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AEROBIC RICE : SUSTAINABLE WAY TO ENHANCE RICE PRODUCTION

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ABSTRACT

Rice is unique among the major food crops by virtue of its extent and adaptability to wider range of climatic, edaphic and cultural conditions. Of India's 1.15 billion population, 70 percent rely on rice for at least a third of their energy requirement indicating its importance in food security. Aerobic rice is a new development in water saving technologies in which grown in well-drained, non-puddled, and non-saturated soils. Traditional lowland rice with continuous flooding in Asia has relatively high water inputs and water is called elixir of life. Aerobic rice saved 73% of irrigation water for land preparation and 56% during the crop growth period. Though, transplanting method of rice establishment supposed to be best but due to high labour wedges and problem of labours during peak critical periods, some alternatives should be explored and aerobic rice is one of the best and sustainable way to enhance the productivity with less water and less labour.

Key words : *Aerobic rice, yield, sustainbility, water saving system.*

Rice is the most important staple in Asia where it provides 35%—80% of total calorie uptake (1). About 55% of the rice area is irrigated and accounts for 75% of total production. Irrigated lowland rice is consequently the most important agricultural ecosystem in Asia, and 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. The reasons for this decline are diverse and location-specific, but include decreasing quality, decreasing resources, and increased competition from urban and industrial users (2). The Water-Saving Work Group of the IRRC is committed to further developing this new technology and making it available to farmers in Asia. Aerobic rice is a production system where rice is grown in well-drained, non-puddled, and non-saturated soils. Water requirements can be lowered by reducing water losses due to seepage, percolation, and evaporation. Promising technologies include saturated soil culture and intermittent irrigation during the growing period. However, these technologies still use prolonged periods of flooding, so water losses remain high. Aerobic rice is a production system where rice is grown in well-drained, non-puddled, and non-saturated soils. Water savings from land preparation, no transplanting costs, seed costs and labor costs from sowing to harvest varied from 520 to 650 mm, compared with 1200-1300mm in lowland rice. Aerobic rice is crops grown in well-drained, non-puddled & non saturated soils without ponded water (3). Growing rice in aerobic soil, with the use of external inputs such as supplementary irrigation, fertilizers and aiming at high yields (4). Main driving force behind aerobic rice is economic water use. A fundamental approach to reduce water inputs in rice is growing like an irrigated upland crop, such as wheat or maize. Aerobic rice varieties developed for the purpose yield as much as irrigated puddled rice varieties traditionally grown in rice paddies. Yields were on par with irrigated puddled rice with an average of 5.5- 6 t/ha with 60 percent less water. Aerobic rice emits 80-85 % lesser methane gas into the atmosphere thus keeping the environment safe. Savings are also from land preparation, no transplanting costs, seed costs and labor costs. Sustainable rice production methodology for the immediate future to address water scarcity and environmental safety in the scenario of global warming.

Comparison of aerobic practice with other water saving system in rice

The adoption of aerobic rice is facilitated by the availability of weed management tools and seed-coating technologies. Case studies showed yields to vary from 4.5 to 6.5 t/ha, which is about double than that of traditional upland varieties and about 20-30% lower than that of lowland varieties grown under flooded conditions. However, the water use was about 60% less than that of lowland rice, total water productivity 1.6-1.9 times higher, and net returns to water use was twofold higher. Aerobic rice requires lesser labor than lowland rice and can be highly mechanized (5). Input water savings of 35-57% have been reported for dry seeded rice (DSR) sown into non puddled soil with the soil kept near saturation or field capacity compared with continuously flooded (5 cm) transplanted rice (6). However, yields were reduced by similar amounts due to iron or zinc deficiency and increased incidence of nematodes. Contrary to the

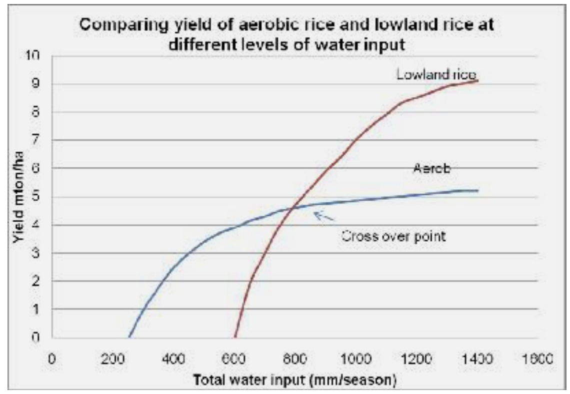
Difference between aerobic and conventional method of rice (Transplanting).

