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ALTERNATIVE MANAGEMENT METHODS AND IMPACTS WITH THE SYSTEM OF RICE INTENSIFICATION (SRI) IN RESPONDING TO CLIMATE CHANGE EFFECTS

Norman Uphoff, Cornell University*

Rice producers face various adverse consequences resulting from climate change. In the future, droughts, storm damage, cold snaps, and hot spells are likely to become more frequent and more severe, with pressures from crop pests and diseases also likely to increase. While some protection may be conferred by making changes in rice genotypes, most buffering against biotic and abiotic stresses will likely need to come from modifications in crop management.

The practices that constitute the System of Rice Intensification (SRI) are reported to confer a degree of protection against climatic hazards and also against losses from pests and diseases. Such effects could derive from the larger, deeper, longer-lived root systems that SRI practices elicit, and from the greater fertility and water-holding capacity of soil systems managed according to SRI recommendations. Experimental evidence has indicated, for example, that rice plants grown with SRI methods can produce more than twice as much photosynthate per unit of water transpired, reported below. Such water efficiency will become more important in the decades ahead.

Developed in Madagascar in the 1980s, SRI has been demonstrating widespread applicability, despite some early conclusions that it would be only a 'niche' innovation or would have no general relevance for rice improvement (Dobermann 2004; Sheehy et al. 2004). Governments in China, India, Indonesia, Vietnam and Cambodia -- where two-thirds of the world's rice is produced – are now supporting the extension of SRI concepts and methods based on their SRI farmers achieving greater output with reduced inputs of seed, water, fertilizer, agrochemicals, and often even less labor. SRI methods are contributing to higher yields and water saving in a variety of agroecosystems with a wide range of soils and climates in over 40 countries (http://sri.ciifad.cornell.edu). SRI practices are not described here since they are fairly widely known; full information is available on the SRI website.

The results from SRI crop management are quite variable, being affected by the abundance, diversity and activity of soil biota which can support more robust, productive rice phenotypes. Soil biological activity is highly variable, being contingent on many factors (Uphoff et al. 2006; Whalen and Sampedro 2010). Much research remains to be done on the potentials and limitations of SRI methodology, and to understand better the mechanisms and interactions involved. However, reports that SRI cultivation practices have positive effects in countries as diverse as Mali, India and Vietnam should no longer be controversial (Africare-Oxfam-WWF 2010).

The changes that SRI makes in the growing environment for rice plants induce much larger root systems and more tillering and larger, heavier panicles, as well as changes in the soil biota (Uphoff et al. 2009). These effects reflect changes in gene expression that affect morphological and physiological parameters, such as root branching and delayed senescence (Lin et al. 2005, 2009; Mishra and Salokhe 2008, 2010; Thakur et al. 2010; Zhao et al. 2009). The epigenetic and other processes at work, inducing contrasting phenotypes, remain largely unexamined.

Most attention with SRI has focused primarily on yield and water-saving. However, given the changes in climate now emerging, interest is likely to grow in how SRI crop management can help farmers deal with the effects of climate change. Climate considerations increasingly need to be factored into agricultural policy-making at governmental levels, into farmers' decision-making at field level, and into evaluations made by agronomists, economists and other analysts. About 24-30% of the world's freshwater resources are currently used for irrigating rice fields (IWMI 2007), and irrigated rice production contributes >10% of anthropogenic methane to the build-up of GHGs. Rice scientists, policy-makers and practitioners thus should be interested in how the rice sector's demand for water can be reduced as well as in 'climate-proofing' the sector as much as possible (Uphoff and Mishra 2009; V&A Programme 2009).

Our knowledge of how SRI management can help withstand or mitigate climate change is still fragmentary, not consolidated or systematically evaluated for lack of research support. Below are ways in which SRI practices appear to offer opportunities to reduce the impacts of climate change on the rice sector, and possibly even to counter some factors contributing to climate change.

Reduced crop requirements for water: As precipitation becomes more irregular, and functionally less (because there is more rainfall runoff rather than soil infiltration, the need to get 'more crop per drop' becomes greater. By ceasing continuous flooding of paddy fields, SRI methods cut demand for irrigation water.

- In India, Tamil Nadu's Minister of Agriculture reported that his state had increased its rice production in 2009 despite a reduction in the area planted to rice causes by monsoon failures. He reported that SRI paddy yields in Tamil Nadu ranged from 6 to 9 t ha^{-1} compared to the state's average yield of 3.45 t (*The Hindu* 12/1/09: http://www.hindu.com/ 2009/12/01/ stories/2009120155040500.htm).

