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Modern Techniques of Rice Production

A key for ecosystem sustainability in changing climate

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Rice (Oryza sativa L.) is one of the most important staple food crops in the world. In Asia, more than two billion people are getting 60-70 percent of their energy requirement from rice and its derived products. In India, rice occupies an area of 44 million hectares with an average production of 90 million tonnes at productivity of 2.0 tonnes per hectare. Demand for rice is growing in India and it is estimated that by 2025 AD the requirement would be 140 million tonnes. To sustain present food self-sufficiency and to meet future food requirement, India has to increase productivity by 3% per annum.

THE post green revolution period, showed a decline in yield, mostly because of imbalanced use of fertilizers and pesticides, over-exploitation of the natural resources, particularly water, deterioration in physical conditions of the soil and emergence of new bio-types of pests and diseases. Thus the major challenge before the researcher is to innovate appropriate technologies to produce more food from diminished land resources for the burgeoning population pressure and to improve and conserve the natural resources of small and marginal farmers. One of the possible options for further increase in rice production is through the application of new technologies such as system of rice intensification (SRI), laser land leveling, direct seeded rice (DSR), precision farming, use of leaf colour chart (LCC), brown manuring, crop residue management, crop diversification, water conservation technologies, integrated crop management (ICM) and site-specific nutrient management (SSNM) along with application of resource conserving techniques (RCTs), to ensure their optimal utilization and enhance resource or input use-efficiency. Later mechanization in this cropping system also improved the labour efficiency and increased the production and productivity of crops. These are the long-term solutions for sustainable rice production.

Sustainability Issues in Rice

Soil degradation: Rice is grown predominantly under anaerobic puddled soil condition, whereas wheat is grown under well-aerated soil having good tilth. Puddling reduces infiltration of water at the risk of destruction of soil structure, however, destruction of soil aggregates due to puddling in rice resulting in poor tilth and increases soil strength in the surface and subsurface layers, decreases hydraulic conductivity and infiltration, and inadequate charging of the soil profile for the crop following rice.

Decline in water table: Rice is a water-guzzling crop. To fulfill its additional water need, excessive pumping of underground water leads to decline in water table. The farmers are shifting from centrifugal pumps to submersible tube well, costing ₹ 1 lakh and requiring extraction of water from the lower strata.

Inadequate plant population: To harvest optimum yield of rice, 33 hills/m^2 are required but usually in farmers' fields it varies from 18 to 22 hills/m^2.

Drop in soil organic matter: Long-term experiments conducted in Indo-Gangetic Plains (IGPs) showed that the yields of rice and wheat were constantly greater in all the years when complete doses of NPK were applied through fertilizers or 50% doses of NPK were applied through fertilizers along with organic materials compared with that of unfertilized control.

Nitrate pollution in ground water: Pollution of ground water owing to leaching of nitrates appears to be a serious concern in rice-wheat cropping system, which requires more than 300 kg N/ha. The situation is worse in coarse-textured soils where use of N fertilizer is still higher with excessive irrigations.

Emergence of multiple nutrient deficiencies: In recent years, deficiencies of Mn in salt-affected soils of Punjab and B in calcareous soils of Bihar have become evident. In the highly permeable soils of Punjab, wheat grown after rice suffered from Mn deficiency.

Appearance of new weed biotypes and resistance to applied herbicides: Many new weed species have emerged in rice crop such as *ghrilla ghas*, wrinkle grass, and broad-leaved weeds, which is not controlled by the commonly recommended herbicides. Wrinkle grass is not controlled by butachlor application.

Cultivation of rice on light-textured soil: Another problem encountered is the appearance of Fe deficiency in rice and S deficiency in wheat when grown in sandy soil. The crops remain stunted and produce fewer tillers, leading to low yield.

Inadequate and imbalanced use of fertilizer: The farmers in general are applying N and P but not K. Moreover, the appropriate N: P: K ratio of 4: 2: 1 is not being followed. The excessive use of N leads to lodging, and greater incidence of pests and diseases, and ultimately low yield.

