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The "system of rice intensification (SRI)": implications for agronomic research

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1. Introduction

Wetland rice is generally considered to be an aquatic crop, grown under flooded conditions with several standard agronomic practices (De Datta, 1981). But does the wetland rice crop really require all that water? Is the anaerobic soil condition an absolute requirement? Or, is rice a crop that "survives" flooding and anaerobic soil condition at the expense of a large physiological effort resulting in lower agronomically attainable yields? Must we continue to promote a standard wetland rice system, derived largely during the early days of the 'green revolution' in Asia, with assertion that it is appropriate for all types of rice farmers everywhere in the developing world? Is the conventional wetland rice agronomy amenable to manipulation for improved productivity?[1] These are some fundamental questions that are raised by the successful use, initially in Madagascar and subsequently in major rice growing areas of South and South-east Asia, of the *"system of rice intensification"* (SRI).

2. SRI history and background

In 1983 after two decades of experimenting (in close consultation with local farmers) Fr. Henri de Laulaníe –a Jesuit priest in Madagascar- synthesized the "*système de riziculture intensive*" (SRI). Under the pressures from a drought and shortages of rice seeds, he started to experiment at his agricultural school near Antsirabe (1500 m elevation). The experiments initially focussed on transplanting very young rice seedlings of just 10-15 days old in a fairly wide spacing (25x25 cm) of single seedlings. A square planting pattern was used to facilitate mechanised weeding. The rice was not grown in flooded paddies, but in moist soil, with intermittent irrigation. Under such conditions Laulaníe observed tremendous increases in **tillering** and **rooting** as well as **number of panicles** and **panicle sizes,** contributing to spectacular grain yields (sometimes even exceeding 15 tons/ha).

In 1990, Laulaníe helped to establish a Malagasy NGO called Association Tefy Saina (ATS) and became its technical advisor. ATS (http://www.tefysaina.org/) began introducing SRI with farmers in a number of communities around the country. In 1994, the Cornell International Institute for Food, Agriculture and Development (CIIFAD) started working with ATS to introduce SRI as an alternative to slash-and-burn cultivation. From 1998, CIIFAD (http://ciifad.cornell.edu/sri/) has become increasingly active in drawing attention to the potential of SRI also in other major rice-growing areas in particular Asia (Uphoff et al., 2002), leading to a serious controversy with scientists of some established rice research institutes.

[1] In other words, should we continue to assume that rice productivity improvements must come mainly from genetic manipulation rather than from agronomic manipulation or from both ?

In line with de Laulanie's (1987) development vision and the prevailing conditions in rural Madagascar, external inputs, such as mineral fertilisers and other agricultural chemicals, have not been part of SRI. Instead, locally available sources of organic nutrients -- compost in particular -- are used. Water is carefully managed to avoid flooding and to facilitate rapid drainage after heavy rainfall. Well-drained, moist soil conditions are a critical element, leading to greatly reduced (up to 50%) water application compared with the quantity normally employed. Farmers reported minimal pest and disease problems under these conditions.

3. Critical elements of SRI

The initial publications by de Laulanié (1993a and b) and the review article by Stoop et al. (2002) together with a field study in Madagascar (Stoop, 2003) have revealed a relatively large number of different factors that in one way or another affect the performance of SRI. The following list of critical factors was established:

- soil and climatic factors (mostly temperature and rainfall),
- nursery preparation, and seed rates,
- field preparation for transplanting,
- carefully[2] transplanting of very young seedlings (2 leaves) of only 8 to 15 days old,
- transplanting as single plants,
- wide spacing between individual transplants, ranging from 25 x 25 to even 50 x 50 cm,
- responsive rice varieties with respect to their maturity cycle and tillering ability,
- soil moisture regimes at different stages of crop development; irrigation and drainage requirements,
- frequency of soil cultivation and weeding,
- soil fertility and plant nutrient management: organic manures and/or mineral fertilisers (rates, composition),
- preparation of organic manures (quality/origin of materials), and
- rotations / preceding off-season crops.

In addition to these mostly bio-physical factors, a number of crucial, more general issues were identified:

- farmer intelligence, motivation, interests, and overall educational level, and
- farmer ability to control and correctly manage the calendar of operations from the initial land preparation and nursery phases through to the harvesting operations in dealing with the various biological/technical factors mentioned above.

