Traditional Methods of Rice Cultivation and SRI in Uttarakhand Hills

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Abstract

Out of twenty-eight Oryza species, only two are cultivated. The indigenous practices of different regions vary. But the essence of the indigenous practices are low external input (LEI) based farming system, organic produce, preferences for taste and quality, and a number of innovations involved. The present paper elucidates the traditional organic rice farming in Uttarakhand, India and its commonalities with the System of Rice Intensification (SRI).

In SRI, six principles of rice cultivation are followed: use of small young seedlings, single plant transplantation, wide spacing in square geometry, use of organic manure, limited irrigation instead of flood irrigation, and mechanical weeding. The yield obtained is 60% higher in comparison to conventional transplanting. The cost savings are through the operations such as low seed rate (7.5 kg ha⁻¹), water saving, and mechanical weeding. The increased drudgery in transplanting operations is compensated by other complementary operations like saving of time in weeding, watering, and disease and pest control. The added benefits are higher yield and reduction in emission of greenhouse gases.

Rice is a staple food of the world’s 33 percent population. Nutritionally, it contains 80% carbohydrates, 7–8% proteins, 3% fat, and 3% fiber (Juliano, 1985). Medicinally, it is valued for curing ailments like diarrhea, vomiting, fever, hemorrhages, chest pain, dyspepsia, worm disorders, and burns (Charaka Samhita, c. 700 BC; and Susruta Samhita, c. 400 BC). Rice also has hemostatic and aphrodisiac properties (Uma Ahuja et al., 2008).

Archaeological evidence

Mehra (2002) has reviewed archaeological findings of the Indus-Saraswati civilization. He pointed that wild rice was eaten in the advanced Mesolithic or pre-Neolithic (c. 8080 ± 115 BC) period at Chapani Mando. Prolific use of rice (cultivated – Oryza sativa; wild annual – Oryza nivara; and wild perennial – Oryza rufipogon) husk and chaff as pottery temper at Koldiwal (c. 6570
± 210 BC) and Mahagara (c. 5440 ± 240 BC), and the discovery of the grains of cultivated rice at Mahagara establish the cultivation of *O. sativa*. Incidentally, all three locations, Chopani Mando, Koldiwah, and Mahagara are in the Ganga region of central Uttar Pradesh in India. (Nene, 2005). Rice cultivation apparently diffused in all directions from the Ganga valley. Perhaps more information could be obtained on the diffusion of cultivated rice to other parts of India if archaeobotanical investigations are carried out in Bihar, Orissa, and southern India (Nene, 2005).

Rice belongs to the genus *Oryza* comprising 28 different species and subspecies. Of these, six are of wild type and two belong to cultivated species, i.e., *O. sativa* and *O. glaberrima*. *Oryza sativa* is grown throughout Asia, Europe, and America, while *O. glaberrima* is grown in Africa. The Asian rice represents geographically two distinct races. The *race Indica* belongs to the Indian subcontinent and *Japonica* to Japan and North China. *Oryza sativa* var. *fatuus* is a common weed in many parts of India. Another species, *O. perennis* is a wild type from Orissa. It is a floating type with branched stem and perennial in nature with short rhizome. Generally, grains in wild types get shattered before maturity and thus are difficult to harvest.

Rice is being cultivated in Uttarakhand in North India ever since humans inhabited the region. Use of unbroken rice (*akshat*) in rituals are evident from Shankaracharyan literature, where it is also used as *prashad* in the most primitive Vishnu temple ‘The Badrinath’. Varieties of rice and their cultivation in Uttarakhand supports the view of ‘Diffuse Origin’ (Nayar, 1973). The common cultivars of Uttarakhand are Lal Rikhawa, Safed Rikhawa, Thapa Chini, Chonriya, Garudiya, Kirmuli, Lal Japani, Hansraj, and Basmati (Kediyal et al., 1996).

**Global relevance of rice cultivation**

Food requirement had been a major debatable issue in Asia during 1960s. Consequently, the International Rice Research Institute (IRRI) was established in 1960 in the Philippines. Paddock brothers (1967) predicted: “Ten years from now parts of the underdeveloped world will be suffering from famine. In fifteen years, the famine will be catastrophic and revolution and social turmoil and economic upheavals will sweep areas of Asia, Africa, and Latin America” (Khush, 2004). The old Asian varieties were potentially yielding 4 t ha$^{-1}$ grain only, with higher biomass (10–12 t ha$^{-1}$). The scientists' concern was to increase harvest index of 0.3 (3:7 grain-straw ratio).