Weather aberration: The erratic distribution of rainfall in time and space also affects the crop yield

TECHNIQUES FOR SUSTAINABLE PRODUCTION OF RICE

Resource Conserving Technologies

Conservation agriculture is a broad term and it encompasses all conserving techniques that conserve resources any way. It also involves following RCTs.

- Soil cover, particularly through retention of crop residues on the soil surface
- Sensible, profitable rotation; and
- A minimum level of soil disturbance.

Resource conserving techniques (RCTs) refer to those practices that conserve resources and ensure their optimal utilization and enhance resource or input use-efficiency. These techniques include zero or minimum tillage (save fuel), direct seeding, permanent or semi-permanent residue cover, new varieties that use nitrogen more efficiently, laser land levelling, system of rice intensification (SRI), direct seeded rice (DSR), precision farming, use of leaf colour chart (LCC) and integrated crop management (ICM). Some important RCTs have been discussed here.

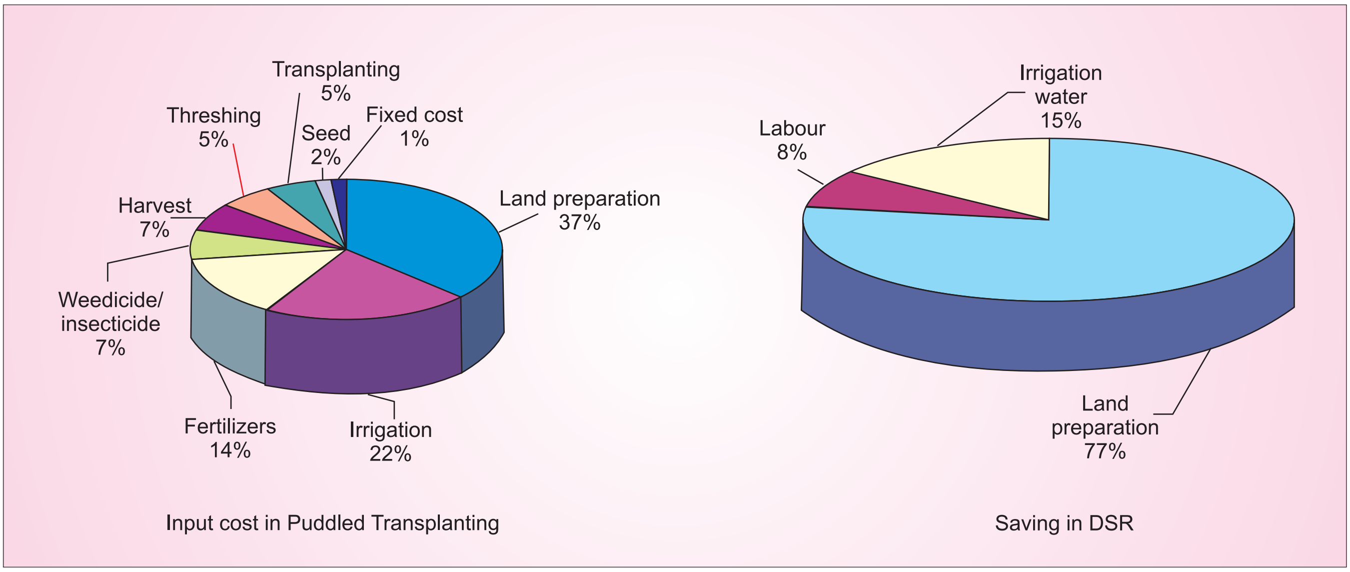
Direct seeded rice: Rice can be directly seeded either through dry or wet (pre germinated) seeding. Dry seeding of rice can be done by drilling the seed into a fine seed bed at a depth of 2–3 cm. Wet seeding requires leveled fields to be harrowed and then flooded (puddling). The field is left for 12–24 hours after puddling, then germinated seeds (48–72 hours) are sown using a drum seeder. Seed can be broadcast for either dry or wet seeding, but manual weeding is more difficult. Indeed, weed management is a critical factor in direct seeding. Timely application of herbicides (timing is dependent on the method of seeding) and one or two hand weeding provide effective control.

