Indian Farming **64**(10): 10–12, 15; January 2015

Aerobic rice

Growing Rice Successfully in Water-Shortage Areas of Eastern India

Santosh Kumar[1], S. K. Dwivedi[2], S. S. Singh[3] and P. K. Sundaram[4]

ICAR Research Complex for Eastern Region, Patna-800014

RICE (*Oryza sativa*) is the most important staple food in Asia where it provides 35-80% of total calorie uptake. It is cultivated under diverse ecologies ranging from irrigated to rainfed and upland to lowland to deep water system. 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 the population depends on it.

Increasing water scarcity, necessitates to develop alternative systems that require less water for growing rice. Aerobic rice is a new concept of growing rice: it is high yielding rice grown in non-flooded conditions in non-puddled and unsaturated (aerobic) soil under supplement irrigation and high external inputs. Aerobic rice promises substantial water saving by minimizing seepage and percolation greatly reducing evaporation. Compared with lowland rice, water inputs in aerobic rice are more than 40-50 percent lower, water productivity 40-75 % higher and labor use 30-40 % lower. Dissemination and adoption of high-yielding, good-quality, input-responsive water scarcity tolerant aerobic rice varieties such as MAS 946, MAS 26, APO, Pusa RH10, PA6444, PA6201, PA6129, IR55419-04, Sahbhagi, Rajendra Bhagwati and some new breeding lines, IR84899-B-179-16-1-1-1, IR83920-B-B-277-2-1-1-1, IR77298-14-1-2-130-2, IR84899-B-182-3-1-1-2 and IR83867-B-B-250-3-1-1 in water shortage areas of eastern India will provide sustainable food security in this region.

Almost 28% of world's rice is grown under rainfed lowland and frequently affected by uneven rainfall distribution pattern. In India, the total area under irrigated, rainfed lowland and upland rice is 22.0, 14.4, and 6.3 million ha, respectively. Out of the total 20.7 million ha of rainfed rice area reported in India, approximately 16.2 million ha lie in eastern India, of which 7.3 million ha of lowland area are highly water stress prone. A recent estimate on climate change predicts the water deficit to deteriorate further in years to come and the intensity and frequency of drought are predicted to become worse. Scarcity of freshwater resource has threatened the production of the flood-irrigated rice crop. By 2025, 15 out of 75 million hectare of Asia's flood-irrigated rice crop will experience water shortage. Being an extravagant consumer of water, rice uses around 3000-5000 liters of fresh water to produce 1 kg of rice. The increase in depletion of fresh water resources is a major threat to the traditional way of rice cultivation. It has been estimated that 22 million hectare of irrigated dry season rice in South and Southeast Asia was experiencing "economic water scarcity" and 2 million hectare of Asia's irrigated dry season rice and 13 million hectare of its wet season rice would suffer from "physical water scarcity" by 2025.

Water scarcity that we are facing today is the greatest threat to rice cultivation. Because of increasing water scarcity, there is a need to develop alternative system that requires less water for rice crop production. Several technologies have been developed to reduce water loss and increase the water productivity. However, the fields are still kept irrigated for some periods in most of the systems, so water losses remain high. Aerobic rice is a new concept of growing rice; it is high yielding rice grown in well-drained, nonpuddled and nonsaturated (aerobic) soils under supplement irrigation and high external inputs. Aerobic rice promises substantial water saving by minimizing seepage and percolation and greatly reducing evaporation.

The eastern region represents 21.85% geographical area of the

It requires approximately 3000-5000 litres of water to grow one kilogram of rice. About 22 million hectares of irrigated dry season rice experience "economic water scarcity" in South and Southeast Asia and two million hectare of Asia's irrigated dry season rice and 13 mha of its wet season rice would suffer from "physical water scarcity" by 2025. Declining water availability is threatening the sustainability of this rice ecosystem. Most of the high-yielding varieties grown in irrigated and rainfed lowland ecosystems are highly susceptible to water scarcity condition.

country and supports 33.64% of country production. Though the region is endowed with rich natural resources but the production level remains low. In eastern India, rice production is directly correlated with regional and national food security. The challenge of growing in water scarcity and frequent occurrence of drought is a threat to food security in the eastern region. Most of the high-yielding varieties of rice—IR36, IR64, Swarna, and Sambha Mahsuri—grown in irrigated and rainfed ecosystems are highly susceptible to water scarcity condition. Keeping this fact in view, there is an urgent need to disseminate and adopt high-yielding, good-quality, input responsive and water scarcity tolerant varieties to achieve food self sufficiency at national level from eastern region.

