Soil and Nutrient Management

The discussion group on these issues addressed a set of practices that are central to the success of SRI. This area included implicitly and often explicitly the ***management of soil micro-organisms*** that constitute a separate but interdependent domain in the complex SRI universe.

Land Preparation

Good land leveling is important to facilitate successful transplanting and to produce vigorous stands of young plants. At the same time, a proper drainage system for the field should be established so that alternate wetting and drying of the soil can be done effectively.

Proper land preparation and plant spacing also can provide an opportunity to sow a green manure/cover crop (GMCC) within rows of rice plants and to incorporate it into the soil with a mechanical hand weeder 30 days after sowing. This has been done by researchers at the Tamil Nadu Agriculture University. A paper on **green manures and cover crops** that was prepared by Roland Bunch for the Sanya conference follows this report to provide more detailed information.

Nutrient Management

SRI has been found to give best results with organic fertilizer. But under poor soil conditions, inorganic fertilizer may be used in combination with organic fertilizer to provide higher biomass production. Once organic matter in the soil is built up, inorganic fertilizer use can be reduced or even ended.

Sources of organic inputs are many. The management principle is to trap nutrients in the biomass and localize them in one place. The movement of organic matter such as compost over long distances to fields is not economically viable and constrains the adoption of organic inputs. GMCCs need not be restricted to leguminous species. Any species that provide large amounts of biomass that can be incorporated into the soil can be used. For instance, in Brazil, about 200,000 ha of soybean fields are planted with millet as a GMCC.

The use of GMCCs should be considered in relation to their effect on microbial activities. Leguminous GMCCs fix nitrogen and create additional organic matter. The wetting and drying of soil will affect survival of microorganisms, since some are aerobic and others are anaerobic. Effective micro-organisms (species and populations) are important elements affecting the decomposition of GMCCs and their release of nutrients.

The use of compost in rice production should link up with the livestock component in farming systems wherever possible. Animal manure and crop residues are commonly used as raw materials to produce compost. Many technologies for effective compost production are available, and effective micro-organisms (EM) as a supplementary technology is being used with SRI in Sri Lanka to many farmers' satisfaction.

Other sources of organic inputs found on farm that can provide significant contributions to improved and stable rice yields are dispersed tree stands or trees in the paddy fields as commonly seen in the rainfed lowland rice areas of India and northeast Thailand. Trees such as *Glyricidia septum* on paddy bunds are proving beneficial in Cambodia. Tamarind and neem are commonly found associated with rice lands of India.

The potential contributions of GMCCs to improving crop yield are many. However, farmers' adoption and adaptation of GMCCs varies. A suitable niche of GMCCs has to be found on land that has no opportunity cost, such as wasteland, fallow land, land along roads and paths, etc.

The introduction of GMCCs should not compete with the production of cash crops. The most sustainable systems incorporating GMCCs are those developed by farmers themselves, for instance, using species that are multipurpose and edible. The use of GMCCs should not be restricted to just one species. Rotational use of species is recommended to avoid building up nematode populations, in particular with leguminous species. Fortunately, in the rice ecosystem, nematode populations are suppressed by periods of submergence.

SRI is a high-performing system that needs nutrient inputs. Therefore, SRI will often best be undertaken in a rotational cropping system. Incorporation of GMCCs either before rice (e.g., *Sesbania rostrata*, mung bean or bush bean) or after rice (e.g., jackbean, mung bean or rice bean) could work well with SRI. The high-yielding performance of SRI provides opportunities for crop diversification that will make SRI itself more sustainable as a production system. GMCCs are discussed more in the next section.

Nitrogen Management

Two approaches to improving N management were identified:

- Adding more nitrogen into the system, such as application of inorganic and organic fertilizers, incorporation of GMCCs, or adaptation of crop rotations, as described above.
- Preventing or stopping losses and leakages from the system.

The latter set of options was focused on in the group discussion, since activities under the first set had already been considered.

Combining SRI with zero or minimum tillage

With the transplanting methods generally used in SRI, this is not practical. In a broadcast rice system, however, a legume such as mungbean could be planted (broadcast) as a green manure crop before the rice crop. After the legume has been growing for 30-40 days, the field is flooded to stop the legume's growth. Pregerminated rice seed is then broadcast. This practice is considered as a kind of natural farming for rice, particularly in rainfed lowland environments. This method will not achieve the soil aeration accomplished by weeding with a rotating hoe. However, if there is a build-up of earthworms in the absence of plowing or other soil disturbance, they could contribute to this effect.

Incorporation of rice straw without burning

Rice farmers commonly burn rice straw as part of their land preparation. Other uses of rice straw in the tropics include: rice straw mushroom production; straw mulch for vegetable production; conversion to improved livestock feed with addition of urea, etc. If sufficient yield improvements can be achieved by incorporating straw into the soil, this will improve soil nutrient status. Growing legumes such as *Sesbania rostrata* in among standing straw makes the straw decompose more rapidly.

Use of slow-release nitrogen

Urea granules coated with neem powder to slow down the release of N have been used in India. This is a possible variation on SRI nutrient management methods.

Nutrient Dynamics

Improved nutrient-use efficiency is observed in SRI, particularly in soils with low phosphorus. The productivity of P thus appears high in SRI, offering a possible explanation for the high performance of this system.

Alternate wet-and-dry irrigation management will affect the survival and balance of micro-organisms in the soil, given different responses from aerobic and anaerobic microbes. The process and consequence of biological changes under such conditions are not well understood. In acid sulphate soils, wet/dry irrigation systems can cause the release of toxic substance, sulphuric acid, which damages rice plants. So SRI might not be so successful in acid sulphate soils.

The suppression and survival of different species of micro-organisms as a result of a wet/dry irrigation management regime should end up releasing various nutrients (contents of the lysed microbes) within the root's rhizosphere. Soil cracking would cause dislodging as well as renewal of plant roots. Thus, soil cracking can facilitate decomposition processes and the release of plant nutrients, in addition to facilitating the exchange of oxygen.

Knowledge Needs

Much more needs to be known about soil and nutrient management with SRI. We are presently forced to draw upon knowledge of soil and nutrient dynamics, still limited, from other cropping systems with quite different soil and water conditions and accordingly different plant, water, soil and nutrient interactions and interdependencies. Little work has been done on processes of biological nitrogen fixation (BNF) or P solubilization in paddy rice, and what has been done has usually been carried out in continuously flooded environments, unlike those created by SRI practices.

Very little is known about **micronutrient dynamics and availability** in soils that have alternating aerobic and anaerobic conditions. While macronutrients (N, P, K) are important, some of the success of SRI may be due to its acquisition of micronutrients (B, Cu, Zn, etc.) when the root system is much larger and accessing a greater volume of soil. At the same time the rhizosphere is made larger and more active microbiologically. There are thus many new horizons of research and experimentation that SRI opens up for the study of soil and nutrient interactions and effects.

