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Response of Aerobic Rice to Nitrogen Doses and Weed Management Practices

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ABSTRACT

A field experiment was conducted during *kharif*, 2011 in sandy loam soils of Regional Agricultural Research Station, Warangal to find out the optimum dose of nitrogen and best weed management practice for aerobic rice. The experiment was laid out in randomised block design in factorial concept with three doses of nitrogen and four weed management treatments, replicated thrice. Among the nitrogen doses, application of 240 kg N ha^{-1} was significantly superior to 120 kg N ha^{-1} with respect to the number of tillers m^{-2} yield attributes and yield of aerobic rice, but it was at par with 180 kg N ha^{-1}. However, nitrogen uptake by the crop, net returns and returns per rupee invested were higher with 240 kg N ha^{-1} than the other two doses of nitrogen. Pre-emergence application of pendimethalin @ 1.2 kg a.i. ha^{-1} + post-emergence application of pyrazosulfuron ethyl @ 30 g a.i. ha^{-1} at 25 DAS significantly reduced the density and dry weight of weeds over weedy check and mechanical weeding twice at 20 and 45 DAS which led to higher weed control efficiency, lower weed index and nitrogen removal by the weeds. The grain yield, net returns and returns per rupee invested were also higher with the application of herbicides than the mechanical weeding.

Key words : Aerobic rice, Pendimethalin, Pyrazosulfuron ethyl, Nitrogen, Weed index.

Rice production system, without constant standing water in non-puddled soils, referred to as 'aerobic rice' is considered to be one of the most promising technologies in terms of water saving. In this system, rice is sown directly into dry soil and irrigation is given to keep the soil sufficiently moist for good plant growth, but the soil is never flooded. Aerobic rice cultivation reduces water use as much as 50% compared to lowland rice. The soil N dynamics and path way of nitrogen losses in dry sown rice system are different from lowlands and result in different fertilizer nitrogen recoveries. The alternate moist and dry soil conditions may stimulate nitrification-denitrification processes in dry sown rice, leading to loss of nitrogen through N_2 and N_2O (Prasad, 2011). Hence, traditional lowland rice fertilizer doses may not be optimum for aerobic rice. Further, aerobic soil conditions and dry tillage practices, besides alternative wetting and drying are conducive for germination and growth of highly competitive weeds, which cause grain yield losses ranging from 50-91%, compared to conventional production systems (Singh *et al.,* 2006), in which weeds are suppressed by standing water and transplanted rice seedlings have a "head start" over germinating weed seedlings. As the concept of aerobic rice in Andhra Pradesh is new, relatively few insights into weed management and nitrogen fertilization exist. Hence, the present investigation was carried out to find out the optimum dose of nitrogen and effective weed management practice in aerobic rice.

MATERIAL AND METHODS

Field experiment was conducted during *kharif*, 2011 at Regional Agricultural Research Station, Warangal, Andhra Pradesh. The soil of the experimental site was sandy loam in texture, medium in available nitrogen (288 kg ha^{-1}), low in available phosphorus (7.6 kg ha^{-1}) and medium in available potassium (73 kg ha^{-1}) with a pH of 8.1. The experiment was laid out in randomized block design (factorial concept) with three nitrogen doses *viz*., 120, 180 and 240 kg ha^{-1} and four weed management treatments, *viz.,* pre-emergence application of pendimethalin @ 1.2 kg a.i. ha^{-1} + post-emergence application of pyrazosulfuron ethyl @ 30 g a.i. ha^{-1} at 25 DAS, mechanical weeding at 20 and 45 DAS, weed free check and weedy check replicated thrice. Rice variety 'WGL-32100' was sown by dibbling at 30 cm row spacing with solid rows with a seed rate of 40 kg ha^{-1} on 4 July, 2012. The plot size was 4.5 × 4.0 m. Thinning and gap filling were done at 15 days after sowing. Phosphorus and potash @ 60 : 50 kg ha^{-1} were applied uniformly as basal in the form of single super phosphate and muriate of potash, respectively. Nitrogen was applied in the form of urea as per the treatments in three equal splits, each at basal, active tillering and panicle initiation stage. A range of mean minimum temperature of 19.7 to 26.1 ^{0}C and mean maximum temperature of 27.1 to 33.0 ^{0}C was recorded during the crop growth period. A total rainfall of 349.4 mm was received during the crop season in 26 rainy days. Supplemental irrigation was given as and when required to maintain the soil in moist condition. Recommended plant protection measures were taken up. The crop was harvested on 11 November, 2012. Total number of tillers was recorded at 30, 60, 90 DAS and harvest in demarcated one m^2 area in each plot. The weed density and dry weight were recorded in each plot using a quadrant of one m^2 size. Weed species in each quadrant were separated and dried in shade for 48 hours and later oven dried till the constant weight was recorded. The data on weed density and dry weight was subjected to square root transformation of "x+1 before statistical analysis.

