Potential Technology of Rice cultivation with limited Water resources

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Rice is the staple food for nearly half of the world's population, most of whom live in developing countries. The crop occupies one-third of the world's total area planted to cereals and provides 35-60% of the calories consumed by 2.7 billion people. More than 90% of the world's rice is produced and consumed in Asia (Barker and Herdt 1985 and IRRI, 1989). Rice is the most widely grown of all crops under irrigation. More than 80% of the developed fresh water resources in Asia are used for irrigation purposes and more than 90% of the total irrigation water is used for rice production (Bhuiyan 1992). But, water is becoming increasingly scarce. Per capita availability of water resource declined by 40-60% in many Asian countries between 1955 to 1990. For various reasons such as diminishing rainfall, depletion of ground water resources and increasing demand from other sectors, the availability of water for agriculture will diminish both in quantity and quality in the years to come. Yet, more rice needs to be produced with less and less water to feed the ever increasing population.

Of all the crops grown under irrigation, more than 50-60% of the irrigation water is used for rice, the staple food for nearly half the world's population. Since more than 90% of the world's rice is produced and consumed in Asia, water scarcity will be a threat to food security in this region. Success and sustenance of future rice production will therefore depend primarily on developing and adopting strategies that will use water more efficiently.

Aerobic Rice

Rice is the unique plant that grows well both under aerobic and anaerobic conditions. When it is grown under aerated conditions without standing water it is called aerobic rice as against the usual transplanted rice which is grown under unaerated flooded conditions. Aerobic rice is an alternative and contingent rice production system (Sreedevi *et al.*, 2014), wherein rice crop is cultivated under nonpuddled and non-saturated soil conditions. This concept is mainly targeted for irrigated lowlands, less water available areas and uplands facilitating water saving and increasing water productivity by reducing its use during land preparation and limiting seepage, percolation and evaporation (Peng *et al.*, 2012). Aerobic rice is characterized by the presence of air in the soil medium and its limited water requirement as compared to the irrigated rice. The term aerobic rice became popular after the development of rice varieties with high yields (close to the irrigated lowlands) for cultivation in Latin American countries, particularly in Brazil, where rice is grown on non-puddled soils with irrigation water as high external input.

The cultivation of aerobic rice aims to minimize the water requirements of rice, but at the same time retaining the high yielding ability and input responsive characteristics of irrigated lowland varieties. The yields of aerobic rice are close to those irrigated lowlands, but with water savings of 40-50%. Early experiments suggested that only half the amount of water is needed for aerobic rice, aerobic

Aerobic field after sowing and irrigation

Aerobic Rice seedling stage

Aerobic Rice Tillering stage

Unweeded aerobic rice plot

varieties can be grown on water limited environments of irrigated lowlands. Since, they are able to root deeply and maintain leaf area development under non-saturated soil conditions. The aerobic rice varieties are considered to be more promising under both aerobic and flooded conditions.

Since 'aerobic rice' is a water saving technology, it provides enormous scope to sustain the rice production even during the limited water situations.

Under this changing scenario, water saving technologies that were investigated in the early 1970's such as saturated soil culture, and Alternate Wetting and Drying (AWD) are receiving renewed attention from researchers. Generally, the water saving irrigation practices shift away from continuous anaerobic conditions to alternate anaerobic-aerobic and continuous aerobic conditions. Aerobic rice cultivation has been a successful market integrated system in Brazil and it is also being grown in northern China with yield levels reported to be close to irrigated levels.

Expected problems associated with aerobic rice cultivation

The greatest benefit derived from flooding in lowland systems is that standing water acts as most efficient non-toxic weed killer. So, if farmers switch to growing aerobic rice, management of weeds will become an important issue. Another problem which is popularly called as 'yield collapse' may also occur in aerobic rice cultivation. This is characterized by good yields in the first season, which may slump by about 20% in the following season and continued further. But it is reported that with suitable cropping patterns (management techniques) it could be averted.

Package of practices developed at Indian Institute of Rice Research

Land Preparation: Well ploughed, and no or very little clods/clumps in field is required

like any dry land crops. Any type of organic manure, composted crop residues / vermi manure / green leaf manuring @ 5 t/ha. is strongly recommended.

Suitable Cultivars: Hybrids or High Yielding Varieties of mid early, medium duration, drought tolerance & weed competitiveness are suitable. e.g. : IR64, DRRDhan44, MTU1010, PMK3, PHB71, PA6444, DRRH3, JKRH3333, DRRH2, KRH2, GK5003, Rasi, Naveen, IET 20653,Vandana, Apo, Kalinga3 and Shabagidhan.

Seed rate: 25-30 kg/ha

Time of sowing: It has been observed that dry seeding one week before the onset of monsoon has performed similar to that of with the onset of / immediately after the onset of monsoon. The time of sowing had profound influence on grain yield and water requirement of the crop.