What is aerobic rice?

Aerobic rice is a production system in which especially developed "aerobic rice" varieties are grown in non-flooded conditions in non-puddled and unsaturated (aerobic) soil under supplement irrigation and high external inputs. Aerobic way of growing rice saves water by eliminating continuous seepage and percolation, reducing evaporation and eliminating wet land preparation. It is efficient water saving rice technology for water shortage irrigated and rainfed lowland rice areas. The usual establishment method of aerobic rice is direct seeding, as opposed to transplanting seedlings, into a flooded field. Aerobic rice can be irrigated or rainfed and tolerates (occasionally) flooding. Irrigation can be applied through flash flooding, furrow irrigation (raised beds) or by sprinklers. Unlike flooded rice, irrigation when applied is not used to flood the soil but to just bring the soil water content in the root zone up to field capacity.

Target areas for aerobic rice

Aerobic rice can be found or can be a suitable technology in the following areas:

Water-short irrigated lowlands: Areas where farmers do not have access to sufficient water anymore to keep rice field flooded for a substantial period of time.

Favorable uplands: Areas where the land is flat, where rainfall with or without supplemental irrigation is sufficient to frequently bring the soil water content close to field capacity and where farmers have access to external inputs such as fertilizers.

Field on upper slopes or terraces in undulating rainfed lowlands: Quite often soils in these areas are relatively coarse-textured and well drained, so that ponding of water occurs only briefly or not at all during the growing season.

Comparison of water requirement between irrigated lowland rice and aerobic rice

Studies across the country indicate that puddled irrigated rice requires about 900-2250 mm of water (average 1500 mm) depending on the management, soil and climatic conditions (Table 1) in comparison to 935 mm under surface irrigated aerobic rice and 500 to 700 mm under drip irrigated aerobic rice (Table1). Pot experiments and greenhouse studies conducted at IRRI, Philippines has shown that rice plants growing under a range of water application transpired 500-1000 liters of water to produce 1 kg of rough (unmilled) rice.

Differences between aerobic rice and upland rice

Upland rice is grown in rainfed and naturally well drained soils that are usually on sloping land with erosion problems, drought prone, and poor in physical and chemical properties. Upland rice varieties are low–yielding but drought and low fertility tolerant, thus giving low but stable yield under the adverse environmental conditions of uplands. High levels of inputs of fertilizer and supplemental irrigation to upland rice will lead to lodging and thus reduce yield.

Aerobic rice is targeted at more favourable environments where land is flat or terraced, and soil can be frequently brought to water field capacity by rainfall or supplemental irrigation or where land is sloping but frequent rainfall can keep soils moist throughout the growing season. Aerobic rice can be an alternative to lowland rice wherever available water is insufficient for lowland rice but sufficient for aerobic rice. Both aerobic and upland rice are adapted to aerobic soils conditions, but aerobic rice varieties are more input-responsive and higher yielding than traditional upland ones.

Development of Aerobic Rice

In view of increasing water scarcity, there is need to develop high yielding drought tolerant aerobic rice varieties by combining the high yield potential and input responsiveness of lowland rice genotypes with the drought tolerance , early vigor and weed competitiveness of upland rice genotypes.

