Aerobic Rice System for Water-Scarce Areas

Rice is the staple food in Asia but is also the single biggest user of freshwater. It is mostly grown under submerged soil conditions and requires more water compared with other crops. Asia's irrigated rice fields consume more than 40% of the world's freshwater that is used for agriculture (Bouman 2001). Tuong and Bouman (2003) estimated that, by 2025, approximately two million hectares of irrigated dry-season rice and 13 million hectares of wet-season rice will experience water scarcity. The declining availability and increasing costs of water threaten the traditional way of producing irrigated rice. Moreover, lack of rainfall is a major production constraint in rain-fed areas where many poor rice farmers live. Under these circumstances, new technologies and methods need to be developed to help farmers cope with water shortages for rice production.

Aerobic rice production is a revolutionary way of growing rice in well-drained, non-puddled, and non-saturated soils without ponded water. This system uses input-responsive specialized rice cultivars and complementary management practices to achieve at least 4-6 t/ha using only 50-70% of the water required for irrigated rice production. This is recommended in areas where water is too scarce or expensive to allow traditional irrigated rice cultivation.

The CGIAR Challenge Program on Water and Food (CPWF) Project, Developing a System of Temperate and Tropical Aerobic Rice in Asia (STAR), evaluated and selected varieties for a range of target environments, including temperate, lowland areas in China; the sub-tropical, irrigated regions in India; favorable rain-fed uplands in Laos and Thailand and tropical irrigated lowlands in the Philippines. Varietal evaluation included on-station trials on-farm trials and participatory variety selection (PVS) in farmers' fields.

Where to grow aerobic rice

Rice varieties that are suitable for aerobic production systems grow in soil with moisture content at or below field capacity. Unlike upland rice varieties, aerobic rice varieties should have yields from 4 to 6 t/ha under favorable conditions. Aerobic rice is drought-resistant like upland rice.

Favorable uplands

- Land is flat or terraced
- Rainfall or supplemental irrigation is sufficient to bring soil moisture content to or close to field capacity
- No serious soil chemical limitations (e.g., salinity)
- Farmers have access to external inputs (e.g., fertilizer)

Fields in the upper toposequence of rainfed lowlands

- Deep groundwater table
- Well-drained, coarse-textured soil so that fields are flooded only for a limited part of the growing season

Water-scarce irrigated lowlands

Areas where farmers do not have access to water to keep their fields flooded for a substantial period of time, for example:

- Tail-end part of a large-scale surface irrigation system
- Areas where groundwater has been drawn down so that cost of pumping water is high
- Areas where water for irrigation is re-directed for other uses (e.g., domestic, industries)

Aerobic rice can also be grown in non-rice-growing areas for crop diversification.

Farmers' views on aerobic rice

Favorable:
- **Contributes to food self-sufficiency**
- **Grows in water-scarce environments**
- **Can withstand both dry and flooded conditions**
- **Good alternative to other upland crops (e.g., maize) in the event of flooding**
- **Easy to establish the crop**
- **Requires less labor than lowland rice**
- **Has good eating quality**

Unfavorable:
- **Lower yield compared with lowland rice**
- **Difficult to control weeds**
- **Insufficient extension support to the farmers**
- **Difficult to market new varieties**

How to manage aerobic rice

Aerobic rice is basically managed like a wheat or maize crop. The STAR project developed management options and guidelines for crop establishment, irrigation, fertilizer management and weed management.

1. Crop establishment

Direct dry seeding

◈ Prepare the land by plowing and harrowing to obtain a smooth seed bed before seeding.

◈ Sow seeds at a depth of 1-2 cm in heavy soil (clay) and a 2-3 cm depth in light-textured soil (loam). Sowing may be done manually by dibbling seeds into slits opened by a stick or tooth harrow or mechanically using direct seeding machines. The optimum seeding rate is 70-90 kg/ha.

◈ Maintain 25-35 cm row spacing.

Transplanting

Note: This crop establishment method can only be done in clay soil with good water-holding capacity.

◈ Transplant seedlings into wet soil that is kept around saturation for a few days to ease transplanting shock.

◈ Let the field dry out to field capacity.

2. Irrigation

Irrigation is applied by flash flooding, furrow irrigation or sprinkler. The amount of irrigation should be enough to maintain the soil moisture condition at field capacity (30-40 kPa). Some visible signs that the soil moisture is below field capacity are hair-line cracks in the soil and rolling of the tips of leaves.

In the dry season, light irrigation (approx. 30 mm) is applied after sowing to promote emergence.

3. Fertilizer management

The site-specific nutrient management (SSNM) [http://www.knowledgebank.irri.org/rkb/ssnm] approach is recommended to determine the need for supplemental nutrients. One useful tool under SSNM is the use of the leaf color chart (LCC) to assist in the application of nitrogen (N) fertilizer. In the absence of knowledge or training on SSNM, farmers can initially apply 70-90 kg N/ha in three splits.

The first split should be applied 10-12 days after emergence to minimize N losses from leaching. The second split should be applied at active tillering and the third split at panicle initiation. Note that basal N fertilizer application promotes early weed growth.

Dry, aerobic soil can reduce the indigenous supply of phosphorus (P), hence, the application of P fertilizer is more critical for aerobic rice production than for conventional flooded rice production systems.

4. Weed management

- Use manual or mechanical weeding in the early phase of crop growth.
- Use pre- or post-emergence herbicides when weed pressure is high.

Identified aerobic rice varieties

The STAR project has identified potential aerobic rice varieties from released varieties or from breeding programs in the following countries (see table below):

Aerobic rice varieties identified in the project's target sites

Country	Variety/ Breeding line	Yield
China	Han Dai 502 Han Dao 297	6 t/ha
India	Pusa Hybrid 10 Proagro 6111 (Hybrid) Pusa 834 IR55423-01 (Apo1)	>4 t/ha
Laos	B6144F-MR-6-0-0	3.6 t/ha
Philippines	Apo (PSBRc9) UPLRi5 PSBRc80	5-6 t/ha

Key recommendations

Extensive studies on the potential and impact of aerobic rice yielded promising results. Focus should be directed at some other issues and concerns detailed in the following recommendations:

- Aerobic rice should be recognized as a special crop type (different from lowland and upland rice) and should be promoted with a complete understanding of the system.

- The technology is considered sufficiently mature in China, but more research is needed to create sustainable and high-yielding tropical aerobic rice. Further research should focus on; a) breeding and improved management (especially nutrient management to increase yield potential and attainable yield at the farm level); b) water accounting at the regional scale; c) creating an inventory of soil health issues in the target domains; d) establishing a long-term, continuous cropping experiment to address sustainability issues; e) understanding and solving the phenomenon of yield collapse and f) understanding the biophysical and socioeconomic factors that lead to the adoption of the technology by farmers. Focus should be given to setting up dedicated aerobic rice breeding programs and strengthening research and development capacity to develop sustainable production systems.

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