Aerobic Rice: A Production System for Water Scarceness

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Abstract:

Aerobic rice is a new type of rice cultivation adopted in non-puddled and non-saturated soils with a water content of 70 per cent to 100 per cent of water holding capacity throughout a growing season. It is specifically developed rice, for combining drought tolerance of upland rice and yield potential of lowland rice. Aerobic rice varieties have the ability to maintain rapid growth in soils with moisture content at or below field capacity, and can produce yields of 4-6 t/ha with a moderate application of fertilizers under such soil water conditions and it saves around 50 per cent of irrigation water in comparison with lowland rice and also it saves 73 per cent of irrigation water for land preparation and 56 per cent during the crop growth period. Main driving force behind aerobic rice is economic water use. In aerobic rice nematode and weed infestation are the major problem for yield decline due to changes in soil nutrient level and growth inhibition by toxic substances from root residues are key point for poor yield of continuous aerobic cultivation. Aerobic rice is better remedy for future climate change under drought condition with lesser green house gas (GHG) emission.

Keywords: aerobic rice, drought tolerance, micro irrigation, economic water use, climate change

Introduction

Rice (Oryza sativa L.) is the staple food for more than 85 per cent of Asian population and it also the single biggest user of freshwater. It is mostly grown under submerged soil conditions and requires more water compared with other crops and it has been cultivated majorly in irrigated ecosystem as 57 per cent gives 75 per cent of total rice production (Bouman 2001). In Asia, irrigated agriculture accounts for 90 per cent of total diverted fresh water, and more than 60 per cent of this used for irrigated rice (Sunil et al.,2014) and it has very low water-use efficiency as it consumes 3000–5000 litres of water to produce one kilogram of rice. 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. The traditional transplanted rice production system in puddle soil on long run leads to destruction of soil aggregates and reduction in macro pore volumes, and there is an increase in micro pore space, which subsequently reduces the yields of post rice crops. (Shashidhara, 2007). Moreover, lack of rainfall is a major production constraint in rain-fed areas where many poor rice farmers live. Until recently, this amount of water has been taken for granted, but now the global “water crisis” threatens the sustainability of irrigated rice production. The available amount of water for irrigation is becoming scarce. While emerging water scarcity in many parts the world, the traditional way of lowland rice cultivation can no longer be sustained.
Under these circumstances, new technologies and methods need to be developed to help farmers cope with water shortages for rice production. Therefore, farmers and researchers alike are looking for ways to decrease water use in rice production and increase its use efficiency (Bouman, 2001).

**Aerobic Rice:**

Aerobic rice is a new type of rice cultivation adopted in non-puddle and non-saturated soils with a water content of 70 per cent to 100 per cent of water holding capacity throughout a growing season. Aerobic rice is specifically developed rice, for combining drought tolerance of upland rice and yield potential of lowland rice. Aerobic rice varieties have the ability to maintain rapid growth in soils with moisture content at or below field capacity, and can produce yields of 4-6 t/ha with a moderate application of fertilizers under such soil water conditions. Aerobic rice can save as much as 50 per cent of irrigation water in comparison with lowland rice.

**Aerobic Rice: A Water Saving System**

Aerobic rice is a water-saving rice production system in which potentially high yielding, fertilizer responsive adapted rice varieties are grown in fertile aerobic soils that are non-puddle and have no standing water. Supplementary irrigation, however, can be supplied in the same way as to any other upland cereal crop (Parthasarathi et al., 2012). In Asia, upland rice is aerobically grown with minimal inputs and it is usually planted as a low yielding subsistence crop in the adverse upland conditions. With predictions that many Asian countries will have severe water problems by 2025, aerobic rice gives hope to farmers who do not have access to enough water to grow flooded lowland rice. 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.

The water use efficiencies of the aerobic varieties under aerobic conditions were higher than that of the lowland variety under lowland conditions. Aerobic rice maximizes water use in terms of yield and is a suitable crop for water limiting conditions. Aerobic rice cultivation will curb methane production and saves water without affecting the productivity. It is the time to save water from the irrigated system of rice cultivation by adopting the aerobic rice cultivation (Lal et al., 2013). As the aerobic rice concept is in the initial development stage, little research has been done so far and most of the researches are confined to establish management practices like weed and nutrient management for this new system. Planned breeding experiments are very much lacking in this area and only limited studies have been made with few varieties for their response under aerobic rice cultivation.

