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AEROBIC RICE: MITIGATING WATER STRESS

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Udita Mondal [1], Snigdha Chatterjee [2*] and Satarupa Ghosh [3]

[1] Ph.D. Scholar, Department of Soil and Water Conservation, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal-741252, India

[2] Ph.D. Scholar, Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal-741252, India

[3] Ph.D. Scholar, Aquatic Environment Management Department, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal- 700037, India

Email: snigdhachat160@gmail.com

One of the most vital inputs in agriculture is water which is providing a significant contribution in food grain production and productivity. India has 2.4 per cent of land mass and 4.2 per cent fresh water resources of the World, but it supports 17.0 per cent of the human population and 16.3 per cent of livestock population of the world. The per capita per year availability of water in India was 5300 m^3 in the year 1950 which is projected further to dwindle to 1465 and 1191 m^3 by the year 2025 and 2050, respectively. Water supply considers a limiting factor for crop production and food security under the current and future conditions.Notably, above 98% of the irrigated lands are under the coverage of surface irrigation where more than 50% of water is considered as wastages. Under such circumstances water should be applied and used judiciously and economically to mitigate the increasing food demand. Keeping that water scarce situation in mind, adoption of Micro irrigation systems (e.g. drip and microsprinkler) can ensure higher water use efficiency, besides obtaining higher yields with considerable saving in irrigation water in the Indian agriculture.

Origin and history of aerobic rice cultivation

International Rice Research Institute (IRRI) developed the aerobic rice technology to manage the water crisis in tropical agriculture. In aerobic rice systems, the crop is grown in non-puddled, non-flooded fields and rice is grown like an upland crop (unsaturated condition). Adequate inputs and supplementary irrigation is provided when rainfall is insufficient. This brandnew concept of aerobic rice may be an alternate strategy, in combination with the characteristics of rice varieties adopted in upland with less water requirement and irrigated varieties with high response to inputs. In China, it has been observed that the water use for aerobic rice production was 55–56% lower than the flooded rice with 1.6–1.9 times higher water productivity. It proves that aerobic rice may be a viable alternative for cultivating lowland rice in spite of the fact that shortage of water is prevailing in that particular area.

Upland and Aerobic rice

In most cases upland rice is grown in rain fed and naturally well-drained soils that are usually on sloping land with erosionproblems, drought-prone, and poor in physical and chemical properties. Upland rice varieties are low-yielding butdrought- and low-fertility-tolerant, thus giving low but stable yields under the adverse environmental conditions ofuplands. However, high levels of inputs of fertilizer and supplemental irrigation to upland rice will lead to lodgingand thus reduce yield.Aerobic rice is targeted at more favourable environments where land is flat or terraced, and soil can befrequently brought to water field capacity by rainfall or supplemental irrigation, or where land is sloping butfrequent rainfall can keep soils moist throughout the growing season. Aerobic rice can be replacement oflowland 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.

Why aerobic rice

With an aim to increase crop water use efficiency aerobic rice is definitely an emerging cultivation system. Rice is water loving crop which mostly love submergence condition. For fulfilling the demand of irrigated rice cultivation approx...2000 litre of water is needed for producing 1 kg of rice which results is very low water use efficiency in irrigated rice cultivation. By reducing water use during land preparation and limiting seepage, percolation,

and evaporation, aerobic rice had about 51% lower total water use and 32-88% higher water productivity, expressed as gram of grain per kilogram of water, than flooded rice. The labour use is also saved in aerobic rice because more labour is required for land preparation such as puddling, transplanting, and irrigation activities in flooded rice.Along with high water demand, the traditional system of transplanted rice production in puddled soil on long run leads to destruction of soil aggregates and reduction in macro pore volumes, and to an outsized increase in micro pore space which subsequently reduce the yields of post rice crops. Aerobic rice varieties produce yield as much as traditional irrigated puddled rice varieties.Yields were on par with irrigated puddled rice with an average of 5.5-6.0 t/ha with 60 percent less water use.Aerobic rice production system eliminates continuous seepage and percolation losses, greatly reduces evaporation as no standing water is present at any time during the cropping season, and effectively uses the rainfall and thus helps in enhancing water productivity, concomitant loss of soil sediments, silt and fertility from the soil. A comparison of water requirement of lowland flooded rice and aerobic rice system clearly shows that aerobic rice system can save about 45 per cent of water. Water saving in the aerobic rice system compared with the conventionally irrigated lowland rice results mainly from (1) no water losses during land preparation, (2) less percolation and seepage due to the elimination of the pressure head of the ponded water layer normally maintained in an irrigated field, and (3) less evaporation.

