AEROBIC RICE: WATER SAVING RICE PRODUCTION TECHNOLOGY

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Abstract

Field experiments were conducted at Central Farm, Coimbatore to develop a technology package for aerobic rice cultivation from 2004 to 2007. Among 12 rice varieties evaluated, PMK 3 proved to be the best variety in terms of production. The study of plant population in aerobic rice revealed that 100 hills/m2 (20 x 5 cm) was comparable with 50 hills/m2 (20 x 10 cm) in terms of grain yield. Irrigation at IW/ CPE of 1.2 (with water requirement of 618 mm) registered a grain yield of 4.9 ton/ha and was comparable with the grain yield of 4.8 ton/ha in irrigation at IW/CPE of 1.0 (with water requirement of 556mm). Among the N levels, N at 175 kg/ha produced the highest grain yield of 4183 kg/ha and it was comparable with N at 150 kg/ha (4030 kg/ha). To find out the suitability of aerobic rice in Cauvery delta region, a field experiment was initiated in PAJANCOA & RI, Karaikal to screen suitable rice varieties (ADT 36, ADT 43, ADT 48, PMK 3, MDU3 and ADS 18) for aerobic cultivation in comparison with other rice production systems. The grain yield of rice is higher in transplanting and wet seeding when compared to aerobic rice system. However, the most salient feature of this study is that about 92, 42 and 40.6% of water (including rainfall) was used for evapo-transpiration or consumptive purpose while remaining 8.0, 58.0 and 59.4% of water would have left the root zone as seepage and deep percolation, respectively.

1. INTRODUCTION

"International year of rice-2004 AD" had the slogan "*Rice is life*" as its broad meaning encompasses the entire scope of rice as way of life, the source of livelihood. Irrigated lowland rice is consequently the most important agricultural ecosystem in Asia. The present and future food security of most of its population depends on it. However, there are signs that declining water availability is threatening the sustainability of this system. In view of these demands and constraints, the question is – does rice need standing water for optimum production? Flooding in rice is used as management tool, not a specific requirement. Rice is unique in the sense that transplanted paddy requires lot of water for land preparation. Can we go for an alternative that reduces this component? As a result, the concept of aerobic rice was first developed in China (Bouman and Tuong, 2001). The term "Aerobic rice" was coined recently by International Rice Research Institute (Bouman *et al*., 2002). Aerobic cultivation entails the growing of rice in aerobic soil, with the use of external inputs such as supplementary irrigation and fertilizers, and aiming for high yields. Growing rice aerobically saves water by eliminating continuous seepage and percolation, reducing evaporation and eliminating wetland preparation. To make aerobic rice successful, suitable package of practices should be developed. Hence, research has started at Tamil Nadu Agricultural University, to develop technology package for aerobic rice cultivation. The technology for growing aerobic rice includes the following land preparation and sowing methods:

- Dry ploughing - after the harvest of the previous crop
- Ensure that fields are well harrowed and leveled
- The field should be thoroughly prepared by using disc plough, cultivator and rotavator.
- Sowing either by using manual seeding or drum seeder
- Seed rate of 40-45 kg/ha with the spacing of 20x10cm (50 hills/m2)

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2. RICE VARIETIES FOR AEROBIC CULTIVATION

A field experiment was conducted in Central Farm wetlands, Coimbatore to screen suitable rice varieties for aerobic rice cultivation. The field was clay loam in texture. The soil was neutral in pH (7.1) and the EC was 3.9 dS/m1. The soil was low in available N (219 kg/ha), medium in available P (17 kg/ha) and medium in available K (396 kg/ha). Twelve rice varieties *viz*., ADT 38, ADT 39, ADT 43, ADT 46, CO 43, CO 45, CO 46, CO 47, White Ponni, PMK 3, MDU 3 and ADS 16 were evaluated in randomized block design with three replications. The field was prepared under dry conditions. Sprouted seeds were line sown with a spacing of 20 x 5 cm. Pre emergence herbicide pendimethalin at 0.75 kg a.i./ha was applied at 3 days after sowing (DAS). Hand weeding was done at 20 and 45 DAS. Need based plant protection was given. Irrigation was given with 2.5 cm depth of water during the first 30 days and 3.0 cm depth of water later by using Parshall Flume.