Later on harvest index was improved (0.5), and early maturity was induced (only 110 days instead of 150–180 days) through the use of nitrogen (N) fertilizer. All together the disease and pest control measures increased the per capita availability of grain to the population. However, the global community's apprehension was not only the high external input (HEI) based cultivation but also global warming with emission of the greenhouse gas methane. It was time for search of some alternate method of rice cultivation, which would be more environmentally friendly.
Fertility response of *Indica* type rice

Optimum plant population and balanced use of fertilizer are the two most yield influencing factors for rice productivity (Tanaka, 1964). Application of 160 kg N, 90 kg phosphorus, and 90 kg potash was the most suitable fertilizer dose for better productivity of *Indica* type rice if planted at a distance of 15 cm × 20 cm (Verma, 1972). Response of N-fertilizer varies as per the soil reaction and variety. The highest response (0.2 t ha⁻¹) of N-fertilizer was at 150 kg N ha⁻¹ in saline soils; however, higher yields were obtained in the cultivars Taichung Native-1, Tainan-3, Jaya, and BC-6 (Daya Nand et al., 1972). Application of magnesium (40 kg ha⁻¹) along with potassium (75 kg ha⁻¹) influenced grain and straw yields with good root growth and uptake of other favorable chemicals (Vijayalakshmi and Mathan, 1991).

Modern technology

New high-yielding varieties (HYVs) developed through traditional selection or hybridization, integrated weed control methods, improved agronomical practices including crop geometry and tillage practices, use of indigenous avesicular and vesicular mycorrhizae, fertilizer management, and disease and pest control were given importance in technology release (CRRI, 2002–03). Varieties were released for production of hybrid rice, fine rice, and so-called nutritive (golden) rice. Genetic engineering (gene extraction from daffodil and *Erwinia*) and biotechnology tools are used to develop carotenoid rich golden rice varieties (Babu et al., 2006).

Methodology

Uttarakhand is a Himalayan state in North India, consisting of 13 districts of which 10 fall under the Hill and Mountain Zone. The district Tehri Garhwal starts from Shiwaliks touching the boundary of district Dehradun to High Himalayan ranges in community block Bhilangana (Panwali Bugyal). The major rice growing areas in Tehri Garhwal district are valleys of Song, Bilangana, Henwal, Alaknanda, Bhagirathi, and Yamuna. However, the mid-altitude regions comprising Nagani, Satyanu, Nelchami, Pangar wasa, Gaja Pokhari, Nageswar saur, Badiyar Garh, and Dangchaura also represent sites of rice cultivation. The varietal diversity represents more than nine types (Lal Rikhawa, Safed Rikhawa, Thapa Chini, Chonriya, Garudiya, Kirmuli, Lal Japani, Hansraj, Basmati) of coarse to fine grade rice. Though the time of sowing varies minutely from region to region as per the community decision and monsoon situation, all the farmers grow paddy by following three prevalent practices, viz., direct sowing, transplanting, and ‘SAINDA’, i.e., pre-sprouted seed sowing in puddled fields (Fig. 1).

The study was conducted during 2005–2009 to see the diversity of practices and their impact on rice intensification. In all, 761
farmers belonging to 12 villages representing 3 clusters (Hariya Nainbag, Satyanu, and Jamanikhal) of district Tehri Garhwal were identified in National Agricultural Innovation Project (NAIP) ‘Sustainable Livelihood Security’ component III (ICAR) and a base line survey was conducted through participatory rural appraisal (PRA). The information provided by respondent farmers was further triangulated among the group members for confirmation.

**Indigenous practices of rice farming in Uttarakhand hills**

In Uttarakhand, rice is one of the major crops in the hills. Rice is cultivated in two seasons, i.e., spring and summer. Spring rice is cultivated on rainfed land whereas summer season rice is cultivated on rainfed as well as irrigated lands. Spring rice is cultivated to capture the winter moisture. The seed is sown by direct sowing method through broadcasting. Partially decomposed farmyard manure (FYM) is dumped at farm site for complete decomposition and 18–20 t ha\(^{-1}\) compost is applied at the time of plowing. Usually profuse weeds appear during rainy season and weeding is one of the most cumbersome operations in the fields. Summer rice cultivation comprises of three methods, i.e., direct seed sowing (as for spring rice), transplanting, and pre-sprouted seed sowing (priming) in well puddled fields (Figs. 2, 3, and 4). Pre-sprouted seed sowing method is
called ‘SAINDA’. The rice nursery is raised through two methods, i.e., pre-sprouted seed sowing in puddled beds and pre-soaked (in water) seed sowing in dry leveled beds. Pre-sprouted seed nurseries are hardy for weed competition as these smother weeds faster (Fig. 5).

