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

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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

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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., 2005), 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