RESULTS AND DISCUSSION

Weeds

The weed spectrum of the experimental field consisted of three groups of weeds like grasses, sedges and broad leaved weeds. The observed sedges were *Cyperus rotundus, Fimbristylis argentea*; grasses were *Cynodon dactylon, Echinochloa colona, Dinebra retroflexa, Panicum javanicum* and broad leaved weeds were *Corchorus olitorius, Eclipta alba, Digera arvensis, Cyanotis axillaris, Psoralea corylifolia, Ammannia baccifera, Euphorbia geniculata, Phyllanthus niruri, Portulaca oleracea, Abutilon indicum, Celosia argentia, Commelina benghalensis, Merremia emarginata, Gynandropsis pentaphylla* and *Parthenium hysterophorus*. Among these, broad leaved weeds were dominant followed by grasses and sedges in aerobic rice.

The weed parameters like weed density, dry weight, weed control efficiency and weed index were not significantly influenced by the application of different doses of nitrogen except weed density at 60 DAS and weed dry weight at 15 DAS and harvest (Table 1). At 60 DAS, the weed density recorded with 240 kg N ha^{-1} was significantly higher than 120 kg N ha^{-1} but was at par with 180 kg N ha^{-1}. Pre-emergence application of pendimethalin @ 1.2 kg a.i. ha^{-1} followed by pyrazosulfuron ethyl @ 30 g a.i. ha^{-1} at 25 DAS registered significantly lower weed density at all the stages of observation compared to weedy check and mechanical weeding except at 60 DAS where they were at par with each other (Table 1). Similar trend was observed with respect to the dry weight of weeds including at 60 DAS. Higher weed control efficiency was recorded with herbicides than mechanical weeding at all the stages which led to lower weed index in the former treatment. The interaction between the nitrogen levels and weed management treatments was significant with respect to the dry weight of weeds at 15 DAS and harvest only (Table 4). The weed dry weight was significantly higher with mechanical weeding compared to herbicides application at all the doses of nitrogen both at 15 DAS and harvest. Similarly, the dry weight of weeds significantly increased at 240 kg N ha^{-1} compared to 120 kg N ha^{-1} at 15 DAS and 180 kg N ha^{-1} as well at harvest except in the weed free treatment. This might be attributed to vigorous growth and development of weeds owing to higher uptake of nutrients at higher rate of nitrogen application. Similar results were reported by Sharma *et al.* (2007).

Nitrogen removal by weeds

The nitrogen removal by the weeds at harvest was significantly higher at 240 kg N ha^{-1} over 120 kg N ha^{-1} but at par with 180 kg N ha^{-1} (Table 3). It was also significantly more with mechanical weeding compared to herbicidal application which was at par with weedy check due to higher density and dry weight of weeds in the latter treatment. The interaction between the nitrogen doses and weed management was not significant. The increase in nitrogen removal by weeds was mainly due to increase in the number and dry weight of weeds with increase in the dose of nitrogen. Singh and Tripathi (2007) also reported similar results.