Aerobic	Conventional method of rice (Transplanting)
No need of land levelling	Land should be leveled
Direct seeding	Nursery raising is needed
Reduced seed rate	Higher seed rate (25 kg per ac)
40–50% water saving No constant maintenance of water	Maintenance of water level Level is necessary
Labour requirement is less	More
Intercropping of any other arable crop is possible Aerobic condition in soil	Not possible
Soil structure is maintained	Anaerobic condition prevails
Crop rotation can be practiced (with pulses for balanced nutrition)	Destroyed. Subsurface hard pan is made by repeated plowing
Faster organic matter decomposition	Not common
Oxygenated rhizosphere is found	Slower
Nitrogen use efficiency is more	Not found
Nitrous oxide is not produced	Less
Better water use efficiency	Produced Less efficient
Efficient utilization of rain water utilization of rain water	
No occurrence of methanogenesis	Methanogenesis occurs

Comparison of seasonal water requirement between lowland flooded rice and aerobic rice

Water expense component	Seasonal water requirement (mm)	
	Lowland rice	Aerobic rice
Land preparation	150-300	100
Evaporation	200	100
Transpiration	400	400
Seepage and percolation	500-1500	335
1650-3000	935	

results of small plot replicated experiments, participatory trials in farmers' fields in India and Pakistan suggest a small increase or 10% decline in yield of DSR on the flat compared with puddled transplanted rice, and around 20% reduction in irrigation time or water use (7). High-yielding lowland rice variety like an upland crop under furrow irrigation



that total water savings were 56% and irrigation water savings 78% compared with growing the crop under flooded conditions. However, the yield was reduced from 7.9 - 3.4 t/ha. The WUE of the aerobic varieties under aerobic conditions was 164- 188% higher than that of a lowland cultivated rice variety. Aerobic rice maximizes water use in terms of yield and is a suitable crop for water-limiting conditions (8). In a study, rice yields under aerobic conditions were 2.4-4.4 t/ha, which were 14-40% lower than under flooded conditions (9). However, water use decreased relatively more than yield, and water productivity under aerobic cultivation increased by 20-40% (in one case even 80%) over that under flooded conditions. The aerobic rice technology eliminates puddling and flooding, and presents an alternative system in reducing water use and increase water productivity. Aerobic rice saved 73% of irrigation water for land preparation and 56% during the crop growth period . Nevertheless, decline in yield was observed when aerobic rice was continuously grown and the decline was greater in the dry than in the wet season (10).

Major problems in aerobic rice cultivation

- Weed competition
- Nematode infestation
- Nutrient Availability

Causes for continuous cropping obstacle in aerobic rice (11).

Future thrust

A successful change from the traditional flooded to aerobic rice production requires the breeding of special aerobic rice varieties and the development of appropriate water and crop management practices. Although, considerable progress has been made in the improvement of transgenic rice for improved water-use efficiency and productivity; however, the achievements are not satisfactory. Nevertheless, with the study of the functional genomics of plants, considerably more

Cause	Source
Biotic factors	
Nematode	(12)
Fungi	(13)
Abiotic factors	
Toxic substances	(14)
n0N deficiency	(15)
Increase in soil pH	(16)
Ammonia toxicity	(17)
Interaction among biotic and abiotic factors	
Biotic and abiotic factors	(18)
Nematode and micronutrient deficiency	(19)

information about the mechanisms by which plants perceive and transducer these stress signals to initiate adaptive responses will be obtained, and with the improvement of the transgenic approach, marker-free transgenic rice will be produced. Therefore, to combine novel regulatory systems for the targeted expression with useful genes, more effective and rational engineering strategies must be provided for the improvement of rice for higher water productivity. Different strategies need to be tested experimentally to genetically improve the water-use efficiency and drought stress tolerance in rice. Different strategies need to be integrated, and the genes representing distinctive approaches be combined to substantially increase rice water productivity. Wide hybridization using hardy wild rice species is another area to be emphasized. Moreover, combining the transgenic with traditional breeding methods may be an effective approach to develop abiotic stress-tolerant rice cultivar.