Table 1. Water Input (I=irrigation, R=Rainfall) and rice yield under different production environment

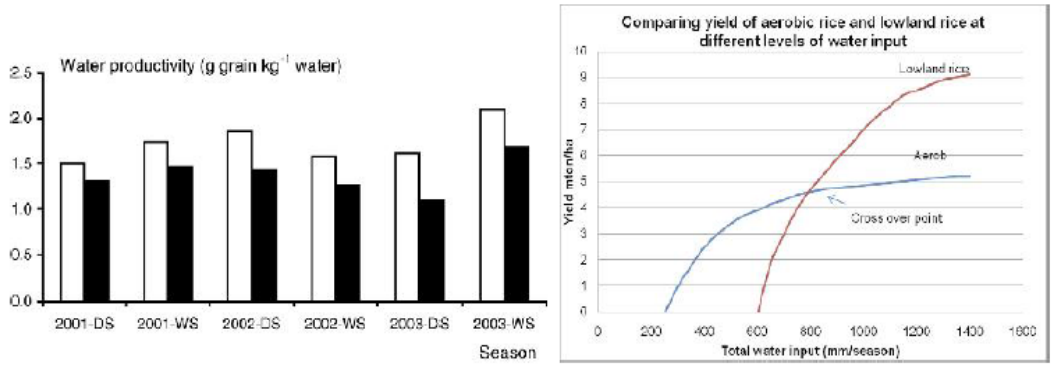
Year	Variety	Water Input I+R(mm)	Yield(t/ha)	Water productivity(kg/m3)
2001	Aerobic	1350	5.4-6.8	0.45
2002	Aerobic	1250	4.6-5.3	0.40
2007	Lowland	1200	6.0	0.50
2001	Aerobic	470-650	2.5-5.7	0.73
2002	Aerobic	550-900	2.9-5.7	0.59
2003	Aerobic	688	3.6-4.5	0.59
2003	Aerobic	600-700	5.0-6.0	0.85
2002	Aerobic	566	5.5	0.97
2007	Low Land	560	3.15	0.57

(Bouman*et al*., 2004)

Table 2. Water use of hypothetical aerobic and lowland rice on different soils

Water flow process	Aerobic Rice (mm)		Lowland Rice (mm)		
Lowland Soil SP rate	-	-	1 mm d-1	5 mm d-1	15 mm d-1
Irrigation Efficiency	85%	60%	-	-	-
Evaporation	100	100	200	200	200
Transpiration	400	400	400	400	400
Seepage and percolation	-	-	100	500	1500
Irrigation inefficiency loss	90	335	-	-	-
Total	590	835	700	1100	2100

(Bouman*et al*., 2004)



DS: dry season; WS: wet season (Bouman *et al*., 2005)

Figure 1. Yield of aerobic rice and lowland rice at different levels of water regimes

Some problems

Among rice ecosystems, therefore, the greatest weed pressure and competition occurs in upland and aerobic rice, and the least in transplanted irrigated and rainfed lowland rice.In conventional transplanted system, weeds are suppressed by standing water and by transplanted rice seedlings, which have a head start over germinating weed seedlings. On the other hand, aerobic soil dry-tillage and alternate wetting and drying conditions are conducive for germination and growth of weeds causing grain yield loss of 50 to 91%. Thus, it appears that weed is the major constraint to aerobic rice production and therefore, success of this technology mostly depends on effective weed management.In spite of these limitations, 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.

Carbon footprint

According to reports from several researches it has been observed that certain pests and diseases don't breed in aerobic conditions, therefore, use of chemicals is also reduced. A lot of aerobic rice varieties have been released in India and abroad.Paddy fields today are known to be one of the biggest agricultural anthropogenic sources of greenhouse gases (nitrous oxide and methane, in particular)."Aerobic rice severely reduces these gases by eliminating standing water, and thus, as a nation, we can reduce our carbon footprint and accrue carbon credits," Agrawal added.All this is possible without any compromise in grain yield. Mixed cropping and crop rotation practices are possible. Soil health improves since continuous mono-culture is curtailed.

Management of aerobic rice

As we know that dry direct seeding is the usual establishment method in rice cultivation. But in case of aerobic rice cultivation conservation agriculture such as mulching and minimum tillage can also be used. Several water saving technologies such as flash-flooding, furrow irrigation, drip and sprinkler irrigation can be used. But here mostly micro sprinkler irrigation was talked about aerobic rice cultivation system for mitigating water stress. In case of flooded rice, just to bring the water to the root zone up to field capacity flooding of the soil is done. Although it has been discussed that certain pests and diseases don't grow in case of aerobic rice but some soil borne pathogens such as nematodes, fungi are known to occur more in aerobic rice than in flooded rice. This incidence of infestation is more in tropical regions to curb the problem aerobic rice cultivation with a crop rotation of upland flooded rice cultivation is recommended.

Conclusion

Aerobic rice technology is a better scope for future climate change under drought situation aiding lesser greenhouse gas (GHG) emission. But selection of varieties with desired physiological attributes results in better performance. Proper care & cultural practices must be there for a weed free environment which is a great threat to aerobic rice cultivation

compared to upland rice cultivation. Yield penalty and yield stability has to be considered for adoption in the farmers for aerobic rice culture.

Future scope

Drought tolerant varieties along with high yielding characters are suitable for aerobic cultivation. Stay green mutant plants on aerobic environment must be developed for future findings and research. The signalling mechanism of aerobic rice that reveal molecular mechanism involved under aerobic environment should be analysed.

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