

Sustainable cultivation of rice:

Challenges and opportunities

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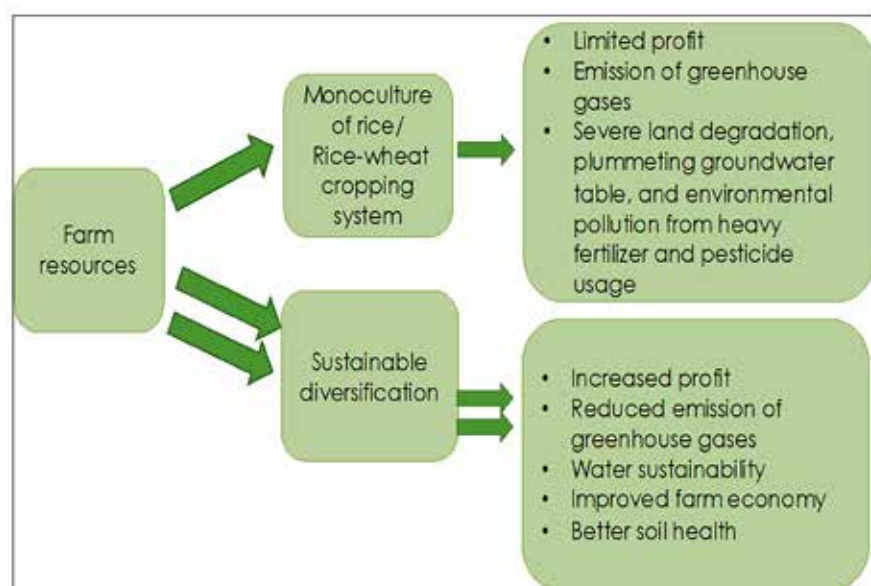
As a universal call to action to end poverty, protect the planet and ensure peace and prosperity by 2030, the United Nations have adopted 17 Sustainable Development goals (SDGs). In accord with these goals, India being an emerging global leader is truly committed to achieve these SDGs. Although India is the fourth largest economy in terms of GDP, its world ranking in SDG index has gone down from 117 to 120 rank in 2022. Rice is the third largest crop which provides one-fifth of the total calories consumed in the world. However, present day cultivation methods of rice contribute to global warming through the release of greenhouse gases (GHGs) like methane and nitrous oxide more than other crops and also place a heavy demand on the available fresh water resources. Hence, a shift to sustainable cultivation practices can act as a key driver for India to achieve SDGs by 2030.

Keywords: *Oryza sativa*, Sustainable cultivation, System of rice intensification

Sustainable cultivation of rice (*Oryza sativa* L.) can be achieved through development of rice varieties which are high yielding, short duration, amenable to advanced agronomic practices like system of rice intensification (SRI) and alternate wetting and drying (AWD) and have less methanogenic bacteria in their rhizosphere. The concept of carbon credit is gaining more and more attention with time and hence sustainable cultivation of rice is an issue which demands a greater attention of the stakeholders starting from the smallholding farmers (SHFs) to the policy-makers. Rice can be grown more sustainably by adoption of crop rotation, advanced agronomic practices of cultivation which reduce the amount of time fields are flooded, reducing tillage and breeding varieties that have a rhizosphere which emit less methane.

Sustainable diversification of rice

The wheat-paddy cycle which has been followed in India since the green revolution days has resulted in lowering of ground water table,



Advantages of crop rotation for sustainable diversification

severe degradation of land and heavy environmental pollution due to the excess use of chemical fertilizers and pesticides. Diversification can be practiced primarily in the form of (1), Multiple cropping, i.e. growing two or more crops in the same field within a given year with a definite row arrangement and; (2), Sequence cropping, i.e. growing

two or more crops in sequence on the same piece of land in a farming year. Diversification of rice based cropping systems by including crops like other cereals, pulses, millets and even fishery and duckery can help in reversing the damage done to the soil, environment and groundwater. Additionally, crops like pulses, bananas etc.

