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Climate Smart Water Management Techniques for Sustainable Rice Cultivation

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Abstract

Rice is a crucial staple food, feeding over 800 million people in India and playing a vital role globally. However, traditional rice farming is water-intensive, leading to challenges for cultivation due to unpredictable rain patterns and climate change. To address this, innovative water-saving technologies are required. Methods like sunken and raised beds, field bund raising, and laser land leveling enhance water efficiency, reducing runoff and increasing water use efficiency. Check basins and improved irrigation methods minimize water loss. Water-efficient rice production systems, including aerobic rice and the system of rice intensification (SRI), demand 20-60% less water than conventional approaches. Direct Seeded Rice (DSR) and its agronomic practices offer efficient alternatives, optimizing water use and reducing labor. These advancements contribute to sustainable rice cultivation, vital for food security in India and global sustainability goals.

Introduction:

Rice crops have a significant part and role in India's overall food grain production. Rice is staple food for more than half of the world's population and in India serve as staple food for 800 million people. One fifth of world's population depends on rice cultivation for their livelihood. Cultivation area of rice in India is 46 Mha and have produces total 3296.87 Lakh tonnes of food grain in year of 2022-2023.

Out of total food grain production (3296.87 Lakh tonnes) Rice alone contributed 1357.55 Lakh tonnes and become major contributor in the year of 2022-2023. Last five years' average rice production is 1203.90 Lakh tonnes.sourced from the carbonization of organic

In India during 1950-51 area, production and irrigated area of rice is 30.81 Mha, 20.58 million tonnes, and 31.7%, respectively but in 2019-20 area, production

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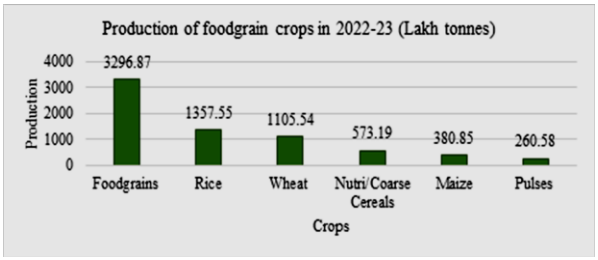
and irrigated area of rice is reached 43.66 Mha, 118 Million tonnes, and 64.97%, respectively. During this long journey rice production increased more than five times and India not only becomes self-sufficient but also world's largest rice exporter.



Leading rice producing states of India is west Bengal, Uttar Pradesh, Punjab, Odisha. Rice is very high water demanding crop. In recent years rain water distribution is very uncertain due to climate change. Some areas facing drought and in some areas flooding is common along with this frequency of rainy day is decrease and due to high intensity rain water is lost by runoff. Sustainable rice cultivation is very crucial for counties like India for their self-sufficiency in food security and for achievement of sustainable development goals. Rice crop is very in-efficient user of water, and 60-83% applied water is lost via deep percolation, Seepage. Hence water use optimization by best water management techniques, agronomic measures, and advanced tools and techniques.

Water-saving technology on farms-

Agronomic practices- Various agronomic practices like field bund raising, sunken and raised bed, and laser land leveling are used to save water from rice fields.

Sunken and raised bed

Alternating sunken and raised beds involve excavating 5m strip (20-30 cm depth), raising adjacent strip by 40-60cm. Due to removal of top fertile soil fertility loss balanced by application of FYM @ 10 t ha^{-1}. In rainy season crops like chillies, brinjal, okra, amaranthus, cucumber, and bitter gourd can be cultivated on these raised beds. This modified system enhances rice grain yield by approximately 13-15% compared to unmodified practices.

Field bund raising

In flooded paddy, water loss occurs due to seepage, percolation, and runoff. Flow through bunds contributes to decreased water productivity. A 50 cm earthen bund with mud plastering retains water, reduces runoff, and preserves topsoil. Raising the field bund by 18-20 cm stores 90% rainwater, conserving water and enhancing rice yield.

Laser land leveling

This involves precision land leveling with laser-equipped drag buckets, achieving ±2 cm accuracy from mean elevation. It maintains a constant 0-0.2% slope across the field, ensuring uniform irrigation with minimal runoff or waterlogging. High-power tractors and soil movers with GPS/laser guidance cut or fill soil for even surfaces. Laser leveling boosts water savings by 20-25%, expands cultivable land by 3-5%, cuts GHG emissions, and enhances crop yields.

Improved method of irrigation

Selecting the appropriate irrigation method hinges on various factors, including water availability, topography, climate, soil type, intended crops, economic considerations, local traditions, and skill sets.