Among 12 rice varieties evaluated, the variety PMK-3 produced higher root length and dry matter, higher panicle per unit area and filled grains resulting in the highest grain yield of 3684 kg/ha during *rabi* season of 2004 - 05 (Table1). This was followed by the variety ASD 16 with a grain yield of 3138 kg/ha. The water productivity varied among the varieties depending upon their field duration. The variety PMK 3 with a duration of 137 days registered the highest water productivity of 7.06 kg/ha mm of water. White Ponni recorded the lowest water productivity of 1.5 kg/ha mm of water. The second best variety was ASD 16 which registered 5.79 Kg/ha mm of water.

Table 1: Screening of Rice Varieties for Aerobic Rice Production

Treatments	Panicles m^{-2}	Grain yield (kg/ha)	Irrigation Water used (mm)	Rainfall(mm)	Total water used (mm)	Water productivity in rice (kg/ha mm)
ADT 38	193	1389	503.4	116.4	619.8	2.24
ADT39	255	1753	488.2	116.4	604.6	2.90
ADT 43	294	1248	432.4	89.7	522.1	2.39
ADT 46	262	1321	467.9	116.4	584.3	2.26
CO 43	306	2805	526.4	127.4	653.8	4.29
CO 45	265	2418	488.2	116.4	604.6	4.00
CO 46	283	2755	467.9	116.4	584.3	4.72
CO 47	256	2316	467.9	116.4	584.3	3.96
W. PONNI	186	984	526.4	127.4	653.8	1.51
PMK 3	346	3684	432.4	89.7	522.1	7.06
MDU 3	309	2943	447.7	93.9	541.6	5.43
ASD 16	315	3138	447.7	93.9	541.6	5.79
CD(P=0.05)	17	317				

3. OPTIMIZATION OF PLANT POPULATION FOR AEROBIC RICE

The experiment was laid out in a factorial randomized design with three replications. The treatments included six rice varieties *viz*., PMK 3, ASD 16, MDU 3, MDU 5, CO 47 and RM 96 019 and three plant populations *viz*.,100 hills/m^2 (20 x5cm), 50 hills/m^2 (20x 10 cm) and 33 hills/m^2 (20 x 15 cm). Of the six rice varieties tested with three plant spacing, the variety PMK-3 recorded the highest grain yield of 4517 kg/ha (Table 2). The plant spacing of 20x 5 cm (100 hills/m^2) registered the highest grain yield of 3099 kg/ha. However, this was comparable with a plant spacing of 20x10 cm which recorded a grain yield of 2834 kg/ha

Table 2: Effect of varieties and plant populations on grain yield and water productivity in rice

Treatments	Grain yield (kg/ha)					
	100 Hills	50 Hills	33 Hills	Mean	Total water used (mm)	Water productivity in rice (kg / ha mm)
PMK 3	4787	4647	4117	4517	526	8.6
ASD 16	3410	3083	2557	3017	554	5.4
MDU 3	3053	2833	2690	2859	526	5.4
MDU 5	2580	2227	2217	2341	554	4.2
CO 47	1607	1407	1347	1453	554	2.6
RM 96019	3160	2807	2247	2738	506	5.4
Mean	3099	2834	2529			

	SEd	CD(P=0.05)
Variety (V)	237	500
Spacing (S)	205	433
VXS	0.18	119

4. IRRIGATION AND NITROGEN MANAGEMENT FOR AEROBIC RICE

The experiment was laid out in a strip plot design with three replications. The treatments included four irrigation regimes *viz*., IW/CPE 0.8, IW/CPE 1.0, IW/CPE 1.2 and 200 % PE (microsprinkler) and four N levels *viz*., 100, 125,150 and 175 kg/ha. The variety PMK-3 was used for the study. A common fertilizer dose of 50: 50 kg P, K/ha was adopted. The entire dose of P was applied as a basal dose. N and K fertilizers were applied in four equal split doses at 15 DAS, tillering, panicle initiation and heading stages.

Study on irrigation and nitrogen management in aerobic rice reveled that the irrigation at IW/ CPE of 1.2 was the best with a grain yield of 4884 kg/ha (Table 3). This was comparable with the irrigation at IW/CPE of 1.0 which produced a grain yield of 4771 kg/ha. The irrigation water requirement under IW/ CPE ratio of 1.0 and 1.2 were 442, 504 mm, respectively. Among the N levels, N at 175 kg/ha produced higher grain yield of 4183 kg/ ha and it was on par with N at 150 kg/ha (4030 kg/ha).