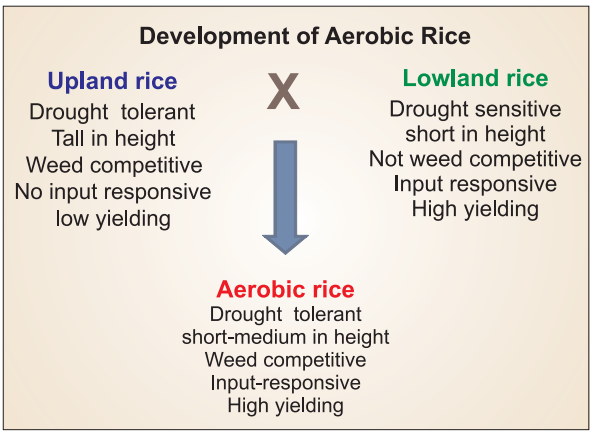


Table 1. Water requirement between irrigated lowland rice and aerobic rice

Purpose of water requirement	Irrigated lowland rice (mm)		Aerobic Rice(mm)	
	Low	High	Surface irrigation	Drip irrigation
Land preparation	150	250	100	100
Evapo-transpiration	500	1200	500	400-600
Seepage and percolation	200	700	335	Nil
Mild season drainage	50	100	Nil	Nil
Total	900	2250	935	500-700

Status of drought tolerant aerobic rice varieties

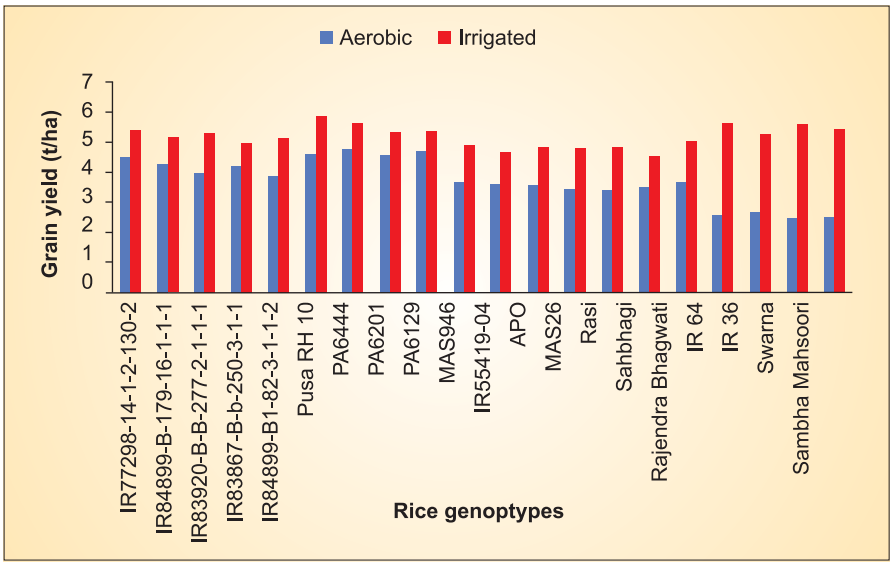
Despite the importance of water stress as a constraint and increasing water scarcity, little effort has been devoted to developing drought-tolerant aerobic rice cultivars. Most of the high-yielding varieties—IR36, IR64, Swarna, and Sambha Mahsuri—grown in irrigated and rainfed lowland ecosystem of eastern India are highly susceptible to water scarcity condition. In water stress condition, these varieties inflict high yield losses, leading to a sudden decline in the country's rice production. Because of the absence of high-yielding, input-responsive, good-quality drought-tolerant aerobic rice varieties, farmers in the irrigated and rainfed lowland ecosystem continue to grow these varieties. Farmers of water scarcity prone areas require varieties that provide them with high yield under good rainfall and sustainable good yield in water scarcity condition.

India released for cultivation its first drought tolerant aerobic rice variety MAS 946-1 followed by MAS 26 (2008) at University of Agricultural Sciences, Bengaluru. Yields were on par with irrigated puddle rice with an average of 5-5.6 t/ha consuming 60% less water. Aerobic rice emits 80-85% lesser methane gas into the atmosphere thus keeping the environment safe. Savings are also from land preparation, costs of transplanting, seed and labour.

Weed management in direct seeded aerobic rice

Weed infestation is a major constraint to wider adoption of direct seeded aerobic rice. In direct seeded aerobic rice, weeds and aerobic rice seeds germinate at the same time,

Weed infestation in aerobic rice field



Yield difference in rice genotypes under aerobic and irrigated condition

which creates a serious weed-crop competition for all resources. Integrated weed and water management practices, with selective pre-emergence herbicide, pendimethelin (stomp 30 EC) 2.5 l/ha in 500 liters water helps in minimizing weed establishment for 2-3 weeks after sowing. In 25-30 days after sowing (DAS), to control weeds, a spray of Bispyribac (Nominee Gold 10SC) 2, 250ml/ha in 375 litre water is recommended. The soil moisture condition should be optimum at the time of application of these herbicides. In addition to herbicide application, manual or mechanical weeding in the early phase of crop growth, is therefore needed to control weeds.