Surface irrigation

It is very old irrigation practice and practiced on large area. Water application followed gravity principle. In such instances, the efficiency of irrigation application seldom surpasses 45-60%.

Check basins

Check basins, rectangular or square (10-100 m^2), enclosed by bunds, regulate irrigation water. Small channels between beds aid water conveyance through main and lateral channels. This water-efficient method, with well-designed check basins, saves 10-30% more water than traditional flooding. Effective for crops like rice and fodder, it suits heavy soils with low infiltration rates.

Water-efficient rice production system

Rice cultivation demands a substantial water supply, with irrigated rice constituting around 52% in India. Irrigated rice utilizes 40% of irrigation water resources in India. A significant portion, about 60-83%, of the total water applied to rice fields is lost through deep percolation. This concerning scenario is likely to worsen with climate change. However, water-efficient rice production systems, such as aerobic rice, the system of rice intensification, and dry direct-seeded rice, require 20-60% less water compared to conventional cultivation methods.

Aerobic rice

Aerobic rice production technology entails cultivating rice in non-puddled and non-flooded conditions. Irrigation is provided intermittently, triggered by a lower threshold of soil moisture content measured by a tensiometer reading between -20 and -30 kPa. However, a thin film of water (1-2 cm) should

be maintained post panicle initiation. This method, serving as both a water and energy-smart approach, has the potential to save approximately 37-60% of water compared to conventional flooded systems. This cultivation practice is not suitable for high rainfall areas.

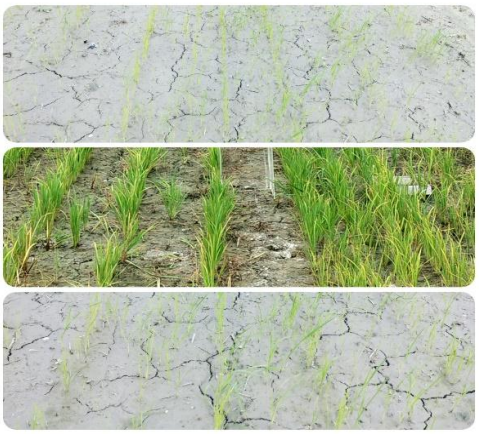
System of rice intensification

System of Rice Intensification (SRI) is an enhanced rice cultivation method originating in Madagascar in 1983. It's a water-efficient technology, saving 20-50% water. Ideal for irrigated medium and favorable bunded uplands in the wet season, as well as rainfed shallow lowlands with water control, and irrigated boro/rabi rice. It involves a set of five simple principles that synergistically work to enhance yield-

- Transplanting is optimal at an early stage, preferably with seedlings aged 8-12 days, having only two small leaves, before the fourth phyllochron.
- Single-seedling transplanting with wider square spacing is employed. Seedlings, attached to the seed, are transplanted at 1-2 cm depth with roots kept horizontally, following grid points marked by a marker.
- Mechanical weeding (rotary hoe/conoweeder) is advised 2-3 times. The initial weeding should conclude by 10 days after transplanting (DAT), followed by subsequent sessions every 10-15 DAT.
- Maintaining moist soil without saturation during the vegetative phase encourages the growth of additional tap and primary roots.
- Applying organic manures promotes optimal biological activity and a steady release of nutrients.

Direct seeded rice

Direct Seeded Rice (DSR) is a method where seeds are sown directly in the main field instead of transplanting seedlings from the nursery. This can be done by sowing pre-germinated seeds in puddled soil (wet DSR) or well-prepared non-puddled seedbed (dry DSR). Weed infestation, especially in dry DSR, is a major concern, potentially causing up to 85% yield loss if not properly managed. Seed priming with water and KCl is a promising solution for better crop establishment. Short to medium duration rice varieties are preferred for DSR in upland and medium land. Water stress during critical stages should be avoided. DSR reduces the overall crop duration by about 10 days compared to transplanted rice, offering benefits such as reduced labor for nursery bed raising, transplanting, and lower methane emissions.



Summary

Rice is pivotal for global and Indian food security, with India emerging as the world's largest rice exporter. However, traditional cultivation methods are water-intensive and face challenges due to climate change. Innovative water-saving technologies, including sunken and raised beds, field bund raising, laser land leveling, and improved irrigation, enhance water efficiency. These practices, along with water-efficient rice production systems like aerobic rice and the system of rice intensification, mitigate water loss. Direct Seeded Rice (DSR) offers an alternative with reduced labor and methane emissions. As water scarcity looms, these advancements are crucial for sustainable rice cultivation, aligning with India's self-sufficiency goals and sustainable development.