‘More Crop Per Drop’ in India

NORMAN UPHOFF

Modifying the methods of plant establishment and water management, changing agricultural practices, and creating more favourable growing conditions for crops, both above and below the ground, farmers have begun producing more crop per drop of water, more crop per acre of land and more crop per unit of work

Prime Minister Modi’s recent challenge to India’s agricultural scientists and farmers to produce ‘more crop per drop’ is fully justified by the country’s economic, social and environmental conditions, both present and foreseeable. As the Prime Minister pointed out, when speaking at the Indian Council of Agricultural Research’s (ICAR’s) 86th anniversary celebrations, India’s land resources are limited whereas the demand for food keeps growing. India, thus, needs to produce more crops per unit of land and also per day or hour of labour: *Kam zameen, kam samay, zyaada upaj*.

Meeting this challenge has been made more difficult and more urgent by the disruptive effects of climate change, which is making water supply less sufficient and less reliable. This constraint is magnified by the continuing degradation of land and water, and by the decline in soil health and water quality from the overuse of fertilizers and agro-chemicals.

Fortunately, farmers in many states of India, over the past decade, have already begun producing more crop per drop of water, more crop per acre of land and more crop per unit of work, by changing their agricultural practices. By modifying their methods of plant establishment and water management, farmers can create more favourable growing conditions for their crops, both above and below the ground. This is especially true for rice and is applicable to many other Indian crops also.

Modifications in crop management while using water more sparingly and carefully can lead to larger, better-functioning root systems and also to more beneficial soil organisms that live symbiotically around, on, and even inside plants’ roots and leaves. Complex microbial communities and the plant-soil micro-biome contribute positively to the growth and health of plants, in much the same way that the human micro-biome is proving to be essential for our own well-being.

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The concern for roots and the soil biota was, unfortunately, entirely left out of the Green Revolution's strategy for crop improvement. Focussing just on water conservation for agriculture will not generate as much benefit for farmers or for the country as can be generated by more biological, less mechanistic thinking, which takes a more integrated approach to crop and water management.

To give a specific example, ICAR researchers at the Directorate of Water Management in Bhubaneshwar have found that the integrated management of crops can produce rice plants that have quite a different capability for converting solar energy and nutrients into carbohydrates. For a given amount of water transpired, the processes of photosynthesis of rice plants can be made more than twice as efficient, enabling them to produce 'more crop per drop'. Rice plants grown using the System of Rice Intensification (SRI) methods discussed here can fix 3.6 micro-mols of carbon dioxide (CO_2) per milli-mol of water transpired, compared to just 1.6 micro-mols of CO_2 being transformed into photo-synthate by rice plants of the same variety grown conventionally. Attention to such physiological improvement in the performance of plants will become all the more important with the increasing water scarcity in India and elsewhere.

ALTERNATIVE SYSTEMS OF CROP MANAGEMENT

Our understanding of the important contribution that better root systems and more abundant and diverse life in the soil can make to crop production and efficiency is based on more than a decade of experience in India with SRI. This was developed in Madagascar some 30 years ago and was introduced in India about 15 years ago.

In recent years, Indian farmers have also begun adapting and extrapolating the ideas and methods of SRI to crops beyond rice. There is an expanded version of the SRI called the System of Root Intensification in Bihar, and a more encompassing System of Crop Intensification (SCI) that improves the productivity and resilience of crops such as wheat, *ragi*, sugarcane, maize, mustard, all the grams, and even some vegetables.

In Bihar, over 1,00,000 households are already benefitting from SRI and SCI practices, as documented in a 2013 World Bank/JEEVIKA report.

Crops with better-developed root systems and a more symbiotic relationship with soil organisms are more productive and more robust. Better root growth enables them to access the water available at lower depths in the soil and to take up more nutrients from the soil, making the plants better able to withstand pests, diseases and climatic stresses.

SCIENTIFIC EVALUATION

The first scientific evaluations of SRI in India began in 2000 at the Tamil Nadu Agricultural University (TNAU). Extensive on-farm comparison trials were conducted in the Thamirabarani river basin in 2004, with 100 farmers managing side-by-side rice plots, planted with SRI or using standard methods. SRI methods increased the average paddy yields by 28 per cent (7,227 vs. 5,657 tonnes/ha) while using 40–50 per cent less water and 80–90 per cent less seeds. Farmers' cost of production was 11 per cent less per hectare, with their labour requirements reduced by 8 per cent. (This contradicted the idea that SRI was more labour-demanding). The net income from the SRI crop was calculated as Rs 31,000

per ha, more than double the Rs 15,000 that was received from the rice crop that was conventionally managed.

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Among other things, TNAU researchers found that SRI-grown rice plants were more resistant to damage from wind and rain, during severe storms. In the *kharif* season 2006, researchers at the ANGRAU in neighboring Andhra Pradesh found that SRI plants could withstand colder temperatures than 'regular' rice plants. Despite temperatures remaining below 10°C continuously for five days during the season, SRI trial plots gave a paddy yield of 4.16 tonnes per ha. The cold snap, on the other hand, caused crop failure in the conventionally-managed plots, which produced just 0.21 tonnes per ha.

BROADER INDIAN EXPERIENCE WITH SRI METHODS

Since 2004, the practice of using the SRI method has been spreading to other states as well. In Tripura, the SRI method has been received well. It was first introduced in 2005–06 on 352 ha and was increased to 14,308 ha the next year, after the state government decided to promote new methods.