Table 3: Influence of Irrigation and Nitrogen Management on Aerobic Rice

Treatments	Yield (kg/ha)					Irrigation Water used (mm)	Total water used (mm)	Water productivity in rice (kg/ ha mm)
	100 kg	125 kg	150 kg	175 kg	Mean			
IW/CPE - 0.8	3810	4263	4457	4567	4274	384	498	8.6
IW/CPE - 1.0	4450	4757	4883	4993	4771	442	556	8.6
IW/CPE - 1.2	4727	4763	4950	5097	4884	504	618	7.9
Microsprinkler	1783	1680	1830	2077	1843	545	659	2.8
Mean	3693	3866	4030	4183				

5. WEED MANAGEMENT

Transforming crop establishment technique from transplanting to direct seeding has resulted in dramatic changes in the type and degree of weed infestation. Weed management is one of the most critical factors for successful production of direct seeded rice as the soil conditions favour simultaneous germination of weed seeds along with paddy seeds (Subramanian and James Martin, 2006). Though the conventional method of manual weeding is widely practiced, it is difficult to differentiate and remove the grassy weeds especially *Echinochloa colonum* and *E. crus-galli* due to phenotypical similarities between weeds and rice seedlings in the early stages. The only effective method to control weeds in the early stage is pre-emergence application of herbicides.

- Application of pre-emergence herbicide pendimethalin at 1.0 kg a.i/ha on 3 DAS
- Followed by mechanical or hand weeding twice at 25 and 50 days after sowing

To find out the suitability of aerobic rice in Cauvery delta region, a field experiment was initiated at PAJANCOA & RI, Karaikal during *Kharif* season, 2007 to screen suitable rice varieties for aerobic rice cultivation. Seven rice varieties *viz*., ADT 36, ADT 43, ADT 45, ADT 48, PMK 3, MDU 3 and ADS 18 were evaluated in randomized block design with three replications under three systems of rice cultivation (Transplanting, Wet seeding and Aerobic rice). The grain yield of rice was higher in transplanting, and wet seeding methods when compared to aerobic method.

The most salient feature of aerobic rice in the study was the extremely low water input: the total of rainfall and irrigation water input from sowing to harvest varied from 470 to 650 mm, compared to 1200-1300 mm in transplanting and wet seeding. Compared to lowland rice, water consumption in aerobic rice was lower than 50%; water productivity was 60% higher with yield reduction of 25%. This attempt gave much novel ideas of crop-water relationships in aerobic rice (Table 4). Further research is being continued at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal to screen varieties and management technologies for aerobic rice cultivation.

Table 4: Consumptive Use of Water Under Different Systems of Rice Establishment

Particulars	Aerobic rice	Wet seeded rice	Transplanted rice
Land preparation (mm)	-	175	250
Water used for crop growth including rainfall *(mm)	560	1025	1050
Total water used (mm)	560	1200	1300
Evapotranspiration (mm)*	515	504	528
Yield (kg/ha)*	3021	3401	3842

* Mean of seven varieties tested

6. CONCLUSION

The yield of aerobic rice varied from 3.5 to 4.8 t/ha, which is about double the amount obtained from traditional upland varieties and about 20-25% lower than that of lowland varieties grown under flooded conditions. However, the irrigation water use from sowing to harvest in aerobic rice varied from 470 to 650 mm compared to 1200-1300 mm in transplanting which was about 60% less than that of lowland rice.The total water productivity was 1.6 to 1.9 times higher than that of low land rice. In terms of water saving for aerobic, wet seeding and transplanted rice, about 92, 42 and 40.6% of water (including rainfall) was used for evapotranspiration or consumptive purpose while remaining 8.0, 58.0 and 59.4% of water left the root zone as seepage and deep percolation flows, respectively. Because of its low water use with reasonable higher yield, aerobic rice has greater scope in areas where water availability is limited. However, special high-yielding aerobic rice varieties need to be bred and a lot of research is still needed to develop sustainable and viable aerobic rice systems.

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