

Technical and Biophysical Issues for Research and Practice

Methodology for Improving Evaluations of SRI

From a scientific perspective, more precise and better documented comparisons are needed both to gain a better understanding of SRI and more standard methods of evaluation and statistical analyses are necessary for scientific credibility. To the extent possible, when SRI results are reported they should include:

- **Plot size** for comparing results; results from very small plots can be hard to evaluate, so a minimum size of at least 100 m² (1 are) should be used for evaluations.
- **Sampling methods** should be specified whenever sample-based estimates are reported. Whole-field harvest results and resulting calculations of yield are always preferable.
- **Control plots** should be established wherever possible since comparisons with a country's national average are not very useful or valid given differences in soil, climate and other conditions that affect specific yields.
- **Moisture content** of rice should be measured and reported for the sake of comparison; this is not be so important where comparisons are made with a control plot where comparative measurements are made with the same methods.
- **Total biomass** should be recorded along with yield wherever possible, at least *above-ground biomass*, though roots can be weighed to give some rough measure of below-ground biomass. Other measures and comparisons of roots can give useful information if dried or wet weight of roots cannot be measured:
 - *root length* in cm;
 - *root volume* measured by water displacement; or
 - *root resistance* assessed by a pull test — kg of force required to uproot a plant where soil characteristics and wetness are reasonably similar for the plants being compared.

This latter test gives data that are useful for *relative* rather than absolute comparisons.

- Components of yield are **always important to document, from a random sample of at least 10 plants**:
 - *tillers per plant*;
 - *effective tillers per plant* — and percent of effective tillers;
 - *grains per panicle*; and
 - *grain weight* — weight of 1000 grains in grams.
- **Soil organic matter content**, and **microbiological diversity and activity** should also be documented if possible, along with **standard soil characterizations** (pH, clay content, etc.). Soil biological factors are considered important with SRI, but there is little systematic data.

Cooperation with Farmers

The measurements and criteria listed above speak to the concerns of researchers. From the perspective of farmers and NGOs, we recognize that **participatory processes** are important for gaining wider understanding and acceptance. It is hoped that scientists can learn from farmers' and NGOs' experience and documentation even if this information is not as extensive or exact as scientists desire. Conversely, it is hoped that farmers and NGOs will help to generate more detailed and complete information on their SRI experience and performance that can be of use to scientists. Participatory processes and scientific investigation can and should be made compatible.

Issues for Assessment

From discussions of the technical aspects of SRI, a number of important concerns were identified for consideration and investigation. Because many of these practices are interactive, they need to be looked at from several vantage points.

Land preparation

- Although *no change* in land preparation practices is required for SRI, *good land preparation* is needed when planting younger seedlings. *Experimentation* with preparation and leveling techniques is advisable to get the most benefit from soil, water, plant and nutrient resources.
- Questions were raised about *puddling and groundwater recharge*: whether changes in land preparation would have a favorable or unfavorable effect on hydrology. Possibly plants would benefit from practices that eliminate any soil pan but this could change water dynamics. Research and experimentation should be done in this area of practice.
- With wide spacing of plants, *broadcasting of fertilizer* is less efficient. We need experiments and evaluation to find what are the most appropriate methods for application of fertilizer, e.g., granulated forms, wherever inorganic nutrients are used with SRI.
- Use of *raised beds* with SRI practices is very promising as this method of land use can maintain more soil aeration and use less water when flooding becomes unnecessary. Initial research supported by the Rice-Wheat Consortium with raised beds is very promising.

Nursery

- Evaluation and use of *seedling trays* is recommended as these can help to protect and preserve tender root systems intact during transplanting.
- Use of *bamboo trays* is a farmer innovation that can help with transport of tiny seedlings from the home to the field very efficiently.
- *Direct seeding* is an alternative to transplanting that should be experimented with. It can save labor if the seed germination rate is high enough.
- One way to improve germination is *seed priming*. Evaluation of methods for this practice was suggested.

Seed quality and crop establishment

- Quality of seed can be a problem for many farmers. They should be taught methods for good *seed selection*. This becomes more feasible with SRI since many fewer seeds are needed.
- With SRI practices, the *multiplication of breeder seed* can be much greater as many more grains can be produced from a single seed, 1,000-2,000 or more. Also the resulting seed is usually more uniform and of higher quality.