Table 1. Influence of nitrogen doses and weed management on weed density, weed dry weight, weed control efficiency and weed index in aerobic rice

Treatment	Weed density (no. m^{-2})					Weed dryweight (g m^{-2})					WCE (%)					WI
	15 DAS	30 DAS	45 DAS	60 DAS	Harvest	15 DAS	30 DAS	45 DAS	60 DAS	Harvest	15 DAS	30 DAS	45 DAS	60 DAS	Harvest	
Nitrogen dose (kg N ha^{-1})																
120	4.8	4.3	4.5	4.1	3.3	1.4	4.4	8.7	13.0	18.7	62.0	69.1	64.1	55.9	53.9	47.1
	(34.5)	(31.0)	(27.5)	(22.6)	(12.3)	(1.2)	(33.0)	(128.)	(248.5)	(500.7)						
180	5.2	5.0	4.9	4.9	3.5	1.6	4.8	9.4	13.8	22.8	60.4	68.2	63.6	55.6	50.6	42.7
	(41.5)	(35.9)	(32.2)	(31.0)	(14.8)	(1.8)	(38.0)	(144.0)	(274.2)	(717.9)						
240	5.4	4.9	5.3	6.0	3.8	1.9	5.0	9.7	14.3	26.4	59.4	66.2	63.0	54.5	47.5	40.8
	(48.0)	(41.6)	(38.3)	(44.8)	(16.9)	(3.1)	(40.4)	(151.7)	(294.0)	(937.3)						
SEm±	0.5	0.3	0.3	0.5	0.2	0.07	0.3	0.4	0.4	0.6	-	-	-	-	-	-
CD(P=0.05)	NS	NS	NS	1.5	NS	0.23	NS	NS	NS	1.7	-	-	-	-	-	-
Weed management (W)																
Pendi. + py.ethyl	2.0	2.6	3.9	5.3	3.6	1.3	1.9	4.0	9.7	20.9	83.3	97.7	95.9	84.0	67.1	37.3
	(4.0)	(9.0)	(16.5)	(32.2)	(12.1)	(0.8)	(2.6)	(16.4)	(96.5)	(470.7)						
M.W at 20 and	8.6	5.6	5.6	5.8	4.6	2.0	5.4	12.5	19.5	31.8	58.5	73.8	58.5	37.2	35.5	49.6
45DAS	(77.5)	(32.0)	(30.5)	(34.9)	(21.4)	(3.3)	(30.3)	(160.2)	(381.4)	(1029.1)						
Weed free	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	100.0	100.0	100.0	100.0	100.0	0.0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)						
Weedy check	9.6	10.1	9.1	7.9	5.0	2.3	10.8	19.7	24.7	36.9	0.0	0.0	0.0	0.0	0.0	87.1
	(97.3)	(102.7)	(83.7)	(64.0)	(25.1)	(4.3)	(115.7)	(388.7)	(611.0)	(1374.7)						
SEm±	0.5	0.3	0.3	0.6	0.2	0.09	0.3	0.4	0.5	0.6	-	-	-	-	-	-
CD(P=0.05)	1.6	0.9	0.9	1.8	0.7	0.20	0.9	1.3	1.5	2.0	-	-	-	-	-	-
Interaction (N×W)																
SEm±	1.0	0.6	0.6	1.0	0.4	0.1	0.6	0.8	0.9	1.2	-	-	-	-	-	-
CD(P=0.05)	NS	NS	NS	NS	NS	0.4	NS	NS	NS	3.5	-	-	-	-	-	-

Data subjected to square-root ("x+1) transformation; Figures in parentheses are original values.
Pendi.-pendimethalin; py.ethyl-pyrazosulfuron ethyl; M.W-mechanical weeding; DAS-days after sowing

Table 2. Tiller number m^{-2} at 30, 60, 90 DAS and harvest as influenced by nitrogen levels and weed management in aerobic rice

Treatment	Tiller number m^{-2}			
	30 DAS	60 DAS	90 DAS	Harvest
Nitrogen level (kg N ha^{-1})				
N_1: 120	173.6	286.8	319.1	312.5
N_2: 180	200.4	324.3	355.6	345.5
N_3: 240	238.6	357.0	390.0	378.2
SEm±	6.6	7.5	7.2	6.1
CD(P=0.05)	19.3	22.1	21.2	18.1
Weed management (W)				
W_1: Pendimethalin + Pyrazosulfuron ethyl	194.4	413.4	453.6	444.2
W_2: Mechanical weeding at 20 and 45 DAS	235.3	315.8	356.0	343.1
W_3: Weed free	297.7	462.8	507.3	499.1
W_4: Weedy check	89.3	98.9	102.7	94.7
SEm±	7.6	8.7	8.3	7.1
CD(P=0.05)	22.3	25.6	24.52	20.9
Interaction (N×W)				
SEm±	13.2	15.1	14.4	12.3
CD(P=0.05)	NS	NS	NS	NS