The yields in ‘SAINDA’ rice fields are 30–40% higher than those in transplanted and direct seeded fields. The reason is probably quick establishment of seedlings and zero post-transplantation shock that is deemed after uprooting from nursery beds. This practice is much alike the SRI (System of Rice Intensification) methods and thus can be termed as indigenous SRI technique.

**Organic farming**

The population increase, decline in food production due to resource limitation, and agricultural sustainability are issues of high concern among the global society. The idiosyncrasy of human mind to fetch high to higher profitability within a short duration confined the accessibility of common people to the common resources. This compelled common people to remain far from food security as well as nutritional and employment security. In India, the food production is confined to few states only whereas a larger chunk of area is resource scarce and can afford only a low external input (LEI) based agriculture.

Agriculture in Uttarakhand is by default ‘organic’, as the small and scattered land holdings of farmers do not encourage them to adopt costlier agronomical practices. Principally, LEI based agriculture shows potential guarantee towards sustainability. Global environmental concern and emission of greenhouse gases has invited the attention of intellectuals towards new endeavors for carbon sequestration (Adams *et al.*, 1999). Studies suggested that significant opportunities for carbon sequestration exist all over the world and the specific cost

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![Figure 2. Direct seeded paddy in two villages in Tehri Garhwal: (a) Atali, (b) Jadhgar.](image-url)
estimates varied substantially across studies from 5 to 500 dollars per ton. Since organic farming is a kind of green agriculture and has potential to reduce greenhouse effects, the carbon sequestration policy may insure environmental royalty to the nation. The benefit of royalty policy may be a way for additional earning to the organic farmers of Himalayan states. However, this kind of earning may not benefit farmers individually.

Figure 3. Transplanted paddy and SAINDA fields in the village Lambkandai in Tehri Garhwal.

Figure 4. Preparation of SAINDA rice fields in May (when the wheat crop is still standing) in the village Muriya in Tehri Garhwal.

Figure 5. Women carrying out 2nd weeding in SAINDA rice field in the village Dharkot in Tehri Garhwal.
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but states can formulate such projects out of which support price for organic rice may be declared to tune up individual stakeholder’s benefit. Ethically, the following are the good practices for organic farming, i.e., respect towards indigenous technical know-how pointing to the soil health erosion, in-situ moisture conservation, broadening the functional biodiversity, and disease and pest control using eco-friendly methods. In addition, recording and certification under global accreditation is equally important for export oriented global marketing.

Kharif (rainy season) is one of the potential seasons under rainfed situation as optimum moisture may benefit the production. Paddy seeds are sown either directly in the nursery or after pre-soaking in water; however, direct seeding may harbor more weed infestation. Similarly, pre-soaked seed are more prone to fungal infection, which may affect seed germination severely. Seed treatment (Singh and Tomar, 1972) will increase cost of cultivation of rice.

In Uttarakhand, organic rice cultivation is practiced using the following steps:

- The seed is then sown in the nursery.
- The field is burned and fumigated before plowing to eradicate the undecomposed litter of weeds and previous crop.
- About 20–25 t ha⁻¹ FYM is mixed with the soil during plowing.
- Manual weeding and hoeing for good aeration are carried out followed by thinning and gap filling.

The most important components of rice cultivation are the cropping system of irrigated land and the agronomical practices. In general the most common one-year crop rotation is rice-wheat but few other rotations are also followed after 3–4 years to manage the yield limiting factors, e.g., diseases, pests, weeds, and soil fertility deficit components of repetitive crop rotation. The other rotations are onion-rice, potato-rice, wheat-local beans + soybean, chickpea/lentil-rice, and berseem-rice. These alternate crop rotations are beneficial because of additional organic litter, N₂-fixation, manual weed control in cash crops, and time management. To reduce the drudgery of weeding operations in rice cultivation, farmers rotate seed type every year so that on the basis of root color (e.g., white in ‘Safed Rikhawa’ and blue in ‘Kala Rikhawa’) roguing of offtypes could be done.