Practically all assessments of SRI methods show that they reduce crop consumption of irrigation water. Rainfed versions of SRI where there are no facilities or possibilities for irrigation are able to produce successful rice crops with lower water requirements.

More efficient use of water: Getting more crop per drop ultimately depends on higher crop physiological efficiency in the use of water.

- Trials at ICAR's Water Technology Center in Bhubaneswar, India, compared rice plants raised with SRI practices with plants grown according to the practices recommended (BMP). For each millimol of water transpired by SRI rice plants, 3.6 millimols of CO_2 were fixed vs. 1.6 millimols of CO_2 fixed by BMP plants per millimol of water transpired (Thakur et al. 2010).

This finding of greater physiological water use efficiency helps to account for the greater water use efficiency of SRI plants at plot level, reported from Chinese research (Lin et al. 2009; Zhao et al. 2009, 2010). This effect warrants further examination.

Drought resistance: Reports of drought tolerance and drought resistance have been received anecdotally from several countries in South Asia, with systematic data starting to be gathered and reported (Adhikari et al. 2010).

- In India, the 2009 kharif (rainy) season was marked by drought in many parts of the country. There were frequent reports of SRI fields withstanding the heat and water shortage, some of which got into the press (*The Hindu*, 11/21/09). Institutional resources were not available for a systematic program for documentation and evaluation, unfortunately.
- In Sichuan province of China, the productivity gains with SRI methods combined with plastic mulch on raised beds are reported to be even greater in drought years than in 'normal' years (Li 2009; Lv et al. 2009). SRI methods reportedly added 3 t/ha or more in a drought year compared with additions of 2.25-3 t/ha with usual rainfall. In a typical year, it was calculated that SRI methods could raise net income/ha from $220 to $1500; in a drought year, then could reverse a loss of $550/ha to an income of $800/ha.

Greater root mass and deeper roots of SRI plants absorb more water, and SRI soil management makes better use of whatever water is available by enhancing soil organic matter and making soil more water-retentive.

Other impacts:

- **Resistance to storm damage and cold temperatures:** SRI plants are more resistant to lodging (Chapagain and Yamaji 2009). SRI crops have been seen to remain upright even through typhoons in China, Vietnam and India that knocked down 'regular' rice crops. In an experiment managed by ANGRAU researchers in India, a 5-day cold snap with temperatures <10^{o}C lowered control-plot yield to 0.21 t/ha; yield on the adjacent SRI plot was 4.16 t/ha (Uphoff 2011).
- **Pest and disease resistance:** This is likely to become more important with climate change. An evaluation by Vietnam's National IPM Program across 8 provinces in 2005-06, assessing sheath blight, leaf blight, small leaf-folder and brown planthopper incidence, found this 55% lower in the spring season and 70% lower in the summer (Uphoff 2011).
- **Shorter crop duration:** Contrary to previous claims that SRI crops take longer to mature (Surridge 2005), their crop cycle is usually 1 or 2, even 3 weeks, shorter, with higher yield. This reduces crops exposure to extreme events and to pest and disease damage, also reducing water requirements.
- **Greenhouse gas emissions:** SRI's stopping continuous flooding of paddies reduces methane emissions as expected, but recent research in Nepal has found nitrous oxide also reduced (Karki 2010). Some Indonesian studies have produced similar SRI findings when the soil was organically fertilized (Dr. Iswandi Anas, Soil Biotechnology Laboratory, IPB, personal communication). The implication that with SRI practice, CH_4 reductions would not be offset by N_2O increases is consistent with the computer modeling results reported by Yan et al. (2009).

Because GHG emissions are highly variable, between locations and within seasons, no firm conclusions can yet be drawn on this effect. But initial reports provide justification for undertaking systematic evaluations of SRI impact on GHG mitigation.

SRI is still an evolving innovation. However, there are many reasons – including now its potential for buffering adverse impacts of climate change and countering forces that drive such change – to take SRI seriously and to evaluate its effects systematically.

Key words: biotic and abiotic stresses, drought, greenhouse gas emissions, crop lodging, System of Rice Intensification

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* SRI International Network and Resources Center, Cornell International Institute for Food, Agriculture and Development, Cornell University, Ithaca, NY 14853
ntu1@cornell.edu