Number of tillers m^{-2}

The number of tillers m^{-2} was significantly influenced by the nitrogen levels and weed management options at all the stages of crop growth but their interaction was not significant (Table 2). Between the two weed management options, mechanical weeding at 20 and 45 DAS (W_2) was found to be superior to herbicide's application (W_1) at 30 DAS but found to be inferior at the later stages i.e., 60, 90 DAS and harvest. Both the treatments were significantly superior to weedy check even though inferior to weed free treatment at all the stages of observation. This might be due to the slow action of herbicides than mechanical weeding in controlling the weeds which might have created favourable environment for crop growth and tillering. The application of pendimethalin followed by pyrazosulfuron ethyl at 25 DAS also controls the weeds emerging at later stages of crop thus contribute to higher tiller production. These results corroborate the findings of Rajkhowa *et al.* (2006) and Sunil *et al.* (2010). Among the nitrogen levels, application of 240 kg N ha^{-1} (N_3) caused significant increase in the number of tillers m^{-2} over 180 kg ha^{-1} (N_2) which in turn was superior to 120 kg ha^{-1} (N_3) at 30, 60, 90 DAS and harvest. This was mainly due to more nitrogen availability at higher levels of nitrogen provided proper nutrition to the crop and thereby the tillering has increased at higher N levels (Sathiya *et al.,* 2008).

Yield and yield attributes

Application of 240 kg N ha^{-1} recorded significantly higher yield attributes like number of panicles m^{-2}, filled grains $panicle^{-1}$ and 1000-grain weight and grain yield over 120 kg N ha^{-1} but at par with 180 kg N ha^{-1} except the test weight (Table 3). But, the straw yield was not significantly different among the different nitrogen doses. Increased yield under higher nitrogen levels might be due to adequate nutrient supply which would have resulted in increased growth and yield components. Similar findings were reported by Shekara *et al.* (2010). Among the weed management practices, pre-emergence application of pendimethalin @ 1.2 kg a.i. ha^{-1} + post-emergence application of

Table 3. Influence of nitrogen doses and weed management on yield attributes, yield, nitrogen uptake by crop and weeds and economics in aerobic rice

Treatment	Panicles m^{-2}	Filled grains $panicle^{-1}$	1000-grainweight (g)	Grain yield ($kg\ ha^{-1}$)	Straw yield ($kg\ ha^{-1}$)	N uptake by crop		N removal by weedsat harvest ($kg\ ha^{-1}$)	Economics	
						Grain ($kg\ ha^{-1}$)	Straw ($kg\ ha^{-1}$)		Net returns (Rs ha^{-1})	Returns per rupee invested
Nitrogen dose (kg N ha^{-1})										
120	175.0	107.0	11.4	2149.0	3582.0	42.5	42.8	2.5 (7.6)	19,675	1.3
180	210.0	137.7	12.0	2645.0	3917.0	51.3	48.3	3.4 (13.9)	24,051	1.5
240	221.4	152.6	12.6	2902.0	4195.0	68.0	64.6	4.0 (18.9)	26,564	1.6
SEm±	11.3	4.6	0.1	101.2	195.8	4.0	3.7	0.2	-	-
CD(P=0.05)	33.3	13.6	0.3	297.0	NS	11.7	10.9	0.6	-	-
Weed management (W)										
Pendi. + py.ethyl	252.2	183.2	12.5	2860.0	4270.0	61.3	57.7	3.0 (8.2)	28,924	2.0
M.W at 20 and 45DAS	181.8	131.0	11.6	2300.0	3823.0	51.2	49.1	4.4 (20.0)	21,376	1.6
Weed free	279.4	203.4	13.3	4520.0	5710.0	89.0	88.9	1.0 (0.0)	45,638	2.5
Weedy check	94.5	11.6	10.7	582.0	1790.0	14.3	11.9	5.0 (25.7)	-2,218	0.2
SEm±	13.1	5.4	0.1	116.9	226.1	4.6	4.3	0.2	-	-
CD(P=0.05)	38.5	15.8	0.3	342.9	663.3	13.5	12.5	0.6	-	-
Interaction (N×W)										
SEm±	22.7	9.3	0.1	202.4	391.6	8.0	7.4	0.4	-	-
CD(P=0.05)	NS	27.3	NS	NS	NS	NS	NS	NS	-	-