REFERENCES

1. IRRI (1997). Rice almanac, second edition. *IRRI,* Los Baños, Philippines. 181 pp.
2. Postel, S. (1997). Last Oasis. Facing water scarcity. Norton and Company, New York, USA. 239 pp.
3. Bouma, B.A.M.; Humphreys, E. Tuong, T.P. and Barker, R. (2007). Rice and water. *Adv Argon 92 :*187–237.
4. Bouman, B.A.M.; Tuong, T.P. (2001). Field water management to save water and increase its productivity in irrigated rice. *Agricultural Water Management, 49(1) :* 11-30.
5. Huaqi, W.; Bouman, B.A.M.; Zhao, D.; Changgu, W. and Moya, P.F. (2003). Aerobic rice in northern China: Opportunities and challenges. *In proceedings of a Thematic Workshop on Water-Wise Rice Production,* 8–11 April 2002 at IRRI Headquarters in Los Banos, Philippines.
6. Sharma, P.K.; Bhushan, L.; Ladha, J.K.; Naresh, R.K.; Gupta, R.K.; Balasubramanian, B.V. and Bouman, B.A.M. (2003). Crop–water relations in rice-wheat cropping under different tillage systems and water-management practices in a marginally sodic, medium-textured soil. *In proceedings of a Thematic Workshop on Water-Wise Rice Production,* 8–11 April 2002 at IRRI Headquarters in Los Banos, Philippines.
7. Gupta, R.K.; Naresh, R.K.; Hobbs, P.R. and Ladha, J.K. (2003). Adopting conservation agriculture in the rice–wheat system of the Indo-Gangetic Plains: New opportunities for saving water. *In proceedings of a Thematic Workshop on Water-Wise Rice Production,* 8–11 April 2002 at IRRI Headquarters in Los Banos, Philippines.
8. Xiaoguang, Y.; Huaqi, W.; Zhimin, W.; Junfang, Z. Bin, C and Bouman, B.A.M. (2003). Yield of aerobic rice (Han Dao) under different water regimes in North China. *In proceedings of a Thematic Workshop on Water-Wise Rice Production,* 8–11 April 2002 at IRRI Headquarters in Los Banos, Philippines.
9. Castaneda, A.R.; Bouman, B.A.M.; Peng, S. and Visperas, R.M. (2003). The potential of aerobic rice to reduce water use in water-scarce irrigated lowlands in the tropics. *In proceedings of a Thematic Workshop on Water-Wise Rice Production,* 8–11 April 2002 at IRRI Headquarters in Los Banos, Philippines.
10. Peng, S.; Bouman, B.A.M.; Visperas, R.M.; Castaneda, Nie A.L. and Park, H. (2006). Comparison between aerobic and flooded rice in the tropics: Agronomic performance in an eight-season experiment. *Field Crops Res. 96 :* 252-259.
11. Nie, L.; Peng, S.; Chen, M.; Shah, F.; Huang, J.K.; Cui and Xiang, J. (2012). Aerobic rice for water-saving agriculture. A review. *Agron. Sustain. Dev. 32 :* 411-418.
12. Watanabe, T.; Yasuo, M.; Ishii, K.; Nagai, M. and Ichiki, K. (1963). Studies on the malnutrition in upland rice resultedfrom its successive cropping. *J Centr Agric Exp Sta 5 :* 1-44.
13. Nishio, M. and Kusano, S. (1975). Effect of fungi associated with roots on the growth of continuously croppedupland rice. *Soil Sci Plant Nutr 21:* 161-171.
14. Fageria, N.K. and Baligar, V.C. (2003). Upland rice and allelopathy. *Soil Sci Plant Anal 34:* 1311–1329.
15. Nie, L. Peng, S.; Bouman, B.A.M.; Visperas, R.M.; Huang, J. and Cui K. (2008). Alleviation of soil sickness caused by aerobic monocropping: growth response of *aerobic rice to nutrient supply. Field Crops Res 107:* 129–136.
16. Xiang, J.; Haden, V.R.; Peng, S.; Bouman, B.A.M.; Visperas, R.M.; Nie, L.; Huang, J, and Cui K. (2009). Improvement of N availability, N uptake and growth of aerobic rice following soil acidification. *Soil Sci Plant Nutr 55 :* 705–714.
17. Haden, V.R.; Xiang, J.; Peng, S.; Bouman, B.A.M.; Visperas, R.M.; Ketterings, Q.M.; Hobbs, P. and Duxbury, J.M. (2011). Relative effects of ammonia and nitrite on the germination and early growth of aerobic rice: relative effects of ammonia and nitrite on the establishment of aerobic rice. *J. Plant Nutr Soil Sci 174 :* 292-300.
18. Ventura, W.; Watanabe, I.; Castillo, M.B. and Dela, Cruz, A. (1981). Involvement of nematodes in the soil sickness of a dryland rice-based cropping system. *Soil Sci. Plant Nutr. 27 :* 305-315.
19. Kreye, C.; Bouman, B.A.M.; Faronilo, J.E. and Llorca, L. (2009). Causes for soil sickness affecting early plant growth in aerobic rice. *Field Crops Res. 114 :* 182-187.