System of Rice Intensification (SRI)

During early 1980s, the French priest Fr. SJ Henri de Laulanié worked for 34 years with Malagasy farmers in Madagascar. In 1983, he coined a term ‘System of Rice Intensification’ (SRI). Subsequently, in 1990 a non-governmental organization
(NGO) ‘Association Tefy Saina’ was established. In 1994, Tefy Saina started working in collaboration with Cornell International Institute for Food, Agriculture and Development (CIIFAD) in Ithaca, New York, USA. Their task was to minimize the adverse effect of slash-and-burn agriculture for upland rice. Surprisingly, this method of rice cultivation was found superior over the other past practices as four times increase in productivity (8 t ha⁻¹) was obtained. The first article of Fr. de Laulanié appeared in the journal Tropicultura (13:1, 1993, Brussels) in June 1995 (cited in Shambu Prasad, 2006). As per Fr. de Laulanié, SRI is a bunch of six practices as given below:

- Eight- to fifteen-day old seedlings are most suitable for transplantation that supports maximum tillering and rooting.
- Planting of single seedling favors minimizing the chances of root meshing followed by inverting the young root tips.
- Widened space planting (at least 25 cm × 25 cm and in some cases even 50 cm × 50 cm) in a square crop geometry.
- Weed control through the use of a simple mechanical hand weeder (rotary hoe) to aerate the field soil.
- Optimizing the soil moisture during vegetative growth phase to flowering stage and grain formation instead of flood irrigation.
- Enrichment of soil through use of organic manure or compost.

The SRI method involves the transplanting of single plants of 8- to 15-days old grown in the nursery. The seed rate required is 7.5 kg ha⁻¹ (Uphoff et al., 2002; Vijayakumar et al., 2004) as against 40 kg ha⁻¹ in normal irrigated fields (VPKAS, 2006). SRI method comprises the common practice of sowing pre-sprouted seeds (priming) in a disease- and pest-free, well puddled, and leveled nursery. A layer of fine manure is spread over sown beds. Paddy straw mulching is useful for moisture conservation. Light irrigation is applied only if required to keep the soil moist. Critical watering is required during the vegetative, flowering, and grain-filling stages. Use of banana leaf sheath or any other soft material is common for seedling transportation. The square transplanting design (in place of different row and plant spacing) is preferred by keeping seedling distance at 25 cm or rarely 50 cm apart. The wider spacing is beneficial for luxuriant root and shoot growth. It is beneficial for profuse tillering. ‘Square planting’ in wider spacing facilitates the use of rotary hoe for manual weeding. One or two weedings after 10–12 days of transplanting followed by 3–4 days prior to complete canopy cover is sufficient for weed control. Yields in SRI fields are high (about

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60% more), compared to 4 t ha\(^{-1}\) in conventionally cultivated fields (Lakshmi Reddy, 2008).

SRI is a LEI based technology; hence it can be used both by the rich and poor. SRI crops ripen about 7 days earlier than regular crops. It reduces the requirement of water and emission of the greenhouse gas methane. The taste of ‘SRI’ rice is also considered better due to the organic way of cultivation.

**SRI in India**

TM Thiyagarajan of Tamil Nadu Agricultural University, Coimbatore first started working on SRI in the year 2000. He was interested in water saving devices for rice cultivation. The ‘Modified SRI’ practice was evaluated and three SRI principles were standardized (single seeding, wider spacing, and use of weeder) in place of the six old principles (as mentioned earlier) (Thiyagarajan, 2002).

Later on in the year 2004, Alapati Satyanarayana, former Director of Lam research station (Guntur), Andhra Pradesh, was deputed to Sri Lanka to see the potential of SRI system. Accidentally he came across a SRI field in which he observed the remarkable robustness of a plant even under the extreme water stress. At that time most of the drought-affected plants were highly morbid. Eventually, SRI system was attributed to the hardiness of the crop in that particular field (Satyanarayana, 2004).

At present farmers in Andhra Pradesh, Orissa, and Tamil Nadu are practicing SRI with some modifications as per their needs.

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**SRI in Uttarakhand**

Rice cultivation was common in many parts of Uttarakhand. The growers’ main attention was on higher yield, LEI, best time utilization, and labor management. At least more than one traditional practice was found to be more appropriate to obtain high yield. As time advanced, water scarcity was considered one of the prime yield limiting factors. Later on, the growers felt the importance of quick plant establishment in competing against weeds due to its robust growth and consequently higher yield. Transplanting was helping them for natural weed control and managing plant population but higher water and labor requirement made it little impractical in hill farming. As a solution, ‘SAINDA’ practice was evolved, where water was available (Table 1 and Fig. 6).