Data subjected to square-root (“x+1) transformation; Figures in parentheses are original values.
Pendi.-pendimethalin; py.ethyl-pyrazosulfuron ethyl; M.W-mechanical weeding; DAS-days after sowing

Table 4. Interaction effect between nitrogen doses and weed management on weed dry weight and filled grains panicle^{-1} in aerobic rice

Treatment	Weed dryweight at 15 DAS			Weed dryweight at harvest			Filled grains panicle^{-1}		
	120 kg ha^{-1}	180 kg ha^{-1}	240 kg ha^{-1}	120 kg ha^{-1}	180 kg ha^{-1}	240 kg ha^{-1}	120 kg ha^{-1}	180 kg ha^{-1}	240 kg ha^{-1}
Weed management (W)									
Pendi.+ py.ethyl	1.0 (0.0)	1.3 (0.7)	1.6 (3.2)	14.2 (204.7)	20.9 (443.3)	27.6 (764.1)	160.0	188.0	203.0
M.W at 20 and 45 DAS	2.0 (2.8)	2.0 (3.2)	2.2 (3.8)	26.7 (443.3)	32.3(1044.1)	36.4 (1331.2)	84.0	137.0	173.0
Weed free	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	175.0	214.0	222.0
Weedy check	1.7 (2.0)	2.1 (3.6)	2.9 (7.3)	32.9 (764.1)	37.1(1384.0)	40.7 (1654.0)	9.0	13.0	13.0
	N	W	N×W	N	W	N×W	N	W	N×W
SEm±	0.07	0.09	0.15	0.6	0.7	1.1	4.7	5.3	9.3
CD(P=0.05)	0.20	0.20	0.40	1.7	2.0	3.5	13.7	15.8	27.3

Data subjected to square-root (“x+1) transformation; Figures in parentheses are original values.
Pendi.-pendimethalin; py.ethyl-pyrazosulfuron ethyl; M.W-mechanical weeding; DAS-days after sowing

pyrazosulfuron ethyl @ 30 g a.i. ha^{-1} at 25 DAS recorded significantly higher yield attributing parameters, grain yield and straw yield over mechanical weeding and it was comparable with weed free treatment. The increased grain yield was mainly due to effective control of weeds in herbicide applied plots(Jayadeva *et al.,* 2011). The significantly lowest yield attributing parameters and yield among the treatments were observed with unweeded check owing to severe crop-weed competition throughout crop growth period. The interaction effect on the number of filled grains panicle^{-1} was found significant between nitrogen levels and weed management practices. The number of filled grains panicle^{-1} recorded with weed free treatment and application of herbicides was at par at all the doses of nitrogen and they were superior to mechanical weeding (Table 4).

Nitrogen uptake by crop

Nitrogen uptake by grain and straw of rice increased significantly with increasing doses of nitrogen upto 240 kg N ha^{-1} (Table 3). This might be ascribed to increase in nitrogen concentration in grain and straw and more drymatter production due to addition of nitrogen. Among all the weed management practices, significantly higher nitrogen uptake by grain as well as straw was observed with herbicides compared to weedy check but at par with mechanical weeding (Table 3). The better nitrogen removal by crop was associated with its better growth and development, resulting in higher yield owing to the elimination of competition from weeds (Singh and Tripathi, 2007).

Economics

The highest net returns and returns per rupee invested were obtained with the application of 240 kg N ha^{-1} over other two doses (Table 3). Among the weed management practices, weed free check recorded the highest net returns and returns per rupee invested followed by pre-emergence application of pendimethalin @ 1.2 kg a.i. ha^{-1} + post-emergence application of pyrazosulfuron ethyl @ 30 g a.i. ha^{-1} at 25 DAS. These results corroborate the findings of Jayadeva *et al.* (2011).

From this study, it can be concluded that application of 180 kg N ha^{-1} was found to be optimum for aerobic rice in sandy loam soils of Telangana region and pre-emergence application of pendimethalin @ 1.2 kg a.i. ha^{-1} + post-emergence application of pyrazosulfuron ethyl @ 30 g a.i. ha^{-1} at 25 DAS was found to be effective and economical weed management practice in aerobic rice during *kharif* season.

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