- *Optimum sowing dates* need to be evaluated anew with SRI practices. There is also much evaluation to be done of sowing under different conditions, comparing photosensitive and non-sensitive varieties, to understand their implications for optimum sowing dates.
- In some areas, there are problems with *cold temperature* that will slow seedling growth so much that the usual SRI recommendations on seedling age need to be adjusted (lengthened). Recommendations should be by physiological age rather than calendar age.
- *Optimum sowing rates* should also be evaluated. Usually these have been 5-10 kg/ha with SRI methods, reflecting the sparser planting of seedlings. Sowing so few seeds can be one of the hardest things to get accepted, though once demonstrated it is very popular with farmers.
- Methods of *direct seeding*, with primed or pregerminated seeds, should be experimented with to see what labor-saving might be achieved this way.
- It may be possible that *mechanization* of transplanting young SRI seedlings can save labor, perhaps with seedlings grown in plastic trays as presently done in China for the broadcast of seedlings.

Water management

- *Water control* can be a problem for farmers who want to use SRI but who get their water according to a fixed schedule rather than on demand, when needed. Adjustments in plant, soil and water management to accommodate *different kinds and degrees of water control* should be evaluated. Often the issue will be one of making investments in better water control facilities.
- How to deal with *excess water* during a monsoon season where these rains cause serious flooding is a particularly serious issue for SRI water control.
- *Field leveling*, part of land preparation, needs to be done well to get an even rather than a rough surface, so that the reduced water applications can be both minimal and effective.
- *Drainage methods* should also be reviewed and improved, such as the installation of in-field furrows or other means to keep the soil well-drained when it is not supposed to be flooded.
- *Alternate flooding and drying* of fields is another area for experimentation and evaluation, as farmers are finding this saves them labor compared to continuous (sometimes intermittent) application of small amounts of water to keep the soil moist but not

Group Reports

flooded during the vegetative growth phase. There is presently a wide range of cycles being used by farmers. What is the most productive cycle? How should the cycle be adjusted for different soils? We need considerable experimentation and research to answer these questions.

- *Water saving* — How much saving is possible with SRI? What are the agronomic and the economic implications of different methods for water management with SRI?
- *Varietal differences* surely will have some influence on alternative water management practices, e.g., interactions with water uptake that affect nutrient losses. So these should be considered in doing evaluations.
- SRI for *rainfed conditions* should be experimented with, using SRI principles as a guide. This work will intersect with nutrient management practices, particularly mulching.

Weed control

- Some weeds are very difficult to control without continuous flooding. Studies on the *use of herbicides* should be done: What are the agronomics and economics of this compared to soil-aerating manual weeding practices? What are the environmental implications? What effects on tillering? In Sri Lanka, they have found herbicides reduce rice tillering somewhat. Also, what are the effects of herbicide use compared to use of green manures and cover crops (GMCCs)?
- *Improvement of mechanical weeders* should be done, evaluating alternative designs for different soils and different users. One new design used in Sri Lanka can apparently reduce weeding time to one-two days per acre.
- *Access to weeders* is important to facilitate SRI adoption. What kinds of credit schemes can support wider access? How can local fabricators and merchants be gotten to make and distribute weeders at reasonable prices?
- *Coordination of water issues* (flooding) with weeding timetables should be addressed to gain water- and labor-use efficiency and for timeliness of weed control.
- *Water management* practices should be varied experimentally to see whether intermittent flooding during the early stages of rice plant growth, normally to be avoided with SRI, could accomplish an acceptable degree of weed control. We do not know how long rice plants can be flooded before their roots begin

forming aerenchyma (air pockets) and begin the process of root degeneration due to hypoxia (suffocation).

- Use of *intercropping* or *cover crops/green manures* such as sesbania, cowpeas and other species to smother weeds is a practice whose evaluation is just beginning. This is an interesting approach from several perspectives as leguminous species could enrich soil nutrients, as discussed on page 181-185.
- *Rotational cropping* might also be undertaken with SRI to achieve a degree of weed control.
- *Mulching* could make manual weeding unnecessary, but there is little systematic experience with this practice in SRI.
- There could be *varietal differences* worth examining in terms of competitiveness with weeds that would reduce the problem of weed control with SRI methods.