Table 1. Major rice-based cropping systems of India

Irrigated condition	Upland condition	Rice under integrated farming system
Rice-Rice-Rice	Rice-Chickpea	Rice-Fish-Poultry
Rice-Rice-Cereal	Rice-Lentil	Rice-Fish-Duckery
Rice-Rice-Pulses	Rice-Mustard/Linseed	
Rice-Wheat-Pulse	Rice-Barley	
Rice-Toria-Wheat	Rice-Wheat	
Rice-Wheat	Rice-Pea	
Rice-Mustard		

and flowers like marigold can be planted on rice bunds which not only can act as a source of beneficial insects/biocontrol agents but also can generate extra income. In low lying areas which have frequent inundation, rice-aquaculture has been adopted successfully. In this system fish generates secondary income, and an increased soil health and food security is achieved. In comparison to monoculture, adoption of a diversified cropping system helps in increasing farm profits, reducing greenhouse gas (GHG) emissions, improving soil health, protecting against vagaries of climate change and sustainable water use.

Zero and reduced tillage

In the rice-wheat cropping system which is predominant in the Indo-Gangetic plains, zero-tillage practices are encouraged for wheat, pulses etc. after rice have been developed. In the zero-tillage system, it is possible to opt for surface seeding where the wheat seeds are broadcast before or just after the harvesting of rice without any field preparation. Zero tillage causes a drastic reduction in tillage intensity which directly results in cost cutting and at the same time, early planting of wheat helps in better yields. Additionally there could be a potentially huge environmental benefit if the challenge of reducing rice tillage can be handled through better agronomic practices. However, this method needs adequate moisture in the field during seed broadcasting. Surface seeding has been reported to give higher yield and also reduce the cost of field preparation. Reduced tillage is practiced using a tractor driven rotavator which

fluffs up the top layer of the soil superficially followed by surface seeding. Reduced tillage also requires adequate moisture in the soil and has been reported to produce additional yield and reduced weeds mainly due to the fact that early planting is possible in this system. Addressing the knowledge gaps which exist in zero-tillage's livelihood, socio-economic and environmental impacts would enhance sustainability in a cost effective and equitable manner.

Alternate wetting and drying (AWD)

This is an upcoming advanced water management technique which is practiced in irrigated low-land rice cultivation, which consumes much less water than the traditional system of rice cultivation maintaining continuous standing water in the field. In this method of irrigation, water is applied a few days after the first flooding. Following this, the field is kept flooded and non-flooded alternatively in intervals of 1 to more than 10 days depending on weather, crop growth stage and soil type. The critical water level can be monitored in the field by using a pani-pipe which is a 30 cm long and 10–15 cm wide perforated pipe. Apart from the major advantage of reduced water requirement, AWD also prevents nutrient loss and if properly practiced, improves plant growth parameters like number of tillers, biomass, plant height, number of panicles, 1000 grain weight, grain yield and quality. It has also been reported that the adoption of alternate wetting and drying (AWD) technique in rice reduces the incidence of brown plant hopper (BPH) in rice. However, the mitigation potential of AWD depends on its proper execution and

monitoring. Incomplete drainage causes negligible reduction of greenhouse gases emission. If properly practiced, AWD is able to reduce wastage of irrigation water by up to 30% without compromising on yield. AWD has also been reported to reduce methane emissions by 43%. This method is most suitable for lowland rice growing areas where soil can be drained easily at 5-day intervals.

For efficient application of AWD, proper coordination among farmers, irrigation authorities, and local government is critical. The incentive for farmers so that they are able to adopt AWD varies according to the irrigation scheme available locally. Overall, AWD should not be seen as an isolated package/scheme. It has to be efficient with suitable land management practices, nutrient availability and pest management for this technology to achieve a sustainable economic benefit.