Irrigation management in Aerobic rice

Soil must be kept aerated to get the advantages of aerobic condition. Need based irrigation (twice a week) is needed to maintain moist situation upon noticing visible symptoms of hairline cracks on soil surface. Maintenance of saturated condition at critical stages of active tillering, panicle initiation, flowering to grain filling stage is essential. Irrigation can be applied through flash flooding, furrow irrigation (raised beds) or by sprinklers. Unlike flooded rice, irrigation-when applied-is not used to flood the soil but to just bring the soil water content in the root zone up to field capacity.

Aerobic rice can save 40-50% irrigation water compared with transplanted rice and this could be a viable alternative for water short areas of the eastern India.

Evaluation of rice genotypes and hybrid varieties under aerobic condition

Water crisis being faced today is the greatest threat to rice cultivation. Irrigated and rainfed lowland field are regularly affected by water stress conditions. The years with low rainfall or that show a long spell between two consecutive rains, drought also occurs in severe form in lower lowland fields where submergence is a regular problem. Screening for two hundred and thirty two rice genotypes and hybrid varieties is being carried out in the wet season during 2010-2013 at ICAR Research Complex for Eastern Region. Experiment has been conducted in two different treatments i.e. normal flooding and aerobic conditions. Control field was kept continuously wet with 5 cm water after transplanting until 25 days before harvest. A leveled, well drained field was selected for aerobic screening. The aerobic field has been away from any water source or irrigated or flooded rice. Sowing in aerobic field has been done by manually. In aerobic field, surface irrigation was given once in a week at vegetative stage and 2-3 days interval at reproductive stage. Surface irrigation was given only when the soil moisture tension at 15cm depth

(Continued on page 15)

(Continued from page 12)

reached -30 kPa. At the time of flowering, the threshold for irrigation was reduced to -10 kPa to prevent spikelet sterility. Out of two hundred and thirty-two rice genotypes evaluated, fifteen genotypes viz. MAS 946, MAS 26, APO, Pusa RH10, PA6444, PA6201, PA6129, IR55419-04, Sahbhagi, Rasi, Rajendra Bhagwati and some new breeding lines, IR84899-B-179-16-1-1-1, IR83920-B-B-277-2-1-1-1, IR77298-14-1-2-130-2, IR84899-B-182-3-1-1-2 and IR83867-B-B-250-3-1-1 were identified as promising for aerobic condition, which performed better than check and existing high yielding varieties of eastern region. The yield difference of rice genotype between direct seeded aerobic and irrigated conditions ranged from 11.6 to 55.4%. In general hybrid varieties performed better under aerobic condition. PA6444, Pusa RH10, PA6201 and PA6129 were identified promising hybrid varieties for aerobic condition. Current high yielding varieties of eastern India IR64, IR36, Swarna and Sambha Mahsoori showed susceptibility towards water scarcity (aerobic) condition.

SUMMARY

The challenge of increasing water scarcity and frequent occurrence of drought has been identified as the key to low rice productivity in irrigated and rainfed lowland ecosystems of eastern region, threatening food security. Aerobic rice is a new concept of growing rice that requires less water. Compared with lowland rice, water inputs in aerobic rice are more than 40-50 percent lower, water productivity 40-75 % higher and labor use 30-40 % lower and could be a viable alternative for water-short areas in the country. Adoption of high-yielding, good-quality, input-responsive and drought tolerant aerobic rice varieties will play pro-active and decisive role in developing sustainable food production and lead to food security among farm families in the water scarcity prone irrigated and rainfed lowland areas of eastern region of India.

[1]Scientist (Plant Breeding), [2]Scientist (Plant Physiology), [3]Principal Scientist & Head, Division of Crop production (IIPR), [4]Scientist (DLWM)