3	22.90	76.80	22.86
W_5 : 2, 4-D (Ethyl ester) @ 1.00 kg ha^{-1} as post-emergence at 20 to 25 DAS	64.30	325.2	287.3	22.30	76.50	22.50
W_6 : W_1 + Hand weeding at 40 DAS	75.60	437.5	391.6	24.50	86.50	25.10
W_7 : W_2 + Hand weeding at 40 DAS	73.80	415.9	379.0	24.20	84.80	24.93
W_8 : W_3 + Hand weeding at 40 DAS	74.30	425.6	385.2	24.30	86.10	24.95
W_9 : W_4 + Hand weeding at 40 DAS	73.20	409.3	373.3	24.00	84.10	22.68
W_{10} : W_5 + Hand weeding at 40 DAS	71.90	404.0	365.8	23.70	83.20	22.30
W_{11}: Un weeded control	60.20	308.8	322.0	22.50	70.30	22.01
W_{12} : Weed free condition by hand weeding at 20, 40 and 60 DAS	78.60	452.3	407.3	25.80	90.00	24.00
S. Em. ±	3.50	16.06	19.30	1.44	3.68	1.55
C.D. at 5 %	10.25	47.10	56.60	NS	10.81	NS
C.V. %	8.65	7.26	9.56	10.52	7.87	11.41

dry weight of weeds of 73.47, 78.87, 76.53 and 79.80 kg ha^{-1}, with higher weed control efficiency of 88.98, 88.05, 88.46 and 87.97 per cent, lower weed index of 3.45, 11.26, 6.64 and 17.26 per cent, respectively, while treatment unweeded control recorded the highest dry weight of weeds (662.70 kg ha^{-1}) and higher weed index (50.66%) at harvest (Table 2).

Effect on growth, yield attributes and yield

Almost all the growth and yield attributes *viz*., plant height, number of tillers plant^{-1}, number of panicles m^{-2} and number of grains panicle^{-1} were significantly influenced by various weed management treatments (Table 3). Higher values of all the growth and yield attributing characters ultimately resulting in the highest grain (43.83 q ha^{-1}) and straw (57.49 q ha^{-1}) yields were recorded under weed free treatment, which is hand weeding at 20, 40 and 60 DAS (T_{12}) and being at par with T_1 + Hand weeding at 40 DAS (T_6), T_2 + Hand weeding at 40 DAS (T_7) and T_3 + Hand weeding at 40 DAS (T_8). Maintaining high soil fertility status by way of removing less plant nutrient through weeds might have modified yield attributes. Significant improvement in growth characters also might have resulting maximum number of grain panicle^{-1} under these treatments. This might be due to effective control of weeds by these treatments which provided better nourishment reflected in number of panicles m^{-2}, panicle length (cm) and number of grain panicle^{-1}. Tomar (1987), Vaishya and Tomar (2000), Sharma *et al.,* (2007) and Singh et al., (2007) also reported almost similar results.

There was no significant difference observed in panicle length (cm) and test weight by different weed management treatments. This might be due to being genetically governed character, panicle length (cm) and test weight may not influence. Similar findings were also reported by Selvam *et al.,* (2001), Raju *et al.,* (2003), Sharma *et al.,* (2007) and Singh *et al.,* (2007) in rice crop.

Effect on nutrient

The maximum and minimum nutrient removal by grain and straw were recorded under treatments of weed free condition by hand weeding at 20, 40

Table 4. Seed and straw yield and economics as influenced by various weed management treatments in summer aerobic rice crop

Treatments	Seed yield (Q ha^{-1})	Straw yield (Q ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross realization (Rs. ha^{-1})	Net realization (Rs ha^{-1})	CBR
W_1 : Butachlor @ 1.25 kg ha^{-1} as pre-emergence	33.40	44.72	6344	16709	10365	1: 2.63
W_2 : Pendimethalin @ 1.00 ha^{-1} as pre-emergence	28.80	39.70	6844	17596	10752	1: 2.57
W_3 : Pretilachlor @ 0.75 kg ha^{-1} as pre-emergence	32.01	43.47	7094	17748	10654	1: 2.50
W_4 : Aniloguard @ 0.5 kg ha^{-1} as pre-emergence	28.93	38.70	7344	25588	18244	1: 3.48
W_5 : 2, 4-D (Ethyl ester) @ 1.00 kg ha^{-1} as post-emergence at 20 to 25 DAS	22.50	29.81	7844	27418	19574	1: 3.50
W_6 : W_1 + Hand weeding at 40 DAS	42.29	57.20	8069	21152	13083	1: 2.62
W_7 : W_2 + Hand weeding at 40 DAS	38.90	55.37	8319	21921	13602	1: 2.63
W_8 : W_3 + Hand weeding at 40 DAS	40.91	56.09	8179	23097	14918	1: 2.82
W_9 : W_4 + Hand weeding at 40 DAS	36.40	50.91	8429	24753	16324	1: 2.93
W_{10} : W_5 + Hand weeding at 40 DAS	35.10	48.87	7464	18707	11243	1: 2.51
W_{11} : Un weeded control	21.27	33.68	7944	20291	12347	1: 2.55
W_{12} : Weed free condition by hand weeding at 20, 40 and 60 DAS	43.83	57.49	7714	19515	11801	1: 1.53
S. Em. ±	2.63	3.21				
C.D. at 5 %	7.72	9.24				
C.V. %	13.61	11.70				