As a new technology screening approach, 3–4 years ago, one NGO working in Uttarakhand in Bhilangana valley of district Tehri Garhwal demonstrated the borrowed SRI practice on farmers’ fields. Farmers appreciated this modified technique of rice cultivation but equated it as a hybrid technology evolved from their traditional practices, except the use of semi-mechanized weeder along with the use of young seedlings for transplantation (Fig. 7).
<table>
<thead>
<tr>
<th>Performance indicator</th>
<th>Direct seeding</th>
<th>Transplanting</th>
<th>SAINDA</th>
<th>SRI</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Plowing followed by puddling during rainfall</td>
<td>Plowing, bed preparation, and marking for transplanting</td>
</tr>
<tr>
<td>Seed treatment</td>
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<td>Sun drying followed by dipping in lukewarm water</td>
<td>Sun drying followed by dipping in lukewarm water until sprouting</td>
<td>Sun drying followed by dipping in lukewarm water</td>
</tr>
<tr>
<td>Seed rate (kg ha⁻¹)</td>
<td>80–100</td>
<td>40</td>
<td>80–100</td>
<td>7.5–12.0</td>
</tr>
<tr>
<td>Time of sowing</td>
<td>Spring rice: March</td>
<td>Nursery: May end</td>
<td>May end</td>
<td>May end</td>
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<td></td>
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<td>Transplanting: July end</td>
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<tr>
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<td>Seed broadcasting on nursery bed</td>
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<td>Seed broadcasting on small nursery beds</td>
</tr>
<tr>
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<td>30–45 days</td>
<td>Thinning only after 30–45 days</td>
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</tr>
<tr>
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<td>1ˢᵗ weeding 15 days after transplanting followed by 3–4 weedings as per field condition</td>
<td>1ˢᵗ weeding 10–12 days after transplanting followed by 2ⁿᵈ weeding after 3–4 days by using wheel hoe/weeder</td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
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<td>4–5 to keep field flooded throughout</td>
<td>2–3 to keep field moist</td>
<td>2–3 to keep field moist</td>
</tr>
<tr>
<td>Disease and pest incidence</td>
<td>Apparently higher than in SAINDA and SRI fields</td>
<td>Apparently higher than in other fields</td>
<td>Apparently low due to robust plants</td>
<td>Apparently low due to robust plants</td>
</tr>
<tr>
<td>Harvesting time</td>
<td>Spring rice: May end</td>
<td>2ⁿᵈ fortnight of October</td>
<td>1ˢᵗ fortnight of October</td>
<td>1ˢᵗ fortnight of October</td>
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<td></td>
<td>Summer rice: October end</td>
<td></td>
<td></td>
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<tr>
<td>Yield (t ha⁻¹)</td>
<td>3.5–4</td>
<td>4–4.5</td>
<td>5–6</td>
<td>5–6</td>
</tr>
</tbody>
</table>
Double transplanting

Tapovan Basmati is one of the prime rice delicacies of Uttarakhand. The oral history of the villagers narrates that a king of Garhwal was fond of this particular variety. Later on, one of the head priests (Mahant ji) of Bharat Mandir Rishikesh procured the land. The produce was exclusively for religious offerings of the temple. The best quality grain is 7.9 mm length and 2.2 mm width for uncooked rice, with transforming ability after cooking as 15.2 mm in length and 2.8 mm in width.

Double transplanting or two-step transplanting is one of the common practices traditionally followed in Haryana, Punjab, Uttar Pradesh, and Uttarakhand where the tall, traditional Basmati variety faces the problem of lodging. Rice seedlings are transplanted twice in the same field at an interval of 15–30 days. In the beginning, a clump of seedlings is placed
at wider spacing to achieve robustness and then thinning of such clumps provide seedlings for re-transplantation at a normal spacing so that the whole field would be homogenously packed. In Uttarakhand, with slight modification, some additional clumps are also placed in transplanted rice field for the same purpose.

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**Conclusion**

The present article explains how traditional rice cultivation practices motivated farmers to make their own innovations and ensure sustenance in the past. This wisdom of farmers further can be augmented with all existing good practices of the world for evolving SRI, provided these must be LEI oriented.

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References