**Difference between Aerobic Rice and Upland Rice**

**Upland rice** is grown in rain fed 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 yields under the adverse environmental conditions of uplands. However, high levels of fertilizer application and supplemental irrigation to upland rice lead to lodging and thus reduce yield.

**Aerobic rice** is targeted at more favorable 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 a replacement of lowland rice wherever available water is insufficient for lowland rice but sufficient for aerobic rice. Both aerobic and upland rice are adapted to aerobic soil conditions, but aerobic rice varieties are more input-responsive and higher yielding than traditional upland ones.

**Aerobic Rice: In Farmer’s view**

**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

**Cultural Practices for Aerobic Cultivation**

**Seed bed preparation:** Minimum Tillage is enough for aerobic rice cultivation. Dry direct seeding ensures that fields are well harrowed and levelled. Field should be thoroughly prepared by using disc plough, cultivator and motivator.

**Seed rate and sowing method:** Sowing can be done either by using manual seeding or drum seeders. Seed rate should be 40-45 kg/ha with the spacing of 20 x 10cm (50 hills/m2).

**Varieties suitable for aerobic rice:** Apo, Pyari, Sahabhagi dhan, Annada – grain yield 4.5-5.0 t/ha.

**Weed control:** Pre emergence herbicide application pendimethalin/oxadiazon or Post emergence herbicide (bispyribac sodium) and manual weeding recommended.

**Nutrient management:** 120:50:50 kg ha⁻¹ NPK to obtain a yield of 4-6 t ha⁻¹. First split can best be given at 10-12 days after emergence, second split at active tailoring (AT) and third split fertilizer application at panicle initiation (PI) stage.

**Irrigation:** Irrigation can be given through flooding up to just enough to bring the soil water content in root zone up to field capacity (FC). Light irrigation (30 mm) after sowing may be needed to promote emergence. Irrigation needed when soil water tension at 20 cm depth is more than 20 kPa (or leaves start to roll). Amount of each irrigation application should be sufficient to bring the topsoil of 20 cm to field capacity. The optimum soil water condition would be maintained around field capacity (30-40 kPa” or 0.3-04 bar soil moisture potential) across the growth stages. Apply irrigation upon visible symptom of developing hair cracks on surface soil, or initiation of tip rolling of first top leaves. Irrigation, applied at this stage attaining the condition of saturated soil moisture regime. Usually, scheduling irrigation at 5-7 days interval may supplement the optimum water requirement in aerobic rice.
The different planting systems on rice crop showing clear evidence on reduction in total water use in aerobic rice cultivation than the other irrigated and upland condition which are using more water. But aerobic cultivation recorded a maximum yield with very minimum level of water for its growth with a moderate drought tolerant capacity. The aerobic fields showed high presence of nematodes, not only in continuous aerobic fields, but also after fallow and in fields where aerobic and anaerobic conditions were alternated. Their presence is one of the probable causes of yield decrease in aerobic rice management. Understanding the causes of yield decline under continuous aerobic conditions is crucial to develop new management strategies and new technologies to reduce water input. Moreover, the development of aerobic rice varieties with a minimum yield gap compared with flooded rice have to be developed before adopting aerobic rice technology in tropical large areas. Aerobic rice is actually grown in some areas of Brazil and China. This rice management is generally a suitable option for areas where water availability is too low or too expensive to grow in flooded lowland rice. Anyhow, aerobic rice is not yet a good alternative to flooded rice. Therefore, it is advisable to introduce aerobic rice management in those areas where water is not abundant, preferably alternating aerobic and anaerobic management or growing rice after a fallow period.

Conclusion

The concept of aerobic rice holds promise for farmers in water-short irrigated rice environments where water availability at the farm level is too low or where water is too expensive to grow flooded lowland rice. Aerobic rice technology is better remedy for future climate change under drought condition with lesser green house gas (GHG) emission. Selection of good aerobic rice variety with desired physiological attributes along with good cultural practices and weed free environment would give better performance. However, yield penalty or yield stability parameter of aerobic rice is one, which has to be considered by the farmers before its adoption.

References: