DTD 5
ARTICLE IN PRESS

Available online at www.sciencedirect.com
SCIENCE DIRECT®

Field Crops Research xxx (2005) xxx–xxx

Field Crops Research
www.elsevier.com/locate/fcr

Does the system of rice intensification outperform conventional best management? A synopsis of the empirical record

A.J. McDonald [a,b,*], P.R. Hobbs [b], S.J. Riha [a]

[a] Department of Earth & Atmospheric Sciences, 1123 Bradfield Hall, Cornell University, Ithaca, NY 14853, USA
[b] Department of Crop & Soil Sciences, 232 Emerson Hall, Cornell University, Ithaca, NY 14853, USA

Received 1 May 2005; accepted 10 May 2005

Abstract

Irrespective of its influence on agricultural productivity, the System of Rice Intensification (SRI) has certainly increased discussion over optimal rice cultivation practices, with many agricultural development practitioners at odds with a good deal of the established rice research community. To date, much of the debate over the putative benefits of SRI has been theoretical or speculative and has not persuaded adherents on either side. In aggregate, sufficient empirical data now exist to put SRI performance in a meaningful context by evaluating the productivity of SRI with respect to conventional best management practices (BMP). For this retrospective analysis, 40 site-years of SRI versus BMP comparisons were assembled into a common database. In addition to data from Madagascar where SRI was first conceived, findings from a broad geographic region were compiled including studies from Nepal, China, Thailand, Laos, India, Sri Lanka, Indonesia, Bangladesh, and the Philippines. Aside from one set of experiments in Madagascar where SRI more than doubled rice productivity with respect to BMP, we found no evidence of a systematic or even occasional yield advantage of this magnitude elsewhere. Indeed, none of the 35 other experimental records demonstrated yield increases that exceeded BMP by more than 22%. Excluding the Madagascar examples, the typical SRI outcome was negative, with 24 of 35 site-years demonstrating inferior yields to best management and a mean performance of −11%. With recognition that SRI yields in Madagascar are substantially beneath productivity levels predicted by bioclimatic factors, we find no evidence in the empirical record that SRI fundamentally changes the physiological yield potential of rice. Exceptional yield advantages from SRI – or some component(s) thereof – should not be projected beyond Madagascar.

Keywords: SRI; BMP; Productivity; Yield potential; Controversy

1. Introduction

Despite several controlled studies, farmer surveys, and theoretical arguments by proponents and opponents alike, disagreement over the merits of the System of Rice Intensification (SRI), continues apace in the agricultural research and development community (e.g. Sheehy et al., 2005; Stoop and Kassam, 2005). The larger context for this debate is the perception that rice (*Oryza sativa* L.) yields are stagnating and that new solutions are required to keep ahead of the caloric demands of a growing world (Surridge, 2004). SRI was first conceptualized as a complementary suite of rice management techniques in Madagascar during the early 1980s by Henri de Laulanie, a French missionary priest. Since the mid-1990s, SRI has been promoted as a sustainable route towards superior rice yields both within Madagascar, principally by the NGO Tefy Saina (http://www.tefysaina.org/), and internationally, most notably through the leadership of the International Institute for Food, Agriculture, and Development at Cornell University (http://ciifad.cornell.edu/). Together with a fair deal of skepticism, interest in SRI has been driven by reports from Madagascar of tremendous rice productivity increases in

* Corresponding author. Present address: 1121 Bradfield Hall, Cornell University, Ithaca, NY 14853, USA. Tel.: +1 607 279 6310; fax: +1 607 255 2106.
E-mail address: ajm9@cornell.edu (A.J. McDonald).

0378-4290/$ – see front matter
doi:10.1016/j.fcr.2005.05.003

controlled experimentation (ca. 200%; Uphoff and Randriamiharisoa, 2002) along with bumper yields for individual farmers (ca. 20 mt ha^{-1}; Rafaralahy, 2002). Moreover, *good responses* to SRI are commonly reported in farmer fields well beyond the confines of Africa (e.g. Husain et al., 2004; Anthofer, 2004).

The principles of SRI have been reviewed in detail elsewhere (Stoop et al., 2002; Uphoff, 2002). The main components include careful transplanting of young seedlings at wide spacings on a precise grid with only one seedling per hill, water management that keeps the soil moist but not continuously flooded, frequent (i.e. three to four times) manual or mechanical weeding before canopy closure, and reliance on high rates of organic compost for fertilizer. SRI advocates suggest that synergies among these unconventional management practices unlock the physiological potential of rice, with results that challenge prevailing notions of yield ceilings for this food staple (Stoop et al., 2002). In many senses, the rhetorical promise of SRI satisfies the often conflicting objectives of agricultural development: tremendous grain yields with few external inputs, placing benefits commensurate with those achieved with green revolution technologies within the reach of the poor while reducing environmental externalities and improving sustainability. Irrespective of productivity claims, there are practical reasons why the SRI combination of techniques may have a limited application domain, specifically the lack of water control in hydric landscape settings and, for most agricultural systems, no clear source of organic composts to supply large areas with the macronutrients required to achieve high yields. Moreover, the collective labor demands of SRI can be onerous, leading to significant disadoption rates in some locations (Moser and Barrett, 2003; Namara et al., 2003). Nevertheless, these limitations are best addressed once the agronomic value of the SRI approach to rice management has been more firmly established.

The theoretical case for (Stoop et al., 2002; Uphoff, 2003) and against (Dobermann, 2004; Sheehy et al., 2004; Sinclair, 2004) SRI has been presented in various levels of detail elsewhere, but definitive judgment of its worth must be made in the context of actual multi-site field data. SRI advocates have argued that negative results in individual experiments are confounded by the damaging influence of previous land management practices or are artifacts of missing or misapplied management components, while SRI detractors maintain that positive results are errors emanating from improperly replicated and controlled experimentation or through flawed inferences drawn from individual plants. While the robustness of several existing studies can certainly be questioned with either set of criticisms, it is our view that sufficient empirical evidence now exists to draw broad conclusions about SRI that transcend the limitations of individual experiments. The primary question we seek to answer in this analysis is simple: is SRI productivity superior to that achievable with conventional best management? We hope that this analysis, based strictly on multi-location field evidence, will clarify the agronomic potential of SRI.

2. Materials and methods

Results from field trials where SRI productivity was concurrently compared to accepted best management practices (BMP) were compiled in a common database with average yield values reported for both management systems ($n = 40$, Table 1). In some cases, this average represents the mean value of several replicates, whereas for others it is the response from a single field. Except for a small subset of these studies (e.g. Sheehy et al., 2004; Latif et al., in press), no data were available on the variability of yield responses for each management system nor were statistics commonly reported to assess the significance of any productivity differences. These factors preclude a formal meta-analysis of the aggregated database. BMP practices varied from site-to-site, reflecting local conditions; an overview of what commonly constitutes best management for rice is available from IRRI (http://www.knowledgebank.irri.org/troprice). Among the 40 site-year or site-year-variety records, 5 are from Madagascar and the remainder from nine different Asian countries. Sources for these data ranged from the peer-reviewed literature to informal reports from non-governmental organizations (i.e. grey literature). Experiments with treatments that did not closely approximate the principles of SRI (e.g. included only one or two SRI elements) or of legitimate best management (e.g. compared SRI to local farmer practices) were excluded from the database. For each experimental record, relative SRI productivity deviations from BMP (i.e. % deviation = ((SRI t ha^{-1}/BMP t ha^{-1}) − 1) × 100) were calculated to assess the advantage or disadvantage from SRI adoption. Simple descriptive statistics (mean ± 95% confidence interval, median) are used to characterize the typical performance of SRI relative to BMP.

3. Results

Productivity values from all experiments included in this analysis are presented in Table 1. A scatter graph of BMP (*x*-axis) versus SRI (*y*-axis) yield is given in Fig. 1 with each point representing an individual record ($n = 40$). While all five examples from Madagascar are above the 1:1 line, outside of Madagascar (i.e. Asian sites) only 11 out of 35 records (31%) had higher rice yields with SRI than with BMP. This trend is even more pronounced at sites with lower yield potential (i.e. <6 t ha^{-1} BMP) with only 3 out of 14 site-years (21%) exhibiting positive responses to SRI. Expressed as percentage deviation from BMP, relative SRI performance for each experimental record is displayed in Fig. 2, with the Asian sites segregated from those in Madagascar. The yield advantage for SRI in Madagascar

Table 1
Aggregated database of experiments where SRI was concurrently evaluated against accepted best management practices (BMP)

	Source	Location	Setting	SRI yield t ha^{-1}	BMP yield t ha^{-1}	SRI yield deviation (%)[a]	Comment
1	Uphoff and Randriamiharisoa (2002)	Madagascar (Anjomakely)	Farmer field	10.4	3.0	245	Good soil
2	Uphoff and Randriamiharisoa (2002)	Madagascar (Anjomakely)	Farmer field	6.4	2.0	213	Poor soil
3	Uphoff and Randriamiharisoa (2002)	Madagascar (Morondava)	Exp. station	6.0	2.1	182	Trad. cult.
4	Uphoff and Randriamiharisoa (2002)	Madagascar (Morondava)	Exp. station	6.8	2.8	140	HYV
5	Barison (2002)	Madagascar (Beforona)	Exp. station	6.3	4.9	27	
6	BRRI (http://ciifad.cornell.edu/sri/countries/bangladesh/bangrisrifnl.pdf)	Bangladesh (Comilla)	Exp. station	5.3	4.4	22	
7	Shengfu et al. (2002)	China (Anqing)	Exp. station	12.2	10.0	21	
8	MSSRF (http://ciifad.cornell.edu/sri/countries/india/)	India (Pondicherry)	Exp. station	6.4	5.4	19	
9	Welthungerhilfe (http://ciifad.cornell.edu/sri/countries/laos/laoritrl02.pdf)	Laos	Unreported	3.9	3.5	11	
10	Nissanka and Bandara (2004)	Sri Lanka (Hinguraggoda)	Farmer field	7.6	6.9	10	
11	Sheehy et al. (2004)	China (Jiangsu)	Exp. station	9.9	9.1	9	
12	Markarim et al., 2002	Indonesia (S. Sulawesi)	Farmer field	7.1	6.6	9	
13	Qingquan (2002)	China (Yunshun Co.)	Unreported	12.0	11.7	2	Pei'ai cult.
14	Shao-hua et al. (2002)—Exp. #3	China (Jiangsu)	Exp. station	9.3	9.1	2	
15	Shao-hua et al. (2002)—Exp. #4(b)	China (Nanjing)	Exp. station	11.8	11.5	2	Hybrid
16	Duxbury (Personal communication)	Bangladesh (Rajshahi)	Exp. station	10.0	9.8	2	2002 Boro
17	Sheehy et al. (2004)	China (Guangdong)	Exp. station	7.2	7.2	−1	
18	Evans et al. (2002)	Nepal (Bhairawa)	Exp. station	5.4	5.7	−5	
19	Shao-hua et al. (2002)—Exp. #1	China (Nanjing)	Exp. station	7.9	8.3	−5	
20	Shao-hua et al. (2002)—Exp. #2	China (Jiangyin)	Farmer field	8.4	8.9	−6	
21	Latif et al. (in press)	Bangladesh (Comilla)	Exp. station	7.1	7.6	−7	
22	Shao-hua et al. (2002)—Exp. #4(a)	China (Nanjing)	Exp. station	9.8	10.6	−7	Indica cult.
23	Duxbury (Personal communication)	Bangladesh (Rajshahi)	Exp. station	9.2	10.0	−8	2003 Boro
24	Sheehy et al. (2004)	China (Hunan)	Exp. station	6.7	7.4	−9	
25	Gypmantasiri (2002)	Thailand (Chiang Mai)	Exp. station	4.4	4.8	−10	Dry season
26	Latif et al. (in press)	Bangladesh (Vagurapara)	Farmer field	6.0	6.8	−11	
27	DED (http://ciifad.cornell.edu/sri/countries/laos/laoritrl02.pdf)	Laos	Unreported	2.5	2.9	−14	
28	Latif et al. (in press)	Bangladesh (Matiara)	Farmer field	5.9	7.0	−16	
29	Duxbury (Personal communication)	Bangladesh (Joydebpur)	Exp. station	7.4	8.9	−17	2003 Boro
30	Duxbury (Personal communication)	Bangladesh (Joydebpur)	Exp. station	6.4	7.8	−18	2002 Boro
31	Duxbury (Personal communication)	Bangladesh (Rangpur)	Exp. station	6.2	7.7	−20	2003 Boro
32	Duxbury (Personal communication)	Nepal (Khumultar)	Exp. station	4.7	6.3	−25	
33	Rickman (2004)	Philippines (Los Banos)	Exp. station	3.0	4.1	−27	Wet season
34	Annapurna farm (http://ciifad.cornell.edu/sri/countries/india/)	India (Auroville)	Farmer field	0.8	1.1	−33	2 cult. ave.
35	Sooksa-nguan et al. (2004)	Thailand (Chiang Mai)	Exp. station	3.8	5.9	−36	
36	GTZ (http://ciifad.cornell.edu/sri/countries/laos/laoritrl02.pdf)	Laos	Unreported	2.2	3.5	−37	2 site ave.
37	Gypmantasiri (2002)	Thailand (Chiang Mai)	Exp. station	2.6	4.2	−38	Rainy season
38	Gypmantasiri (2002)	Thailand (Chiang Mai)	Farmer field	3.2	5.4	−40	8 farmers
39	Rickman (2004)	Philippines (Los Banos)	Exp. station	1.4	3.1	−55	Dry season
40	NRRP (http://ciifad.cornell.edu/sri/countries/laos/laoritrl02.pdf)	Laos	Unreported	1.3	3.3	−61	

Mean yields are reported for SRI and BMP, with SRI performance judged as relative deviation from BMP[1]. Records are listed in descending order of SRI performance with respect to best management.

[a] Relative SRI productivity deviations from BMP: deviation (%) = ((SRI t ha^{-1}/BMP t ha^{-1}) − 1) × 100).

DTD 5
ARTICLE IN PRESS

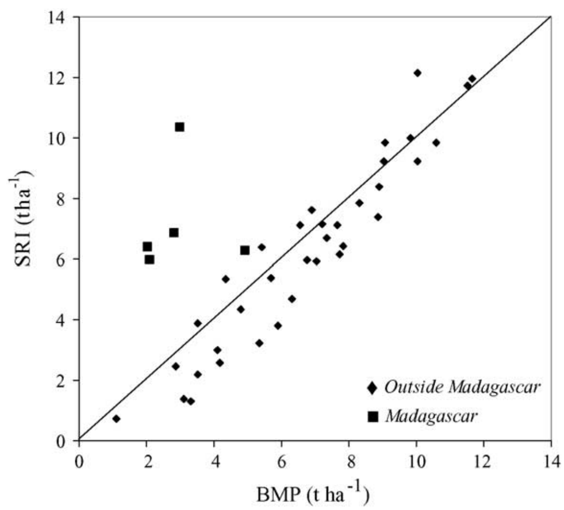

Fig. 1. Actual SRI yields (t ha^{-1}) displayed as a function of yields concurrently achieved with conventional best management practices (BMP) for Madagascar (■) and sites in nine different Asian countries (◆). Each data point represents one experimental record (i.e. site-year or variety-site-year). Points above the 1:1 line have favorable productivity responses to SRI.

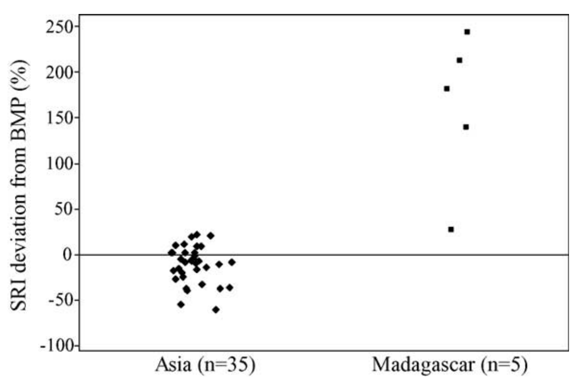

Fig. 2. Relative yield deviations (deviation (%) = ((SRI t ha^{-1}/BMP t ha^{-1}) − 1) × 100) of SRI from conventional best management (BMP), with results grouped by geographic region. Each data point represents one experimental record (i.e. site-year or variety-site-year).

($n = 5$) is striking, with all but one record demonstrating an increase of 140% or above. In vivid contrast, none of the Asian sites ($n = 35$) experienced a relative yield advantage with SRI that exceeded BMP by more than 22%. The mean and median relative performance of SRI outside of Madagascar was negative at −11 and −8%, respectively, with the 95% confidence interval for the mean ranging from −18 to −4%.

4. Discussion

Stoop and Kassam (2005) claim that neither SRI advocates nor its critics have a complete understanding of the biophysical basis of the relatively higher yields associated with this technology. In this synopsis of empirical results, we address the central question: relative to what? Beyond Madagascar, we found no systematic or even isolated evidence that SRI remarkably improves rice productivity above levels achievable with accepted best management practices. In fact, both the mean and median performance of SRI outside of Madagascar was negative. As a technology package, SRI appears to have little scope for increasing global rice yields over other intensive management approaches.

While we do not question the experimental validity of results achieved within Madagascar, close examination of these findings suggests why substantial yield advantages with SRI were not repeatable in nine other Asian countries. Sheehy et al. (2004) applied a dynamic rice model to simulate theoretical yield potential for several regions in Madagascar given site-specific climate characteristics. At Morondava (see Table 1), BMP yields reported by Uphoff and Randriamiharisoa (2002) are less than 25% of the predicted yield potential (ca. 13 t ha^{-1}). SRI does perform remarkably better than BMP at Morondava, but still only achieves 50% of the theoretical productivity. With sufficient fertility, no drought stress, and abundant solar radiation, the 2–3 t ha^{-1} yields achieved with BMP in the Madagascar experiments are exceptionally low and probably indicative of an acute soil constraint. Persistent flooding, a typical practice with conventional rice management methods, is associated with toxic levels of ferrous iron in the strongly acid oxisols of Madagascar (Vizier et al., 1990; Dobermann, 2004). Moreover, the high levels of organic amendments utilized with SRI probably complex with a substantial amount of exchangeable aluminum, hence moderating a second damaging characteristic of acid soils (e.g. Mokolobate and Haynes, 2003). Rather than realizing an untapped physiological potential of the rice plant, the water and compost fertilizer elements of SRI appear to reduce a site-specific edaphic limitation to growth. Most of the principal rice growing areas in Asia are located on young alluvial soils with moderate pH (Dobermann, 2004). Based on this generalization and the lack of positive yield responses to SRI in Asia, it seems likely that none of the other evaluation sites share similar physio-chemical soil characteristics with those in Madagascar.

SRI advocates often maintain that conventional research approaches to SRI evaluation ignore what is happening in farmer's fields and that the rapid geographic spread of SRI is *prima facie* evidence of its value (Stoop and Kassam, 2005). In a narrow regard this argument is accurate: on-farm surveys of SRI performance with reference to farmer practices demonstrate consistent increases in productivity. For instance, Husain et al. (2004) document a 30% yield advantage for SRI in Bangladesh and Namara et al. (2003) show an even larger benefit (44%) in Sri Lanka. Does this evidence support the contention that SRI increases rice yield potential? In the aforementioned Bangladesh study, farmer practices include dense plantings (ca. 15 cm × 15 cm) with very old seedlings (ca. 45 day), while the survey in Sri Lanka shows that most farmers use seed broadcasting for crop establishment. The Food and Agriculture Organization (FAO) examined the difference between attainable rice yields (i.e. with best management) and those achieved with local practices (Papademetriou et al., 2000), documenting a sizable rice productivity gap in much of the developing world. Suboptimal agronomic practices like those used by the surveyed farmers in Sri Lanka and Bangladesh are prime candidates for explaining this gap. The tangible impression that SRI *works* in farmer fields would likely be the same for any other intensive management system (e.g. conventional best management) that ensures careful weeding and sufficient fertility with timely and precise crop establishment. Interestingly, SRI yields reported in these surveys are similar to those achieved on nearby experiment stations with conventional best management (e.g. Bangladesh: Latif et al., in press; Sri Lanka: Dhanapala, 2000), further supporting the conclusion that SRI does not change the intrinsic yield potential of rice.

The most charitable interpretation of the empirical record is that few experimentalists outside Madagascar have mastered the complexities of SRI management, thereby explaining why tremendous productivity benefits are not universally realized. The plausibility of this theory was greater while the empirical evidence was limited. With 35 site-years across nine different Asian countries, it is reasonable to expect that at least a handful would have achieved an optimal combination of SRI elements to realize its synergies. We found no evidence outside of Madagascar that SRI produces remarkable yield increases when compared to accepted best management. Advocates also speculate that the full advantages of SRI only accrue in the medium to long-term once the legacy of poor management (e.g. low soil organic matter and biological activity) is overcome (Surridge, 2004). To our knowledge, no time-series data exist that substantiates this claim. A corollary argument is the belief that favorable SRI responses are typically constrained to farmer's fields because biologically impaired soils predominate on agricultural experiment stations as a consequence of intensive agro-chemical use (Stoop and Kassam, 2005). Outside of Madagascar (see Table 1), experiment station ($n = 23$) and on-farm ($n = 7$) responses to SRI were indistinguishable in our database at −9.2 and −12.5%, respectively.

The apparent popularity of SRI is growing in some regions, reflecting many factors including the attractiveness of its rhetorical claims, passionate and sincere promotion from its advocates, and perhaps most importantly the rather dismal performance of typical farmer practices. To the extent that the pervasive yield gap between attainable and achieved yields in many rice growing areas is a product of a knowledge limitation rather than economic or risk considerations, the experience with SRI illuminates the challenges of extending the principles and virtues of modern agronomic practices to farmers. There may well be lessons to be learned from the methods used to advance SRI by its champions.

SRI has also contributed to an evolving debate on the water requirements for rice (e.g. *Water-wise Rice Production*, Bouman et al., 2002) and the benefits of cultural practices such as planting single (e.g. San-oh et al., 2004) and younger (e.g. Horie et al., 2004) seedlings. The analysis presented in this paper does not seek to discredit the possibility that some aspects of SRI may prove valuable, only that the conversation must be simplified: there is no empirical evidence that adopting all SRI components in tandem unlocks a previously unexploited yield potential in rice.

5. Conclusions

The law of parsimony advises that the simplest explanation consistent with a set of facts most often proves correct. The preponderance of empirical evidence supports what accepted theory has always suggested: the system of rice intensification does not fundamentally change the physiological yield potential of rice. By basing much of their case for SRI on experiments in a single country with distinctive soils (Madagascar) and, outside Madagascar, to comparisons with farmer practices or national yield averages, SRI proponents have overextended inductive logic to promote the system of rice intensification as a global model for advancing the yield potential of rice. Beyond Madagascar, experimentalists and agricultural development practitioners must be appraised that there is no empirical or theoretical basis for promoting SRI as a singular method for maximizing rice productivity over other forms of intensive management.

Acknowledgements

We gratefully recognize the cooperation of Prof. John Duxbury, Dr. Julie Lauren, Dr. Thanwalee Sooksa-nguan, and Prof. Janice Thies, who generously provided access to unpublished experimental data for this analysis.

References

Anthofer, J., 2004. The potential of the system of rice intensification (SRI) for poverty reduction in Cambodia. In: Conference on International Agricultural Research for Development, Berlin, 5–7 October.

Barison, J., 2002. Evaluation of nutrient uptake and nutrient-use efficiency of SRI and conventional rice cultivation methods in Madagascar. In: Uphoff, et al. (Eds.), Assessments of the System of Rice Intensification (SRI): Proceedings of an International Conference, Sanya, China, 1–4 April 2002, CIIFAD, Ithaca, NY, USA, pp. 143–147.

Bouman, B.A.M., Hengsdijk, H., Hardy, B., Bindraban, P.S., Tuong, T.P., Ladha, J.K. (Eds.), 2002. Water-Wise Rice Production: Proceedings of the International Workshop, 8–11 April 2002, IRRI, International Rice Research Institute, Los Banos, Philippines, p. 356.

Dhanapala, M., 2000. Bridging the rice yield gap in Sri Lanka. In: Papademetriou, et al. (Eds.), Bridging the Rice Yield Gap in the Asia-Pacific Region. FAO, RAP Publication 2000/16, Rome.

Dobermann, A., 2004. A critical assessment of the system of rice intensification (SRI). Agric. Syst. 79, 261–281.

Duxbury, J.M., 2005. Personal communication, Department of Crop & Soil Sciences, Cornell University, Ithaca, NY, USA.

Evans, C., Justice, S., Shrestha, S., 2002. Experience with the system of rice intensification in Nepal. In: Uphoff, et al. (Eds.), Assessments of the System of Rice Intensification (SRI): Proceedings of an International Conference, Sanya, China, 1–4 April 2002, CIIFAD, Ithaca, NY, USA, pp. 64–66.

Gypmantasiri, P., 2002. Experience with the system of rice intensification in northern Thailand. In: Uphoff, et al. (Eds.), Assessments of the System of Rice Intensification (SRI): Proceedings of an International Conference, Sanya, China, 1–4 April 2002, CIIFAD, Ithaca, NY, USA, pp. 75–79.

Horie, T., Shiraiwa, T., Homma, K., Katsura, K., Maeda, Y., Yoshida, H., 2004. Can yields of lowland rice resumes the increases that they showed in the 1980s? Fourth International Crop Science Congress (ICSC2004) (http://www.cropscience.org.au/icsc2004/symposia/2/4/1869_horiet.htm#TopOfPage).

Husain, A.M., Chowhan, G., Barua, P., Uddin, A.F.M., Rahman, A.B.M, 2004. Final evaluation report on verification and refinement of the system of rice intensification (SRI) project in selected areas of Bangladesh. PETRRA-Project, IRRI, Dhaka, Bangladesh.

Latif, M.A., Islam, M.R., Ali, M.Y., Saleque, M.A. Validation of the system of rice intensification (SRI) in Bangladesh. Field Crop Res., doi:10.1016/j.fcr.2004.10.005.

Markarim, A.K., Balasubramanian, V., Zaini, Z., Syamsiah, I., Diratmadja, I.G.P.A., Arafah, H., Wardana, I.P., Gani, A., 2002. System of rice intensification (SRI): evaluation of seedling age and selected components. In: Bouman, B.A.M., et al. (Eds.), Water-Wise Rice Production: Proceedings of the International Workshop on Water-Wise Rice Production, 8–11 April 2002, International Rice Research Institute, Los Banos, Philippines, p. 356.

Mokolobate, M.S., Haynes, R.J., 2003. A glasshouse evaluation of the comparative effects of organic amendments, lime and phosphate on alleviation of Al toxicity and P deficiency in an Oxisol. J. Agric. Sci. 140 (4), 409–417.

Moser, C.M., Barrett, C.B., 2003. The disappointing adoption dynamics of yield-increasing, low external-input technology: the case of SRI of Madagascar. Agric. Syst. 76, 1085–1100.

Namara, R.E., Weligamage, P., Barker, R., 2003. Prospects for Adopting System of Rice Intensification in Sri Lanka: A Socioeconomic Assessment. Research Report #75. IWMI, Colombo, Sri Lanka.

Nissanka, S., Bandara, T., 2004. Comparison of productivity of system of rice intensification and conventional rice farming systems in the dry-zone region of Sri Lanka. Fourth International Crop Science Congress (ICSC2004) (http://www.cropscience.org.au/icsc2004/poster/1/2/1177_nissankara.htm).

Qingquan, Y., 2002. The system of rice intensification and its use with hybrid rice varieties in China. In: Uphoff, et al. (Eds.), Assessments of the System of Rice Intensification (SRI): Proceedings of an International Conference, Sanya, China, 1–4 April 2002, CIIFAD, Ithaca, NY, USA, pp. 109–111.