Last year, SRI use in Tripura reached 92,340 ha, approximately 36 per cent of the state's total rice area. The average paddy yields with the standard methods continue to be less than 2.5 tonnes per ha in Tripura whereas SRI yields have averaged almost twice as much, moving the state towards rice self-sufficiency. The additional income farmers got by using SRI methods (figuring a purchase price of Rs 10,000 per tonne) would have been at least Rs 3.3 crores in 2013–14, produced *with less cost and with less water.* The value of the additional rice produced with SRI methods in Tripura since 2006 has probably been over Rs 17 crores, giving both 'more crop per drop' and enhancing household income and food security as well.

SRI methods were introduced in Bihar in 2007 by the NGO PRADAN, working with 128 farmers on 30 ha in Gaya district. The SRI yield increase over the conventional methods that year was almost three-fold, and the use of the new methods began spreading rapidly, especially as Jeevika, the Bihar Rural Livelihood Promotion Society, began supporting SRI extension with World Bank (IDA) funding. By 2013, the area under SRI management, in full or in part, had expanded to 6,16,000 ha, cultivated by probably over two million farmers. Their yields with less water use (no more continuous flooding of paddy fields) have averaged over 4 tonnes per ha, compared with the usual yields about 2.5 tonnes per ha.

The additional income generated by SRI management in Bihar in 2013, with a lower cost of production and with less consumption of water, would be something over Rs 1,220 crores. A further consideration is that SRI crops have been more drought-resistant, an important factor for India. In 2010, a major drought year for Bihar farmers, crop cuttings were made from pairs of adjacent fields, where SRI methods were used on one, and the other continued with the standard practice. SRI yields averaged 3.22 tonnes per ha, more than the state's normal average of 2.4 tonnes. The yield for conventionally grown rice of the same variety was 1.66 tonnes per ha. These statistics help explain the growing acceptance of SRI methods by the farmers in Bihar.

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CONTROVERSY OVER HIGH REPORTED YIELDS

SRI is perhaps best known in India for the controversy over certain 'super-yields' that have been reported, and welcomed in some circles while rejected in others. In the 2011 *kharif* season, Sumant Kumar, a farmer in Nalanda district, Bihar, had a yield of 22.4 tonnes per ha, measured by the standard methods used by the Bihar Agriculture Department personnel, with hundreds of observers watching.

Subsequently, in 2013–14 in Tamil Nadu, a farmer in a village near Madurai achieved a yield of 23.4 tonnes per ha using SRI methods. This report however, hardly drew any notice.

Such high yields are outliers but they show the productivity that exists within our current rice varieties when the best conditions for plant growth and health are provided, enabling them to express their full potential. Such super-yields are not as important as the large differences in the average yield that are seen between SRI and conventional management, using less water. It is the averages rather than the outliers that feed the majority of the people and make farmers more prosperous. But we should be trying to understand how and why the outlying results are achieved so we can move the average in that direction.

IMPACTS AND BENEFITS

From the data supplied by Indian colleagues in different states, I have calculated that the average SRI yields across quite varying conditions in the country are about 5.6 tonnes per ha compared to 3.7 tonnes per ha produced through standard methods. The value of this increment, 1.9 tonnes per ha, will amount to, at common purchase prices, about Rs 3,230 crores for 2013, and is rising every year. This estimate does not take into account the lower cost of SRI production or the value of reduced water requirement, or the improvements being made in soil quality and soil health.

A study in four districts of Tamil Nadu found that SRI methods, even when not fully utilized, give farmers higher yields with lower costs of production, approximately 17 per cent lower expenditure per hectare. The economic return for farmers was thus increased by more than the gains in yield. The study also reported that SRI required 23 per cent to 39 per cent less water, and 92 per cent less seed.

A larger study across the 13 rice-growing states similarly reported higher yields with lower costs and more net income. Farmers, who followed all of the SRI recommendations, had 31 per cent higher yield on average whereas even the partial adoption of the method gave farmers more yield and higher earnings. Across all degrees of SRI adoption (high, middle or low), farmers' average cost per kilogramme of paddy produced reduced by 29 per cent because of their savings on seed, irrigation water, and the time required for weeding with mechanical hand weeders.

A meta-analysis conducted last year of the water savings, water productivity, and yield under SRI management looked at data from 251 comparison trials in 29 published evaluations across eight countries. It should be noted that 55 per cent of the trials were from the Indian research studies.

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Analysed in terms of the kilogrammes of rice produced per litre of water, the productivity of the total water applications (rainfall + irrigation) was 52 per cent higher, on an average, in SRI trials whereas in terms of irrigation water use, it was 78 per cent higher. These and other studies underscore that alternative management methods can produce 'more crop per drop' and give higher returns to land and to labour, to seed and capital.

NEED FOR LINKING RESEARCH AND PRACTICE

A lot of research still remains to be conducted on these ideas and methods. Scientists at the ICAR and outside can be productively occupied in helping achieve the goals mapped out by the Prime Minister by working to understand and utilize better what SRI/SCI practices can achieve. There is already a fund of knowledge and experience in India that can move the agricultural sector very quickly toward these goals.

This knowledge and experience are, however, widely scattered and need to be assessed and consolidated through systematic efforts. Civil society, university, government and private sector actors, through the National Consortium for SRI (NCS), can advance both the knowledge and the practice of SRI. NCS can help to connect the pockets and reservoirs of expertise, much of it with farmers, to assist in a pooling of information. Such efforts could lead to both a fruitful research agenda and a plan of action for all parties to move more quickly towards achieving urgent progress in eco-friendly food production called for by the Prime Minister.

The references for this article are available on request from newsreach@pradan.net