Crop residue management: Crop residues are the parts of plants left in the field after the crops have been harvested and thrashed. Crop residues are good sources of plant nutrients, are the primary source of organic material added to the soil, and are important components for the stability of agricultural ecosystems Crop residue is not a waste but rather a tremendous natural resource. Recent work shows that system of raised bed planting of crops may be particularly advantageous in areas where groundwater levels are falling and herbicide-resistant weeds are becoming a problem. This tillage and crop establishment option also facilitates crop diversification

Laser land leveling: It is a precursor of resource conserving technique and a process of smothering land surface (± 2 cm) from its average elevation using laser equipped dragged buckets. It leveled the surface having 0 to 0.2% slope so that there is uniform distribution of water and thus enhance resource use efficiency. Advantages of laser land leveling are as follows:

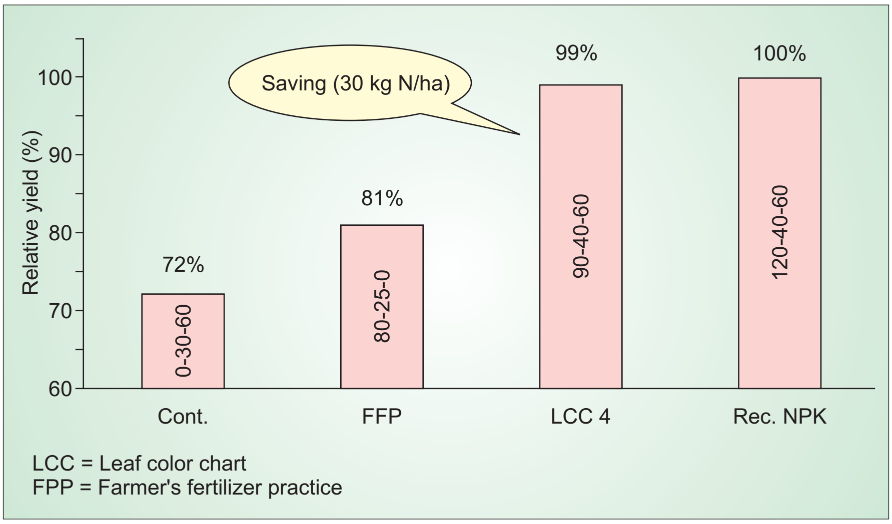
- About 4% rise in area under cultivation due to removal of bunds and channels;
- Saves 10-15% water due to uniform distribution;
- Increases resource (N and water) use efficiency;
- Reduces cost of production and
- Enhances productivity.

Brown manuring: Green manuring



Rice- Wheat Consortium Technical Bulletin is not picking up by the farmers due to scarcity of water. Nowadays, brown manuring is being recommended instead of green manuring. In brown manuring, sesbania is intercropped with direct seed rice. At 30-35 days stage of the crop, 2,4-D is sprayed to kill the sesbania without any adverse effect on rice. After 2-4D spray sesbania turns brown, falls down on the surface and act as mulch. Brown manuring has following benefits:

- No need of additional irrigation water for raising a sesbania crop in summer before rice when evaporation demand is close to 10-13 mm/days.
- Brown manuring keeps the soil moist for long time.
- Improving soil fertility.
- Help to control weed up to 40-50 per cent.



LCC-Based Nitrogen Management in Rice Saves 25% Fertilizer

Site Specific Nutrient Management

Leaf colour chart popularly known as LCC is now used in determination of leaf nitrogen content based on chlorophyll content in the leaves at different growth stages. A LCC value of 4 indicates that there is 1.4 to 1.5 mg N/g leaf weight. The critical LCC value for rice hybrids and HYVs is 4 and for basmati rice is 3. These values have to be taken from 7-10 DAS or 20-25 DAT to heading.

Resource conserving method was developed in Madagascar by Fr. Henri De Laulanié, a French priest with a background in agriculture and passion for rural development. His keen observation of deviant practice and continued experimentation led to SRI emerging over a decade with six principles of growing rice that were different, often radically, from conventional rice cultivation techniques.