Nutrient management

- What are the implications for nutrients of *alternate flooding and drying*? Is there *more loss*, e.g., due to leaching and volatilization of N, or *nutrient gain*, through processes such as biological N fixation and P solubilization? Little is known about this.
- How can *compost and other organic sources* of nutrients be best used with SRI practices? Some research reported to the conference suggested that only fairly small amounts of compost, e.g., 2 t/ha, may be needed to achieve significant nutrient benefit for SRI crops.
- How can *multiple cropping*, either through intercropping or rotations, contribute to soil nutrient status with SRI practices?
- What scope is there for use of *effective microorganisms* within SRI to improve soil fertility?
- The biggest question is probably *for how long can high productivity be maintained* with SRI practices? What soil, water, nutrient and plant management practices can best sustain productivity?

Labor

Many aspects of SRI require more labor. Finding ways to make SRI practices more *labor-economizing* will be important to make the system more widely acceptable. We need also to understand agronomic issues and dynamics better to know *how labor can be made most productive*.

- *Nursery preparation* — size and location of the nursery and soil mixtures are important but not well evaluated yet.
- *Seedling transport* — interesting farmer innovations are coming up in this area.
- *Land preparation* — so far SRI has not recommended any changes in this area, to avoid making SRI more complicated to adopt; but possibly improvements can be made in this area.
- *Organic matter use* — how can making and applying compost be made more efficient in terms of time and labor? Should legumes or other biomass be grown in arable or non-arable areas to make more organic matter available?
- Methods for marking fields for *spaced planting* — using a simple wooden rake, instead of using ropes tied to sticks, has become a labor-saving technique in several countries.
- *Planting practices and optimum spacing* — these should vary according to soil type and other conditions, but we have little systematic knowledge on what to recommend where.
- *Soil types* vary widely, so adjusting water and plant management practices accordingly is important. Farmers are making a lot of adjustment in this respect already, but we do not have good explanations or recommendations to offer. This calls for systematic evaluation.
- *Water management* at planting time and during the growing season — there is wide variation in farmer practices that remains to be understood in scientific terms.
- *Weeding methods*, including use of the mechanical push weeder — additional weeding appear to raise yields, but we have few systematic evaluations of how much return there can be to labor invested in soil-aerating weeding.
- *Large variations in yield* — how to explain these? Soil quality, assessed in biological as well as chemical and physical terms, seems an important area for investigation.
- *Organic vs. inorganic nutrient supply* presents many interesting issues, whether either gives superior results, or when and why? Quite possibly, *some combinations of nutrient sources* will be optimal.
- *Microbial activity* — how can this be evaluated and to the extent that it is found beneficial, how can it be increased?
- *Earthworms* — we know that these contribute to soil productivity in general terms. How can vermiculture be incorporated usefully within SRI?
- *Root damage* during mechanical weeding can be a problem — how can this be minimized? Or is there some benefit to root system development from having root pruning close to the surface, causing deeper root growth?
- *Varietal performance* with SRI practices — this is obviously an important consideration as we find considerable variation in growth and yield by varieties. How this can be assessed and addressed was taken up by a subsequent group.

Scale and transformation of production

- SRI is presently practiced mostly on a small scale. What practices would have to be changed or adapted for successful *larger scale production*?
- What are the opportunities for *mechanization* within the suite of SRI practices, and what are the economics and practical aspects of this?
- SRI should be seen and practiced within the context of *diversification and modernization* of the agricultural sector since as SRI raises productivity and yields, there should be less and less need to devote so much land, labor and other resources to rice production. SRI should be seen and evaluated within a farming systems framework, with objectives beyond just growing more rice.

Biological problems and issues

A number of these issues were discussed to focus attention on matters that should be resolved or minimized to make SRI more feasible and attractive:

- *Unproductive tillers* — how to minimize? There is wide variation in this percentage, from 10 to 50%, which we cannot yet explain very well. One hypothesis that emerged during the conference was that large applications of N fertilize increase rather than decrease the proportion of unfertile tillers.