Use of paani-pipe to monitor the water level in rice fields for AWD method of irrigation

Source: <http://www.knowledgebank.irri.org/training/fact-sheets/water-management/saving-water-alternate-wetting-drying-awd>

System of rice intensification (SRI)

System of rice intensification (SRI) is a set of agronomic practices which involve the use of maximum possible organic manure, planting of very young seedlings (8–15 days old), in wide spacing (25–50 cm) with one seedling per hill, minimum three initial weeding, intermittent irrigations and frequent use of mechanical weeder to increase soil aeration. This method was developed by French Jesuit father Henri de Laulanie in Madagascar and has been developed and modified after decades of

agricultural experimentation. This method of rice cultivation is not only suitable for mid and heavy textured soils but also less fertile soils where the number of seedlings needs to be increased. This method of rice cultivation has been adopted by millions of smallholder farmers worldwide, especially in Asia and Africa. However, despite its success it still needs a lot of institutional intervention for dissemination of knowledge about the technique and providing training. Although this method is more labour intensive, this method has been reported to fix more carbon per unit input, has profuse tillering, reduced lodging, higher grain and straw yield and a larger root biomass. It has been observed that SRI's non-flooding practices, along with organic soil management can potentially reduce methane emissions by 50%. In addition, SRI practices are excellent for maintaining as well as restoration of soil health. This is due to the fact that active soil aeration, mulching and organic fertilization adds additional organic matter to the soil, reduces soil erosion, and effectively improves nutrient cycling, which in turn helps to create better soil structure and fertility.

Breeding more sustainable rice varieties for sustainable cultivation

Modern rice breeding programs need to accommodate changes in new rice varieties so that they are more amenable to sustainable agriculture. Currently, most of the AWD practices have been implemented on pure line rice varieties. It has been observed that hybrid rice varieties which have a better yield potential, enhanced competitiveness against weeds, are short duration and drought tolerant due to more extensive root systems offer a net benefit with respect to water usage and GHG emitted per unit yield. Furthermore, rice varieties are being developed by

adopting genetic approaches which alter allocation of photosynthates to biomass above ground rather than roots, which in turn decreases methanogen-enhancing root exudates. Scientists have observed that optimizing photosynthate distribution can help in increasing rice yields and at the same time reduce the methane emissions by the roots. Molecular rice breeding with barley HvSUSIBA2 gene which causes elevated photosynthate flux towards grains rather than towards the roots has been identified to increase grain yield and at the same time mitigate methane emission in paddy. Recently, this gene has been transferred to varieties of rice which have been observed to show better grain filling and reduced methane emission due to root exudates. Additionally, rice varieties which have an increased tolerance to water deficit are an attractive input for practicing sustainable cultivation methods like AWD and SRI.

Way forward

Sustainable cultivation of rice can act as a key driver for India to achieve its sustainable development goals. The main challenges that need to be addressed in order to shift to a more sustainable system of cultivation of rice in India are the predominance of wheat-paddy cycle practiced by Indian farmers, rainfed agriculture, the sub-optimal and overuse of resources like fertilizers, land and water, fragmentation of land holdings, large proportion of small holding farmers (SHF) and a comparatively weak agro-based industry. Hence the sustainable diversification in rice has to be encouraged by policy and technology-based support systems. A major area of research and investigation is the study and documentation of the climatic, as well as socio-economic variation which is prevalent across the country. The adoption of advanced

methods of agronomy are highly dependent on the local terrain of the farmer and the institutional interventions adopted for reaching out to the farmer have to be tailor-made for the latter. Adoption of advanced agronomic practices like SRI and AWD have been observed to be the most promising techniques which can benefit the farmers and reduce GHG emissions at the same time. There is a tremendous scope for policy changes as well as institutional interventions for fine-tuning the adoption of these techniques by small-holder farmers. Farmers need to be provided price guarantee, assured procurement policy, credit, insurance and rural infrastructure and an efficient agri-food supply and value chain needs to be developed. Overall, an integrated approach with the cooperation between researchers, farmers and mills needs to be adopted for making rice cultivation sustainable for India.

SUMMARY

Rice farming is demanding on freshwater resources, and at the same time its cultivation practices are highly vulnerable to climate change. Hence there is an urgent need to develop agronomic practices and rice varieties which would reduce the water footprint (WF) associated with rice cultivation. As the world is progressing towards a higher economic and sustainable growth, sustainable agriculture is gaining more and more importance. In that direction, the advancements in irrigation techniques have proved to be the most efficient developments targeted towards sustainable cultivation of rice. Moreover, the development of varieties with a higher yield and shorter duration of maturity can help in sustainable increase of cropping intensity of rice.

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