- Transplanting of very young seedlings between 8 and 15 days old to preserve potential for tillering and rooting;
- Planting seedlings singly very carefully and gently rather than in clumps of many seedlings that are often plunged in the soil, inverting root tips;
- Spacing them widely, at least 25 × 25 cm and in some cases even 50 × 50 cm, and in a square pattern rather than in rows;
- Using a simple mechanical hand weeder (rotary hoe) to aerate the soil as well as to control weeds;
- Keeping the soil moist but never continuously flooded during the plants' vegetative growth phase, up to the stage of flowering and grain production.
- Use of organic manure or compost to improve soil quality.

Nursery management: Seed rate 2 kg/acre; Nursery area 1 cent; Select healthy seed; Pre-sprouted seeds are sown on raised nursery bed; Prepare nursery bed like garden crops; Apply a layer of fine manure; Spread sprouted seed sparsely; Cover with another layer of manure; Mulch with paddy straw; Water carefully; Banana leaf sheath may be used for easy lifting and transport of seedlings.

Main field preparation: Land preparation is not different from regular irrigated rice cultivation; Levelling should be done carefully so that water can be applied very evenly; With the help of a marker draw lines both way at 25 x 25 cm apart and transplant at the intersection; At every 5-10 m distance form a canal to facilitate drainage.

Benefits of SRI Cultivation

Reduction in seed requirement 65-75%; Water requirement 35-45% reduction; Fertilizer requirement No or initially 50% less; Head rice recovery 20-25% increased; Maturity period uniform; Duration 10-20 days less; Yield 25-30% increased; Strong root anchorage withstand cyclonic gales; Pest and disease management less; Soil health sustained

Management Practices in SRI/Standard Method

Management Practices	Standard Methods	SRI
Type of Nursery	Wet nursery	Modified mat nursery
Seed rate (kg /ha)	20	5
Seedling age for transplanting (days)	21	8
Seedlings/hill	2	1
Spacing (cm)	20 x 10	25 x 25
Weed management	Hand weeding at 20 and 40 DAT	Rotary/ Cono-weeder to uproot/ incorporate weeds
Water management	Cyclic submergence of water up to 2.5cm height throughout the cropping period	Irrigation on appearance of hairline cracks up to PI; 1-2 cm after PI to 15 days before harvest
Nutrient management	Recommended fertilizer dose of NPK(150:60:60 Kg/ha)	*Azolla* (750 Kg/ha)+ Compost (2.5 t/ha) + 50% recommended dose of N, P and K. Application of N based on LCC value

improvement.

Integrated Crop Management (ICM) Options in Rice

Uniform land leveling; Quality seed; Young, robust seedlings for TP; Row seeding by drum seeder; Bed planting; Intermittent irrigation; Balanced NPK, with LCC for N application or deep placement; IPM: Need-based pest control.

Technologies to Reduce Existing Yield Gaps

Tillage practices (Land levelling for direct seeding, including laser leveling); Water Management (Water-saving technologies (controlled irrigation, aerobic rice for temperate zones); Nitrogen Management (Site-specific nutrient management, integrated nutrient management and leaf colour chart); Integrated pest management (for seeds, diseases, insects, rodents); Conservation agriculture (reduced tillage, direct seeding, residue management); Crop establishment techniques DSR and SRI; Weed control; Varietal Selection.

SUMMARY

Resource Conserving Techniques (RCTs) are more effective in combinations rather than their individual application. SRI method of rice cultivation is an efficient natural resources utilization and it is a solution for enhancing the production and productivity. Among different water-wise rice establishment techniques DSR is cost-effective and gives a higher net return. *Sesbania* brown manuring is helpful in suppressing weeds and increases the yield. LCC reduced N requirement approximately 25% of applied N. Diversification of rice based cropping sequence is a need of the hour for sustainable production. Site specific nutrient management in rice (SSNM) is helpful to achieve higher yield. Laser land leveling enhances the yield and water productivity.

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