The ramification of this list of critical factors is that complex, multi-facetted issues are involved in terms of both adaptive and more fundamental technical research, as well as the socio-economic aspects of an adoption and dissemination process. Indeed, all of the above elements appear to be essential "building blocks" for SRI type techniques or practices, their adaptation and adoption by farmers, and their evolution over time.

4. Research and development implications

[2] This implies the selection of only the most vigorous seedlings for transplanting; minimizing the time between uprooting from the nursery and transplanting to the field (< 1 hour) while keeping the roots moist; and shallow transplanting with roots pointing downwards.

In a strict scientific sense, SRI must be considered so far to constitute a mostly *empirical* approach. To exploit the agronomic potential of the approach fully for rice (and eventually for other cereal cropping systems), as well as to achieve its efficient dissemination and adaptation to different agro-ecological conditions still requires considerable fundamental research. SRI agronomy" still needs to be worked out almost from scratch: what categories of rice varieties (e.g., early, intermediate or late maturing) are likely to respond best?; is the tillering feature brought about by the low plant population and wide spacing, or are the water regime and soil nutrient supply the critical factors? Further, some basic issues related to soil biota need to be clarified such as the possible roles of soil micro-organisms in meeting the supposedly considerable plant nutrient requirements by the crop under the SRI production environment.

SRI is characterised by soil-water and solar radiation regimes that are essentially different from those of conventional wetland rice under irrigated practices. The SRI soil condition will be *aerobic* with important implications for the structure and functioning of soil biota and of the root system. The crop canopy will be more open due to a reduced plant density and an increased spacing between plants. Therefore, research may well expose other important agronomic alternatives for the current practices of lowland rice cultivation, with potentially large impacts on the prevailing theoretical thinking about crop growth models, yield ceilings and *ideal* plant types. Further, issues like natural resource use-efficiency for land and water, as well as environmental pollution from agricultural chemicals and the release of methane gas from irrigated wetland rice systems would be touched upon by such research. Thus, the importance of this research therefore goes far beyond just SRI and rice.

An important observation made in SRI trials in Madagascar and Ivory Coast has been the impact of drained, yet moist, soil condition on the development of the plant root system. Just prior to flowering, SRI plants showed extensive and still actively growing roots; under the conventional fully irrigated and flooded conditions root development was reduced and most roots were in a senescent state. This observed difference in the size and functioning of the root system is fully in line with reports about increased drought tolerance and lodging resistance recorded for SRI crops (Uphoff, 2005)

Under drained soil conditions a symbiosis between rice roots and aerobic soil micro-organisms such as N-fixing bacteria, azospirillum and/or mycorrhyzae, becomes likely and particularly so in relatively rich soils and when organic fertilisers such as compost are used. The extensive root development under SRI would logically translate into a prolonged and/or accelerated vegetative development phase and consequently an increased nutrient uptake capacity presumably leading to an extended, more effective, grain-filling phase (Stoop, 2005).

However, the field research of these phenomena can be rather complex, because of the confounding effects between various critical factors (Stoop and Kassam, 2005). This applies in particular under on-farm conditions but also on research stations where soils might be non-representative from those under farmer conditions because of prolonged intensive cultivation, mono-cropping, and frequent use of agricultural chemicals (Bullock et al., 2004). The many empirical SRI trials conducted so far indicate that there still might be large, presently un-exploited, agronomic gains to be made in production, as well as in resource use efficiency for the respective production factors. As a result substantial improvements in overall crop productivity performance in comparison with the current conventional practices of wetland rice, where many plants are cramped together in a limited space below and above the soil, appears likely.

The SRI case illustrates the need for some innovative agronomic / eco-physiological research of a rather fundamental nature. Counter to the currently fashionable advanced plant and crop research into genomics, bio-technology and genetic manipulation, as well as a wide range of agricultural chemicals, such agronomic research does not need to be very costly. Yet, as argued also by Horie et al. (2005), its impact on farming practices and agricultural production by small rice farmers could be substantial, and this at low levels of expenditure. This research would aim first for a better appreciation of the natural processes in the plant / crop environment, including the soil and the dynamics in its biota. Next the exploitation of these processes through adjusted agronomic management practices would constitute the basis for higher yields and input factor productivities as are currently being obtained empirically by SRI farmers in Madagascar, India, China, Philippines, Nepal and elsewhere (Uphoff, 2005), and as had been achieved by Japanese smallholders in the fifties and sixties (Horie et al., 2005).

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