Papademetriou, M.K., Dent, F.J., Herath, E.M. (Eds.), 2000. Bridging the rice yield gap in the Asia-Pacific region.. FAO, RAP Publication 2000/16, Rome.

Rafaralahy, S., 2002. An NGO perspective on SRI and its origins in Madagascar. In: Uphoff, et al. (Eds.), Assessments of the System of Rice Intensification (SRI): Proceedings of an International Conference, Sanya, China, 1–4 April 2002, CIIFAD, Ithaca, NY, USA, pp. 17–22.

Rickman, J.F., 2004. Preliminary results: rice production and the system of rice intensification. (http://ciifad.cornell.edu/sri/countries/philippines/irrieval.pdf).

San-oh, Y., Mano, Y., Ookawa, T., Hirasawa, T., 2004. Comparison of dry matter production and associated characteristics between direct-sown and transplanted rice plants in a submerged paddy field and relationships to planting patterns. Field Crop Res. 87, 43–58.

Shao-hua, W., Weixing, C., Dong, J., Tingbo, D., Yan, Z., 2002. Physiological characteristics and high-yield techniques with SRI rice. In: Uphoff, et al. (Eds.), Assessments of the System of Rice Intensification (SRI): Proceedings of an International Conference, Sanya, China, 1–4 April 2002, CIIFAD, Ithaca, NY, USA, pp. 116–124.

Sheehy, J.E., Peng, S., Dobermann, A., Mitchell, P.L., Ferrer, A., Jianchang, Y., Zou, Y., Zhong, X., Huang, J., 2004. Fantastic yields in the system of rice intensification: fact or fallacy? Field Crop Res. 88, 1–8.

Sheehy, J.E., Sinclair, T.R., Cassman, K.G., 2005. Curiosities, nonsense, non-science and SRI. Field Crop Res. 91 (2–3), 355–356.

Shengfu, A., Xiehui, W., Zhongjiong, X., Shixiu, X., Chenquan, L., Yangchang, L., 2002. Assessment of using SRI with the super hybrid rice variety Liangyoupei 9. In: Uphoff, et al. (Eds.), Assessments of the System of Rice Intensification (SRI): Proceedings of an International Conference, Sanya, China, 1–4 April 2002, CIIFAD, Ithaca, NY, USA, pp. 112–1115.

Sinclair, T., 2004. Agronomic UFOs waste valuble scientific resources. Rice Today (IRRI) July–September, 43.

Sooksa-nguan, T., Teaumroong, N., Boonkerd, N., Gypmantasiri, P., Thies, J.E., 2004. Microbial community activity and structure associated with the system of rice intensification in northern Thailand. In: Soil Science Society of America, 68th Annual Meeting, Seattle, WA, October 31–November 4.

Stoop, W.A., Uphoff, N., Kassam, A., 2002. A review of agricultural research issues raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming systems for resource-poor farmers. Agric. Syst. 71, 249–274.

Stoop, W.A., Kassam, A.H., 2005. The SRI controversy: a response. Field Crop Res. 91 (2–3), 357–360.

Surridge, C, 2004. Feast or famine? Nature 428, 360–361.

Uphoff, N., 2002. Changes and evolution in SRI methods. In: Uphoff, et al. (Eds.), Assessments of the System of Rice Intensification (SRI): Proceedings of an International Conference, Sanya, China, 1–4 April 2002, CIIFAD, Ithaca, NY, USA, pp. 8–14.

Uphoff, N., Randriamiharisoa, R., 2002. Reducing water use in irrigated rice production with the Madagascar System of Rice Intensification. In: Bouman, B.A.M., et al. (Eds.), Water-Wise Rice Production: Proceedings of the International Workshop on Water-Wise Rice Production, 8–11 April 2002, International Rice Research Institute, Los Banos, Philippines, p. 356.

Uphoff, N., 2003. Higher yields with fewer external inputs? The system of rice intensification and potential contributions to agricultural sustainability. Int. J. Agric. Sustainability 1 (1), 38–50.

Vizier, J.F., Giudici, P., Raunet, M., 1990. Physiochemical study of a bottomland soil in the Madagascar highlands: effects on rice cultivation. Agron. Trop. 45 (3), 171–177.