Method of sowing and Spacing: Seeding can be done manually or by seed drill in shallow furrows of 2-3 cm depth, at a spacing of 20X10cm for HYVs and 20X15 cm for Hybrids. 2-3 seedlings can be maintained per hill to maintain optimum plant stand and also to avoid thinning and wastage of seed and other resources. Care should be taken to avoid excess use of seed and thinning at later stage. The Irrigation channels, should be made along the slope, and light irrigation has to be given if there is no rain.

Fertilizer Management: Nutrition is the critical input in yield realization of aerobic rice ecosystem as availability of required nutrients is low. Iron deficiency is one of the serious nutritional disorders in aerobically grown rice on upland alkaline and calcareous soils leading to decline in productivity. Optimum fertilizer schedule for hybrids is 150:50:50 NPK and 120:50:50 for HYVs. Entire dose of fertilizer phosphorus and 75% potassium should be applied at sowing and first dose of Nitrogen i.e., 50%N should be applied after the seedlings reach 2-3 leaf stage. Top dressing of 25% nitrogen at maximum vegetative stage (45 DAS), 25% N, 25% K at 50% flowering stage is recommended. If Iron deficiency is noticed, spraying of ferrous sulphate @2.0% ferrous sulphate 3 to 4 times at weekly interval. Weekly irrigation with high Nitrogen fertilization resulted in high yields

Table 1. Interaction influence of different Nitrogen & Water Schedules on Hybrid Rice PA 6444

Irrigation regimes	Grain yield kg/ha			Water requirement hamm
	Fertilizer schedules $N_0P_{50}K_{50}$	$N_{100}P_{50}K_{50}$	$N_{150}P_{50}K_{50}$	
Need based irrigation	2553	3233	4293	~ 1000
Weekly irrigation	2565	3518	4835	~ 1200
Continues water level of 5 cm	3069	4621	5010	~ 1500

Biofertilizers: Biofertilizers are cost effective, eco-friendly and can act as a partial supplement chemical fertilizers and they also play a vital role in maintaining long term soil fertility and sustainability. Azospirillum and phosphorus solubilizing bacteria(PSB) inoculants @5 kg/ha mixed with gruel for seed coating and remaining quantity was broadcasted in the field by mixing with 200 kg Farm Yard Manure and 200 kg of soil just before sowing of rice. Combination of Azospirillum and PSB were found to save 15-25% fertilizer N and P.

Irrigation: Soil must to be kept aerated to get the advantage of aerobic cultivation. Need based irrigation (5-7 days interval)is 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.

The irrigation scheduling at 150mm cumulative pan evaporation (CPE) resulted in significant crop growth, yield attributes and grain yield (Table)

Table: Mean Grain yield and yield attributes of aerobic rice under different irrigation schedule

Irrigation schedules	Grain yield (t/ha)	Panicle/ m^2 (No.)	Panicle weight (g)
I1 (150 mmCPE)	3.89	243	2.65
I2 (100 mmCPE)	3.64	233	2.53
I3 (75mm CPE)	3.42	222	2.44
C.D.(0.05)	0.08	4	0.04

Weed Management: Weeds are one of the major constraints to aerobic rice production system, as dry-tillage, alternate wetting & drying conditions are conducive to germination, growth of weeds causing grain yield losses of 50-91%. Sequential application of Pendimethalin 30 EC @1.5 kg a.i./ha. application as pre-emergence 1-2 days after sowing, followed by Bispyribacsodium 10%SC @ 20 g a.i./ha at 3-4 leaf stage of weeds is recommended.

Inter-cultivation: Soil between the rows can be disturbed and added to the base of the rice plants so as to aerate the soil and also strengthen the base of the plants.

Plant Protection: Prophylactic sprays of one dose of any systemic insecticide needs to be sprayed as required. Carbofuron. soil application in case of the nematode incidence is necessary.

Harvesting: The crop will flower in 75 - 80 days and attain maturity in 118 - 120 days.

Aerobic rice based cropping systems: Location specific Pulse crop or Oil seed crop in rotation with aerobic rice in *kharif* .

Prospects of Aerobic Rice in India

Although it is difficult to quantify the exact area that would be suitable for aerobic rice cultivation, one would expect that most of the irrigated rice grown in command area, particularly in southern India and under tube well irrigation is the potential area for growing aerobic rice. On the other hand, about 1.0 m ha of area under uplands is characterized as favourable due to higher precipitation received during wet season. Similarly, about 2.0 m ha of rainfed lowlands remains non-flooded for most part of the crop growth making it most suitable for aerobic rice cultivation. Large area under rice-wheat system in northern India could be most potential area for aerobic rice cultivation.

Conclusions

The adoption of water saving technologies in general and aerobic rice in particular at the farm level will contribute to increasing water productivity, safe guarding food security and alleviating poverty. Assuming an average farm size of 1 hectare, some 17 million farmers who face physical water scarcity and 22 million farmers who face economic water scarcity in 2025 will benefit from water saving technologies.

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