and 60 DAS (T_{12}) and unweeded control (T_{11}), respectively (Table 5). Significantly highest nutrient content and uptake of NPK was found with treatment weed free condition by hand weeding at 20, 40 and 60 DAS because crop provide weed free condition through out growth period as well as minimize the competition with weed for nutrient ultimately increased the content and uptake by crop.

Economics

The highest net profit of Rs. 19573/ha was obtained from treatment of two hand weedings + hoeing at 20 and 40 DAS followed by treatments of two hand weedings at 20 and 40 DAS (Rs. 18244 ha^{-1}) and Pendimethalin @ 0.75 kg ha^{-1} + hand weeding and hoeing at 40 DAS (Rs. 16324 ha^{-1}) (Table 4). while the highest cost benefit ratio (3.49) was obtained under treatment of two hand weedings and hoeings at 20 and 40 DAS followed by treatments two hand weeding at 20 and 40 DAS (3.48) and Pendimethalin @ 0.75 kg/ha + hand weeding and hoeing at 40 DAS (2.93).

On the basis of one year experimentation it can be concluded that higher profitable yield of *summer* aerobic rice variety Jaya can be obtained by keeping the crop weed free either by hand weeding coupled with hoeing or only two hand weedings at 20 and 40 day after sowing. In scarcity of laboures, pendimethalin @ 0.75 kg ha^{-1} may be applied coupled with hand weeding at hoeing at 40 days after sowing under South Gujarat conditions.

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Table 5. Nutrient content and uptake by crop as influenced by various weed management treatments in summer aerobic rice crop.

Treatment	Nutrient content (%)						Nutrient uptake (kg ha^{-1})					
	Nitrogen		Phosphorus		Potassium		Nitrogen		Phosphorus		Potassium	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
W_1: Butachlor @ 1.25 kg ha^{-1} as pre-emergence	1.133	0.043	0.133	0.063	0.507	1.477	37.85	1.45	4.45	2.12	16.92	49.32
W_2: Pendimethalin @ 1.00 kg ha^{-1} as pre-emergence	1.043	0.037	0.120	0.057	0.503	1.456	29.97	1.06	3.45	1.63	14.46	41.85
W_3: Pretilachlor @ 0.75 kg ha^{-1} as pre-emergence	1.067	0.037	0.123	0.060	0.507	1.467	34.14	1.22	3.95	1.92	16.22	46.95
W_4: Aniloguard @ 0.5 kg ha^{-1} as pre-emergence	1.017	0.027	0.113	0.057	0.493	1.463	29.41	0.77	3.28	1.64	14.27	42.33
W_5: 2, 4-D (Ethyl ester) @ 1.00 kg ha^{-1} as post-emergence at 20 to 25 DAS	0.987	0.027	0.100	0.050	0.470	1.437	22.20	0.60	2.25	1.13	10.58	32.33
W_6: W_1 + Hand weeding at 40 DAS	1.183	0.053	0.177	0.077	0.580	1.640	50.04	2.26	7.47	3.24	24.53	69.36
W_7: W_2 + Hand weeding at 40 DAS	1.147	0.047	0.170	0.067	0.563	1.620	44.61	1.82	6.48	2.59	21.91	62.89
W_8: W_3 + Hand weeding at 40 DAS	1.157	0.050	0.167	0.069	0.573	1.627	47.32	2.05	6.95	2.82	23.46	66.55
W_9: W_4 + Hand weeding at 40 DAS	1.147	0.047	0.160	0.068	0.530	1.623	41.74	1.70	5.82	2.48	19.29	58.85
W_{10}: W_5 + Hand weeding at 40 DAS	1.110	0.037	0.147	0.057	0.510	1.603	38.96	1.29	5.15	1.99	17.90	56.28
W_{11}: Un weeded control	0.840	0.027	0.087	0.050	0.443	1.490	17.87	0.57	1.84	1.06	9.43	31.69
W_{12}: Weed free condition by hand weeding at 20, 40 and 60 DAS	1.260	0.057	0.190	0.087	0.607	1.860	55.23	2.48	8.33	3.80	26.59	81.52
S. Em. ±	0.07	0.00	0.01	0.01	0.03	0.08	3.23	0.15	0.48	0.20	1.51	4.76
C.D. at 5 %	0.20	0.01	0.03	0.02	0.09	0.24	9.49	0.43	1.40	0.58	4.43	13.96
C.V. %	11.40	16.01	13.33	15.44	10.58	9.04	14.96	17.62	16.70	15.62	14.56	15.45

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(Received on 13.07.2010 and revised on 07.07.2011)